The Vowels of California English before /r/, /l/, and /ŋ/

by

Joshua Samuel Guenter

B.A. (University of Oregon) 1992
M.A. (University of California, Berkeley) 1994

A dissertation submitted in partial satisfaction of the requirements
for the degree of

Doctor of Philosophy
in

Linguistics

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA, BERKELEY

Committee in charge:

Professor John J. Ohala, Chair
Professor Gary Holland
Professor James Matisoff
Professor Thomas Shannon

Spring 2000

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The Vowels of California English before /r/, /l/, and /ŋ/

© Copyright 2000

by

Joshua Samuel Guenter

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table of Contents

List of Figures vii

List of Tables xi

List of Abbreviations and Symbols xii

Acknowledgments xiii

Chapter 1: Introduction. 1

Chapter 2: Historical Background 16

- 2.1. Introduction 16
- 2.2. The Changes 21
  - 2.2.1. Deletion of Short Vowels 23
  - 2.2.2. Assimilatory Changes 26
  - 2.2.3. Middle English Long High Vowels 30
- 2.3. Recent Mergers 35
- 2.4. Summary of Changes 36
- 2.5. Changes to the Phonological System 38

Chapter 3: The Problem 41

- 3.1. Criteria for Deciding Mono- vs. Biphonemicity 42
  - 3.1.1. Trubetzkoy's Rules 45
  - 3.1.2. Other Criteria 53
  - 3.1.3. Evaluation of the RGDs According to the Criteria 55
- 3.2. Past Phonological Analyses of the RGDs 62
  - 3.2.1. Syntagmatic Treatments 64
    - 3.2.1.1. Tense Vowel Treatments 65

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Bloomfield 1933 65

Teeter 1966 66

Harris 1994 68

Hammond 1999 72

3.2.1.2. Lax Vowel Treatments 73

Bronstein 1960 73

Kenyon & Knott 1953 73

Lehiste 1964 74

Akmajian *et al.* 1995 76

3.2.1.3. Archiphonemic Treatments: 77

3.2.1.4. Arbitrary Treatments 79

3.2.2. Diphthongal Treatments: 81

3.2.2.1. Monophonemic Treatments: 82

De Camp 1945 82

3.2.2.2 "Glide-Slot" Analyses 84

Trager & Bloch 1941 84

Kahn 1980 87

Veatch 1991 89

3.2.3. Other Treatments 93

3.3. What Needs to Be Determined: 95

Chapter 4: Vowels before /l/. 101

4.1. Introduction 101

4.2. Comparison of /l/ to /r/. 103

4.3. What Needs to be Determined 110

4.4. Past Phonological Analyses 111

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 5: Vowels before /ŋ/. ... 114

Chapter 6: Acoustic Analysis ... 121
6.1. Speech Material ... 121
6.1.1. Speakers ... 121
6.1.2. Data ... 122
6.1.3. Recording and Measurements ... 126
6.2. Vowels before /r/ ... 132
6.2.1. Formant Dynamics (Line Graphs) ... 132
6.2.2. Ranges of Allophony (Scatter Graphs) ... 142
6.2.3. Conclusions: Vowels before /r/ ... 164
6.3. Vowels before /l/ ... 165
6.3.1. Phonetic Classification of Post-vocalic /l/ ... 166
6.3.2. Existence of Stressed Syllabic /l/ ... 168
6.3.3. Mergers of Vowels before /l/ ... 169
6.3.4. Acoustic Categorization of Vowels before /l/ ... 174
6.3.4.1. Formant Dynamics (Line Graphs) ... 175
6.3.4.2. Ranges of Allophony (Scatter Graphs) ... 194
6.3.4.3. Conclusion: Vowels before /l/ ... 196
6.3.5. Syllabicity of /diphthong-l/ Sequences ... 197
6.3.6. Absence of Glides after Tense Vowels before /l/ ... 202
6.4. Vowels before /ŋ/ ... 205
6.4.1. Formant Dynamics (Line Graphs) ... 206
6.4.2. Range of Allophony (Scatter Graphs) ... 219
6.4.3. Conclusion: Vowels before /ŋ/ ... 221

Chapter 7: Psycholinguistic Evidence ... 230

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

7.1. Introduction 230

7.2. The Experiment 234

7.2.1. Expectations 254

7.3. Results and Discussion 255

7.3.1. Control Sets 256

7.3.2. Set R 262

[Ir] Pairs 262

[Er] Pairs 265

[Or] Pairs 267

[ɚ] Pairs 269

[Ar] Pairs 271

7.3.3. Diphthongs 272

7.3.4. Set NG 275

<ong> Pairs 275

<ung> Pairs 276

<ing> Pairs 277

<eng> Pairs 278

<ang> Pairs 280

7.3.5. bee/bead 281

7.3.6. Set L: 283

/il ɪl el ol/ Pairs: 283

/ɑl/ and /ʌl/ Pairs: 284

/ɛl/ and /ʊl/ Pairs: 287

7.4. Uncertainty 290

7.4.1. Comparison with Semantic Prototypes 292

7.4.2. Prototypes and Sound Change 301

7.4.3. Other Phonological Tests 305

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

JAEGER & OHALA 1984 ... 305
DERWING, NEAREY, & DOW 1986 ... 308

Chapter 8: Analysis ... 313
8.1. The Status of Vowels before /r/ ... 314
8.1.1. The Tense Vowel Analysis ... 314
8.1.2. The Lax Vowel Analysis ... 317
8.1.3. The Archiphonemic Analysis ... 319
8.1.4. The "Arbitrary List" Analysis ... 325
8.1.4.1. The Historically Consistent Solution ... 325
8.1.4.2. The Phonetically Consistent Solution ... 329
8.1.5. The Monophonemic Analysis ... 333
8.2. Incorporating the Findings into Phonological Description ... 351
HAMMOND (1999) ... 352
JENSEN (1993) ... 353
HARRIS (1994) ... 354
VEATCH (1991) ... 357
8.3. Analysis of Vowels before /l/ ... 360
VEATCH (1991) ... 372
8.4. Vowels before /ŋ/ ... 374

Chapter 9: Vowels before /r/ in Other Dialects of English ... 381
9.1. LOT=THOUGHT, NORTH=FORCE≠POOR dialects ... 382
9.1.1. Background ... 383
9.1.2. Formant dynamics (line graphs) ... 384
9.1.3. Range of Allophony (Scatter Graphs) ... 388
9.1.4. Conclusions (Acoustic Data) ... 392

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.5. Psycholinguistic Evidence 393
9.1.6. Analysis 395
9.2. LOT≠THOUGHT, NORTH=FORCE=POOR Dialects 397
9.3. LOT≠THOUGHT, NORTH=FORCE≠POOR Dialects 398
9.4. LOT≠THOUGHT, NORTH≠FORCE≠POOR Dialects 400
9.5. Some British Dialects: Rhotic and Non-rhotic 401
9.5.1. GA and RP 402
9.5.2. GA and RP and SSE 404
9.5.3. Rhotic vs. Non-rhotic? 406

Chapter 10: Vowels before intervocalic /r/ 417

Chapter 11: Conclusion 428

Appendix A: Pedagogical Recommendations 436

Appendix B: Acoustic Information 447
B.1. F1, F2, and F3 Measurements 447
B.2. Durations and Rhyme Percentages 486
B.3. Scatter Charts (All Vowels) 487

Appendix C: Psycholinguistic Data 490
C.1. Response Times 490
C.2. Yes/No Responses 494

Bibliography 498

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

List of Figures

3.1. Representation of the word "beer" (Harris 1994) 70
6.1.1. [I] compared to /i ɪ/ (Male) 133
6.1.2. [I] compared to /i ɪ/ (Female Northern) 134
6.1.3. [I] compared to /i ɪ/ (Female Southern) 134
6.2.1. [E] compared to /e ɛ æ/ (Male) 135
6.2.2. [E] compared to /e ɛ æ/ (Female Northern) 135
6.2.3. [E] compared to /e ɛ æ/ (Female Southern) 136
6.3.1. [O] compared to /u ʊ o/ (Male) 136
6.3.2. [O] compared to /u ʊ o/ (Female Northern) 137
6.3.3. [O] compared to /u ʊ o/ (Female Southern) 137
6.4.1. [A] compared to /ɑ/ (Male) 139
6.4.2. [A] compared to /ɑ/ (Female Northern) 139
6.4.3. [A] compared to /ɑ/ (Female Southern) 140
6.5.1. [ɚ] compared to /ʌ ʊ/ (Male) 140
6.5.2. [ɚ] compared to /ʌ ʊ/ (Female Northern) 141
6.5.3. [ɚ] compared to /ʌ ʊ/ (Female Southern) 141
6.6.1. /i/ - Males 146
6.6.2. /i/ - Northern Females 146
6.6.3. /i/ - Southern Females 147
6.7.1. /ɪ/ - Males 147
6.7.2. /ɪ/ - Northern Females 148
6.7.3. /ɪ/ - Southern Females 148
6.8.1. /e/ - Males 150
6.8.2. /e/ - Northern Females 150
6.8.3. /e/ - Southern Females 151
6.9.1. /ɛ/ - Males 151
6.9.2. /ɛ/ - Northern Females 152
6.9.3. /ɛ/ - Southern Females 152
6.10.1. /æ/ - Males 153
6.10.2. /æ/ - Northern Females 153
6.10.3. /æ/ - Southern Females 154
6.11.1. /u/ - Males 154
6.11.2. /u/ - Northern Females 155
6.11.3. /u/ - Southern Females 155

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6.12.1. /ʊ/ - Males 157
6.12.2. /ʊ/ - Northern Females 157
6.12.3. /ʊ/ - Southern Females 158
6.13.1. /o/ - Males 158
6.13.2. /o/ - Northern Females 159
6.13.3. /o/ - Southern Females 159
6.14.1. /ɑ/ - Males 160
6.14.2. /ɑ/ - Northern Females 160
6.14.3. /ɑ/ - Southern Females 161
6.15.1. /ʌ/ - Males 161
6.15.2. /ʌ/ - Northern Females 162
6.15.3. /ʌ/ - Southern Females 162
6.16.1. /i_ɹ/ compared to /i/ (Male) 176
6.16.2. /i_ɹ/ compared to /i/ (Female Northern) 176
6.16.3. /i_ɹ/ compared to /i/ (Female Southern) 177
6.17.1. /ɪ_ɹ/ compared to /ɪ/ (Male) 177
6.17.2. /ɪ_ɹ/ compared to /ɪ/ (Female Northern) 178
6.17.3. /ɪ_ɹ/ compared to /ɪ/ (Female Southern) 178
6.18.1. /e_ɹ/ compared to /e/ (Male) 179
6.18.2. /e_ɹ/ compared to /e/ (Female Northern) 179
6.18.3. /e_ɹ/ compared to /e/ (Female Southern) 180
6.19.1. /ɛ_ɹ/ compared to /ɛ/ (Male) 180
6.19.2. /ɛ_ɹ/ compared to /ɛ/ (Female Northern) 181
6.19.3. /ɛ_ɹ/ compared to /ɛ/ (Female Southern) 181
6.20.1. /æ_ɹ/ compared to /æ/ (Male) 183
6.20.2. /æ_ɹ/ compared to /æ/ (Female Northern) 183
6.20.3. /æ_ɹ/ compared to /æ/ (Female Southern) 184
6.21.1. /u_ɹ/ compared to /u/ (Male) 184
6.21.2. /u_ɹ/ compared to /u/ (Female Northern) 185
6.21.3. /u_ɹ/ compared to /u/ (Female Southern) 185
6.22.1. /ʊ_ɹ/ compared to /ʊ/ (Male) 188
6.22.2. /ʊ_ɹ/ compared to /ʊ/ (Female Northern) 188
6.22.3 /ʊ_ɹ/ compared to /ʊ/ (Female Southern) 189
6.23.1. /o_ɹ/ compared to /o/ (Male) 189
6.23.2. /o_ɹ/ compared to /o/ (Female Northern) 190
6.23.3. /o_ɹ/ compared to /o/ (Female Southern) 190

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6.24.1. /ɑ_l/ compared to /ɑ/ (Male) 191
6.24.2. /ɑ_l/ compared to /ɑ/ (Female Northern) 191
6.24.3. /ɑ_l/ compared to /ɑ/ (Female Southern) 192
6.25.1. /ʌ_l/ compared to /ʌ/ (Male) 192
6.25.2. /ʌ_l/ compared to /ʌ/ (Female Northern) 193
6.25.3. /ʌ_l/ compared to /ʌ/ (Female Southern) 193
6.26.1. ‹i› compared to /i ɪ/ (Male) 206
6.26.2. ‹i› compared to /i ɪ/ (Female Northern) 207
6.26.3. ‹i› compared to /i ɪ/ (Female Southern) 207
6.27.1. ‹e› compared to /e ɛ æ/ (Male) 208
6.27.2. ‹e› compared to /e ɛ æ/ (Female Northern) 208
6.27.3. ‹e› compared to /e ɛ æ/ (Female Southern) 209
6.28.1. ‹a› compared to /e ɛ æ/ (Male) 209
6.28.2. ‹a› compared to /e ɛ æ/ (Female Northern) 210
6.28.3. ‹a› compared to /e ɛ æ/ (Female Southern) 210
6.29.1. ‹o› compared to /ɑ/ (Male) 211
6.29.2. ‹o› compared to /ɑ/ (Female Northern) 211
6.29.3. ‹o› compared to /ɑ/ (Female Southern) 212
6.30.1. ‹u› compared to /ʌ/ (Male) 212
6.30.2. ‹u› compared to /ʌ/ (Female Northern) 213
6.30.3. ‹u› compared to /ʌ/ (Female Southern) 213
6.31. Historical raising of vowels before /ŋ/ 216
6.32.1. Speaker 09's pronunciation of "pull" and "couple" 223
6.32.2. Speaker 04's pronunciation of "pull" and "pool." 223
6.32.3. Speaker 14's pronunciation of "pull" and "pool." 224
6.32.4. Speaker 06's pronunciation of "hole" and "hull." 224
6.32.5. Speaker 03's pronunciation of "hole" and "hull." 225
6.33.1. Speaker 03's pronunciation of "line" and "lion." 225
6.33.2. Speaker 11's pronunciation of "gown" and "MacGowan." 226
6.34.1. Speaker 03's pronunciation of "Nile" and "denial." 226
6.35.1. Speaker 11's pronunciation of "owl" and "avowal." 227
6.35.2. Speaker 06's pronunciation of "owl" and "avowal." 227
6.36.1. Speaker 04's pronunciation of "L" (amplitude) 228
6.36.2. Speaker 08's pronunciation of "L" (amplitude) 228
6.36.3. Speaker 04's pronunciation of "L" (formants) 229
6.36.4. Speaker 08's pronunciation of "L" (formants) 229

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

7.1. Relation of Yes/No% to Response Time....258
7.2. Relation of Response Time to Unanimity of Response....291
7.3. Prototype Representations for /e/ and /ɛ/....300
7.4. Possible Stages for the Raising of /æ/ before /ŋ/. Stage 1....303
7.5. Possible Stages for the Raising of /æ/ before /ŋ/. Stage 2....303
7.6. Possible Stages for the Raising of /æ/ before /ŋ/. Stage 3....303
7.7. Possible Stages for the Raising of /æ/ before /ŋ/. Stage 4....303
8.1. Representation of the word "tie" (Harris 1994)....355
8.2. Representation of monosyllabic pronunciation of "tire" (Harris 1994)....355
8.3. Representation of the syllable [kæm] in "camera" (Harris 1994)....356
8.4. Representation of "fear" (Harris 1994)....357
9.1. [O] compared to /o/ - Speaker 11 (mn)....386
9.2. [O] compared to /o/ - Speaker 14 (fs)....386
9.3. [U] compared to /u ʊ/ - Speaker 11 (mn)....387
9.4. [U] compared to /u ʊ/ - Speaker 14 (fs)....387
9.5. /u/ - Speaker 11 (mn)....389
9.6. /u/ - Speaker 14 (fs)....389
9.7. /ʊ/ - Speaker 11 (mn)....390
9.8. /ʊ/ - Speaker 14 (fs)....390
9.9. /o/ - Speaker 11 (mn)....391
9.10. /o/ - Speaker 14 (fs)....391
9.11. F1 and F2 measurements of Thomas's Speaker 11....399
B.3.1. All Vowels (Males)....487
B.3.2. All Vowels (Northern Females)....488
B.3.3. All Vowels (Southern Females)....489

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

List of Tables

2.1 Modern English Reflexes of Middle English Vowels ... 22

3.1 Distribution of Vowel plus Single Consonant Codas in English ... 59

6.1 Vowel and Rhyme Durations for Speaker 08 ... 128

6.2 Average F1 and F2 Measurements for Canonical Vowels ... 131

6.3 Judges' Identification of Words as "pool/pull" or "hull/hole" ... 170

6.4 Durations of Syllabic Nuclei in American English (Peterson & Lehiste 1960) ... 217

7.1 Percentage of Yes/No and Response Times by Vowel-pair category ... 257

7.2. P-values for Response Times and Yes/No Responses ... 263

7.3. Allophones of /ɛ/ and /ɪ/ before /l/ and ranges of /ʌ/, /u/, and /ʊ/ ... 289

7.4. Categories and Members Used in Reaction Time Experiment (Rosch 1973) ... 293

7.5. Response Times and Error Proportions for Central and Peripheral Category Members (Rosch 1973) ... 294

7.6: Results for [+sonorant] (Jaeger & Ohala 1984) ... 306

7.7. Percent Yes grouping for "tough"-probe (Derwing, Nearey, & Dow 1986) ... 309

8.1. Basic General American Vowel System (Giegerich 1991) ... 323

8.2. Comparison of /r/ to Glides and True Consonants ... 350

8.3. Vowels and Diphthongs of English (modification of Hammond 1999) ... 352

8.4. Short, Lax Vowels (modification of Jensen 1993) ... 354

8.5. Tense Vowels and Diphthongs (modification of Jensen 1993) ... 354

8.6. Reference American Vowel Structure with Representative Words (Veatch 1991) ... 358

8.7. California English Vowel Structure (modification of Veatch 1991) ... 359

8.8. Comparison of /l/ to Glides and True Consonants ... 364

8.9. Future American Vowel Structure (modification of Veatch 1991) ... 372

9.1. Subject 14 and Subject 18's Responses for Set R/Vowel Identification Test ... 394

9.2. Reflexes of ME /Vr/ Sequences in GA and RP ... 403

9.3. Reflexes of ME /Vr/ Sequences in GA, RP, and SSE ... 405

9.4. Comparison of GA and SSE /r/ to Glides and True Consonants ... 406

9.5. Scale of Rhoticity ... 414

9.6. Inventory of RP Vowels (Coleman 1998) ... 415

10.1. Development of ME Vowels before Intervocalic /r/ ... 418

A.1. Symbols for English Vowel Phonemes in Four Dictionaries ... 441

A.2. Representations of /Vr/ Sequences in Four Dictionaries ... 442

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

List of Abbreviations and Symbols

CE: California English

GA: General American

SSE: Standard Scottish English

RP: Received Pronunciation (British English)

IrE: Irish English

RGD: "Rhotic Gliding Diphthong" -- A diphthong which begins with a non-rhotic vowel but moves to a rhotacized off-glide, such as in the American English words *ear, air, are,* and *are*.

[Ir]: The RGD exemplified by the rhyme in the CE word *peer*.
[I]: The nucleus before the off-glide [ɚ] in the RGD [Ir].
[Er]: The RGD exemplified by the rhyme in the CE word *pear*.
[E]: The nucleus before the off-glide [ɚ] in the RGD [Er].
[Ar]: The RGD exemplified by the rhyme in the CE word *par*.
[A]: The nucleus before the off-glide [ɚ] in the RGD [Ar].
[Or]: The RGD exemplified by the rhyme in the CE word *pore*.
[O]: The nucleus before the off-glide [ɚ] in the RGD [Er].
[Ur]: The RGD exemplified by the rhyme in the CE word *poor*, for those who contrast it with the rhyme in *pore*.
[U]: The nucleus before the off-glide [ɚ] in the RGD [Ur].

‹ing›: The [Vŋ] sequence exemplified by the rhyme in the CE word *sing*.
‹i›: The nucleus before the [ŋ] in the sequence ‹ing›.
‹ang›: The [Vŋ] sequence exemplified by the rhyme in the CE word *sang*.
‹a›: The nucleus before the [ŋ] in the sequence ‹ang›.
‹ong›: The [Vŋ] sequence exemplified by the rhyme in the CE word *song*.
‹o›: The nucleus before the [ŋ] in the sequence ‹ong›.
‹ung›: The [Vŋ] sequence exemplified by the rhyme in the CE word *sung*.
‹u›: The nucleus before the [ŋ] in the sequence ‹ung›.
‹eng›: The [Vŋ] sequence exemplified by the rhyme in the CE word *strength*, for those who do not have the alveolar nasal [n] in this word and do contrast this rhyme with the one in *sang*.
‹e›: The nucleus before the [ŋ] in the sequence ‹eng›.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Acknowledgments

I would first of all like to thank Julie Lewis and Margaret Urban, without whom Chapter Seven would not have been possible. Thanks go to Julie for help and support in many other areas of the dissertation as well.

Thanks to John Ohala, of course, for being everything an advisor should be (and particularly for his suggestions pertaining to the relation of prototypes to sound change), and to the other members of my committee: Gary Holland, Tom Shannon, and Jim Matisoff, for helping me make this a better dissertation.

Thanks to Gunnar Hansson, for recommendations concerning the applications of prototype theory to the findings in Chapter Seven. Thanks to Ashlee Bailey for making me aware of the *hole/hull* merger by having it herself. Thanks to the students not already mentioned who were enrolled in Ling 210 during the Spring of 1998 (Aimée Bartosik, Steve Chang, Ben James, Lily Liaw, Kenneth Van Bik) for helping design the experiment in Chapter Seven, and to Sean Ying for aid in the technical aspects of the same experiment. Big thanks go to Jim Ritchie for his role in the preparation and running of the pilot study as well.

Thanks to Alexandre Bureau, Liza Levina, and Jean Yang in Statistics Consulting for their aid when I, well, consulted them on matters pertaining to, well, statistics.

Thanks to the many linguists who have shown interest in my work and whom I have consulted with on a number of topics in person or via e-mail. Specifically, I wish to acknowledge Tom

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Veatch, Erik Thomas, and Corey Miller for their comments, references they have made me aware of, and extremely useful materials they have sent to me personally.

The biggest thanks should go to those whom protocols prevent me from acknowledging by name: the volunteer subjects, speakers, and judges who have given me their time, judgments, and formants with no recompensation except for the knowledge that they were making contributions to the world of linguistics. This dissertation, the field of experiment phonology, and many other fields of experimental research, could not exist without such people.

Most of all, thanks go to Sara and to Emily, for collectively eating only a few pages of the dissertation between them.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 1: Introduction.

Much of the inspiration for doing this research comes from my experience as an instructor teaching Linguistics classes at U. C. Berkeley. I have noticed that students who otherwise completely understand the concept of phonological transcription have trouble figuring out how to represent vowels before /r/ in words like "ear." That is to say, that if told that /ɪ/ represents the vowel sound in "bit", they have no trouble figuring out that this is the same vowel in "fish", "miss", "gift", "tick", "myth", "busy", etc., even figuring out that it's the same vowel when it's nasalized in words like "win."

This problem has a direct parallel in the field of theoretical linguistics. Linguists have no trouble figuring out that the words "bit", "pill", "din", and "bid" have the same vowel (for example, Giegerich 1992: 45ff). How do they know this? No acoustic or experimental evidence is given. Indeed, none is needed. That some dialects of English have the same vowel in all of these words is not controversial. Linguists only need to use their own intuitions and a minimum of subjective acoustic impressions. However, the intuitions seem to fall apart when it comes to the vowels that exist in words like "ear", "air", "are", and "oar." The trained linguist has the same problems as the introductory level Linguistics student in this matter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Many linguists admit that there is a problem determining what the vowels found before /r/ are (Wardhaugh 1995, Giegerich 1992) and do not even attempt to figure out what they are. Others have to set up special devices, such as separate rules, to account for these vowels (for example Harris 1994, Trager & Bloch 1941, others we shall see). Sometimes the difficulty may just manifest itself in inconsistent transcription, as in Ladefoged (1992), in which the vowels in "here" and "hair" are transcribed as /ɪ/ and /e/ respectively on page 31, but those in "beer" and "bare" have had their tense/lax values reversed to /i/ and /ɛ/ on page 87[1].

Often, when people have difficulty figuring out an answer, it is because they are asking the wrong question. The question "What are the vowels before /r/?" is based on the presupposition that the vowels in words like "ear", "air", etc. are "before" the /r/ in a syntagmatic sense. This is not necessarily the case. Let me explain what I mean by that. It is a given that American English /r/ is a central approximant [ɹ], belonging to the same class as the central approximants [j] and [w]. This is freely mentioned even in some introductory level Linguistics textbooks (for example, Finegan 1994:

[1]These cannot be considered phonetic representations from a dialect which contrasts a different vowel in "beer" and "bear" and "hair" and "bare", because on both pages (31 and 87), Ladefoged is specifically trying to list the maximum number of vowels contrasting in the dialects in question.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

37). The central approximant [ɹ] is put in the same class as [j] and [w]. Therefore, the rhymes in words such as "ear", "are", etc. are diphthongs. Is it not then inconsistent to not treat the diphthongs ending in [ɹ] the same way as those ending in [j] and [w]? One might as well ask the question "What are the vowels before /w/?" But this question is not asked. Diphthongs ending in [j] or [w], such as [aj, aw, ɔj] in "buy", "bough", "boy", are just listed in the inventory along with /i ɪ ɛ/, etc. (Finegan 1994, O'Grady *et al* 1997, Fromkin & Rodman 1998). The assumption is that, told that /ɑ/ represents the vowel in "pot", one should have no trouble figuring out that this is the same vowel in "pop", "crotch", "bomb", etc. However, it is assumed that learners could not, after having been told that /ɑ/ is the vowel in "pot" and /j/ is the initial sound in "yes", put these two together to get "eye", because /aj/ in "eye" is not really a sequence of the two independently appearing vowel phonemes (though it resembles one phonetically), but a separate phoneme in its own right. The question "What are the vowels before /j/ or /w/" does not come up. Indeed, linguists even write the diphthongs in words like "buy" or "bough" with a symbol /a/ which is not even considered to be a separate phoneme in the language in question.

The reason for doing this has its background in phonological theory. Namely, in the position that a given diphthong in a given

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

language must be categorized as monophonemic or biphonemic. The matter is one that must be resolved for all diphthongs, and explicit criteria[2] for deciding mono- or biphonemic status are used (see Trubetzkoy 1969, Swadesh 1935, Pike 1947a, Cohen 1952, Burquest 1993), and evaluations made. Parallel arguments are made for diphthongs in other languages (see Benware 1986 on German, Collier *et al* 1982 on Dutch) and for other complex segments, such as affricates, aspirated stops, etc. (Pike 1947b, Burquest 1993). It may turn out that a phonetically nearly identical diphthong is considered biphonemic in one language, but a single (though complex) vowel phoneme in another. For example, Clynes (1997) transcribes both English "my" and Tagalog "may" identically as [maɪ], but claims the English diphthong is a single vowel phoneme, while the Tagalog diphthong is biphonemic, with the [a] in the nucleus, and the [ɪ] in the coda.

If a diphthong is analyzed as biphonemic, then it must be considered a sequence of two other independently occurring phonemes of that language, and is not listed in the inventory of phonemes. A language no more "has" biphonemic diphthongs than it "has" consonant clusters like /st fr/, etc. (Lass 1984: 138)

---

[2]These criteria will be discussed explicitly in Chapter 3.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

But, on the other hand, if a diphthong is considered monophonemic, then it is simply listed in the inventory of phonemes along with the monophthongal vowels, and the question "What is the vowel before the glide?" does not have to, indeed cannot, be answered. By allowing some diphthongs to be analyzed as monophonemic, we are acknowledging that not all vowels are steady-state vowels. It may be that some languages have few or no steady state vowels at all. This has been claimed for English (Delattre 1965: 67-68). So, the existence of monophonemic diphthongs in linguistic analysis is necessary, unless we are prepared to say that there are languages which do not have monophonemic vowel sequences (not a likely situation). We may write /ɪ/ with one phonetic symbol, and /aj/ with two, but that's just a matter of convention.[3]

So, then, why not just consider the rhymes in "ear", etc. to be monophonemic and list them in the inventory alongside /i ɪ e ɛ æ u ʊ o ɔ ə ɑ aj aw ɔj/? This has been proposed explicitly (De Camp 1945),

[3]And there are, of course, even different conventions as to how many symbols are used to represent the same vowel phoneme in English. For example, Finegan (1994: 40) uses one symbol to represent /i e u o/ as in "beat", "bait", "boot", "boat", but Akmajian *et al* (1995: 76) represent these same vowels with two symbols, as /iy ey uw ow/. Nevertheless, Akmajian *et al* still treat the vowels as paradigmatic, placing them in an inventory.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

and suggested (Wells 1982: 50), but never implemented by any linguist that I know of.[4]

This is the analysis I argue for in this dissertation; that the diphthongs ending with [ɹ] should be accorded the same status as those ending with [j] or [w], even though they usually are not accorded this status. The reason for doing this is not just the lack of contrast of vowels before /r/. There are a limited number of vowels that occur before /ʒ/ as well, yet we have no trouble figuring out that the vowels in "beige", "garage", "luge", etc., are /e ɑ u/ respectively (Hammond 1999: 112). The reason for wanting to put /Vr/ sequences in the inventory is because they are phonetically diphthongs. Hence, I will be making use of the explicitly listed criteria linguists have used to decide whether a given diphthong is monophonemic or biphonemic. I will investigate the /Vr/ sequences in a number of domains, including historical, phonological, acoustic phonetic, and psychological. Throughout, I will be comparing [Vr] sequences with both vowel/sonorant (like [Vm] or [Vn]) and vowel/central approximant (like [Vj] or [Vw]) sequences to see which they pattern more similar to. I also will be investigating the status

---

[4]Perhaps the reason for this comes from orthographic bias? The /Vr/ sequences in English are historically biphonemic and this is reflected in the spellings, which always involve at least two letters. However, the diphthong /aj/ can be spelled with one letter, as in "mind", reflecting its historical origin as a presumably monophthongal monophoneme.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of vowels before /l/ and /ŋ/ in English, because, as we shall see, there are certain parallels to that of vowels before /r/.

The limitation of the subjects in this dissertation (both in the phonetic and psychological studies) to native speakers of California English is purely practical. The data was all gathered at the University of California at Berkeley in 1998 and 1999, and this is the only homogeneous group of American English speakers I could reasonably expect to gather a large enough population from. The findings, however, I believe could be applied to English speakers from other areas of North America.

However, the reader is asked to have an open mind when reading the results presented in this dissertation. What I find and conclude may not be true for all speakers of American English and for all age groups, and may not coincide with the reader's personal intuitions. It may be the case that what I claim to be true applies not only to a specific region, but to a specific age group as well (all subjects in the research are under 30). Phonological re-analysis may very well be going on right now.

This dissertation is not a cross-linguistic analysis of the effect "rhotics" may have on preceding vowels, nor is it an attempt to explain the phonetic reasons for the changes that have occurred in English. The latter issue will be addressed in the chapter on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

historical changes (Chapter 2), but is not of paramount importance to help answer the question at hand. The changes have already occurred (as much as four hundred years ago). I am simply trying to address the synchronic phonological situation that exists as a result of these changes. Similarly, a cross-linguistic survey of the effects of "rhotics" on preceding vowels is not immediately relevant, because it is not the effect of the /r/ on the vowel that I am addressing, but how the whole /Vr/ sequences is to be analyzed phonologically. However, parallel phenomena in other languages will be addressed.

It might be questioned whether the assignment of diphthongs to categories such as "biphonemic" or "monophonemic" is warranted, given that phonemic analysis is not the sole method used anymore in formal phonology. I maintain that such an analysis is still extremely useful in all fields of linguistics today. Whether a linguist is explicitly using a phonemic framework or not, the concept of an inventory of segments is used, whether in the inventory of phonemes in Giegerich (1992: 45-47), or the list of "segments" in Chomsky & Halle (1968: 176-177), or the "surface contrasts" and "underlying representations" in Halle & Mohanan (1985: 72), or the charts of vowels and diphthongs in Hammond (1999: 106). Such lists do not contain details such as nasalized vowels, aspirated stop consonants, etc., and must therefore reflect some sort of broad,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

underlying structure. Ultimately, any type of phonological analysis that holds that contrast is important[5] is using a concept very similar to traditional structuralist phonemic analysis, so this is a notion which still has relevance in many phonological frameworks.

Additionally, the concept of an inventory of underlying segments is still used in descriptions of a language, whether in a foreign language grammar, or in, say, the "Illustrations of the IPA" used in the *Journal of the International Phonetic Association* and reprinted in the *Handbook of the International Phonetic Association* (1999). For example, in the latter document, Regueira says Galician [ew ow ej oj] are "sequences of vowels plus consonant" and thus does not put them in the vowel inventory. Likewise, Bowden & Hajek do not put any "sequences of unalike vowels" in their inventory of Taba vowels, because "they are analyzed as vowels sequences, and not diphthongs." However, Landau *et al* and Dankovičová do put some diphthongs of Croatian and Czech respectively into their vowel inventories.

Furthermore, there have been some arguments that the phonemic level is necessary in linguistic analysis. For example, Schane (1971) argues that certain sound changes and synchronic

[5]Such as the UCLA school as exemplified by the work of Edward Flemming, Bruce Hayes, Donca Steriade, Daniel Silverman, etc.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

effects can only be accounted for by appealing to surface contrasts. Also, Nearey (1998) claims that the "segment" (more or less congruent to the traditional phoneme) is a unit of phonetic representation (not larger units such as the syllable, etc.) based on the behavior of subjects in categorization experiments involving the identification of acoustic stimuli.

The phonemic level is also the level of analysis used in introductory linguistics textbooks, and (it will be argued), dictionary pronunciation guides. Applications of my findings to these latter two cases will be discussed in Appendix A.

So, broadly speaking, what I mean when I say "monophonemic" is that the diphthong is paradigmatic, and should be placed in the inventory alongside monophthongal vowels, and when I say "biphonemic", I mean that the diphthong is a syntagmatic sequence of two independently appearing units, and should not be put into the inventory.

Some terminological: I am using GA for "General American" consistently with Wells, Giegerich, etc. I am using "California English" (henceforth, CE) for that dialect of GA spoken by my subjects (and presumably, others of similar age and background). However, as we shall see, there may be sub-dialects of CE present in the study. It

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

should be stated that the dialect in question is by no means restricted to the state of California, and that the usage of the term "California English" should not be interpreted to mean that California is the primary location or place of origin of this dialect.

CE has the vowel phonemes /i ɪ e ɛ æ u ʊ o ɑ ʌ aj aw ɔj/. I will henceforth be referring to the vowels in this set as the "canonical vowels". There is some discrepancy as to how to represent the vowels in a word like "Bubba." Frequently, the first is transcribed as [ʌ], and the second as [ə], hence /bʌbə/, even though they are phonetically very similar. The reason for this is phonological. We don't know for sure that the two vowels in "Bubba" are the same phonologically, or whether the [ə] represents an archiphonemic neutralization of vowel contrasts in unstressed position. However, there is an inconsistency with the parallel situation with the two vowels in a word like "surfer", which can usually both be transcribed as [ɚ], even though they have the same relation to each other as the supposed [ə] and [ʌ] in "Bubba." However, I will be following the conventions set by Ladefoged (1999) and using [ʌ] and [ə] for the vowels in the first and second syllables respectively of "Bubba", but [ɚ] for the vowels in both syllables of "surfer."

There is also the matter as to what to call the rhymes in "beer", "bare", "bar", "boar." The terminology "r-colored vowel" is in common

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

usage, but is not really accurate. An "r-colored" or rhotacized vowel is one that has a lowered third formant throughout (Ladefoged and Maddieson 1996: 313). The vowel [ɚ] in "her" fits that description. However, a look at spectrograms of the words "deer" and "bear" (Ladefoged 1993: 227) shows that at the beginning of the vocalic utterance, F3 is not lowered, hence only the second part of the vowel is rhotic, not the first part.[6] This conflicts with the description in MacKay (1987: 74) of the vowel in "for" as possibly [oʴ] with r-coloring "inherent in the vowel", and no diphthongization; that in Heffner (1964: 149-150), who claims that the vowel in a word like "car" has r-coloring throughout, and can be transcribed as [ɑ˞]; and the transcriptions of the vowels in "beer", "bar, "boor" in Hagiwara (1993) as [ɪ˞, ɑ˞, ʊ˞], etc.

The vocalic utterances under consideration are not steady-state vowels. Nor are they rhotacized throughout. They begin as non-rhotacized vowels, and glide to a rhotic vowel. Olive, Greenwood, & Coleman (1993: 220) claim that a final /r/ "strongly influences the quality of the preceding vowel and usually gives the entire region and /r/ color." It is true that for tautosyllabic sequences of /Vr/, F3

[6]Ladefoged claims rhotacization is "not so evident at the beginning of (such a) vowel" (p. 84). I would say it is not evident at all. In his spectrogram on page 227, lowering of F3 doesn't begin until approximately 100ms into production of the vowels in "deer" and "bear."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

does decline gradually throughout. However, as we can observe from the spectrograms Olive, Greenwood, & Coleman provide (pp. 219-223), at the beginning of the vowel, F3 is high, in a non-rhotic position. It is thus not completely true that the entire vowel region has an /r/ color. Tautosyllabic /Vr/ sequences in American English begin with a vowel which is not rhotacized. MacKay (1987: 74) terms these tautosyllabic /Vr/ sequences "rhotic diphthongs", but that is not accurate. A more phonetically precise label would be "rhotic-gliding diphthongs" (henceforth, RGDs), consistent with the terminology in Donegan (1978: 106), in which diphthongs like [eə iɛ oɑ] are "in-gliding diphthongs."

Linguists are often unsure as to how to categorize the vowels in these diphthongs phonetically as well. For example, in Lavoie and Cohn (1999: 110), we have the statement that "One author feels that the lax member of each pair occurs, while the other feels that the vowel that surfaces is somewhere in between (tense and lax)."

A detailed phonetic description of these vowels, based on measurements of their first three formants, is found in Lehiste (1967), for speakers of Mid-Western dialects of American English. Based on this data, the vowels are as follows:

The rhyme in "here" begins between /i/ and /ɪ/, but closer to the former, so we could call it [i̞ɚ]

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The rhyme in "air" begins between /e/ and /ɛ/, but closer to the latter, so we could call it [ɛ̹ɚ].

The rhyme in "car" begins much like [ɑ], so we could call it [ɑɚ].

The rhyme in "ore" begins much like /o/, but with a lower F2, so we could call it [o̹ɚ] or [o̱ɚ]. Note that in Lehiste's data (1967), the vowel in "ore" is not much like the /ɔ/ in "caught." This contradicts conventional usage (for example, Finegan 1994: 40), in which "bought" and "port" are transcribed with the same vowel, /ɔ/.

The rhyme in "your" begins between /u/ and /ʊ/, but closer to the latter, so we could call it [ʊ̹ɚ].

For purposes of simplicity, I will symbolize these diphthongs, as exemplified in the words "here", "air", "car", "ore", and "your", as [Ir, Er, Ar, Or, Ur] and their nuclei (the vowel which occurs before the [ɚ]) as [I, E, A, O, U], respectively. This is consistent with the usage in Moulton (1962: 77ff). The usage of capital letters should not be construed to be advocating an archiphonemic analysis. It is merely a convenient shorthand, and a lot simpler than writing [ɛ̹ɚ], [i̹ɚ], etc.

Also, let us recall that American English /r/ is usually the central approximant [ɹ]. For purposes of convenience, I am using the plain /r/ to represent this sound throughout this dissertation.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Other than these exceptions, I am using (slightly modified) IPA transcription in this work. There will be some regularization of symbols from borrowed sources.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 2: Historical Background.

2.1 Introduction

Linguists have difficulty trying to account for the English vowels before /r/. But, at some point in history, there must have been no problem. The purpose of this chapter is to show the historical development from the point in time when there was no problem to the problematic situation we have today.

The reason that there was no problem identifying what vowel occurred before /r/ at some point in the history of English was because all the vowels in English at the time contrasted before /r/. For example, prior to the fifteenth century, the general consensus (as per Moore 1951, Mossé 1952, Dobson 1957, Barber 1976, etc.) is that the East Midland dialect of Middle English (the likely ancestor of the dialects under consideration here) had the following vowel inventory:

ā, ă, ę̄, ẹ̄, ĕ, ī, ĭ, ǭ, ọ̄, ŏ, ū, ŭ

as in "name", "crabbe", "cleene", "sweete", "helpe", "ride", "drinke", "stoon", "fode", "oxe", "house", and "sone". Precise Phonetic values for these vowels are not known, but are generally presumed to be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

something like [a: a ɛ: e: ɛ i: ɪ ɔ: o: ɔ u: ʊ] respectively. All of these vowels could be found before /r/ as in:

"hare", "far", "hear", "here", "fern", "fire", "first", "more", "poor", "for", "flour", and "curse", which would have been

/hăr, făr, hẹ̄r, hẹ̄r, fĕrn, fīr, fīrst, mọ̄r, pọ̄r, fŏr, flūr, kūrs/ respectively.

Whether or not these vowels had variant allophones before /r/ cannot be determined, but that does not matter. If there were allophony, it likely was of a regular sort that altered the vowels predictably in the same manner, and did not reduce the number of contrasts. That is to say, even if /ī/ (likely phonetically something like /i:/) were lowered to the point of [ɪ] before /r/, presumably /ĭ/ (likely phonetically something like [ɪ]) was also lowered in such a manner, and the listener would have no trouble figuring out that this vowel found before /r/, which was similar to [ɪ], was /i/.

There are, indeed, still dialects of English that do make such contrasts. Giegerich (1992: 63) cites a dialect of Standard Scottish English (SSE) which contrasts /ir er ar ur or ɔr ʌr ɪr ɛr/ in "here", "hair", "car", "sure, "sport", "short", "word", "bird", and "heard." A big difference between a dialect such as the Scottish one above and GA is in the phonetic nature of the /r/. In this dialect of SSE, /r/ is a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

trilled or tapped consonant, IPA [r] or [ɾ]. In GA, /r/ is the central approximant [ɹ].

At some point in time, it is likely that all English dialects had an /r/ which was phonetically a consonant, even those dialects that are the ancestors of dialects like GA that no longer have a truly consonantal /r/. So, at some point, in some dialects (notably those that were the ancestors of GA), /r/ changed from a consonantal sound to a central approximant. Dobson (1957: 945-946) dates this change somewhere from the fourteenth century onward. Barber (1976: 116) only states that the change had taken place by "early Modern times", likely with an intermediate stage in which /r/ was some kind of fricative.

Evidence of this change can be found by some seventeenth century orthoepists' description of /r/ as a "lesser obstrict", or something with a retroflex articulation, as per some pronunciations of the Modern English central approximant [ɹ] (Dobson 1957: 946).

Why did this happen? It's important to note that unconditioned changes of one type of "rhotic" sound to another type are not uncommon. For example, in Ladefoged & Maddieson (1996: 235-236), we find various dialects of Modern English in which /r/ can be an alveolar central approximant, an alveolar fricative, a uvular fricative, a uvular trill, and alveolar tap, or an alveolar trill,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

all resulting by unconditioned changes from the same source, Middle English /r/. The key factor is perhaps all the sounds have lowered F3, though Lindau (1985: 165) and Ladefoged and Maddieson (1996: 244) disagree with this, citing examples of "rhotics" with high F3s.

In the particular case under consideration here, the unconditioned change of a trilled apical [r] to a central approximant [ɹ] can be explained by the fact that a gestural preparation for a trilled [r] without the relaxed tongue tip necessary for trilling would likely result in a tongue position close to that of [ɹ] (Barry 1997: 42-43).

In any case, /r/ changed from a consonant to a central approximant sometime before the seventeenth century. After this there began to be changes in the vowels found before /r/. This can hardly be a coincidence. Evidence for these changes will be presented with the description of the specific changes below. We will see that there are two motivations for changes in vowels before /r/: the first motivation is simply anticipatory assimilation; the vowel becomes more like the following /r/ in formant structure, presumably because the speaker is anticipating the gestures necessary for the following /r/ during production of the vowel. These changes are similar to the ones that have happened in a language like Spanish, where /e/ is lowered to [ɛ] before the trill [r]

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(Quilis 1981). This sort of lowering also has occurred in French, Danish, and Swedish (Lindau 1985: 157-158). These changes can be attributed to the "rhotic" character of the /r/, having a regular (lowering) affect on preceding vowels. This is the type of change (which results in synchronic allophony) usually termed "r-colorization." This type of assimilation is not limited to vowels followed by /r/. Perseveratory assimilation can also occur when vowels are preceded by /r/, as in Danish (Basbøll 1975: 83ff, 97).

However, many of the changes that took place in vowels before /r/ in the history of English are not explainable by the "rhotic" character of the /r/, but, rather, are due to the fact that /r/ became a central approximant, and, hence, these changes cannot be explained in terms of cross-linguistic "r-coloring" tendencies.

The other motivation is, as mentioned above, the unconditioned change of /r/ from a consonant to a central approximant. It will be argued that this is the primary reason for the altered phonological system of vowels that we find before /r/ today in GA. I disagree, then, with Dekeyser's statement that the change of /r/ from a consonant to a central approximant was really "subphonemic." (Dekeyser 1983: 58) It may have been originally, but it very quickly began to wreak havoc with the vowel system of English.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2.2 The Changes

We shall start the historical discussion with Late Middle English (East Midland dialect), that being the latest period in which English contrasted all Vs before /r/. Middle English had the monophthongal vowels in the first column on Table 2.1. We do not know precise phonetic values for the vowels of Middle English. I am following the convention of using general orthographic symbols as per Dobson.

The separation between Middle English and Modern English is usually considered to be the "Great Vowel Shift," which is believed to have taken place between 1400 and 1600. The first column in the chart has the Middle English vowel phonemes before the Great Vowel Shift in their conventional semi-orthographic/semi-phonetic transcription. The second column has their presumed phonetic equivalencies. The vowels in the third column represent the usual (non-rhotic) values of the descendants of the Middle English vowels in Modern GA, including the results of the Great Vowel Shift and other changes. The vowels in the fourth column represent the approximate phonetic values of the cognates of these same vowels when they occur before tautosyllabic /r/. In the case of [ɚ], the former tautosyllabic /r/ is actually included in the value of the vowel. The symbols in the fifth column are the conventions for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

representing these rhotic reflexes (with their following /r/) as used throughout this dissertation. The sixth column provides illustrations of these vowels in rhotic environments in Modern English.

Table 2.1 Modern English reflexes of Middle English vowels (from Moore 1951; 133, 136-137):

ME	ME Phonetic	ModE	ModE rhotic	Symbol	Example
ā	a: or ɑ:	ej	ẹ	Er	spare
ă	a or ɑ	æ	ɑ	Ar	hard
ę̄	ɛ: or æ:	i	ẹ, ị	Er, Ir	bear, hear
ẹ̄	e:	i	ị	Ir	here
ĕ	ɛ	ɛ	ɚ	ɚ	learned
ī	i:	aj	aj	ajɚ	fire
ĭ	ɪ	ɪ	ɚ	ɚ	first
ọ̄	o:	u	ọ, ụ	Or, Ur	swore, poor
ǭ	ɔ:	ow	ọ	Or	more
ŏ	ɔ	ɑ	ọ	Or	north
ū	u:	aw	aw	awɚ	flour
ŭ	ʊ	ʌ, ʊ	ɚ	ɚ	curse

I am not including in this table the Middle English diphthongs. The diphthongs /ai ẹi/ usually pattern the same as /ā/ from the Early Modern English period on. These two diphthongs first merge with each other, as can be seen by their failure to be distinguished in spelling (Dobson 1957: 765). Later, the remaining diphthong merges with /ā/, as can be seen from some orthoepists' spellings of words like "say" and "day" as *sa* and *da*, and the homonymy of words like "raze" and "raise" (which would have had ME /ā/ and /ai/, respectively), in Modern English (Dobson: 777-778).

The Middle English diphthongs /au ou/ (which became Modern English /ɔ/) do not occur before tautosyllabic /r/, nor did the Middle

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

English diphthongs /oi ui/ (Modern English /ɔj/). The Middle English diphthongs /iu ẹu ę̨u/, which along with the long vowel /y:/ became Modern English /ju/ or /u/, generally pattern with /ọ̄/ (Dobson 1957: 699-702), though there is further discussion on this matter later on in the chapter.

Many of the changes of vowels before /r/ took place simultaneously with or shortly after the Great Vowel Shift. Hence, as we see in Table 2.1, vowels before /r/ often have very different phonetic values than their cognate vowels that descend from the same Middle English ancestor found in non-rhotic environments. Table 2.1 should not be interpreted to mean that those vowels in the third column were at one point like those in the second column, though they may well have been. Rather, the time following the Great Vowel Shift also marks the beginning of the split of English Vowels into rhotic and non-rhotic subsystems.

2.2.1 Deletion of Short Vowels

One of the changes that took place is the merger of /ĭr ĕr ŭr/ to [ɚ]. This change involves both phonetic and phonological shifts. The phonetic shift would be the loss of the vowels /ĭ ĕ ŭ/ and the subsequent syllabification of the /r/. The phonological shift would

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

be the loss of contrast of what was once likely three different phonemes: /ĭ/, /ĕ/, and /ŭ/.

The change of /ĕr/ to [ɚ] appears to have been the first of these three. Likely, /ĕ/ was something like [ɛ]. This change is dated to the early seventeenth century (Dobson: 746). The next change was that of /ĭr/, which was likely something like [ɪr]. This change is dated to around 1600 (Dobson: 750). Note that there is no reason to believe that the contrast between /ĕ/ and /ĭ/ before /r/ was lost before they both became [ɚ].

The change of /ŭr/ to [ɚ] was the last of these three, being dated to the seventeenth century (Dobson: 755). The vowel /ŭ/ was undergoing a general change at the time, moving from something like [ʊ] to something like [ʌ] in most environments (it has remained [ʊ] after labials in words like "put" and "bush", etc. It has also remained [ʊ] in all environments in dialects of Northern England).

These changes can be explained due to the fact that this post-vocalic /r/ had become a central approximant. Hence, we would have [ɛɹ ɪɹ ʌɹ], which are really equivalent to [ɛɚ ɪɚ ʌɚ]. What likely happened was that the vowels [ɛ ɪ ʌ] were not heard distinctly, only as transitions to the [ɚ]. This could happen because [ɛ ɪ ʌ] are very short vowels, the shortest stressed vowels (along with [ʊ]) in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Modern English (Peterson & Lehiste 1960). Notice from Table 2.1 that none of the longer vowels deleted before /r/.

A similar sort of things happens in the pronunciation of the word "pretty" [pʰɹɪɾi] (or [pʰɚɪɾi]) as "purty" [pʰɚɾi]. Though this sort of change has been called "metathesis", Ritchie (1999) shows that this is not necessarily the case. In an experiment, Ritchie played subjects utterances of words like "pretty" with 10ms of the [ɹ] doubled, triple, and quadrupled. As the [ɹ] got longer, subjects were more likely to hear the word as "purty", despite the fact that the [ɪ] is still just as much in evidence in the speech signal as it was before. The lengthened [ɹ] "overwhelms" the [ɪ] and makes it impossible to hear, causing reanalysis of the vowel nucleus[1].

It could also be pointed out that these vowels [ɪ ɛ ʌ (and ʊ)], in addition to being short, are very non-peripheral in the vowel space and have formants similar to the [ɹ] itself. The short length and lack of contrast would make it very easy for [ɪ ɛ ʌ] to not be heard as distinct from the cues for the [ɹ], hence only the [ɹ] was heard, as a syllabic [ɚ].

Note that Dobson (and others, for example Barber 1976, Kurath 1964) actually states the change as [ĭr ĕr ŭr] to [ər], not [ɚ]. I have to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

question the need for this intermediate stage (unless, [ər] is just being used as a symbol for the single vowel [ɚ].) Specifically, what would it mean for [ʌr] to become [ər]? The vowel symbol [ʌ] is not always used in transcriptions of English dialects consistently with its IPA value. The IPA value for [ʌ] would be a half-open *back* unrounded vowel, equivalent to an unrounded [ɔ]. The sound it is used to represent in English is a central vowel (Cruttenden 1994: 104, Ladefoged 1999: 42). So, a change of [ʌr] to [ər] may not represent a change at all. Or, if it does represent a change, it's likely a minor one, which would not go noticed. The only change that could be noticed is one of [ʌr] or [ɚ], because then it could merge (as reflected in the spelling) with former [ĭr] and [ĕr], which had already undergone the change to [ɚ].

2.2.2. Assimilatory Changes

The changes that concern the remaining vowels before /r/ can be explained as assimilatory. The variants of these vowels before /r/ are all lower, backer, and/or rounder than their cognates in non-rhotic environments, as can be seen in Table 2.1. In some situations,

[1] Ritchie found the failure to hear [ɪ] more commonly before [t] than before [p] or [k]. It's possible that the historical loss of [ɪ e ʌ] before [r] began in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the effect of the /r/ on the preceding vowel appears to be innovative. In other situations, it may be that the vowel before /r/ reflects a more conservative form, while its cognate vowel has changed more in non-rhotic environments, so perhaps the term "assimilation" is misleading, implying as it does that the assimilated form is the innovated one.

The normal reflex of ME /ẹ̄/ is ModE /i/. Before /r/ there is not a large difference. We find a vowel that is somewhat lower and backer than /i/. Moore has it as [ɪ], but it is actually between /i/ and /ɪ/ (Lehiste 1964: 85). The effect of the /r/ could be either innovative, in which the ME vowel /ẹ̄/ first was raised to [i], and then lowered before /r/, or it could be conservative, in which the ME vowel /ẹ̄/, on its way from [e:] to [i], remained in a lower position before /r/. Another difference is that the post-vocalic glide [j], often found after [i], is missing before /r/. For example, ME /swẹ̄t/ › ModE [swijt], ("sweet"), but ME /pẹ̄r/ › ModE [pIr], ("peer").

The ME vowel /ę̄/ (which might have been phonetically like [ɛ:] or [æ:]) normally merged with ME /ẹ̄/, becoming ModE /i/. In some words, however, it merged with ME /ā/, becoming ModE /e/. Likewise, before /r/, it merges either with the reflexes of ME /ẹ̄/, such as in "spear", or with the reflexes of ME /ā/ (see below), such as

certain environments and then became more general.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

in "bear." For example, ME /klę̄n/ › ModE [klijn] ("clean"), but ME /spę̄r/ › ModE [spIr] ("spear") and ME /bę̄r/ › ModE [bEr] ("bear").

The ME vowel /ā/ became ModE /e/, which is usually the diphthong [ej]. The reflex before /r/ is, parallel to that of ME /ẹ̄/, lower and backer (being between [e] and [ɛ]), and lacking the post-vocalic glide [j]. For example, ME /nām/ › ModE [nejm] ("name"), but ME /spār/ › ModE [spEr] ("spare"). Once again, this could be innovative (a lowering of /e/), or conservative (the vowel remained lower before /r/ on "its way" from [a:] to [e]).

The reflexes of ME /ọ̄/ before /r/ show a similar pattern to ME /ẹ̄/ and /ā/. Here, the reflex of /ọ̄/ is somewhat lower than the non-rhotic reflex /u/. It also lacks the post-vocalic glide [w]. For example, ME /fōd/ › ModE [fuwd] ("food"), but ME /mōr/ › ModE [mUr] ("moor").

The parallel situation that we have seen for ME /ę̄ ā ọ̄/ becomes muddled a bit when dealing with the lower back vowels ME /ǭ/and /ŏ/. ME /ǭ/ usually becomes /o/ in ModE. ME /ŏ/ is /ɑ/ in Modern American English but the rounded /ɒ/ in RP. The rhotic reflexes of these two ME vowels have merged in most American and British dialects but are distinct in some, in which "or" and "ore" are not homonyms.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In dialects in which the vowels in "or" and "ore" are distinct, the rhotic reflex of ME /ō/ is claimed to be /ɔr/. In this situation, the environment before /r/ appears to be the conservative environment, as this vowel, which is usually considered some kind of mid back rounded vowel in ME like [ɔ], has lowered to /ɒ/ and become unrounded to /ɑ/ in GA. In these same dialects, the rhotic reflex of ME /ǭ/ is /or/. In such a situation, the /r/ does not appear to have had much of an effect on the preceding vowel at all. This does not contradict the previous statement of the general effect /r/ has on preceding vowels. Since /o/ is already relatively low, back, and round, it can remain so before /r/.

However, as stated above, in most Modern English dialects the reflexes of ME /ǭ/ and /ō/ have merged before /r/ so that "ore" and "or" (from ME /ǭr/ and /ōr/, respectively) are homonyms. The resulting vowel is somewhat lower than /o/, between /o/ and /ɔ/. For example, ME /stǭn/ › ModE [stown] ("stone"), but ME /mǭr/ › ModE [mOr] ("more"). Likewise, ME /ŏks/ › ModE (American) [ɑks] ("ox"), but ME /kōrn/ › ModE [kOrn] ("corn"). Possible explanations for this merger will be given below.

The remaining vowels to account for are ME /ā/, /ī/, and /ū/ (since the ME diphthongs /oi/ and /au/ did not occur before tautosyllabic /r/.) The usual reflex of ME /ă/ is ModE /æ/. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

rhotic reflex of ME /ā/ is ModE /ɑ/. There is disagreement as to what the precise phonetic character of ME /ā/ was. Therefore, we cannot say whether the rhotic environment is innovative or conservative, but it does fit the general pattern of having a vowel that is lower and further back than the corresponding non-rhotic reflex. For example, ME /krăb/ › ModE [kræb] ("crab"), but ME /jărn/ › ModE [jArn] ("yarn").

2.2.3 Middle English long high vowels

The ME long high vowels /ī/ and /ū/ usually diphthongized to /aj/ and /aw/ respectively (though /ū/ remained [u] before labials and velars). Their reflexes before /r/ do not appear to be different from their non-rhotic reflexes. The diphthongs we find in words like "fire" and "flour" are not different from those in words like "fine" and "clown." The difference we find is in the number of syllables in the word. The words "fine" and "clown" have one syllable each. The words "fire" and "flour" have two syllables each, and are usually transcribed as [fajɚ] and [flawɚ] respectively.

This change, one of re-syllabification of words which have diphthongs before historically tautosyllabic /r/, can be accounted for by the fact that /r/ changed from a consonant into a central

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

approximant. Kahn (1980: 121) and Veatch (1991: 60) give phonological accounts for this, saying that there is a constraint in English against having two central approximants post-vocalically in the same syllable. Hence, /ajr/ is no more a possible syllable than /ajw/ or /awj/. Therefore, the /r/ has to form a new syllable, becoming the syllabic nucleus [ɚ].

The reason for this change can also be given a phonetic and perceptual account. A monophthongal vowel can be perceived in terms of the steady states of its formants, but dynamic cues might also be a factor in perception. Gay (1960) has found that for English diphthongs like /aj aw ɔj/, the steady states of the vowels are not the main cue, but rather the degree of transition of the second formant. For example, the initial state of /aj/ can vary from [ɑ] to [æ], and the final state from [ɛ] to [i], but the rate of change of F2 remains constant.

The problem is that a sequence like [ajr] (equivalent to [aɪɚ]) would have two transitions: that of [a] to [ɪ] and that of [ɪ] to [ɚ]. The sequence in question would have to be analyzed as having two transitions: [aɪ] and [ɪɚ], and hence two syllables.

This explanation would be supported if it could be shown that the resyllabification of words like "hire" took place soon after the change of ME /ī ū/ to diphthongs. This is indeed supported by

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

historical evidence. Dobson dates the diphthongization of ME /ī ū/ to sometime around 1400, while the resyllabification can be dated to the fifteenth or early sixteenth centuries.

Evidence for this chronology is the replacement of foreign [i:] and [u:] sounds by ME /ẹ̄/ and /ọ̄/, not /ī/ and /ū/, from the early fifteenth century on (Dobson: 659), and widespread spellings like <ei> for ME /ī/ and <ou> for ME /ū/, likely indicating diphthongization (Dobson: 683-685). Evidence for the later resyllabification are orthoepists' spellings such as <meier> and <feier> for "mire" and "fire", which are identical for the spelling conventions used for uncontroversially bisyllabic words such as <beiër>, <heiër>, and <deiër> for "buyer", "higher", and "dyer." These spelling are not found until the fifteenth and early sixteenth centuries (Dobson: 760).

An alternative would be for the sequence to lose one of the transitions, and become a simple diphthong. That is, indeed, what has happened in some dialects in which ME /īr ūr/ have become monosyllabic diphthongs like /ɑr/. For example, in some American dialects, the word "fire" is pronounced like [fɑr] (Kahn 1980: 121, Wells 1982: 549).

There is also the situation in the possessive pronoun "our", which in GA can be pronounced [ɑr] or [awɚ] (Veatch, p. 51). The former pronunciation is more commonly heard in everyday

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

situations, while the second one is heard in emphatic situations. The reason for the everyday monosyllabic pronunciation may be that possessive pronouns in English are usually unstressed, and all the others ("my, "your", "his", "her", "its", "their") are monosyllabic. The pronunciation [ɑr] fits the normal pattern required of possessive pronouns.

This explanation can also account for the fact that while the ModE reflexes of ME /ẹ̄ ā ọ̄ ǭ/ usually have post-vocalic glides, being realized as [ij ej uw ow], their rhotic cognates do not have these glides. If we were to attempt to account for this in a purely synchronic phonological manner, we could say that for the ModE vowels /i e u o/, the post-vocalic glide is a redundant feature, while for the diphthongs /aj aw/ it is distinctive. Hence, the choice of "drop the glide or re-syllabify" could easily be resolved in favor of losing the glides after /i e u o/ with no loss of contrast.

However, a historical explanation is also sufficient. It was stated above that evidence for the belief that it was the unconditioned change of /r/ from a consonant to a central approximant that caused the re-syllabification of words like "fire" was supported by the fact that the re-syllabification took place shortly after the change of ME /ī ū/ to the diphthongs /aj aw/. Therefore, the theory would be supported if the development of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

post-vocalic glide after ModE /i e u o/, resulting in the diphthongal [ij ej uw ow] was to have taken place significantly later than the development of the post-vocalic glides in [aj aw].

There is evidence to support this. The first evidence we have of diphthongization of Modern English is not found until the early nineteenth century, specifically the writings of Thomas Batchelor, who states that the words *tree, hey, buy, boy, ay* (= "aye"), *pound, pool,* and *broke* have diphthongs ending in [j] or [w], distinguishing them from the simple vowels in the words like *sin, wed, but, pond, pull,* and *hot* (Zettersten 1974: 42, 53-55).

Thus, the lowered, more lax forms ([ɛɚ], etc.) would have already developed before and would not have participated in the changes that developed the post-vocalic glides after the tense vowels.

The ordering of these changes would go like this:

1) Great Vowel Shift:	ī ẹ̄ ę̄ ā ū ọ̄ ǭ › aj i i e aw u o
2) Vocalization of /r/[2]:	r › ɹ
3) Re-syllabification:	ajɹ awɹ › ajɚ awɚ
4) "r-coloring":	iɹ eɹ uɹ oɹ › ɪɹ ɛɹ ʊɹ ɔɹ[3]
5) Diphthongization:	i e u o › ij ej uw ow

[2]Rules 1 and 2 cannot actually be ordered with respect to each other.
[3]As mentioned previously, the "r-coloring" here might actually be a conservative effect, not a subsequent lowering. The rule should be interpreted as marking the separation of distinct rhotic and non-rhotic reflexes of these former ME long vowels.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Effectively, the Great Vowel Shift and r-vocalization changes "feed" the Re-syllabification, while the "r-coloring" change "bleeds" the Diphthongization change.

2.3 Recent Mergers

In addition to the merger of /or/ and /ɔr/, as mentioned above, there has also been in many dialects a merger of the subsequent vowel with the [Ur] as in "poor." Hence, "poor", "ore", and "or" all have the same vowel. This merger is mentioned in Thomas (1958: 126), Wardhaugh (1995: 196), Allen (1976: 30), and found regularly in New York City and Philadelphia by Labov (1994: 269). The merger has also apparently become common in California, as we shall see in Chapter Six.

Note that after palatals, this /ur/ (which is descended in such environments from ME /y:/ and the diphthongs /iu/, etc.) can show up as either [Or] or [ɚ] depending on emphasis. Hence, "sure" is either /ʃɚ/ or /ʃOr/, "mature" can be /mə 'tʃɚ/ or /mə 'tʃOr/, "pure" can be /pjɚ/ or /pjOr/, etc. Hence, Wells' lexical set CURE (which includes words like both "sure" and "poor") may not actually be a unified lexical set, but should be sub-divided into two further ones (as per his sub-sets on p. 164-165).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

These mergers differ from the merges of ME /ĭr ĕr ŭr/ in that there is still a distinct vowel before the /r/. However, they can still be accounted for by the change of /r/ from a consonant to a central approximant. Once /r/ is a central approximant, sequences like /or ɔr ur/ are phonetically diphthongs. Recall from the discussion of Gay that the rate of change of F2 is the main cue for distinguishing diphthongs in English, not the steady states. English does not distinguish between diphthongs like /ai/, /ɑi/, /ae/, and /ɑe/ or /ei/ and /ɛi/ or /ɔu/ and /ou/, because their transitions would be too similar.

Likewise, if a hearer is using the rate of change of F2 to distinguish diphthongs, [ɔr] and [or] and [ʊr] might not be easy to distinguish, so they are (increasingly) heard as being the same.

2.4. Summary of Changes

To sum up the changes, we have:

Change	date
1. /ĭr ĕr ŭr/ merge to [ɚ]	by 17th c.
2. /ēr ār ọ̄r/ become [Ir Er Ur]	1400-1600
3. /ɔr ăr/ "become" [Or Ar]	conservative?
4. /īr ūr/ become /ajɚ awɚ/	15th/16th c.
5. merger of /or ɔr/	19th/20th c.
6. merger of /ɔr ʊr/	20th c.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There are also changes in vowels before heterosyllabic /r/. They will be discussed in Chapter 8.

Veatch (1991: 66ff) attempts to account for all the changes with a single phonological explanation: /r/ is a glide in the nucleus; everything else follows from this. Specifically, in Veatch's analysis short vowels such as /ɪ ɛ ʌ ʊ/ are distinguished from /i e u o/ by the presence of a following glide (which can be [j], [w], or a lengthening element) in the nucleus. Only one element is allowed in this "glide slot."

Thus, in Veatch's analysis [ɪ ɛ ʌ ʊ] are /i e u o/, while [ij ej uw ow] are /iː eː uː oː/. If /r/ becomes a central approximant phonetically, it cannot be a consonant in the coda any longer, and it will move into the glide slot. Hence, that takes away the possibility of distinguishing between /i/ and /iː/, /e/ and /eː/, etc., since we cannot have two elements in the glide slot.

Likewise, we could not have both /r/ and /j/ or /w/ in the glide slot. Once /r/ vocalizes, it cannot be in the coda any longer like a true consonant, but it cannot move into the glide slot if that slot is occupied by /j/ or /w/, so it must move to the next syllable. Thus, we have resyllabification of former /ajr/ and /awr/ sequences.

This, however, may not be the optimal way of explaining things. Although the change of /r/ from a consonant to a central

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

approximant is indeed very relevant, the chart above shows that not all the changes have taken place at one point in time, but over a span of several hundred years. The merger of [Or] and [Ur], indeed, has not completely spread, and is occurring presently in the late twentieth century. Therefore, accounting for all the changes as being one does not really work. The change of /r/ from a consonant to a central approximant only brought about the tendency toward re-analysis of the previous vowels. It did not force it.

Also, let us recall that the losses of contrast of vowels before historic /r/ did not all come about the same way. In the case of /o/ and /ɔ/, for example, there was a merger. But, in the case of /i/ and /ɪ/, for example, there was no equivalent merger: /ɪ/ was lost.

2.5. Changes to the Phonological System

The total of these historical phonetic changes concerning the vowels before /r/ has resulted in severe changes in the phonological system of English vowels, notably:

1) A new phonological unit, /ɚ/, has come into existence. The distribution of this unit is different from that of other syllabic sonorants such as [n̩] and [m̩] in words like "button" and "chasm" in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that [ɚ] can also occur in stressed syllables in words like "bird" or "gherkin," while this is not possible for [n̩], [m̩], etc.

2) The loss of the short vowels /ɪ ɛ ʌ/ along with the collapse of three-way contrast /u o ɔ/ to two or even one vowel and the resyllabification of /ajr awr/ sequences (thus, there being no tautosyllabic sequences of /aj aw/ before /r/) has resulted in a severely limited distribution of vowels found before tautosyllabic /r/, as few as four in some American dialects, compared with eleven or so monophthongal vowels, as can bee seen on Table 2.1

To recapitulate, ME had

/ā ă ę̄ ẹ̄ ē ī ĭ ǭ ọ̄ ŏ ū ŭ/.

The vowel /ę̄/ neutralized contrast with either /ā/ or /ẹ̄/ in all positions (not just before /r/), leaving us eleven contrasting vowels:

/ā ă ẹ̄ ē ī ĭ ǭ ọ̄ ŏ ū ŭ/.

The short vowels /ĭ ĕ ŭ/ were lost before /r/, leaving us eight contrasting vowels:

/ā ă ẹ̄ ī ǭ ọ̄ ŏ ū/.

The long vowels /ī ū/ diphthongized, bringing about resyllabification, leaving us six contrasting vowels:

/ā ă ẹ̄ ǭ ọ̄ ŏ/.

Then the contrast between /ǭ/ and /ŏ/ before /r/ was lost in some dialects, leaving us with five vowels:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ā ă ẹ ọ ō/.

Then the contrast between /ō/ and /ọ/ was lost before /r/, leaving us only four contrasting vowels:

/ā ă ẹ ō/.

These are our Modern English [Er Ar Ir Or] as in "air", "are", "ear", and "ore", respectively.

In addition, some of the ModE vowels in rhotic environments don't bear much resemblance to their cognates in non-rhotic environments. For example, the standard reflex of ME /ă/ is the front vowel /æ/, but its rhotic reflex is more like /ɑ/. Also, the standard reflex of ME /ŏ/ is /ɑ/ in GA, but its rhotic reflex is more like /o/. So, the rhotic reflex of /ă/ and the non-rhotic reflex of /ŏ/ bear more resemblance to each other than they do to their corresponding cognates in other environments.

The result of these changes is to put into question what the phonological status of /r/ and the vowels found before it is. Or, we could say, it puts into question what the phonological status of the Vr sequences is in Modern American English. This matter will be discussed in the next chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 3: The Problem

The central question remaining is: are the RGDs of American English mono- or biphonemic? And, if they are biphonemic, which of the canonical phonemes of GA /i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ aj aw ɔj/ do their nuclei belong to? The purpose of this chapter is threefold:

1) To review the criteria used to determine whether a given diphthong in a given language is mono- or biphonemic and to evaluate the RGDs of GA according to these criteria.

2) To review the ways the RGDs have been analyzed and treated in the literature. The distinction I am making between an "analysis" and a "treatment" is that the former is explicitly made, while the latter is something that can only be gleaned from the way the data is presented (and what phonological representations are used).

3) To evaluate the analyses and treatments found in part 2 on their own and with regard to the criteria established in part 1, and to determine what further information is needed to resolve the problem.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.1. Criteria for deciding mono- vs. biphonemicity

It is generally accepted that diphthongs and other "suspicious sequences" such as affricates, aspirated stops, palatalized consonants, etc. (Pike 1947b: 131) can be analyzed as mono- or biphonemic. This is a decision, which must be determined for a given diphthong in a given language. For example, Clynes (1997), analyzes the diphthong [aɪ] in the English word "my" as being one unit, but the supposedly phonetically identical diphthong in the Tagalog word "may" is analyzed as being two, as mentioned previously.

Indeed, there is general consensus that the English diphthongs [aj aw ɔj] should be treated as monophonemes. They are treated as such in Bloomfield 1933, Swadesh 1935 De Camp 1945, D. Jones 1950, Cohen 1952, Chomsky & Halle[1] 1968, Trubetzkoy 1969, ten Havre 1975, Wells 1982, Lass 1984b, Halle & Mohanan 1985, Giegerich 1992, Gramley & Patzold 1992, Ladefoged 1992, Bagemihl 1995, Wardhaugh 1995, Burquest 1998, Hammond 1999, etc[2]. Claims for monophonemicity based upon experimental evidence have been made by Gay (1968, 1970) and Gerber (1975). Shattuck-

---

[1]Because /aj aw ɔj/ are derived from the underlying monophthongs /ī ū œ̄/ by an unconditioned rule (p. 183).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hufnagel (1986: 126-127) provides evidence from speech errors showing that the diphthongs [aj aw ɔj] behave like single units in that their nuclei and off-glides are never separated.

There are some dissenting claims to the view that the English diphthongs are monophonemic, most famously Trager & Bloch (1941), whose analysis is later modified by Veatch (1991). Sommerstein (1977: 31-32) chooses a biphonemic analysis, but acknowledges that the arguments for either position are "fairly evenly balanced." Pike (1947a) also argues that the diphthongs /aj aw ɔj/ (though not /ej ow/) are biphonemic. Berg (1986) provides evidence from speech errors to support Pike's position, disagreeing with Shattuck-Hufnagel (1986). However, it is not clear whether these biphonemic analyses of the English diphthongs really contradict the monophonemic ones mentioned above. Pike does say that, however, that diphthongs like [aj] could be monophonemic, "provided that the unity of [aj] is described on a higher level of structural sequence than that of phonemes as such" (p. 154). Veatch says that the nucleus and glide slot can be treated as a single unit (p. 64). On further analysis, it appears that the "glide slot" analysis can be considered a more detailed notational variant of the

---

[2]Vachek (1963) and Trnka (1968) are distinct in considering only /aj aw/ to be monophonemic. Trnka claims /ɔj/ is biphonemic, while Vachek claims /ɔj/ is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

monophonemic analysis for diphthongs. Both are still different from the analysis seen for Tagalog above in which the diphthong is truly biphonemic, with one part in the nucleus and one part in the coda. Unless it is claimed that there can be two supposedly phonetically identical diphthongs in two different languages that differ in that one is monophonemic and one has a "glide-slot", I will regard these two analyses as equivalent.

On the other hand, there is true disagreement as to whether the sequence [ju] as in an English word like "union" is to be treated as biphonemic (with the [j] in the onset), or monophonemic (with the whole [ju] in the nucleus.) Cohen (1952) argues for the biphonemic interpretation of this sequence, and it is generally treated as such in not being listed in phonemic inventories (for example in Halle & Mohanan 1985, Giegerich 1992, Cruttenden 1994). However, [ju] is regarded as monophonemic by Bloomfield 1933, Chomsky & Halle 1968[3], Ladefoged 1992, and Hammond 1999. By bringing this matter up, I am not supporting one side or another, but only showing that there is a parallel argument for the mono- versus biphonemic status of RGDs in the literature for other diphthongs.

"outside the system."
[3]Since it is derived from underlying /ī/ by an unconditioned rule (p. 194).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

More similarly, the cognates of the RGDs in RP British English, which are centering diphthongs like [ɪə ɛə] can be treated as monophonemic as well (ten Havre 1975, Wells 1982, Cruttenden 1994, Giegerich 1992, Coleman 1998), though others (Cohen 1952, Vachek 1963, Halle & Mohanan 1985, Gramley & Pätzold 1992) do not treat them as monophonemic.

3.1.1. Trubetzkoy's Rules

Let us now review and discuss the criteria used to determine whether a given diphthong (or other suspicious sequence) is monophonemic or biphonemic. The most thorough discussion of the matter, and the one most often referred to by other linguists (for example, Sommerstein 1977: 28), is to be found in Trubetzkoy 1969, so I will begin with Trubetzkoy's criteria.

RULE I: "Only those combinations of sound whose constituent parts in a given language are not distributed over two syllables are to be regarded as the realization of single phonemes."

This is also used by Swadesh 1935, De Camp 1945, Trnka 1968, Benware 1986 (for German), and Booij 1989 (for Frisian). This "rule" is pretty self-explanatory. If speakers of a language can separate out

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the parts of a diphthong into separate syllables, they can surely separate them out into separate phonemes. Note that the opposite is not implied. A diphthong that is monosyllabic is not necessarily monophonemic. It could still be biphonemic.

The use of this criterion is, of course, contingent on being able to identify clear syllable divisions. This is not always easy to do based purely on phonetic data. It is not always easy to do based purely on structural data either. We will see in Chapter Ten that American English /Vr/ sequences behave differently in situations where syllable division is not clear. However, most of this dissertation concerns /Vr/ sequences which are found in monosyllabic words.

RULE II: "A combination of sounds can be interpreted as the realization of a single phoneme only if it is produced by a homogenous articulatory movement or by the progressive dissolution of an articulatory complex."

This one isn't really relevant for diphthongs, since they all consist of a "homogenous articulatory movement." The criterion is used to exclude non-homorganic affricates such as [ks] from monophonemic classification. It would also exclude sequences of vowel + consonant such as [an], [ip], etc. Note that Trubetzkoy also

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

uses this criterion to exclude the possibility of monophonemic triphthongs such as [aia] or [aiu] because they involve two articulatory movements.

Trubetzkoy does say, however, that in monophonemic diphthongs "neither the point of departure nor the end point of this change is important, only the general direction of the movement." This criterion is used by De Camp 1945, Benware 1986 (for German), and Collier *et al.* 1982 (for Dutch). Experimental evidence in support of this was found for English by Gay (1968, 1970). For example, /ɔj/ can begin anywhere from [ɔ] to [ʊ], and end anywhere from [i] to [y] to [ɪ] (Gay 1970).

RULE III: "A combination of sounds can be considered the realization of a single phoneme only if its duration does not exceed the duration of realization of the other phonemes that occur in a given language."

I have found no other linguists that use this rule, and I do not think it is valid. My reason for this is that if we look at the vowels of English, we see a large degree of variation of intrinsic duration. Some vowel phonemes are simply longer than others are. For example, in Peterson & Lehiste (1960), we find that the vowel /æ/ might have a duration around 330ms, while the vowel /ɛ/ in the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

same environment might have a duration closer to 200ms. There is no particular duration associated with "one vowel phoneme" in English. Even if a given diphthong were longer than any of the monophthongs of English it could simply be at the high end of the scale (where diphthongs usually are in the Peterson & Lehiste data). Diphthongs, due to their multi-part nature, do tend to be longer than monophthongs. The longer duration does not necessitate, or even suggest, that they are biphonemes.

RULE IV: "A potentially monophonematic combination of sounds. . . must be evaluated as the realization of a single phoneme. . . if it occurs in those positions in which phoneme clusters are not permitted in the corresponding language."

This is also stated by Pike (1947b), and is used as the sole criterion for deciding whether to put diphthongs in the sound inventories by Maddieson (1984). Note that Trubetzkoy does not state the opposite: that if a diphthong occurs in a position in which phoneme clusters are permitted, then it is biphonemic. Nevertheless, Moulton 1962 (and later Wiese 1996) uses this reverse criterion for deciding that the German diphthongs [aɪ aʊ ɔʏ] are biphonemic. Benware 1986 considers the criterion but rejects it in favor of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

phonetic evidence. I do not agree with the reverse use of this criterion. The matter will be discussed later in section 8.1.5.

RULE V: "A combination of sounds fulfilling the conditions of Rules I to III must be considered the realization of a single phoneme if this produces symmetry in the phonemic inventory."

Trubetzkoy gives examples of the affricates of Chechen, Georgian, and Tsimshian, which have both glottalized [ts' tʃ'] and non-glottalized [ts tʃ], completely parallel to the voiceless stops of the languages [p t k] and [p' t' k']. Here, great symmetry is achieved in the system by classifying the affricates with the stops, as monophonemes.

It is not clear how this rule would apply to diphthongs. For example, if a language had five monophthongal vowels [i e a o u] and only two diphthongs [ai au], then there would be a type of symmetry in the phonemic system. Likewise, if a language with the same five vowel system allowed all possible sequences of diphthongs [ie ia io iu ei ea eo eu ai ae ao au oi oe oa ou ui ue ua uo], then that would also impart a type of symmetry to the phonemic system. However, the diphthongs of the first language could likely be judged monophonemic according to the "restricted set" criterion (see section 3.1.2, below), while the diphthongs of the second language would be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

judged biphonemic according to the same criterion. Both systems, however, could be considered "symmetric." This rule might not apply well to diphthongs.

RULE VI: "If a constituent part of a potentially (monophonemic) sound combination cannot be interpreted as a combinatory variant of any other phoneme of the same language, the entire sound combination must be considered the realization of a single phoneme."

Trubetzkoy contrasts the sequences [ər] and [rə] in Serbo-Croatian and Bulgarian. Bulgarian has the independently occurring phonemes /ə/ and /r/, therefore [ər] is biphonemic. Serbo-Croatian, however, lacks the phoneme /ə/, therefore [ər] is monophonemic, being the syllabic realization of /r/.

This is by far the most commonly used criterion for determining whether a given diphthong is mono- or biphonemic: whether its elements can occur independently in the language in question. It is used for English by Swadesh 1935, De Camp 1945, Lehiste & Peterson 1967, Trnka 1968, and Wells 1982, for Dutch by Stutterheim 1962 and Collier *et al.* 1982, for Frisian by Booij 1989, and for Estonian by Piir 1984. For example, De Camp (1945: 3) states that the first element [a] of the diphthong [aj] as in "my" does not

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

occur as a distinct phoneme in many dialects of American English (i.e., someone may have /æ/ or /ɑ/, but not distinct /a/). For another example, Dutch has a diphthong [ʌy] but no vowel /ʌ/ (Collier *et al.* 1982).

Though this criterion is very commonly used, one could argue against it by saying that it doesn't matter that that language does not "have" the element of the diphthong as an independently occurring monophthong. It could be a positional variant of a different monophthong. For example, that [a] in English [aj] could be an allophone of /ɑ/, which would make sense because the /ɑ/ would be assimilating to the [j] by becoming fronted.

This counter-argument, however, is not making use of a point stated earlier in Chapter One, namely:

Diphthongs can be mono- or biphonemic.

That is to say that both monophonemic and biphonemic analyses have to be allowed. Neither is a "default" analysis. We have to consider both possibilities. The fact that we "can" analyze a given diphthong as biphonemic does not mean that it is not monophonemic. We have to have the *a priori* condition that the diphthong can be in the monophonemic category or the biphonemic category, and then

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

decide, based upon all the evidence available, which category the diphthong fits into best.

In the case of this particular criterion (Trubetzkoy's Rule VI), we would definitely take the opposite to be true: namely, that if an element of a given diphthong were to occur with an almost identical phonetic form in the language in question, then we would be more likely to give that diphthong a biphonemic interpretation. By the same token, we must say that the more an element of a diphthong is unlike any of the other vowels of the language, the more likely it should be given a monophonemic interpretation.

Another matter to be considered is how wide a range of allophonic variation the vowels of the language in question are allowed. The width of this range is often inversely proportional to the number of vowel phonemes in the language. For example, in Kabardian, which has very few vowel phonemes, the vowel /ə/ has a wide range of positional variants which include [i ɪ ə y ɯ u], and the positional variants of the vowel /a/ include [ɛ æ œ ɑ ɔ] (Kuipers 1960: 22-23)[4]. However, in English dialects which can have, say, fourteen vowel phonemes /i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ aj aw ɔj/, the range of allophony is not as large as that of Kabardian. Hence, it means a lot

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

more to say that one element of a given diphthong does not occur independently in English. Thus, a linguist who claims that the first element in /aj/ is not the same as /ɑ/ is not saying that it couldn't possibly be an allophone of /ɑ/. They are saying that English does not have this range of allophony. Whatever may be true for Kabardian or another language has no bearing on English phonology. English allows a range of allophones for /ɑ/, but, even given this range, the first element in /aj/ is outside of this range. The concept of "range" here is admittedly not well defined. I intend to define it better in Chapter Six.

3.1.2. Other Criteria

There are also other criteria not used by Trubetzkoy (though they are related to the ones he uses), but which are used by others to determine whether a given diphthong is monophonemic or biphonemic. One is the "restricted set" rule, such as in Burquest 1998

---

[4]The exact number of vowel phonemes in Kabardian is a controversial matter. Nevertheless, all the vowels listed above are positional variants of the same vowel at some level.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"If there is a fairly unrestricted set of. . . (vowel) sequences, such that most unambiguous phonemes can occur indiscriminately in the first or second vowel slot, then a VV (i.e, biphonemic) interpretation is called for. . . If, on the other hand, there are only a few such segments or sequences in the data, the single vowel or diphthong analysis would be preferred." (Burquest 1998: 160).

This is also used for English by Swadesh 1935 and De Camp 1945, for Danish by Basbøll 1975, and for Frisian by Booij 1989. For example, Swadesh (1935: 149) states that "although fourteen combinations of /ɪ ɛ æ ɑ ɔ ʌ ʊ/[5] plus /j w/ are possible, only seven occur. /ɪw ɛw æj æw ʌj ɔw ɑj/ do not occur" (hence, American English diphthongs are monophonemic).

The reason for this criterion is based upon the assumption that given a fairly unrestricted set of vowel/vowel (or vowel/central approximant) combinations, the language learner would have enough data to separate out the elements into discrete units. Whereas, if there were a restricted set of such combinations, the learner would be more likely to always associate the component parts.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Another criterion given by Burquest is that monophonemic interpretations of diphthongs "should be avoided where they add more than three or four vowels to the phoneme inventory" (though, relative to the inventory of monophthongs). This criterion may just be a practical "rule of thumb" way of stating the "restricted set" criterion for the linguist faced with a large amount of data (i.e, if one sees a lot of diphthongs, one probably has a pretty unrestricted set, so assume a biphonemic interpretation).

3.1.3. Evaluation of the RGDs according to the Criteria

Let us now recap the criteria used to determine whether diphthongs are monophonemic or biphonemic and see how the RGDs of American English should be classified according to the criteria:

First Criterion (Trubetzkoy's Rule I): Are the consituent parts of the RGDs distributed over a syllable?

Answer: This is hard to judge unless we have some basis for deciding on syllable division. The matter will be discussed more thoroughly in Chapter Ten. Note that all vowels before /r/ we have considered so far are ones in tautosyllabic situations, such as in "ear".

---

[5]These are not the symbols Swadesh uses. I am regularizing.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"air", etc. Vowels before /r/ in heterosyllabic situations, such as in "merry", "borrow", etc. may pattern differently.

Second Criterion (Trubetzkoy's Rule II): Do the RGDs have a homogenous articulatory movement?

Answer: Yes? The RGDs are phonetically diphthongs like /aj aw/, and are vocalic throughout. They do, however, have one part that is rhotic and one part which is non-rhotic. I don't know whether this violates Trubetzkoy's Rule II or not.

Third Criterion (corollary to Trubetzkoy's Rule II): Are the target vowels of the RGDs reached, or is it the direction of the movement, which is important?

Answer: To be determined.

Fourth Criterion (Trubetzkoy's rule III): Does the duration of the RGDs exceed the duration of the other vowel phonemes in the language?

Answer: This one is not really relevant, as discussed above.

Fifth Criterion (Trubetkoy's rule IV): Do the RGDs occur in the same position as single vowels or phoneme sequences?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Answer: The RGDs would be classified as biphonemic according to this criterion. They have the same syllable positioning as vowel + sonorant sequences, since they are derived historically from /Vr/ sequences. I will argue later in section 8.1.5 that this is not a good criterion.

Sixth Criterion (Trubetzkoy's rule V): Do the RGDs represent symmetry in the phonetic inventory?

Answer: As discussed above, it is not clear how this should apply to diphthongs.

Seventh Criterion (Trubetzkoy's rule VI): Do the elements of the RGDs occur separately?

Answer: Maybe not. It could be argued that on this basis, the RGDs are monophonemic. As we have already seen, the vowel in [Ir] is between /i/ and /ɪ/, the vowel in [Er] is between /e/ and /ɛ/, the vowel in [Or] is between /o/ and /ɔ/, etc. However, I think we need to make our claims more precise. Thorough phonetic evidence is needed to determine just what it means to say that the vowel in [Er] is neither /e/ nor /ɛ/, etc. It could be that English vowels allow this wide range of deviance as allophones before other consonants. What

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is needed is a detailed account of the effects of all English consonants on all preceding vowels. This will be done in Chapter Six.

Eighth Criterion: Is there a restricted set of RGDs?

Answer: Yes. Let us examine what possibilities of tautosyllabic VC are allowed in English. A list of words exemplifying all such possibilities is found in Table 3.1 below.

From the start, there is difficulty with deciding what vowels and consonants to put in the table. Do we put the diphthongs [ej ow aj aw ɔj] in the inventory of vowels, or do we treat them as biphonemic sequences of some other vowel with the [j] or [w] in the coda? Do we count [ɚ] as a single vowel, or /ʌ/ followed by a coda /r/? What about [ju]? And, of course, what do we do with the /Vr/ sequences? We have to consider the /r/ to be a distinct consonant in the coda for purposes of illustrating the point there, but how do we classify the vowels which occur before the /r/?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 3.1. Distribution of vowel plus single consonant codas in English:[6]

	p	b	t	d	k	g	tʃ	dʒ	f	v
i	leap	grebe	seat	reed	seek	league	beach	liege	leaf	leave
ɪ	dip	rib	sit	rid	sick	big	rich	ridge	if	give
e	shape	babe	bait	raid	sake	vague	aitch	rage	safe	gave
ɛ	step	ebb	bet	red	heck	beg	ketch	hedge	deaf	rev
æ	tap	stab	bat	had	sack	bag	hatch	badge	laugh	have
u	soup	boob	boot	food	nuke	fugue	pooch	huge	goof	move
ʊ	shtoop		foot	good	book	"sug"[7]	butch	noodge	hoof	
o	hope	robe	goat	goad	oak	rogue	roach	doge	loaf	cove
ɔ		daub	taut	baud	auk	frog	debauch		off	mauve
ɑ	top	cob	pot	cod	hock	cog	crotch	dodge	doff	Slav
ʌ	pup	dub	putt	cud	puck	rug	crutch	budge	tough	love
ɚ	burp	blurb	hurt	bird	work	erg	church	urge	turf	curve
aj	pipe	jibe	write	ride	pike			oblige	life	five
aw			doubt	loud			crouch	gouge		
ɔj			quoit	void					coif	

	θ	ð	s	z	ʃ	ʒ	m	n	ŋ	l	r
i	teeth	teethe	piece	cheese	leash		team	lean		feel	beer
ɪ	with	with	miss	his	wish		rim	sin	sing	fill	
e	wraith	bathe	mace	faze	crèche	beige	same	sane		fail	
ɛ	death	edh	mess	fez	mesh		hem	hen	eng	fell	bare
æ	wrath		mass	has	mash		ham	man	hang	pal	
u	truth	soothe	noose	booze	douche	luge	loom	boon		fool	
ʊ			puss		push		room			pull	poor
o	both	loathe	gross	nose	gauche	Limoges	tome	bone		pole	
ɔ	moth	moths	loss	laws	wash		shawm	dawn	song	fall	bore
ɑ	Goth		Haas	schnozz	posh	garage	bomb	con	bong	doll	car
ʌ	doth		bus	buzz	lush		dumb	dun	rung	dull	
ɚ	earth		purse	hers	Hersh		squirm	burn		curl	
aj		writhe	mice	rise			dime	pine		dial	
aw	mouth	mouth	mouse	house				down		foul	
ɔj			voice	noise				coin	boing	foil	

I have decided to treat the diphthongs [ej ow aj aw ɔj] as vowels in the inventory (so /j/ and /w/ are not in the list of coda consonants), because that is the most frequent analysis. I have also chosen to put [ɚ] in the inventory, because it is not a phonetic

[6]Some of the words in this table are proper nouns. Others may be marginal in many idiolects (schnozz, shtoop, etc.). Others are variant pronunciations (room). This does not change the essence of my claim: that there are no systematic gaps of vowels before any English consonant besides the ones mentioned above.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

sequence of [ʌ] followed by [r]. I am not listing [ju] as a separate vowel because its nucleus is identical to [u], and we are concerned with what consonants can follow a vowel nucleus here, not what can come before. The vowels before [r] I have classified with the "lax" vowels [ɪ ɛ ʊ ɔ ɑ] following the recommendations of Lehiste (1964). This is merely a convenient choice, though.

There is also the matter of the diphthongs [aj aw ɔj], found in words like "hire", "hour", etc., which might not be truly "before" the /r/, in that what follows is really an [ɚ] in the next syllable. Thus, I am not including such sequences in the table. This could also be claimed for some diphthongs found before /l/ in words like "dial", "boil", etc. I am nevertheless including these in the table until it can be proven they are truly biphonemic.

As we can see from Table 3.1 above, the complete set of American English vowel phonemes (/i ɪ ej ɛ æ u ʊ ow ɔ ɑ ʌ ɚ aj aw ɔj/) does contrast before most consonants. There may be accidental gaps before some of the other consonants. For example, not many vowels contrast before /ʒ/, it being a rare sound of English. Likewise, the rare vowel /ʊ/ does not occur before many consonants, owing to its historical status as a highly restricted positional variant

[7]Short for the affectionate term "Sugar."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of both ME /ū/ and /ọ̄/, which usually became Modern English /ʌ/ and /u/ respectively in most environments (Dobson 1957: 511-512, 720ff). At any rate, there are no systematic gaps before English consonants besides /r/ and /ŋ/.[8]

Thus, according to this criterion, the RGDs do pattern more like monophonemic than biphonemic diphthongs.

Ninth Criterion: (corollary of the Eighth) Are there more than three or four RGDs?

Answer: It depends on the dialect. Therefore, the phonological analysis of the RGDs might depend on the dialect as well. Some American dialects are claimed to have six contrasting RGDs. Others have five. Still others have only four. Most of the speakers producing data for Chapter Six had only four. We appear to be in a borderline case here. In the dialects having only four RGDs, a monophonemic analysis is more likely. For those having more than four RGDs, a monophonemic analysis is less likely. Since most of the subjects of this study have only four, this points to the

[8]The systematic distribution before /ŋ/ is an interesting matter as well, and will be discussed in a later chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

monophonemic analysis. However, as stated before, this criterion is likely just a general rule of thumb.

Tenth Criterion: Does the transition take up a large part of the diphthong?

Answer: This isn't known. At this point, the relationship between the percentage of a given diphthong which is taken up by transition and the mono- versus biphonemic status of that diphthong is not well established. This is a likely avenue for future research, but will not be investigated in this dissertation.

3.2. Past Phonological Analyses of the RGDs

Now that we are aware of the general criteria which are used to determined whether a given diphthong in a given language is monophonemic or biphonemic, and how the RGDs might be evaluated according to such criteria, let us see how linguists have analyzed the RGDs, so we can evaluate the criteria they use.

Phonological analyses of the RGDs of American English can essentially be broken down into two categories:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1) Analyses in which the RGDs are not considered to have an equivalent phonological structure to the diphthongs /aj aw ɔj/, but rather to vowel + sonorant sequences such as /in ɛm/, etc.

2) Analyses in which the RGDs are considered to have an equivalent phonological structure to diphthongs like /aj aw ɔj/, and not the same as vowel + sonorant sequences.

Note that it would be possible to have an analysis in which all canonical diphthongs, RGDs, and vowel + sonorant sequences had the same phonological structure, but I don't know of any. Even an analysis such as Trager & Bloch's (1941), which analyzes the diphthongs /aj aw ɔj/ as being syntagmatic sequences, still allows for a "glide slot" in the syllables which is different from the consonant slot that a sonorant in the coda would occupy.

The list that follows is intended to be comprehensive. There may be other analyses of RGDs in the literature, but I am not aware of them. The paucity of actual defended analyses of RGDs requires that I not only include situations in which the authors actually defend the reasons for their representations and make them explicit,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

but situations in which the RGDs are merely treated one way or another, and the reader must glean how they are to be analyzed from the phonological representations provided.

3.2.1. Syntagmatic Treatments

I will first review the analyses and treatments in which the RGDs are not considered as equivalent to the diphthongs /aj aw ɔj/ but to vowel + sonorant sequences.

What all these analyses share in common is that the RGDs are analyzed syntagmatically, while the canonical diphthongs are analyzed paradigmatically. That is to say, there is an inventory of vowels in the language, and the diphthongs /aj aw ɔj/ are listed in the inventory alongside /i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ/, while the RGDs are not listed in the inventory, but are treated as sequences of one of the vowels that is in the inventory, followed by /r/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

These syntagmatic treatments can be further divided into two categories: ones in which the vowels which form the nuclei of the RGDs are all considered to belong to the same "natural class" of vowels, and ones in which they do not all belong to a natural class. The "natural class" division than can be further divided into two group: ones in which the vowels in the nuclei of the RGDs belong to the group of "tense" vowels of American English, and ones in which they belong to the group of "lax" vowels. In addition, there are "archiphonemic" analyses, in which the RGDs are still analyzed syntagmatically, but the vowel nucleus represents a segment that neutralizes features of two or more of the canonical vowel phonemes.

3.2.1.1. Tense Vowel Treatments

BLOOMFIELD 1933

Bloomfield (1933) treats the RGDs as sequences of tense vowel + /r/, transcribing [Ir Er Ur Or] in "gear", "air", "sure", and "oar" as [ijr], [ejr], [uwr], and [owr] respectively (p. 124). Bloomfield's usage of two symbols to transcribe the vowels [ij ej uw ow] does not mean that he thinks they are syntagmatic sequences of two phonemes, but

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

rather "compound primary phonemes" (p. 91, 124). However, Bloomfield transcribes [Ar] in "far" and "charm" as [ar] (p. 102, 122), indicating that the nucleus in [Ar] would not be a compound phoneme, and not fall into the same natural class as the nuclei in [Ir Er Or Ur]. So, actually, Bloomfield's treatment might fall into the next category ("arbitrary treatments") below.

TEETER 1966

Teeter (1966) considers how to analyze the vowel in "dear." Is it /i/ or /ɪ/? He chooses /i/ based on the following line of reasoning:

1) The vowel in "dear" is the same as the vowel in "dearer" or "merer" (the comparative form of the adjective "mere").

2) The vowel in "dearer/merer" contrasts with the vowel in "mirror" in his dialect.

3) The vowel in "mirror" is definitely more like /ɪ/.

4) Therefore, the vowel in "dearer/merer" must be /i/.

5) Therefore, the vowel in "dear" must be /i/ as well.

Though Teeter does not make such matters explicit, his analysis would doubtless arrive at tense vowel analyses /e u o/ for the vowels in "bear", "boor", "bore" based on similar comparisons to the vowels in pairs of words like "Mary/merry", "poorer/juror", and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"boring/sorry." That is to say, the last word in each of these pairs ("merry", "juror", "sorry") has a vowel which must be lax (/ɛ/, /ʊ/, /ɔ/ respectively), so the vowel before /r/ in the first word in each pair must be tense /e/, /u/, or /o/. And, since "Mary", "poorer", and "boring" have the same vowels as "bear", "boor", and "bore", respectively, these monosyllabic words must have the tense vowels /e u o/ as well.

Teeter's analysis has its strong points. There are problems with it, though (neglecting the fact that it provides no way of analyzing the vowel [Ar] in "bar"). The major problem is that many, if not most speakers of American English around the turn of the millennium, do not contrast the vowels in "dearer" and "mirror" or "Marry" and "merry", etc. Many do not even contrast "boor" and "bore." So, the major evidence for Teeter's analysis is gone. Another problem would be what to do with the stressed vowel [ɚ]. Assuming a dialect which contrasted the vowels in the words "hurry" and "furry", the vowel in the former word is more like the non-rhotic [ʌ] and would have to be identified as /ʌ/. How do we categorize the vowel in "furry", then? It would have to be this distinct phoneme /ɚ/. We would be forced in any situation to allow for the existence of distinct vowel phonemes arising from the historical source /Vr/,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

something that Teeter rejects as "implausible" in the case of [Ir] (p. 478).

HARRIS 1994

Harris (1994) tackles the problem of reduced contrast of Vs before /r/ by stating that since /r/ is not truly a consonant, it is not in coda position like other consonants. Hence, the reduction in contrasts before /r/ in American English can be accounted for by "an independently statable fact about English (and other Germanic languages). . . Domain-final stressed nuclei must branch." (p. 261). As an illustration of this, Harris cites the fact that [fi:], [fej], and [fow] are possible words in English but not *[fɪ], *[fɛ], etc. Earlier, Harris states that "unlike short vowels, diphthongs and long monophthongs can occur in word-final stressed open syllables", hence [gow] and [sej] are possible words, but not *[sɪ] and *[sɛ] (p. 37). We can see from this that Harris's term "domain-final" is here essentially equivalent to "word-final" and that "branching nuclei" means long vowels or diphthongs, but not simple short vowels.

Harris's account can be interpreted in two ways. On the one hand, he seems to be drawing a parallel between word-final and pre-/r/ environments in English. Hence, the vowels which occur before

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/r/ should be drawn from the same restricted set that can occur word-finally in English. While this may seem to be advocating an archiphonemic analysis (i.e., one in which the vowel before /r/ is neutralized for the feature tense/lax), it is actually treating the vowels before /r/ as tense vowels, since those are the only ones that can be found in open syllables in English.

This first interpretation of Harris's analysis has its strong points in that it attempts to resolve the problem in an independently motivated fashion, by making use of phonological rules and constraints that already exist in the language. However, there are some problems with it.

First of all, it is contradictory to say both that the vowel is "before" the /r/, but that the vowel is in an open syllable. The terminology "open syllable" (or Harris's "domain final") implies that there is nothing in the syllable after the vowel itself. The problem here is that Harris is not completely consistent when he claims that /r/ does not behave like a consonant. If /r/ is not phonologically a consonant, but a central approximant, then it should behave phonologically like the central approximants /j/ and /w/. But we do not say that vowels tense ("branch" in Harris's terminology) before /j/ and /w/. Rather, it is considered that the final /j w/ in words like "bee" or "shoe" is a redundant feature of the tense vowel itself.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Indeed, Harris lists these tense vowels (and diphthongs ending in /j w/) in the inventories of several dialects of English (p. 255, 268), all of which presumably have the rule requiring tense vowels in open syllables.

This problem is further compounded in that Harris's analysis would lead to a monosyllabic triphthong ("ternary-branching nucleus"), something he explicitly disallows (p. 33). That is to say, that the nucleus in a word such as "beer" (which Harris gives phonetically as [bɪərl]) would have to be represented as something such as in Figure 3.1.

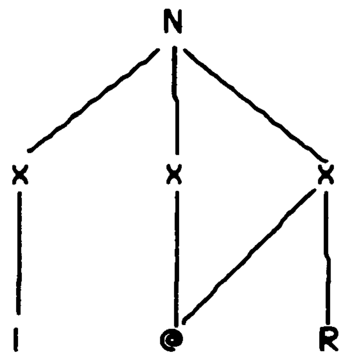


Figure 3.1 Representation of the nucleus in "beer" à la Harris 1994.

In Figure 3.1, we can see three branches coming from the nucleus. The rightmost one is the "**R**" element, which is necessary for the central approximant [ɹ]. As Harris states above, this [ɹ] is in the nucleus, not the coda. The previous two branches are the palatal

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

element "I" and the neutral element "@" (this latter element serves both for the off-glide of the vowel and to mark the central aspect of the [ɹ]). This is a ternary-branching nucleus, which Harris explicitly disallows.

Furthermore, Harris's solution might not even work. It does account for the lack of contrast before /r/ in words like "beer." That is to say, it explains why we don't get [bir] and [bɪr] contrasting. However, if there were a true consonant after the /r/, such as /d/, then we would no longer have an open syllable, and hence could expect contrasting forms such as both [bird] and [bɪrd]. Yet only one such form is possible.

What it boils down to is that Harris is not consistent. He acknowledges that /r/ does not behave phonologically like a consonant, but he is inconsistent in that he doesn't treat it like /j/ and /w/. Were he to treat the RGDs the same way as he treats diphthongs ending in /j/ and /w/, we would have another interpretation of his analysis. In this case, the fact that American English /r/ is in the nucleus would prevent contrast of vowels before it not because of the fact that domain-final nuclei must branch, but due to Harris's prohibition on ternary-branching nuclei (above). Since post-vocalic /r/ would be in the nucleus, we could have only one other branch before it. In Harris's analysis, one feature which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

distinguishes vowels like /i/ and /e/ from /ɪ/ and /ɛ/ in English is that the former vowels have branching nuclei, while the latter vowels do not. Hence, the existence of /r/ in the nucleus would remove one of the features necessary to distinguish between vowel in English.

In this second interpretation of Harris's analysis, /r/ would truly behave like the other glides /j/ and /w/, and [Vr] sequences would be like diphthongs in [j] and [w]. Thus, Harris's analysis could actually belong with the "glide-slot" analyses in Section 3.2.2.2, below.

HAMMOND 1999

The RGDs are treated as sequences of tense vowels plus /r/ in Hammond 1999. He transcribes [Ir Er Ar Or Ur] as [ir er ɑr or ur] (pp. 133-114, 146). Working within the framework of Optimality Theory, he gives a constraint that explicitly prohibits sequences of non-low lax vowels followed by coda /r/ (these would be realized as [ɚ]). Hence, only the tense vowels /i e ɑ u o ɔ/ would be allowed before /r/. But, Hammond has another constraint which disallows /ɔ/ before /r/ (p. 147). Presumably, Hammond is working with a GA dialect that makes no distinction between "fore" and "for." It is not

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

clear how Hammond allows for the non-existence of /æ/ before /r/, since his constraint doesn't actually prohibit it, it usually being classified as a low lax vowel.

3.2.1.2. Lax Vowel Treatments

BRONSTEIN 1960

Bronstein (1960) regards [Ir Er Ar Or Ur] as having the lax vowels /ɪ ɛ ɑ ɔ ʊ/ phonemically[9]. Bronstein's motivations for this are purely phonetic. He regards the nuclei in [Ir Er Or Ur] as being closer to [ɪ ɛ ɔ ʊ] than [i e o u], and is consistent with this in his description of historical sound changes (p. 148, 152, 167, 172).

KENYON & KNOTT 1953

The transcriptions in Kenyon and Knott's *A Pronouncing Dictionary of American English* are usually phonemic. Phonetic

---

[9]Note that there is discrepancy between sources with how the vowels /ɑ ɔ/ are classified according to the feature "tense." Phonologically, they may be classified as "tense" because they are allowed in open syllables, but phonetically they are usually considered "lax."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

positional variants such as aspiration, nasalization of vowels, flaps, etc., are not indicated. Hence, we can glean a phonemic categorization of the vowels in RGDs from Kenyon & Knott's transcriptions. The primary transcriptions they give for the word "ear", "air", "are", "poor", and "horse" in "cultivated colloquial English" are /ɪr/, /ɛr/, /ɑr/, /pʊr/, and /hɔrs/, respectively. Thus, Kenyon & Knott's transcriptions are generally consistent with a lax vowel analysis.

It should be noted that Kenyon & Knott give variant pronunciations for most of these /Vr/ sequences. Words with /ɛr/ always have the variant /ær/ (which is still a lax vowel). Some words, like "hoarse" are given the primary transcription with the tense vowel /o/, but they are also always given an alternative pronunciation with /ɔ/. Likewise, regional and contextual variations such as /ɛə(r)/ for some Southern pronunciations of "ear" and /ɚ/ for unstressed pronunciation of "are" are also given.

LEHISTE 1964

Lehiste 1964 has a very thorough examination of the phonetics of the RGDs and classifies them as lax vowels. Lehiste has a four-way

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

classification of American English vowels (see also Lehiste & Peterson 1961), and makes the following distinctions:

1) Vowels with short nuclei and proportionately long off-glides:

/ɪ ɛ ʌ ʊ/

2) Vowels with long simple nuclei and proportionately short off-glides:

/i æ ɑ ɔ u/

3) Complex vowels with a single target:

/e o ɚ/

4) Complex vowels with double targets:

/aj aw ɔj/

Lehiste observes that the nuclei in the RGDs [Ir Er Ar Or Ur] may fall between some of the canonical vowels based on measurements of F1 and F2, but generally have a short target and long transitions (as opposed to the V + [ɚ] sequences in words like "seer", which have long targets and short final transitions), and therefore classifies them with the "lax" vowels in the first group above (p. 89). Note that Lehiste is not using a complete natural class here: she classifies [Ir Er Ur] with /ɪ ɛ ʊ/ in the "lax" group, but [Ar Or] with /ɑ ɔ/ in the "tense" group (the second group above). Once again, there is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

inconsistency in the way linguists use the terms "tense" and "lax" with regards to the vowels /ɑ ɔ/ of American English.

AKMAJIAN *ET AL.* 1995

Akmajian *et al.* 1995 claim that the nuclei in [Ir Er Ar Or Ur] are the "lax" vowels /ɪ ɛ ɑ ɔ ʊ/ (pp. 89-90). Their reason for this is the claim that putting a true tense vowel like /i/ before /r/ results in a bisyllabic word like "seer" (as opposed to the monosyllabic "sear.") This is not a good analysis, however. It may very well be the case that words like "seer" have tense vowels. It does not follow from this that the word "sear" could not also have a tense vowel. The words "seer" and "sear" might have the same vowel, but might contrast syllabicity of the following consonant. That is to say, that "sear" could be [sir], while "seer" could be [si.ɾ̩]. We can see some clear cases of this type of contrast with syllabic [n] and [l], below.

lax + sonorant	tense + sonorant	tense + syllabic sonorant
"in"	"keen"	"Ian"
"dawn"	"own"	"Owen"
"tell"	"trail"	"betrayal"
"pull"	"pool"	"accrual"

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The fact that "seer" has a tense vowel does not mean "sear" cannot have one as well, anymore than the occurrence of a tense vowel before syllabic [n] in "Ian" prohibits the possibility of a tense vowel before non-syllabic [n] in "keen." The tense/lax status of the vowel in "sear" still has to be resolved.

Wells (1982, Vol. I) also treats the nuclei in the RGDs as lax (p. 242-244), but does consider the possibility that the RGDs should be treated as monophonemic diphthongs (p. 50).

3.2.1.3. Archiphonemic treatments:

There is also a possibility that the RGDs may be treated as syntagmatic sequences, but that the first element in the sequence is not identified with a particular member of the set of canonical vowel phonemes, but as a vowel which is neutralized for some of the features which are normally used to contrast vowel phonemes in English, that is to say, it is an archiphoneme. Thus, for example, the nucleus in [Ir] would be neither /i/ nor /ɪ/, but a vowel which is front, high, and unrounded, but lacking a specification for the feature

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

used to distinguish /i/ from /ɪ/ (tenseness or length, or whatever is used.)

Moulton (1962) uses this analysis in his description of English. Although Moulton claims that the vowels in "beer", "bare", "bore", and "boor" are more like [ɪ], [ɛ], [ɔ], and [ʊ], respectively, he uses an archiphonemic analysis based upon the lack of contrast in vowels before /r/, and on the supposed geographically based phonetic variance in the specific phonetic realizations of these vowels. Hence, the vowel in "beer" is /I/ (a neutralization of /i/ and/ɪ/), the vowel in "bare" is /E/ (a neutralization of /e/ and /ɛ/), the vowel in "boor" is /U/ (a neutralization of /u/ and /ʊ/, and the vowel in "bore" is /O/ (a neutralization of /o/ and /ɔ/). The vowel in "bar" is, however, identified specifically as /ɑ/, not as an archiphoneme.

Moulton's archiphonemic analysis is also followed by Gramley & Patzold (1992), who use both lax vowel symbols and archiphonemic symbols (capital letters) to represent the nuclei in the RGDs, though they describe them as archiphonemes (p. 104).

Likewise, Wardhaugh (1995) also considers the nuclei in the RGDs to be neither tense nor lax, but archiphonemic in nature. He uses the tense vowel symbols to represent these vowels (p. 186), but acknowledges this is an arbitrary choice (p. 196).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.2.1.4. Arbitrary Treatments

In some works, the RGDs are transcribed as syntagmatic sequences of vowel + /r/, but the vowels in question do not all comprise a natural class of vowels. In all of these cases, the transcriptions are not proper analyses, but unexplained treatments. The very nature of phonological analysis is the search for generalities; hence an analysis which requires the positing of an arbitrary list of allowable sequences would never be consciously favored.

Cruttenden (1994: 84) has the vowels in GA "beard", "fare", and "dour"[10] as /ɪr/, /er/, and /ʊr/, respectively. These vowels cannot constitute a natural class, since /ɪ/ and /ʊ/ are lax and /e/ is tense. No description is given for GA [Ar] and [Or] (this work mainly describes the sounds of RP British English.)

Spencer (1996) has the complete opposite of Cruttenden/Gimson, transcribing GA [Ir Er Ur] as /ir ɛr ur/ (p. 34). Like Cruttenden/Gimson, Spencer mainly concentrates on the phonology of RP.

---

[10]Presumably for those who do not rhyme this word with "hour."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Ladefoged (1992) gives GA [Ir Er Ar Or Ur] as /ir ɛr ɑr ɔr ur/. These vowels cannot represent a natural class in and of themselves, since /ɛ/ is lax and /i u/ are tense (I'm still not sure how we classify /ɑ/ and /ɔ/.) To complicate the matter further, Ladefoged's phonemic transcriptions of [Ir Er] on p. 87 are a complete reversal of tenseness from his phonemic transcriptions on p. 31, where [Ir Er] are given as /ɪr/ and /er/, respectively.

Chomsky & Halle (1968) have no explicit discussion on the matter of classifying the RGDs. However, one can glean from the transcriptions of words like "appear", "compare", "car", and "pure" that they regard [Ir Er Ar Ur] as /ir er ær ur/ (p. 69, 216, 217, 222). The sheer number of vowel alteration rules (both conditioned and unconditioned) in their analysis of English phonology makes it difficult to determine what non-rhotic vowels are to be considered equivalent to those in "horse" and "hoarse." They assume a dialect which contrasts the vowels in these two words on the underlying level (p. 217). However, underlying short /o/ and /ɔ/ usually turn out to be [ɔ:ə] and [ɑ:] respectively in Chomsky & Halle's treatment, hence /ɔ/ and /ɑ/ in a phonemic framework. At any rate, it doesn't matter, as Chomsky & Halle are not intending to give a thorough generalized treatment of the RGDs.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.2.2. Diphthongal Treatments:

There are also analyses which regard the RGDs as akin to the other diphthongs of GA, like /aj aw ɔj/. They differ from all the previous analyses in that they treat American English /r/ as being in the same phonological category as the central approximants /j/ and /w/, and not in the same category as other sonorant consonants like /l/, /m/, /n/, and/ /ŋ/. Hence, the RGDs do not consist of a syntagmatic sequence of one of the canonical vowel phonemes of GA followed by /r/, but may be listed in the inventory along with the canonical vowel phonemes, and the diphthongs /aj aw ɔj/.

These diphthongal treatments can be divided into two categories:

1) Those that consider the diphthongs (and all vowels) of GA to be single paradigmatic phonemes

2) Those that regard the diphthongs and long vowels of GA to be syntagmatic sequences of a short vowel followed by a central approximant /j w r/ in a post-vocalic "glide slot."

In the latter situation, however, the long vowels and diphthongs are still not the equivalents of syntagmatic VC sequences such as /ɪn/, /ɛt/, etc.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

It will further be argued that these two types of analysis are not really different, and that the syntagmatic "glide slot" analysis is really a more detailed notational variant of the paradigmatic monophonemic diphthong analysis.

3.2.2.1. Monophonemic treatments:

DE CAMP 1945

De Camp 1945 argues that the diphthongs /aj aw ɔj/ of GA are monophonemic rather than biphonemic (he actually uses the terms "combination trains" and "aggregation trains", respectively) based on the following criteria:

1) Biphonemic diphthongs belong to an unrestricted set. For example, the onset [w] can be followed by an vowel in English ("weed", "with", "wade", "wed", "wag", "woo", "wood", "woke", "walk", "wok", "was", "wide", "wow"[11]), while, for example, the number of diphthongs ending in [w] is severely limited.

2) Elements in biphonemic diphthongs are stable geographically and contextually, but those in monophonemic

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

diphthongs can vary. The nucleus in /aj/ can vary from [æ] to [ɑ], and the off-glide can vary from [i] to [e], for example. I would agree with this line of reasoning, but take issue with De Camp's criterion of "geographic variation." It could be the case that the cognate of a given diphthong has a different phonological analysis in another dialect where it is pronounced differently. De Camp also states that monophonemic diphthongs have monophthongal variants (whether he means geographically or contextually he doesn't say). I also take issue with this criterion. This criterion (also used in Pike 1947a) can only be used to decide whether a given monophoneme can be classified as a diphthong or monophthong in its underlying form. There is no reason a monophonemic diphthong could not always be diphthongal.

3) Monophonemic diphthongs "contain elements not readily assignable to a monophthongal phoneme of that language." For example, the nucleus [a] in /aj/ does not necessarily appear independently in GA (just [ɑ] and [æ]).

4) Biphonemic diphthongs can be broken up syllabically, while GA /aj aw ɔj/ cannot be.

Using the same criteria, De Camp classifies the RGDs as monophonemes akin to /aj aw ɔj/, saying, for example, that the

---

[11]These are my example words, not De Camp's.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

nucleus in "far" can vary from [a] to [ɔ], and the off-glide from [ɹ] to nothing.

De Camp's criteria for deciding the mono- or biphonemic nature of a given diphthong largely echo those used by Trubetzkoy and others (see above). We have already seen that the RGDs could be considered monophonemic based on such criteria, but De Camp is the only one I know who has actually decided to apply the criteria.

Unfortunately, De Camp's claims have had little impact. The RGDs are not widely considered monophonemic. Wells (1982, Vol. I) states that "there is actually a fair case. . .for analyzing such elements as the (RGDs) of GA 'start', 'short', 'near', 'square' as unit phonemes rather than as realization of a vowel phoneme plus /r/" p. 50. However, he does not give his reasons.

3.2.2.2 "Glide-Slot" Analyses

TRAGER & BLOCH 1941

The idea that a diphthong is a syntagmatic sequence consisting of a vowel nucleus and a central approximant that falls into a post-vocalic "glide slot" (not the coda consonant slot) is associated with

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

George L. Trager and Bernard Bloch, particularly with the article "The Syllabic Phonemes of English" (1941). Trager & Bloch identify the basic vocalic nuclei of American English[12] as /ɪ ɛ æ ɔ[13] ʌ ʊ/. Adding a /j/ or /w/ in the glide slot could get us such diphthongs as [ij ej aj ɔj aw ow uw]. Note that such an analysis leads to a situation of complementary distribution. For example, [e] only occurs before [j], but [ɛ] occurs elsewhere. Hence, [e] and [ɛ] would have to be allophones of the same phoneme. Therefore the diphthongs [ij ej aj ɔj aw ow uw] are essentially /ɪj ɛj æj ɔj æw ʌw ʊw/ respectively in their underlying forms.

Trager & Bloch do not use criteria like those of Trubetzkoy (and others) for determining whether a given diphthong is mono- or biphonemic. The reasons for their analysis are to make a symmetrical pattern, and have consistent syllable structure.

They also allow a third central approximant, /h/, in the glide slot alongside /j/ and /w/. This post-vocalic /h/ is an allophone of the onset /h/ heard in words like "hot", but shows up post-vocalically as a lengthening element on the preceding vowel with perhaps a more centralized tongue position, so either [:] or [ə] (p. 240).

---

[12]Trager & Bloch do not use these exact symbols. I am regularizing.
[13]This /ɔ/ is the vowel in "pot", and might actually be more like [ɑ].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The RGDs are identified as sequences of vowel, plus an element in the glide slot, plus /r/. [Ir Er Ar Or Ur] are phonologically /ɪjr ɛhr æhr ɔhr ʊwr/. This post-vocalic /r/, however, is neither in the glide slot alongside /j w h/, nor in the coda consonant slot. It is in a slot of its own. Hence, rhymes have four possible slots in Trager & Bloch's analysis: the vowel slot, the glide slot, the /r/ slot, and the consonant slot.

Their reason for doing this is to distinguish what they see as longer vowel nuclei in words like "dearer", "Mary", "starry", "poorer", and "boring" from the shorter ones in "mirror", "merry", "marry", "jury", and "sorry." The words in the former group would be /dı́jrər méhrij stǽhrij pʊ́wrər bɔ́hrıŋ/, while those in the latter group are /mı́rər mérij mǽrij dʒʊ́rij sɔ́rij/, having short nuclei and lacking off-glides.

However, Trager & Bloch do acknowledge that there are GA dialects in which "mirror" and "dearer", "Mary", "merry", and "marry", etc. rhyme and which do not have the contrasts given above (p. 241). In such an analysis, they give [Ir Er Ar Or Ur] as /ɪr ɛr ær ɔr ʊr/ without an element in the glide slot. In such a situation, where there could be no glide before /r/, would it mean that /r/ is itself in the glide slot? They do not address this question. Trager & Bloch, therefore, do not treat the RGDs parallel to the diphthongs /aj

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

aw ɔj/, but discussion of their analysis is necessary as background to those who use a similar analysis, but treat /r/ parallel to /j w/.

KAHN 1980

Kahn (1980) explicitly argues that GA /r/ should be treated as parallel to /j w/ based on the following reasons:

1) The central approximants /j w/ are not actually found before /r/ in the same syllable. For example, the vowels in the words "code" and "core" are both derived from Middle English /ǭ/, but in the first word we have Modern English [kowd], and in the second we have [kor] (his transcriptions). We have no [kowr] (p. 121). Likewise, we do not have tautosyllabic [jr] or [wr] in words like "tire" and "hour", but usually bisyllabic [tajɚ] and [awɚ]. This may be accounted for by a general prohibition against GG (glide/glide) sequences. We also do not find tautosyllabic sequences of [wj], [jw], etc. (p. 121-122).

2) /r/ is parallel to /j w/ in having three phonetic forms (p. 150-151):

a) A pre-vocalic glide (such as in "yet", "wet", "red")

b) A stressed syllabic (such as in "beat", "boot", "burn")

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

c) The second element of a diphthongs (such as in "toy", "toe", "far")

These reasons aside, it is unclear how Kahn treats the vowels occurring before /r/ phonologically. He claims (p. 151) that only tense vowels like [e o] are found before /r/, and not lax vowels like [ɛ æ], and in this way /r/ is also parallel to /j w/, because GA allows [ej ow], but not [ɛj ɛw æj æw], etc.

However, on page 121, Kahn states that tense vowels are diphthongized in Modern English, which would create the post-vocalic [j] or [w] as a redundant feature. This is an inconsistency because, as we have seen before, if the off-glide [j w] exists in the underlying form, then tenseness is a redundant feature (as it is treated by Trager & Bloch), and it makes no sense to say tense vowels diphthongize. However, if tenseness is considered to be a phonologically contrastive feature, then the off-glide is redundant, and it makes no sense to say only tense vowels are found before [j w]. Kahn's analysis therefore gives us no specific clues as to how to analyze the RGDs, but does suggest that they be considered parallel to diphthongs like /aj aw ɔj/, because /r/ is considered to behave phonologically like /j/ and /w/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Veatch (1991) presents a fully detailed revised version of Trager & Bloch's glide slot analysis, one in which there is no post-vocalic /h/, and /r/ is in the glide slot alongside /j/ and /w/, based upon the following observations:

1) Diphthongs /aj aw ɔj/ cannot occur before /r/ in the same syllable (pp. 50-51) (as per Kahn, above).

2) Most of the sequences in the /Vjr/ and /Vwr/ categories that Trager & Bloch propose are actually heterosyllabic, with the /r/ actually being the onset of the following syllable; likewise the sequences in the /Vr/ class, where the /r/ might actually be considered ambisyllabic (p. 56).

3) There is no contrast of vowel length before /r/, hence there is no need for any /Vjr/, /Vwr/, or /Vhr/ classes contrasting with /Vr/.

Therefore, the /Vr/ sequences should be treated the same as /Vj/ and /Vw/ sequences. Veatch also eliminates the /Vh/ category (indeed, eliminating /h/ from the glide slot) by dismissing "yeah" and "huh" as marginal words, claiming "idea" is trisyllabic, and setting up a separate /V:/ category, which includes what were Trager & Bloch's /ɪj ʊw ɛj ʌw æh ɔh/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Ultimately, Veatch has the following categories (pp. 81-82):

1) Short Vowels: /ɪ ɛ æ ʊ ʌ ɑ/

2) Long Vowels: /i ej a:[14] u o ɔ/

3) /j/ diphthongs: /aj ɔj/

4) /w/ diphthongs: /aw/

5) /r/ diphthongs: /ɪr ɛr ær ʊr or[15] ɑr/. (The /ær/ does not occur tautosyllabically but only heterosyllabically in dialects which contrast "marry" with "Mary.")

Thus, Veatch regards the RGDs as parallel to the diphthongs /aj aw ɔj/, but his analysis would seem to classify all these diphthongs as biphonemic, not monophonemic.

However, I believe Veatch's analysis is compatible with a monophonemic analysis, for the following reasons:

1) Veatch cites studies in which RGDs behave just like other diphthongs and monophthongs with respect to the deletion of following /t/ and /d/ (p. 60).

2) Veatch puts both vowels and glides in the nucleus node of the syllable, distinct from the coda. Hence, there is a way in which

---

[14]Presuming a dialect that contrasts the vowel in "palm" with the one in "lot."
[15]This /or/ (my [Or]) would actually have the same nucleus as /ʌ/ in the same way /o/ does.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

diphthongs pattern like single vowels, and not like VC sequences (p. 62).[16]

3) Veatch (citing Maddieson 1984) claims that severe restrictions of vowel/glide combinations (such as we have seen in the situation of all /j/, /w/, and /r/ diphthongs in English) are common, while restrictions of vowel/coda consonants are rare. Another way of looking at this is that vowel/glide sequences would have to be just listed in the inventory, as items in a paradigm among the inventory of phonemes, while VC sequences are syntagmatic sequences which do not have to be listed in the inventory, because their existence can be determined by a general principle of permutations. Note the similarity between Veatch's statement and the "restricted set" criterion for determining whether a given diphthong is mono- or bi-phonemic (see section 3.1.2, above).

4) Veatch overtly states that "the nucleus and the glide act together as a unit in historical change. Stating these changes is made simpler when these are treated as a single unit" (p. 64). So, there is a sense that Veatch, even though he is using a two-slot analysis, does regard all the vowels and /j w r/ diphthongs as English as behaving like single units at some level. The use of the "glide slot", and separate long and short vowel categories, may be a way of further

---

[16]A similar analysis is found in Giegerich 1991: 165.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

specifying categories of vowels into natural classes, while still claiming that they all behave similarly in some way and should all be listed in the inventory[17]. Therefore, Veatch's analysis does not really contradict De Camp's (see above), but should be considered a more detailed variant of it.

Let us recall that, even in the original "glide slot" analysis (Trager & Bloch 1941), in which the /r/ is in a separate slot from the glides /j/ and /w/, separate categories still have to be set up to explicitly account for all the monophthongs, diphthongs, and RGDs. That is to say, Trager & Bloch have distinct V, Vj, Vw, Vh, Vr, Vjr, Vwr, and Vhr columns and show which vowels go in which column. They do not, however, have separate Vd, or Vjk, or Vhm columns, etc. Were the canonical diphthongs and RGDs truly syntagmatic sequences, there should be no need to explicitly list out all examples; this should fall out naturally by the combination of discrete elements (as it apparently does for vowel + consonant sequences). Hence, there is a way in which a supposed multi-slot analysis like Trager & Bloch's is equivalent to an inventory of phonemes.

[17]This could be what Pike (1947a) was trying to say when he said "the unity of [aj] is described on a higher level of structural sequence than that of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.2.3. Other Treatments;

There are a few early analyses, by Twaddell (1935), Kantner & West (1938), and Jones (1950) that would appear on the surface to be supporting a framework in which the RGDs are treated as distinct from the canonical phonemes, and hence could be considered compatible with a monophonemic analysis. Further investigation, however, shows these analyses to be resulting from an incomplete consideration of all the relevant issues.

Twaddell (1935: 54) says the vowels that occur before /r/ should be regarded as distinct from those that occur before /t/, /k/, etc., because they exist in a different system of contrasts. However, Twaddell also regards the [p] in "spill" as a different phoneme from either of the initial stops in "pill" or "bill." So, Twaddell is not adhering strictly to the principle of complementary distribution, which is part of traditional American phonemic analysis. It may be that Twaddell is actually advocating an archiphonemic solution for the nuclei of RGDs, as per Moulton and others (see above), but this is not clear from his claims, because an archiphoneme is not a distinct phoneme, but the reduction of contrast between two or more otherwise contrasting phonemes.

---

phonemes as such."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Kantner & West (1938) treat the RGDs as parallel to the other diphthongs (p. 328ff), but they are using purely phonetic criteria. They also treat /Vl/ sequences in the same manner, and make no use of any criteria for deciding whether a given phonetic diphthong behaves like a monophoneme or sequence of phonemes.

Jones (1950) claims that r-colored vowels must be treated as phonemes distinct from uncolored vowels (p. 85). Though he makes no overt consideration of RGDs, he does generally regard the English diphthongs as monophonemes (pp. 70ff). However, he claims that all vowels with any sort of colorization (including nasalization, breathy voice, creaky voice, etc.) must be considered distinct phonemes. This view would then presumably lead one to analyze nasal vowels as separate phonemes even in a language where they are in complementary distribution with oral vowels (English, for example). Such a view is not consistent with traditional American phonemic analysis either, and cannot be incorporated into the framework of this dissertation.

There are a few other treatments of the RGDs that bear mentioning. Kreidler (1989) does give overt mention of the RGDs (p. 60-62) and gives them separate listings in his inventory of phonemes alongside the monophthongs and other diphthongs (p. 67). However, this is ultimately not a phonological analysis, but merely a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

way of accounting for the variation in pronunciation of the historical /Vr/ sequences we find across dialects. Kreidler transcribes the nuclei in the RGDs with the same symbols used for the tense vowels, but this appears to be an arbitrary choice or a way of keeping the RGD categories distinct, since Kreidler transcribe the tense vowels redundantly as long vowels or diphthongs, serving to further distinguish them from the lax vowels.

Giegerich (1992) considers the phonological status of the nuclei in the RGDs of GA, but states that he does not know how to resolve the issue (p. 64). He does transcribe the RGDs generally with tense vowel symbols throughout, but this also appears to be an arbitrary choice.

3.3. What Needs to Be Determined:

What needs to be determined is a way of qualifying how the nuclei in the RGDs fit into Trubetzkoy's Rule VI, namely whether they occur independently. Remember that it is not at issue whether the nuclei could be considered allophones of one of the canonical vowel phonemes. Given the large number of vowel phonemes of English, and the large portion of the potential vowel space they occupy, any vowel could be a perfectly plausible allophone of a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

canonical vowel phoneme. Even if we had a diphthong whose nucleus was [œ], there's no reason that couldn't be an allophone of /ɛ/, or /ʌ/, etc.

Rather, the question we need to answer is "Does English allow the nuclei of the RGDs within its normal range of vowel allophony?" Therefore, we need to have information on what the allophones of the canonical vowel phonemes are before every possible consonant (and word finally for those vowels that are allowed in that position). To compare the nuclei of the RGDs with the average formant measurements of the various canonical vowel phonemes is not enough. It could very well be that allophones of vowels before /d/ or /f/, etc. are equally deviant.

So, we need to figure out what the range of all allowable vowel allophones is. The more the nucleus of an RGD is within the range of allophony of a canonical vowel phoneme, the more likely it is that the nucleus does occur independently and thus that the RGD is biphonemic. The more the nucleus of an RGD lies outside the range of allophony of a canonical vowel phoneme, the more likely it is that we can say that this nucleus does not occur independently, and thus the RGD in question is more likely to be monophonemic according to Trubetzkoy's Rule VI.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

However, we have seen analyses of diphthongs (such as Trager & Bloch's, Moulton's for German, etc.) wherein these phonetic criteria are not considered relevant, but having a consistent syllable structure takes precedence over any other considerations. Ultimately then, the decision of whether diphthongs like GA /aj aw ɔj/ are mono- or biphonemic is beyond the scope of this dissertation, despite the thorough discussion the matter has been given in this chapter. What can be determined, however, is whether the RGDs pattern like the diphthongs /aj aw ɔj/, or like the vowel + sonorant sequences like /ɛn ɑm/, etc. That is the ultimate goal of this study. If the RGDs do pattern like /aj aw ɔj/ and not like /ɛn ɑm/, etc., then a monophonemic analysis will be advocated, based on the fact that the diphthongs /aj aw ɔj/ are usually considered and placed in the inventory of GA vowels alongside /i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ/, but this is not to preclude the possibility of a biphonemic analysis for the diphthongs as well.

It is not assumed in this matter that there is a default argument. Remember that there is no default analysis for the classification of a given diphthong as monophonemic or biphonemic either. The classification of the nuclei of the RGDs with the canonical vowel phonemes is in itself a claim that must be defended and cannot be assumed. It must be shown that the vowels before /r/ do

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

behave like the canonical vowel allophones of GA across the various domains.

Based on *a priori* considerations we could make the following contradictory observations:

1) That the RGDs should be classified as vowel + sonorant sequences, because that is what they are historically, and it is simpler to assume that a situation has not changed than that it has changed. However, the historical mergers and changes we have seen before /r/ in Chapter Two show already the difficulty of identification of the nuclei in the RGDs with the canonical vowels, including their historical cognates. For example, the nucleus in [Ar] is cognate with /æ/, but phonetically similar to, and frequently identified as /ɑ/. This points out the impossibility of the assumption of classification of the nuclei in the RGDs with any of the canonical vowels.

2) That the RGDs should be classified as similar in structure to the diphthongs /aj aw ɔj/, because they are phonetically diphthongs as well, and it is simpler to treat all phonetically similar segments (and sequences) as belonging to a natural class.

These two *a priori* assumptions are contradictory, but both are valid. Therefore, what we need to do is compare the RGDs with both the diphthongs and vowel + sonorant sequences to see which group

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

they behave most similarly to. Patterns will have to be observed in a variety of domains. We have already seen that in the domain of distribution, the RGDs behave more like the diphthongs in that they allow only a restricted set of sequences, while the vowel + sonorant sequences allow unrestricted sets. In Chapter Six, we will see which group the RGDs pattern most similarly to in the domain of acoustic phonetics.

In addition, in Chapter Seven, the matter will be investigated in the field of experimental phonology, with the use of psychological testing. It is not assumed that the evidence from any one domain takes precedence over another. Rather, it is the preponderance of evidence, and the consistency in results between different domains, which will determine how the RGDs are to be best classified.

An additional related matter to be determined is the phonological status of the rhotic vowel [ɚ] as in "bird." Though (unlike the situation for the RGDs) there is widespread acknowledgment that [ɚ] can be treated as a distinct phoneme, and not as a sequence of a vowel followed by /r/ (which it arose from historically, see Chapter Two), there is still some discrepancy. For example, De Camp 1945, Lehiste 1964, Delattre 1965, Lehiste & Peterson 1967, Kahn 1980, and Ladefoged 1992 treat [ɚ] as a distinct phoneme, but Trager & Bloch 1941, Gramley & Pätzold 1992,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Wardhaugh 1995, and Hammond 1999 treat it as a biphonemic sequence[18]. The motivation for treating [ɚ] as a distinct monophoneme is clear: it is phonetically a fairly steady-state vowel. However, the discrepancies in phonemic classification for [ɚ] make it advisable for us to examine it using the same criteria we will be using to examine the RGDs.

[18]There are also some other views, such as Bloomfield 1933 and Veatch 1991, in which [ɚ] is treated as a nuclear variant of /r/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 4: Vowels before /l/.

4.1. Introduction

A discussion of vowels found before /l/ (or /Vl/ sequences), and a discussion of their possible phonological status would seem to be unnecessary. Given the standard set of GA vowel phonemes /i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ aj aw ɔj/, we can easily assign these to the contrasting vowels in words like "eel", "ill", "ail", "L", "Al", "pool", "pull", "hole", "all", "doll", "hull", "aisle", "owl", and "oil", respectively, giving us a complete contrast of vowel phonemes before /l/, much like we find before the other English consonants, and unlike what we find before /r/ (see Table 3.1 in Chapter 3, above).

Furthermore, it could be stated that, while /r/ is a central approximant, and therefore parallels to the other central approximants /j/ and /w/ need to be investigated, /l/ is a true consonant, a sonorant akin to /n/ and /m/, and should not be expected to behave like /r/, much less like /j/ and /w/, despite the fact that /l/ and /r/ are often grouped together as "liquid" consonants.

Let us remember, though, that at some point in history English /r/ was both phonetically and phonologically a consonant as well

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(see Chapter Two). It was phonetically likely a trill or tap and allowed the full range of vowel phoneme contrasts before it. The following changes happened to make /r/ behave less like a consonant, and more like the central approximants /j/ and /w/:

1) /r/ became a central approximant phonetically

2) A stressed syllabic version of /r/ has developed (/ɚ/), akin to the stressed syllabic versions of /j/ and /w/: /i/ and /u/[1].

3) The number of vowel contrasts before /r/ became reduced, to as few as four in some dialects.

4) The vowels that did contrast before /r/ came to be not easily identifiable with any of the standard vowel phonemes, and frequently very different from their non-rhotic reflexes.

5) /r/ came to be no longer allowed after another tautosyllabic central approximant. Sound changes associated with this were the re-syllabification of /ajr awr/ sequences and the non-occurrence of off-glides after tense vowels like /i/ and /e/.

We shall see that all of the types of changes listed above also have happened to /l/ and the vowels before it in at least one variety of GA. Hence, the assumption that a discussion of the phonological

---

[1]That is not to say that /i/ and /u/ bear the same historical connection to /j/ and /w/ that /ɚ/ does to /r/, or that there are synchronic alternations involving these glide/vowel pairs, but merely to point out symmetry in the phonological inventory.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

status of /Vl/ sequences is unnecessary may not be a safe one. A thorough investigation of /l/ and the vowels before it must be conducted.

4.2. Comparison of /l/ to /r/.

Let us examine the situation of /l/ to see if it is parallel to /r/ in any way. Many of these parallels are mentioned by Veatch (1991: 68).

1) Is /l/ phonetically a central approximant?

Answer: maybe. Comparing the measurements of the first three formants of onset vs. coda /l/, Lehiste (1964: 18, 20) finds the coda /l/ to have consistently different F1 and F2. Averages of the formants of five midwestern speakers of American English show the following formant values:

	F1	F2	F3
initial /l/	295	950	2610
final /l/	455	715	2585

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The higher F1 indicates that post-vocalic /l/ is more vocalic than the pre-vocalic variety. A high F1 is usually indicative of a lesser degree of constriction in the vocal tract (such as for low vowels), while a low F1 is usually indicative of more constriction (such as for high vowels or central approximants). The lower F2 indicates that the post-vocalic /l/ is more retracted or velarized. Complete vocalization of post-vocalic /l/ has been reported for Pennsylvania by Ash (1982), and in some British dialects by Wells (1982) and Harris (1994).

2) Is there a stressed syllabic /l/? Answer: Yes, in some dialects. This may come about from historical sequences of various short vowels plus /l/. Kantner & West (1938: 328) give the pronunciation [mɫk] for "milk" (from /mɪlk/). Bailey (1985: 237) has "pull" (/pʊl/) as [pɫ:], and has a spectrogram supporting the claim that there really is a pure syllabic consonant here, not a vowel followed by /l/. Wells (1982: 551) describes Southern American English dialects which have a stressed syllabic velar (not velarized alveolar) lateral [ʟ:] out of /ʊl/ in words like "full", "bull", and "wolf", or even out of /ʌl/ in the words "bulge" and "bulk" (though it is not clear whether these latter two words had /ʌl/ directly before they had [ʟ:], or whether /ʊl/ was an intermediate stage). Hammond

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(1999: 143) mentions possible pronunciations of /ʊl/ and/ʌl/ in words such as "bull" or "mull" as [l̩].

3) Is there a reduction of vowel contrasts before /l/? Answer: Yes, in some dialects. Labov *et al.* (1972: 236ff) report mergers of /i-ɪ/ and /u-ʊ/ before /l/ in some Salt Lake City speakers, so that "fill" and "feel" are homonyms, as well as "pull" and "pull." Dickey (1997) mentions the same mergers happening in Pittsburgh, PA, along with the further change of /o/ to /ʊ/ before /l/, so that "pool", "pull", and "pole" are homonyms. This latter merger is also reported for Ohio by Thomas 1996. Merger of /i-ɪ/, /u-ʊ/, and /e-ɛ/ is mentioned in Texas by Bailey 1991 and Bernstein 1993, and in Oklahoma by Bailey *et al.* 1993. Meger of /ʌ-o/ in California is mentioned by Veatch 1992 and Thomas 2001. Veatch 1992 also mentions /æ-ɛ/ merging before /l/ in various dialects.

At least one study has provided evidence that speakers' categorizations of some of the vowels found before /l/ have changed along with the phonetic changes. Di Paolo (1988), performed a study of Salt Lake Valley (Utah) English speakers in which subjects were asked to categorize English words by writing them in one of 10 boxes which already contained words exemplifying one of the 10 vowels /i ɪ e ɛ æ u ʊ o ɑ ʌ/, or in the "other" category at the bottom of the page.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Di Paolo's study was performed on three groups of subjects: 1) teenaged high school students, 2) the parents of these students, 3) a group of older adults, consisting of the grandparents of the students or friends of their families belonging to the grandparents' generations. All subjects tested were from families who were long time residents of Utah.

Di Paolo found that 31.5% of the teenagers tested (compared with 1.5% of their parents and 5.3% of older adults) categorized the words "feel", "deal", and "heal" either with the /ɪ/ words "mitt", "spit", and "mid" or in the "other" category, rather than the /i/ words "meet", "speed", and "Pete." Likewise, she found that 24.3% of the teenagers (0% of their parents, 5.4% of the older adults) categorized the words "sale", "tail", and "pale" either with the /ɛ/ words "met", "bed" and "net" or in the "other" category, rather than with the /e/ words "mate", "maid", and "jade". She also found that 36.9% of the teenagers (22.7% of their parents, 13.2% of the older adults) categorized the words "cool", "school" and "pool" with the /ʊ/ words "could", "book" and "hood" or in the "other" category, rather than with the /u/ words "mood", "hoot" and "food."

De Paolo's findings demonstrate not only a general tendency toward lowering and laxing of vowels before /l/ in at least one dialect of American English, but the possibility that this phonetic

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

shift has resulted in phonological re-analysis for some of the speakers as well. However, it should be noted that in no situation did she find a majority of subjects identifying the vowels before /l/ as other than the vowels they are cognate with. This should be contrasted with her findings concerning vowels before /ŋ/ in the same test group (see Chapter Five, below)

4) Are the vowels that do occur before /l/ difficult to identify with any of the standard vowel phonemes, and are they significantly different from their non-lateral cognates? Answer: the criteria for deciding the answer to this question are somewhat subjective. Certainly, linguists have never seemed to have the trouble identifying what vowel phones occur before /l/ the same way they have with identifying what vowels occur before /r/. Psychological evidence to help answer this question will be provided in Chapter Seven.

However, vowels before /l/ are claimed to differ significantly from their non-lateral cognates in some situations. Bronstein (1960: 252) claims that /e/ before /l/ can be pronounced as [ɛə]. This is also claimed for British English by Cruttenden (1994: 120). Hence, the development of /e/ before laterals is more similar to /ɛ/ than it is to /e/. This is directly parallel to the rhotic cognate of /e/, which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is more like /ɛ/ as well. Indeed, Bronstein claims that words like "fail" and "fare" can have the same vowel: [ɛə]. In addition, Cruttenden (p. 131) and Carr (1991: 61) claim that /i/ is frequently [iə] before /l/, parallel to the cognate of /i/ before /r/.

5) Is /l/ prohibited after the tautosyllabic glides /j/ and /w/? Answer: Yes, sometimes. Kahn (1980: 122) claims that there is a major difference between /r/ and /l/, in that/l/ is allowed tautosyllabically after diphthongs in words like "tile" and "towel", but /r/ isn't (hence /r/ is phonologically a glide, and /l/ is phonologically a consonant).

However, other sources make different claims (at least for some dialects). Bronstein (1960: 201) claims a [ə] is inserted before /l/ after diphthongs in some dialects, hence "file", "scowl", "knoll", "pail", and "foil" are [fajəl, skawəl, nowəl, pejəl, fɔjəl] respectively. This inserted [ə] would likely make the words bisyllabic. Veatch (1991: 68) counts two syllables in words with /aw/ and /ɔj/ before /l/ such as "owl" and "oil".

Lavoie & Cohn (1999) had six native speakers of Northern dialects of American English fill out a questionnaire asking them how many syllables each word in a list of 170 had. They found subjects to be split as to how many syllables they thought were in words with

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the vowels /i e u/ or diphthongs /aj ɔj aw/ followed by /l/, such as "feel", "fail", "file", and "oil." Half the subjects said such words were monosyllabic, half said they had more than one syllable.[2]

Let us also note that the contraction "I'll" has the two variant pronunciations [ajɫ] and [ɑl]. Since [ajl] is supposedly not allowed, we have the same choice to either "syllabify or drop a glide" that we saw with "our" previously (section 2.2.3)

Additionally, one of the changes we have seen above, in which /e/ becomes [ɛə] before /l/, has the same effect. The post-vocalic [j] usually heard after /e/ is not allowed before /l/. This is directly parallel to the changes before /r/. If we remember from Chapter Two, /r/ became syllabic after the diphthongs /aj aw ɔj/, which were diphthongs early in Modern English, but blocked the formation of the glides [j] and [w] after the tense vowels /i e u o/, which didn't become diphthongs until later, and for whom diphthongization is a redundant feature. A parallel situation seems to hold true for /l/.

To sum up, let us compare /l/ and /r/ to both the uncontroversial central approximants /j/ and /w/, along with the true sonorants /n m/.

---

[2]Lavoie and Cohn allowed subjects to claim that words had "1.5" syllables.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

	/j w/	/r/	/l/	/m n/
phonetically a central approximant:	yes	yes	sometimes	no
stressed syllabic?	y	y	sometimes	no
reduced vowel contrasts?	y	y	sometimes	no[3]
vowels which occur before hard to identify?	y	y	?	no
prohibited after tautosyllabic glides?	y	y	sometimes	no

It seems that /l/ could be categorized either with the central approximants or with the true sonorants depending on how true the data is for the dialect in question.

4.3. What Needs to be Determined

What remains to be done is to determine, for the dialect under study (Modern California English), the answers to the following questions:

1) Is the post-vocalic /l/ a true sonorant or a central approximant?

2) Are stressed /ʊl/, /ʌl/, or /ɪl/ pronounced as [ɫ̩] in this dialect?

[3]There are American English dialects which merge /e/ and /ɪ/ before nasals such that "pen" and "pin" are homonyms (Wells 1982: 540-541).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3) Do we have reduced contrast of vowels (such as /i-ɪ/, /e-ɛ/ /ɛ-æ/, /u-ʊ/, /ʌ-o/) before /l/?

4) Are the vowels that do occur before /l/ categorizeable with any of the standard vowel phonemes? This question will have to be answered in two domains (psychological and phonetic) in a parallel manner to the vowels before /r/.

5) Are words like "owl" and "Nile" monosyllabic or bisyllabic?

6) Are glides allowed before /l/ after the vowels /i e u o/?

Most of these questions can be answered by a simple examination of the acoustic data, and will be investigated in Chapter Six. The psychological status of vowels before /l/ will be examined in Chapter Seven.

4.4. Past Phonological Analyses

There have not been many phonological analyses of vowels before /l/, for the reason that most linguists aren't aware of the changes mentioned above that have occurred before /l/. These changes have likely started in the twentieth century and are still spreading. Linguists usually treat /l/ just like other consonants and allow all standard vowel phonemes to occur before /l/ (for example, Hammond 1999: 113-114).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There are a few treatments that should be mentioned, though. Kantner & West (1938) treat /Vl/ sequences just like /Vj/ and /Vw/, but, as mentioned before (section 3.2.3), their treatment is based purely on phonetic considerations. De Camp 1945 (who, as we've seen before in section 3.2.2.1, regards the RGDs as monophonemic) disagrees with Kantner & West, saying that /Vl/ sequences are biphonemic. However, he goes on to say that change is ubiquitous, and a monophonemic analysis might be justified "a century hence" (p. 4).

Since vocalization of coda /l/ and all its concomitants have gone farther in some British English dialects (particularly Cockney English), there are some mentions of phonological re-analysis for such dialects, which might give us clues as to how to deal with parallel situations in GA. Knowles (1987: 83) does remark on the parallelness of /l/ to /r/ and says that (U.K.) dialects are in a state of transition, and that phonemic analysis is difficult at this point in time. Wells (1982: 50, 259) says that diphthongs like [ɪʊ ɛʊ] that arise out of historical /Vl/ sequences in Cockney English could be analyzed as monophonemic. Note here, however, that the post-vocalic /l/ has vocalized all the way to the vowel [ʊ]. We can also find examples of the vocalization of post-vocalic /l/ to a high back

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

rounded vowel in other languages such as French (Boyd-Bowman 1954: 81ff) and Slovene (Šuštaršič, Komar, & Petek 1999).

Veatch (1991: 67-69), taking into account vocalization of /l/, reduction of contrasts, and resyllabification, believes that /l/ may very well be moving into his "glide-slot", and hence be parallel to /r/, /w/, and /j/, not to the other consonants. He proposes the theory that all of the different changes taking place concerning vowels before /l/ derive from a single actual change: the vocalization of /l/. What remains to be seen is whether speakers who exhibit vocalized /l/ also exhibit all of the changes concerning the vowels. It may be the case that, as we have seen for vowels before /r/, the vocalization of the previously consonantal segment merely sets into motion a series of sound changes, which some time later allow for the possibility of the segment being analyzed as a glide instead of a true consonant.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 5: Vowels before /ŋ/.

As we have seen in Table 3.1, the contrast of vowels before the velar nasal /ŋ/ is also severely restricted in English. We can also see that there is no such lack of contrast before the other nasal consonants of English: /m/ and /n/. At most, six vowels contrast before /ŋ/, as exemplified by the vowels in the words "sing", "sang", "length", "song", "sung", and "bong."[1] This lack of contrast is due to the fact that /ŋ/ is derived historically from a positional variant of /n/ before the velar stops /k/ and /g/. In many positions, the /g/ was then lost, leaving us only /ŋ/. This change likely had taken place by the late 17th century and may have been accepted as Standard English as early as 1600, as evidenced by its description by several phoneticians of the time (Dobson 1959: 963-965).

There was a general shortening of long vowels before most consonant clusters (except /mb, nd, ld, rd, rð/) in the late Old English period (Mossé 1952: 16-18). Hence, only short vowels were found before the clusters /ng/ and /nk/ in Middle English. Since only short vowels were found before these consonant clusters in ME, it is only

[1]The diphthong /ɔj/ can also occur before /ŋ/ in onomatopoeias, interjections, and humorous slang words such as "oink", "boing", "yoink", or "boink." Such words would appear to be rather marginal linguistically, so will not be discussed here.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the descendants of short vowels we expect to find before /ŋ/ today. The ME vowels /ī ē ā ō ū/ give us the vowels in "sing", "length", "sang", "song", and "sung", respectively. There may be an additional vowel /ɑ/ in "bong" that contrasts with the /ɔ/ of "song." In my speech, both /ɑ/ and /ɔ/ exist before /ŋ/, but barely contrast. The vowel /ɑ/ only occurs before /ŋ/ when the /ŋ/ is followed by /k/, such as in "donkey", and/or in borrowings, onomatopoeias, and names, such as "honk", "bonk", "gong", "bong", "Ping-Pong", "King Kong", "Ding Dong", "Viet Cong", "ankh", and a few other words. The vowel /ɔ/ never occurs before /ŋk/, but otherwise is found in all native standard words.

In the dialect under consideration in this study, California English, there is no contrast between /ɑ/ and /ɔ/, hence we have only five possible vowels before /ŋ/, as exemplified by the vowels in the words "sing", "length", "sang", "song", and "sung." I will be referring to these vowel + /ŋ/ sequences as ‹ing›, ‹eng›, ‹ang›, ‹ong›, and ‹ung› and the vowels in them as ‹i›, ‹e›, ‹a›, ‹o›, ‹u› respectively for now, since, as we shall see, their phonological classification is not obvious.

Phonological classification of vowels before /ŋ/ has been taken as a simple matter for some linguists, however. Swadesh (1935) says that only lax vowels occur before /ŋ/. Ladefoged (1993: 87) is in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

accordance, classifying ‹ing›, ‹eng›, ‹ang›, ‹ong›, and ‹ung› as /ɪ ɛ æ ɔ ʌ/ respectively. This is also done by Hammond (1999: 113, 117), who classifies ‹ing›, ‹ang›, ‹ong›, and ‹ung› as /ɪ æ ɔ ʌ/, respectively. Hammond does not provide for the ‹eng› vowel, even on his chart listing the distribution of vowels before /ŋk/ clusters (p. 117). This may be because this is a rare sequence, occurring only in "length", "strength", and their derivatives.[2] Or it may be that for some, this vowel has merged with the ‹ang› vowel such as in "sang." It may also be that for some speakers, the velar nasal in the words "strength" and "length" has become [n], giving us [strɛnθ] and [lɛnθ].

However, Ladefoged (1993 and 1999) brings up some phonetic facts which could point to difficulty in the phonological classification of vowels before /ŋ/. Ladefoged claims that all vowels are raised before /ŋ/ in the same syllable (though he only refers to front vowels), so that the vowel in "sing" is closer to [i] than [ɪ], the vowel in "sang" is close to [e], and the vowel in "length" is intermediate between these two, being "virtually the same" as [e] in some dialects, more like [ɪ] in others. Bailey (1985: 59) also transcribes the vowel in ‹ing› as [i], giving [siŋ] for "sing." Wells (1982: 541) says the vowel in ‹ing› can be /i/ for some Southern American speakers. Dobson

---

[2]Perhaps also in "Bengal?" It occurs, of course, in one of the names for the symbol ‹ŋ›, "eng", but this word is not often found in the vocabulary of non-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(1957: 715) describes a Welsh English dialect in which /ɪ/ has become /i/ before /ŋ/ as well.

The back vowels found before /ŋ/ don't appear to be difficult to classify. The vowel in <ung> is clearly /ʌ/. Ladefoged claims the vowel in <ong> can vary from [ɑ] to [ɔ]. In a dialect like CE, however, where there is no contrast between /ɑ/ and /ɔ/, this vowel could only be /ɑ/.

The front vowels represent a problem, however. If <ing> is really closer to [i] than [ɪ], then couldn't it be classified with /i/? And if <ang> is like [e], it would seem difficult to classify it with /æ/. Also, if <eng> is "between" these two, that would suggest it's more like /ɪ/ than the /ɛ/ which it is cognate with.

Veatch (1991: 282) explains these pronunciations as a case of mutual (perseveratory and assimilatory) assimilation between the front vowel and the following /ŋ/. The velar /ŋ/ is fronted due to the effect of the preceding front vowel. Then, the vowel assimilates to the fronted /ŋ/ by becoming more front itself[3]. For the front vowels, an even more fronted position in the vocal tract is often associated with a higher position in the mouth, given the vaguely

---

linguists.

[3]Veatch also describes a dialect of Alabama English in which the opposite effect, lowering and backing, happens to front vowels before /ŋ/. This doesn't contradict the assimilation explanation, however; it only shows that it is not an inevitability.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

trapezoidal shape of the vocal tract. Hence, these fronted front vowels could become higher as well. We shall also see in Chapter Six that there is a [j] off-glide from the front vowel to the following [ŋ]. The perceptual cues associated with a [j] off-glide correlate strongly with the perceptual cues of high front vowels.

At least one study has provided evidence that speakers' categorizations of some of the vowels found before /ŋ/ have changed along with the phonetic changes. Di Paolo (1988), performed a study of Salt Lake Valley (Utah) English speakers in which subjects were asked to categorize English words by writing them in one of 10 boxes which already contained words exemplifying one of the 10 vowels /i ɪ e ɛ æ u ʊ o ɑ ʌ/. Di Paolo's study was performed on three groups of subjects: 1) teenaged high school students, 2) the parents of these students, 3) a group of older adults, consisting of the grandparents of the students or friends of their families belonging to the grandparents' generations. All subjects tested were from families who were long time residents of Utah.

Di Paolo found that 77.8% of the teenagers tested (compared with 54.5% of their parents and 33.3% of older adults) categorized the word "sing" with the /i/ words "meet", "speed", "Pete", rather than the /ɪ/ words "mitt", "spit", and "mid." She also found that 94.4% of the teenagers (61.9% of their parents, 0% of the older

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

adults), categorized the word "bang" with the /e/ words "mate", "maid", "jade", rather than the /æ/ words "mat", "lag", and "bad."

Di Paolo's findings provide ample reason to believe that the phonetic changes involving vowels before /ŋ/ have led to phonological re-analysis, and that this phonological re-analysis has happened recently. Particularly interesting is that all of the older adults identified the vowel in "bang" with /æ/, but virtually all of the teenagers identified it with /e/. The assumption of categorization of the vowels before /ŋ/ with the lax vowels, as has been done by Swadesh, Ladefoged, and Hammond, cannot remain unquestioned.

Di Paolo's findings are extremely interesting, but the following things still need to be done:

1) Precise phonetic data needs to be gathered in order to compare the vowels found before /ŋ/ with other vowels. Di Paolo does provide phonetic transcriptions of her subjects' vowels, but these are admittedly impressionistic.

2) Categorization tests must be done for speakers of the dialect under study in this dissertation: California English.

3) Di Paolo does not have subjects categorize words with the ‹eng› vowel such as in "length." We need to see if subjects pronounce this vowel distinctly from the ‹ang› vowel in "sang", and if they do, we need to see how it is categorized as well.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

4) Di Paolo does not have subjects categorize words with the <ong> or <ung> vowels such as in "song" and "sung." This may be because these vowels are unambiguously /ɑ/ and /ʌ/ respectively. It would still be helpful to have some phonetic and psychological data to see how native speakers of California English pronounce and categorize these vowels.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 6: Acoustic Analysis

The purpose of this chapter is to gather acoustic data for the nuclei of the RGDs in order to determine how they compare with the ranges of allophones of the canonical vowels, as well as to attempt to answer any questions which might have been previously raised regarding the acoustic quality of vowels before /l/ and /ŋ/.

6.1. Speech Material

6.1.1. Speakers

Data was obtained from fourteen native speakers of California English between the ages of 19 and 29. Six of the speakers were male and eight were female.[1] Of the male speakers, three were from Northern California and three were from Southern California. Of the female speakers, five were from Southern California and three were from Northern California. "Southern California" here means the Greater Los Angeles and San Diego Areas. "Northern California" here

[1] I am completely in agreement with Hagiwara (1995) that there is no reason to exclude female data from acoustic studies. I encountered no more difficulty measuring the formants of the female speakers than those of the male speakers.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

means the San Francisco Bay Area, Northern Central Valley, and Sierras. Seven of the speakers were undergraduate students enrolled in introductory-level linguistics classes, one was an undergraduate linguistics major enrolled in upper-division linguistics classes, one was a recent graduate who had been a linguistics major, two were linguistics graduate students, two were undergraduate students from other departments with no formal linguistics education, and one was a non-student with no university affiliation.

6.1.2. Data

Speakers were asked to read a list of words spoken in a frame sentence of "They said (x) twice." Each sentence was read once. Data were recorded using high quality audio equipment. A complete list of all words read for this chapter can be found in Appendix B.

The relevant data for this section consisted of the following words:[2] The words were read in a non-meaningful order (not the order given here):

Rhotic vowels and RGDs: *ear, air, ore, are, her*

---

[2]Many other words were included in the sample but are not relevant for our discussion now. They will be discussed later.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/i/: *dweeb*[3], *E, each, ease, eat, eke, eve, fatigue, heap, heath, heed, keen, O'Keefe, piece, quiche, scheme, siege*[4], *teethe*[5]

/ɪ/: *dish, give, hick, him, hip, his, hiss, id, if, in, it, itch, midge, Pibb*[6], *pig, pith*

/e/: *A, Abe, ace, ache, age, aid, aim, ape, ate, beige, faith, H, haze, pain, pave, safe, scathe*[7], *vague*

/ɛ/: *Beth, Bev, ebb, Ed, edge, etch, F, heck, M, N, peg, pep, pet, Pez*[8], *S, Tesh*[9]

/æ/: *add, Anne, ash, ass, at, badge, hack, hag, half, ham, has, hatch, path, perhaps, scab*

/u/: *douche, dude, goose, hoop, hoot, kook, move, ooze, pooch, rouge*[10], *soothe, spoof, spoon, stooge, tooth, tube, who, whom*

/ʊ/: *butch, hood, hoof, hook, push, puss, put*

/o/: *gauche*[11], *globe, home, hope, hose, host, loathe, oaf, oak, oat, oath, ode, owe, own, poach, stove, vogue*

---

[3]A derogatory slang term.
[4]Eight of the speakers pronounced this word as [sidʒ], six pronounced it as [siʒ]. Since there is not much difference in the effects of [dʒ] and [ʒ], these words were all averaged together. They are labeled with [dʒ] on the scatter graphs (see below).
[5]One of the speakers did not recognize this word.
[6]A brand name of soft drink (Mr. Pibb)
[7]One of the speakers did not recognize this word.
[8]A brand name of candy
[9]A surname
[10]One of the speakers did not recognize this word.
[11]Three of the speakers did not recognize this word

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɑ/: *Goth, hob, hock, hodge-podge*[12], *hog, hop, odd, off, on, ought, Oz, posh, Scotch, spa, Tom, toss*

/ʌ/: *hub, Huck, huff, hug, hum, Hun, Hush, hut, hutch, of, pudge, pus, scuzz, spud, up*

Words were selected based on their assumed familiarity, or at least high degree of pronounceability if unfamiliar. The words were selected in order to have examples of all the allophones of the canonical vowel phonemes before all the consonants they precede. There have been prior studies of contextual variation in vowels caused by contiguous consonants in English, but they have not examined all vowels in all possible consonantal contexts. For example, Stevens, House & Paul (1966) examined the consonantally induced contextual variation in vowels in three speakers, but they only studied the vowels /i ɪ ɛ æ ɑ ʌ ʊ u/ in the context of only the consonants /p b f v θ ð s z t d ʃ tʃ dʒ k g/, noticeably excluding /l/, /r/, and /ŋ/[13].

In order to reduce possible interference from onset consonants, words were selected in the following order of preference:

---

[12]Only the first syllable ("hodge") of this word was measured.
[13]Furthermore, Stevens, House, & Paul's data was all uttered in artificial words of the shape C_1VC_1, (such as /bʌb/, /did/, /sɑs/, etc.), so transitions from preceding consonants were also a factor.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1) With zero onsets

2) With /h/ onsets

3) With voiceless stop onsets, preferably /p/. Actually, English stops are almost always voiceless in onset initial position.

4) With other obstruent onsets

5) With any other onset

The preference for non-sonorant onsets is due not only to the lesser effect they have on following vowels, but also due to the greater difficulty of determining the boundary between some sonorant onsets and the following vowel in a spectrogram.

In order to fit the criteria given above, some words used were proper nouns, letter names, or slang terms. These were judged acceptable if they otherwise followed the phonotactics of Standard English words.

Recordings of the words "tot" and "taught" revealed that none of the speakers make a contrast between the vowel phonemes /ɑ/ and /ɔ/, as expected. Recordings of the words "pore" and "poor" reveal that twelve of the fourteen speakers make no contrast between the RGDs [Ur] and [Or]. The lack of contrast between these two vowels has been noted in New York City and Philadelphia by Labov 1994 (p. 269), and in parts of the upper Midwest by Allen 1976 (p. 30). It is also mentioned elsewhere (Thomas 1958: 126,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Wardhaugh 1995: 196, Wells 1982: 484). This lack of contrast appears to be common in California as well,[14] and perhaps should be considered a widespread feature of General American. For purposes of this chapter, California English will be assumed to have only four RGDs.

However, two of the speakers, speaker 11 (Male Northern Californian) and speaker 14 (Female Southern Californian) did contrast "poor" and "pore." Their acoustic data with respect to these two vowels will considered separately in Chapter 10.

6.1.3. Recording and Measurements

The data were digitized on a Kay CSL Model 3000 at a sampling rate of 16000 Hz. Spectrograms of the words were made at a bandwidth of 234 Hz. Measurements of the first three formants of the vowels were taken at three points in time: the onset of the vowel (T1), the midpoint (T2), and the final point (T3). This raises the question of how we determine these three points for the nuclei of the RGDs when the whole rhyme is a diphthong with a gradual transition from the non-rhotic nuclei to an [ɚ] off-glide. There is no easy

[14]Hagiwara (1995: 69) lists five RGDs for his Southern California speakers as exemplified in the words "beer", "bare", "boor", "bore", and "bar."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

solution to this problem. The method was to define T2 and T3 for the nuclei of the RGDs at pre-determined points in time based upon where they would be in the equivalent /Vn/ sequences for the speaker in question, selecting the /Vn/ rhyme with the closest equivalent vowel and total rhyme duration, either "keen" or "in" for [Ir], "pain" or "N" for [Er], "spoon" or "own" for [Or] (there are no /ʊn/ rhymes in the data), and "on" for [Ar]. Since the vowel [ɚ] in "her" is fairly steady state, the point in time at which formant measurements are taken doesn't matter.

For example, in the data for Speaker 08 in Table 6.1, we can see that the total duration for the rhyme in "ear" is 251ms, equivalent to the duration of the rhyme in "keen." The duration of the vowel in "keen" is 123ms, or 49% (123/251) of the total rhyme. We can apply the same standards to the rhyme in "ear", and take T1 measurements 0 ms from the beginning of the vowel (where they would be in any case), T2 measurements 62 ms from the beginning of the vowel, and T3 measurements 123 ms from the beginning of the vowel, the same places they would be for the vowel in "keen."

When the durations of the /Vn/ and /Vr/ rhymes don't match exactly, percentages must be used. For example, judging from the data below for Speaker 08, the rhyme in "air" is closest in duration to the rhyme in "pain" (not to the rhyme in "N"). The duration of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vowel in "pain" is 91ms, and the duration of the total rhyme in "pain" is 201 ms, making the vowel duration 45% (91/201) of the total rhyme. Therefore T1, T2, and T3 measurements for the vowel in [Er] should come at 0% of the total rhyme, 22.5% of the total rhyme, and 45% of the total rhyme respectively. Applying these percentages to the 224 ms duration of the total rhyme in "air", we determine that T1, T2, and T3 measurements of F1 and F2 must be taken at 0 ms (0 x 224) from the beginning of the vowel, 51 ms (.225 x 224) from the beginning of the vowel, and 101 ms (.45 x 224) from the beginning of the vowel, respectively. Complete data on these durations and percentages will be found in Appendix B.

Table 6.1 Vowel and Rhyme durations for Speaker 08.

word	vowel duration (ms)	rhyme duration (ms)	vowel/rhyme percentage
"keen"	123	251	49%
"ear"	?	251	
"pain"	91	201	45%
"air"	?	224	
"N"	61	181	

It could be argued that, even given this method, the measurements at T2 and T3 will still reflect the influence of the gradual transition to the off-glide [ɚ]. This is certainly likely.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

However, I don't think we should dismiss these assimilatory effects as predictable or irrelevant. If the nuclei of the RGDs display highly variant F1 and F2 measurements at T2 and T3, this would indicate that there are some distinct non-rhotic acoustic characteristics of the nuclei of the RGDs within the duration frame usually used to distinguish vowels in English.

The acoustic analysis in this chapter was primarily done using the formant values as defining characteristics of the vowels. This should not be interpreted to mean that formant values are the sole relevant distinguishing cues for the recognition of vowels. Many studies have focused on different acoustic cues.

For example, House & Fairbanks (1953) found duration, fundamental frequency, and relative decibel levels of vowels to vary significantly according to consonantal environment. Bladon & Lindblom (1981) provide successful experimental evidence showing that a spectral representation of loudness vs. pitch can be a definite cue in the perception of vowels. Syrdal & Gopal (1986) develop a perceptual model of vowel recognition using the distances in critical bands (barks) between neighboring formants (F1, F2, F3, and F4) and the fundamental frequency (F0). Beddor & Hawkins (1990) found that vowel quality was determined by formant frequencies when the spectral peaks of the formant were prominent, but by the overall

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

spectral shape of the area around the formant when the formant was not as prominent.

Nevertheless, the analyses in this chapter will focus on the formant measurements of the vowels, specifically F1 and F2, for the following reasons:

1) Measurements of F1 and F2 are conventionally used as a model for distinguishing between different vowels in the vowel space, for example in Ladefoged (1993: 197), and Veatch (1991: 205ff). If the nuclei of the RGDs are truly distinct, this should show up as F1 and F2 differences.

2) A difference in F3 for the nuclei of the RGDs might not be relevant. F3 is not usually used to distinguish among the canonical vowel phonemes /i ɪ e ɛ æ u ʊ o ɑ ʌ/. A deviant F3 would not show the nuclei of the RGDs to be potentially different from the canonical vowel phonemes, because we would expect F3 to be different due to an assimilatory effect of the following [ɚ].

Nevertheless, measurements of F3 might be significant, particularly in regards to showing the assimilatory effect of the [ɚ] on preceding vowels. Complete data for all formant measurements is found in Appendix B.

Table 6.2 shows the average F1, F2 and F3 measurements (averaged over the three points in time) for all instances of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

canonical vowel phonemes /i ɪ e ɛ æ u ʊ o ɑ ʌ/ divided into groups according to the gender and geographical origin of the speakers.

Females and males have to be considered as separate populations, of course, since formant measurements of males are almost always lower than those of females. A comparison of the formant measurements of the Female Northern Californians with those of the Female Southern Californians shows that the Southern California Females have distinctly higher formant frequencies for

Table 6.2 Average F1, F2 and F3 measurements (Hz) for canonical vowels for all groups:

	Female Northern			Female Southern			Male Northern			Male Southern		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	405	2490	3068	404	2695	3246	366	2272	3021	358	2525	3152
ɪ	494	2079	2825	531	2241	3048	497	1964	2716	482	2064	2856
e	487	2299	2933	498	2494	3078	465	2170	2752	475	2298	2908
ɛ	649	1928	2793	777	2042	2954	630	1805	2677	653	1900	2775
æ	809	1841	2714	905	1915	2835	788	1758	2627	799	1802	2649
u	448	1552	2557	449	1664	2749	427	1440	2381	409	1447	2494
ʊ	548	1547	2612	579	1606	2859	562	1401	2503	535	1391	2568
o	545	1299	2628	579	1366	2802	527	1210	2495	519	1215	2532
ɑ	800	1391	2585	851	1455	2770	782	1333	2652	773	1325	2554
ʌ	717	1618	2655	810	1654	2871	672	1471	2625	704	1464	2629

many of the vowels, particularly the lower vowels /ɛ/, /æ/, /ʌ/, and /ɑ/. This is consistent with the findings of Hagiwara (1995: 40).[15] Therefore, Female Northern Californians and Female Southern Californians are considered as separate populations in this study. However, there does not appear to be a significant distinction in the formants of the Male Northern and Male Southern Californians with

[15]Hagiwara is comparing only female and male Southern Californians. He has no Northern Californians in his study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

respect to this previously noted vowel shift, so all Male Californians will be grouped together as a single population in this study.

Though the formant values are averaged for all three points in time in Table 6.2, the vowels really need to be compared separately at the three different points in time. This is true because it is not only the static acoustic qualities of a vowel that may be used to distinguish it from another vowel in a given language, but also its dynamic cues. For example, a vowel (say /ɪ/) may have roughly the same average formant measurements as another vowel (say /e/), but may be further distinguished by the fact that, in this case, the /e/ has a tendency for larger changes in its formant frequencies, most notably a significantly lower F1 at the end than at the beginning (see Figures 6.2.1, 6.2.2, 6.2.3)

6.2. Vowels before /r/

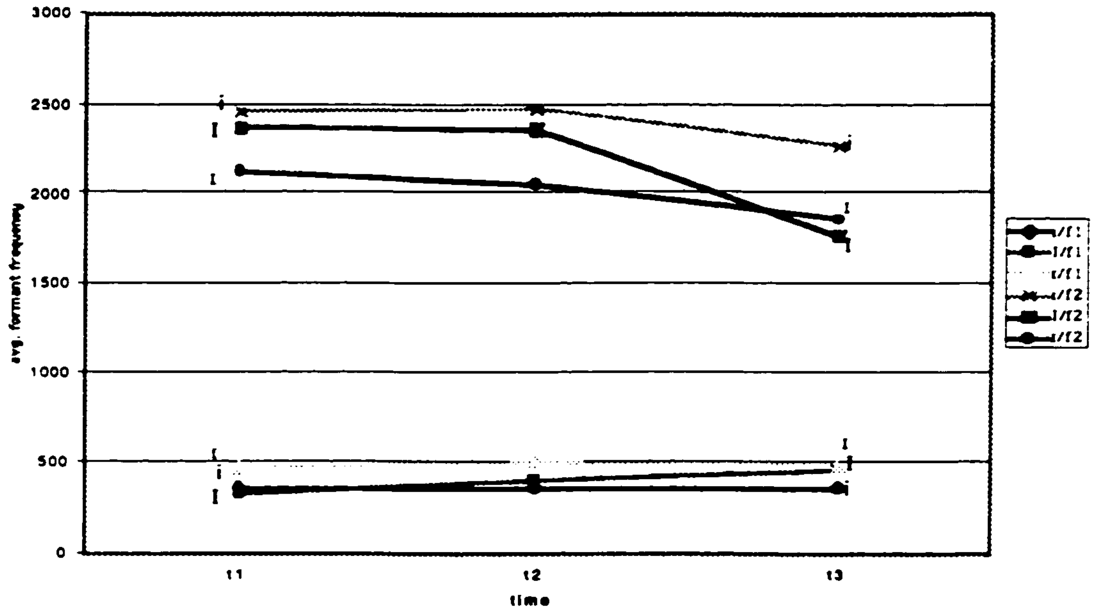
6.2.1. Formant dynamics (line graphs)

The acoustic data are presented in two types of figures. Figures 6.1 through 6.5 show average formant frequencies of the nuclei of the RGDs at T1, T2, and T3 compared with the average formant frequencies of the canonical vowels at these same three points in time. The nucleus in [Ir] is compared with /i/ and /ɪ/. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

nucleus in [Er] is compared with /e/, /ɛ/, and /æ/. The nucleus in [Or] with /u/, /ʊ/, and /o/. The nucleus in [Ar] is compared with /ɑ/, and the vowel [ɚ] is compared with /ʌ/ and /ʊ/[16].

Figure 6.1.1 [I] compared to /i ɪ/ (Males)



The figures show the following: for all groups of speakers (Figures 6.1.1, 6.1.2, 6.1.3), the nucleus in [Ir] starts off with F1 and F2 very much like those of /i/, glides to a point between /i/ and /ɪ/ at T2, and finishes with an F1 much like that of /ɪ/, but an F2 even lower than that of /ɪ/.

For all groups of speakers, both F1 and F2 of the nucleus in [Er] start off much like those of /e/, are between /e/ and /ɛ/ at F2, and are very similar to those of /ɛ/ at T3 (Figures 6.2.1, 6.2.2, 6.2.3).

---

[16]The phonetic resemblance between [ɚ] and /ʊ/ is remarked upon by Peterson and Barney (1952: 182-183).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.1.2 [I] compared to /i ɪ/ (Female Northern)

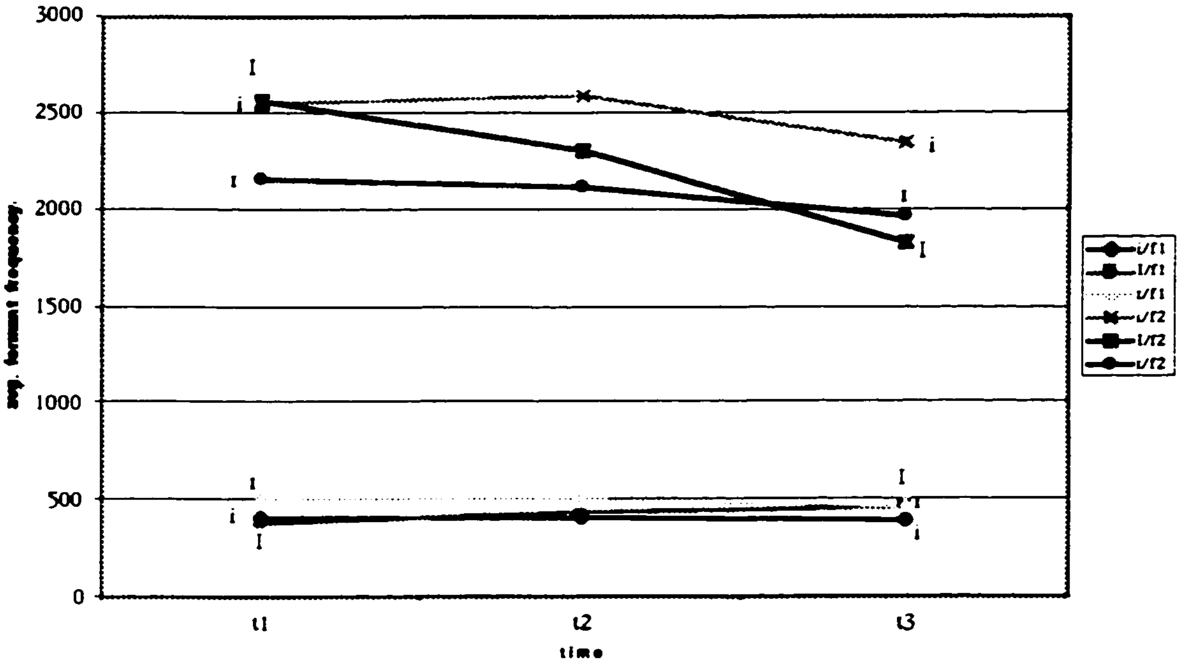
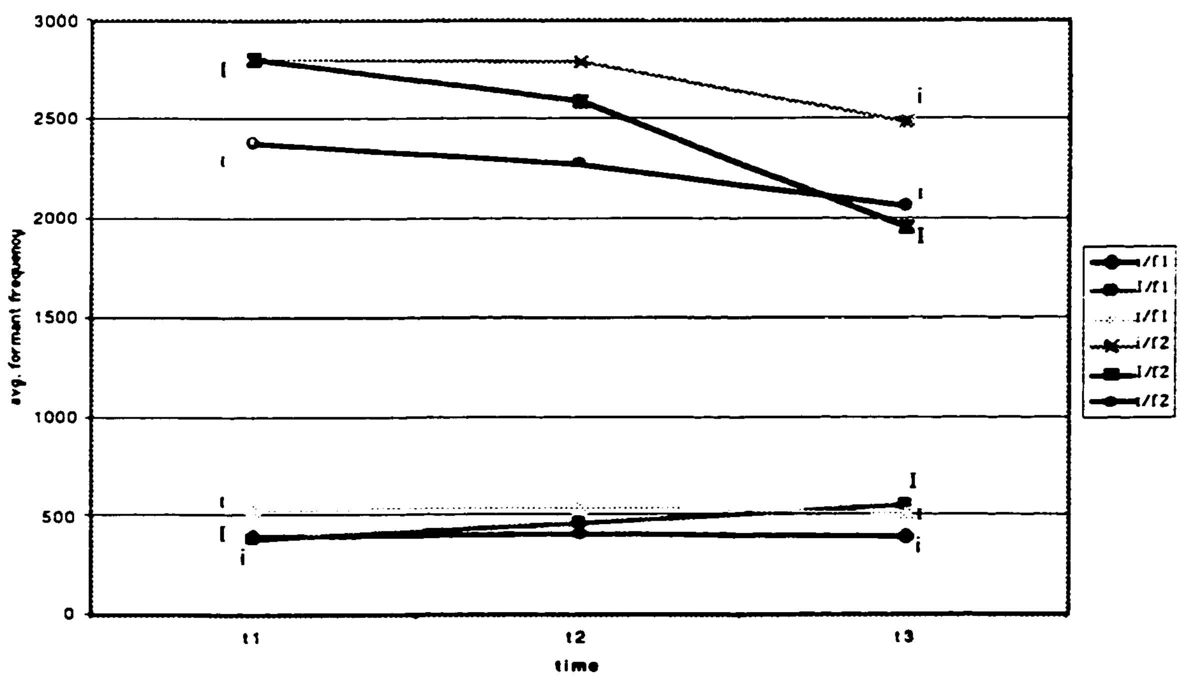


Figure 6.1.3 [I] compared to /i ɪ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.2.1 [E] compared to /e ɛ æ/ (Males)

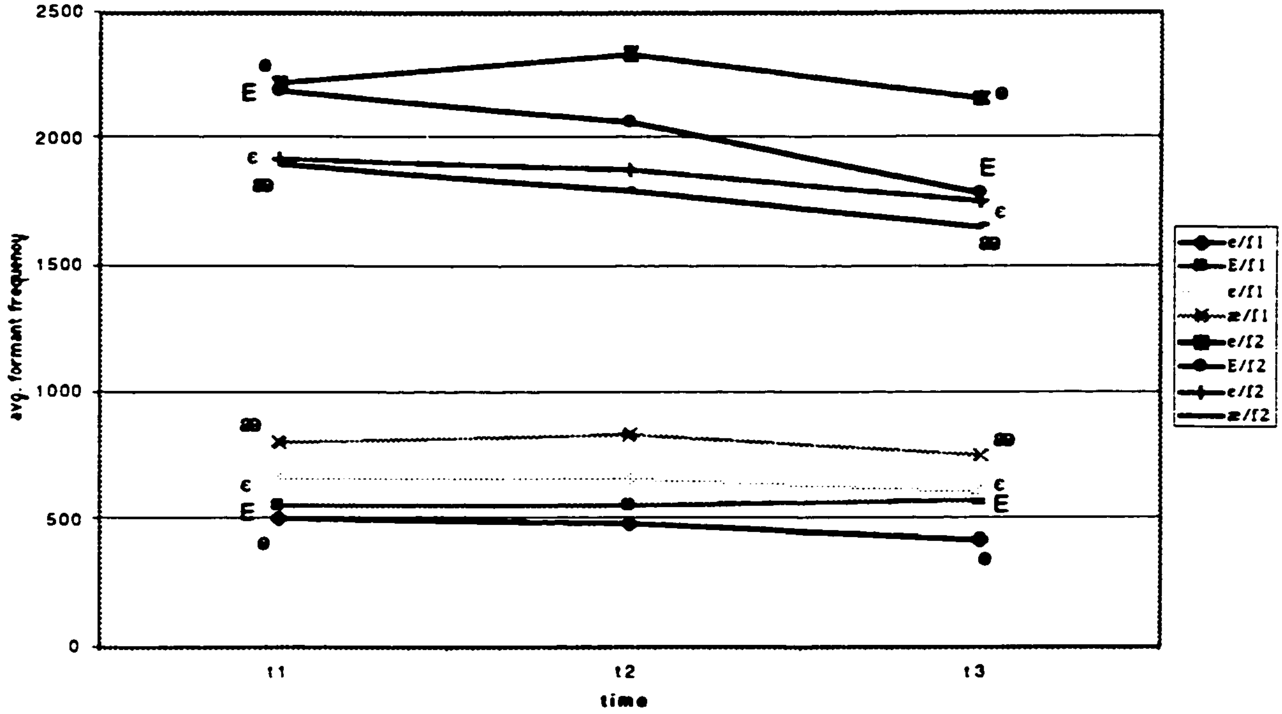
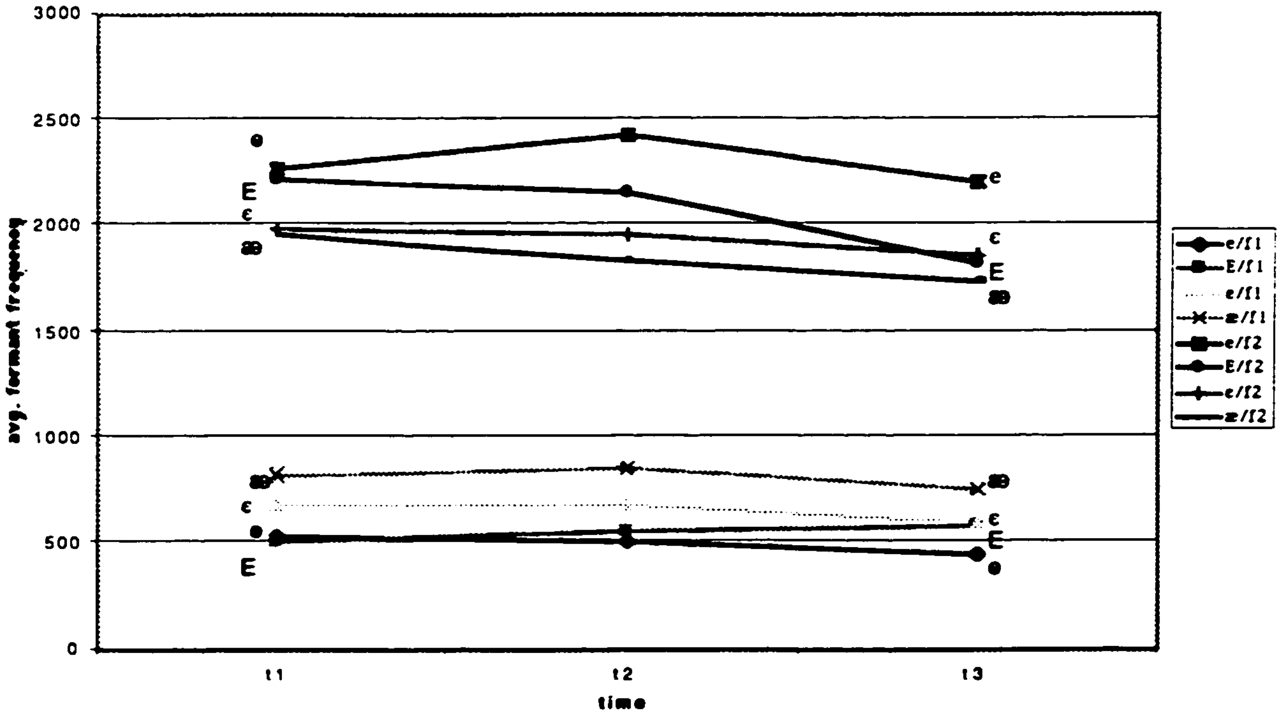


Figure 6.2.2 [E] compared to /e ɛ æ/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.2.3 [E] compared to /e ɛ æ/ (Female Southern)

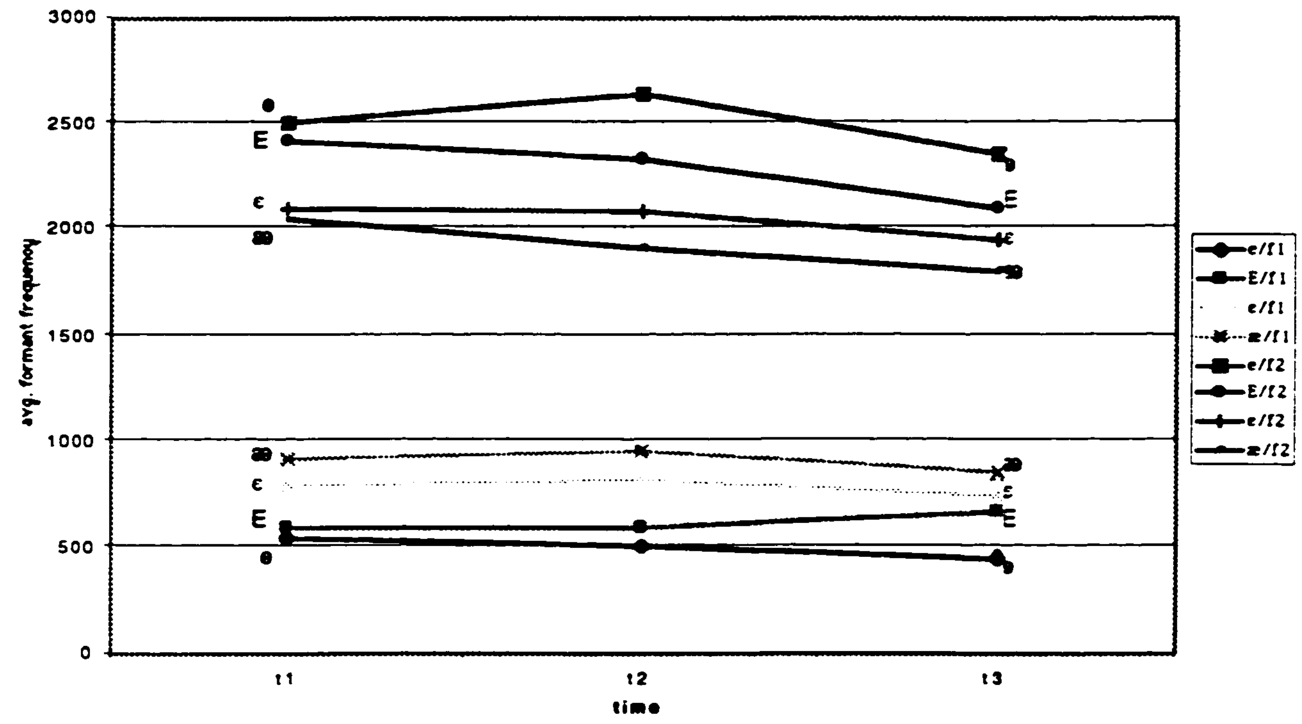
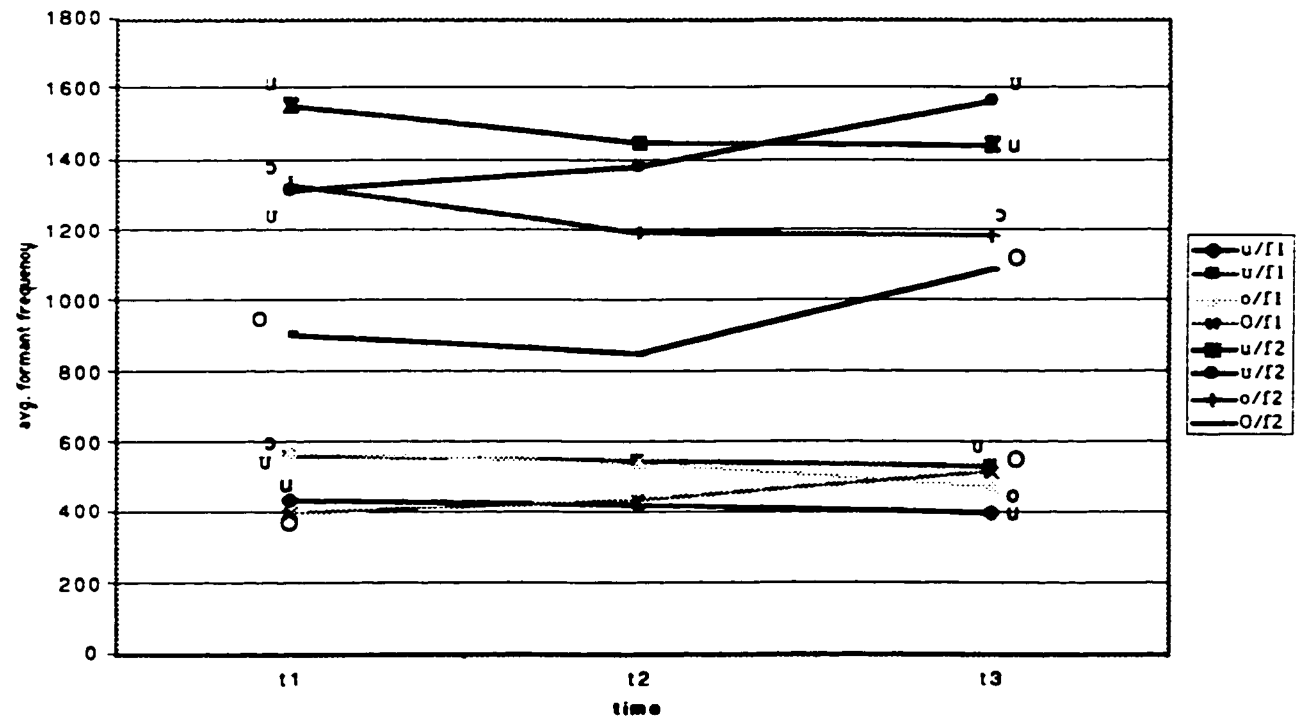


Figure 6.3.1 [O] compared to /u ʊ o/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.3.2 [O] compared to /u ʊ o/ (Female Northern)

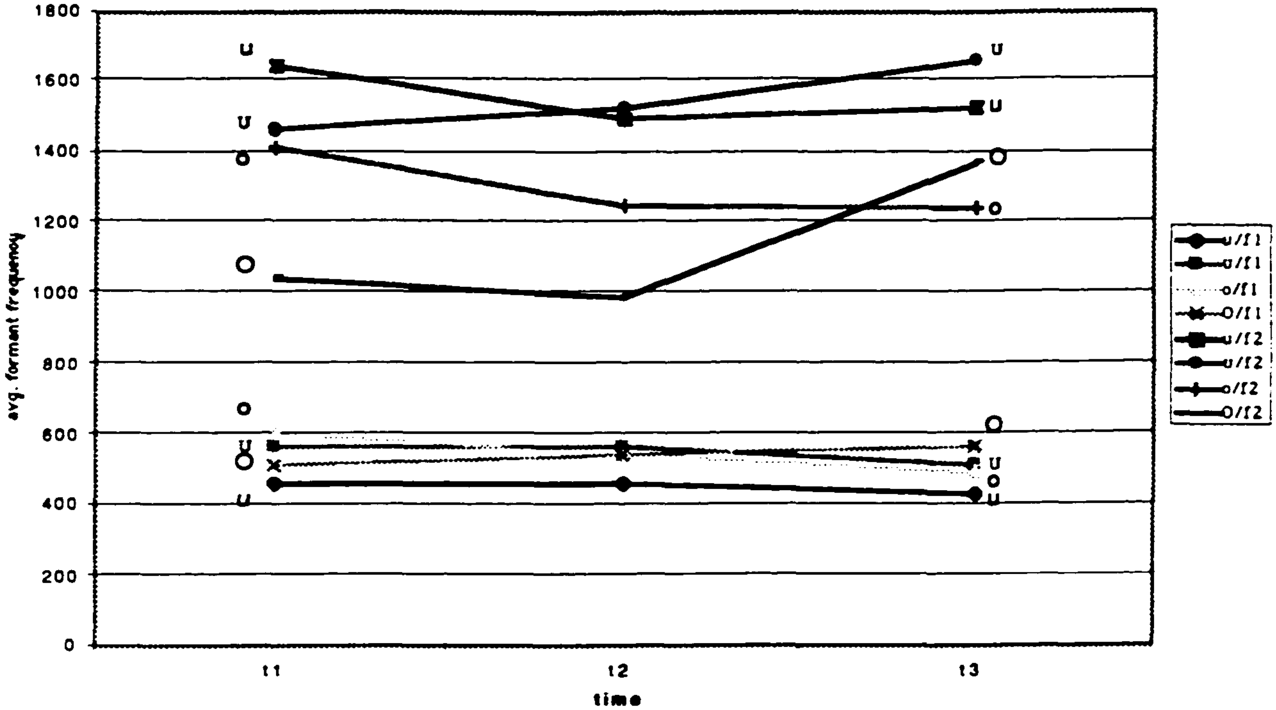
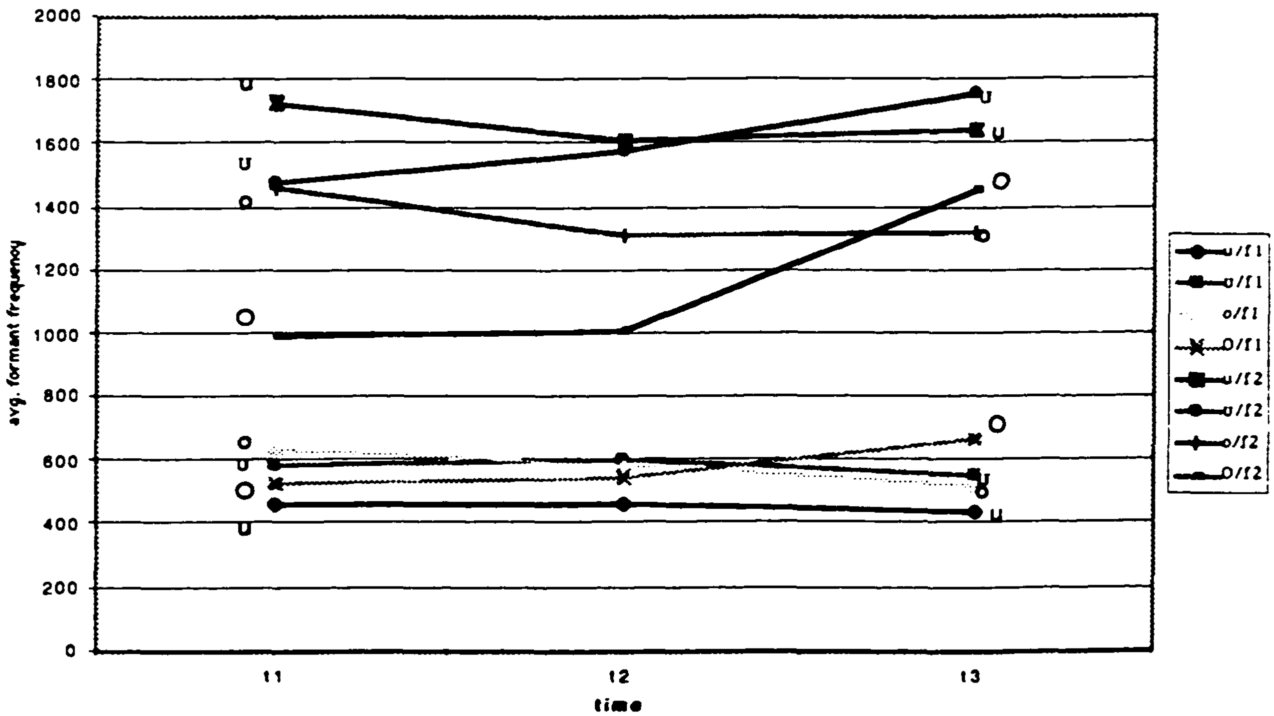


Figure 6.3.3 [O] compared to /u ʊ o/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

For all groups of speakers, F1 of the nucleus in [Or] starts off lower than that of /ʊ/ or /o/, being between /u/ and /ʊ/ for the Females, but very close to that of /u/ for the Males (Figures 6.3.1, 6.3.2, 6.3.3). For the Females, F1 glides very close to that of /ʊ/ and /o/ at T2, while for the Males it remains near that of /u/. For all speakers, F1 at T3 is most similar to that of /ʊ/, but is considerably higher for the Females, while very similar to that of /ʊ/ for the Males. F2 of the nucleus in [Or] is much lower than that of /u/, /ʊ/, or /o/ for all groups of speakers at T1 and T2. For the Males, it approaches that of /o/ at T3 (but is still lower), while for the Females it is between F2 of /o/ and /u/ at T3.

The nucleus of [Ar] behaves similarly for all groups of speakers (Figures 6.4.1, 6.4.2, 6.4.3). It behaves very much like that of /ɑ/ for both F1 and F2 at all three points in time, notably in the progressive separation of F1 and F2 indicating possibly a glide toward something like [ə] at the end.

The F1 measurements of [ɚ] begin between those of /ʌ/ and /ʊ/ at T1 but are very similar to those of /ʊ/ at T2 and T3 for all groups of speakers (Figure 6.5.1, 6.5.2, 6.5.3). F2 of [ɚ] begins somewhere between that of /ʌ/ and /ʊ/ (closer to that of /ʊ/ for Northern California Females, very close to /ʌ/ for Southern California Females) at T1. At T2, F2 of [ɚ] is very much like that of /ʊ/ for all

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.4.1 [A] compared to /a/ (Males)

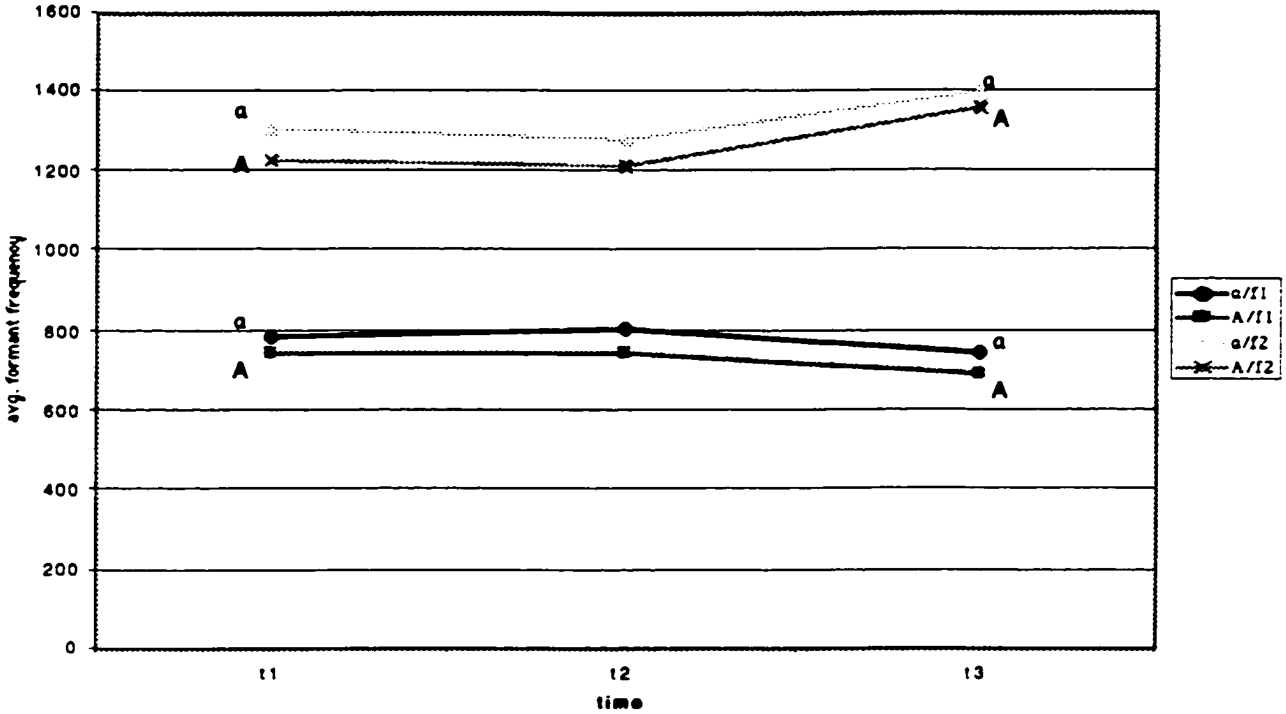
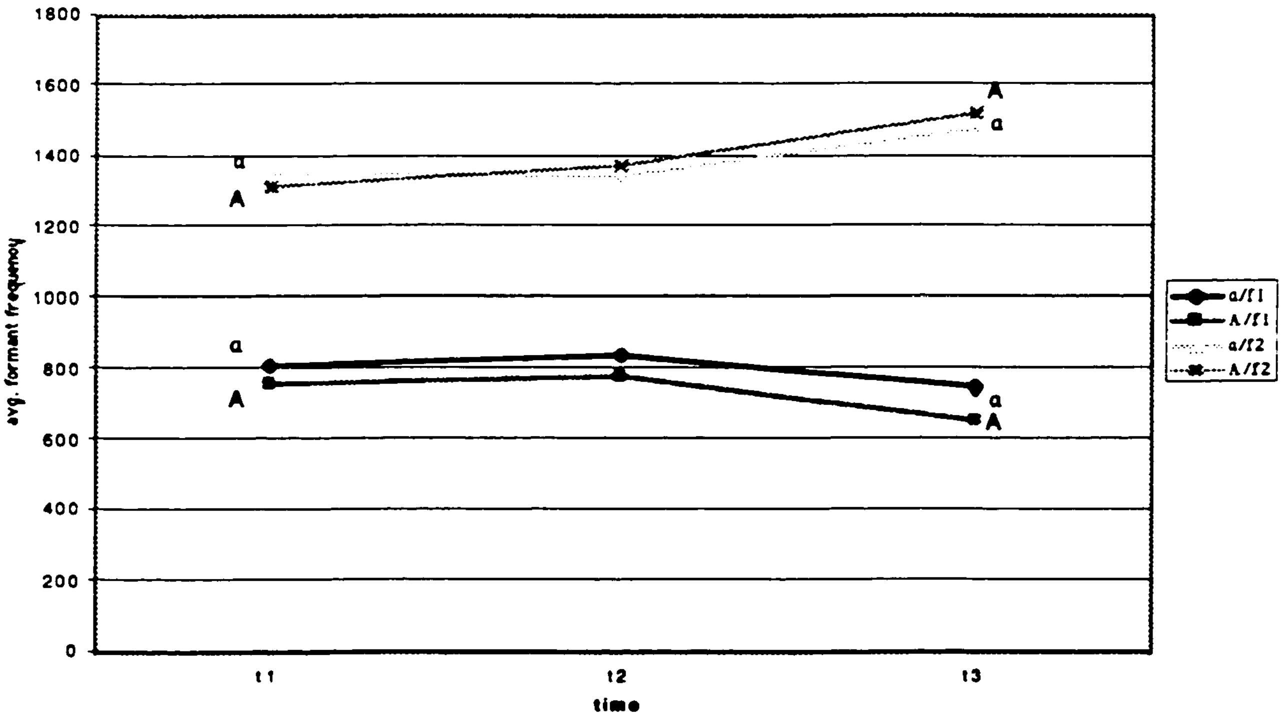


Figure 6.4.2 [A] compared to /a/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.4.3 [A] compared to /ɑ/ (Female Southern)

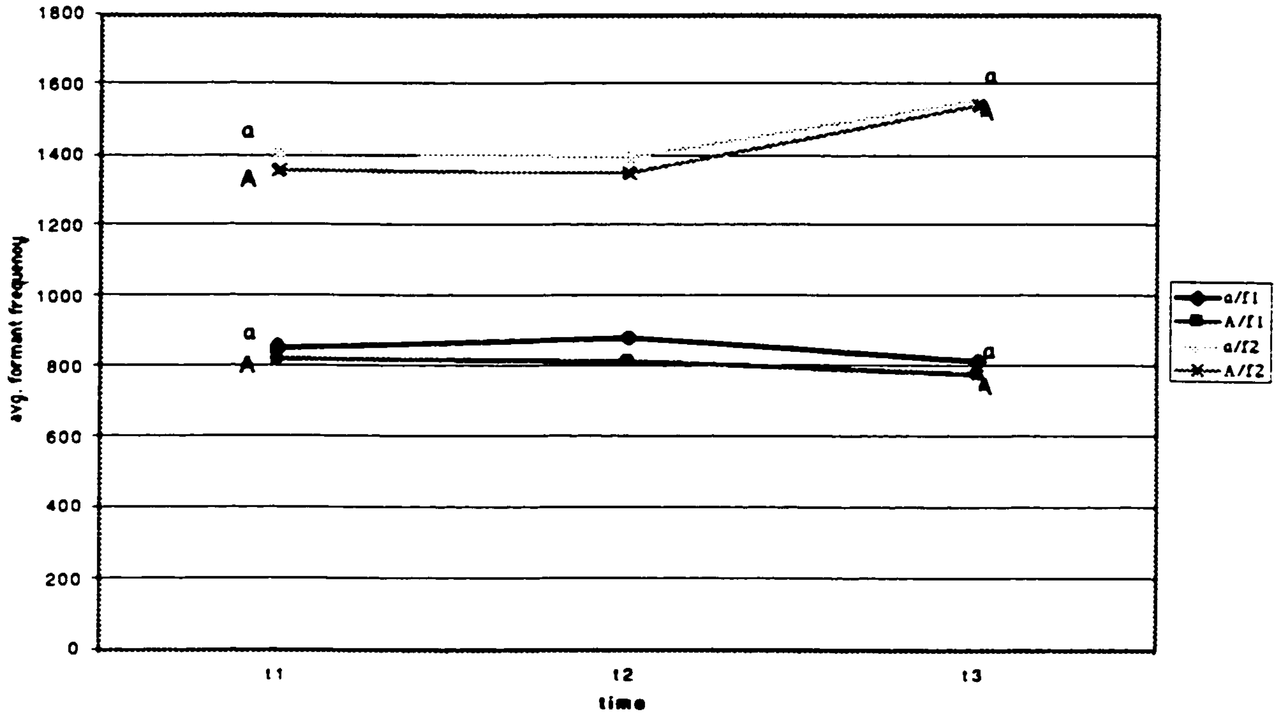
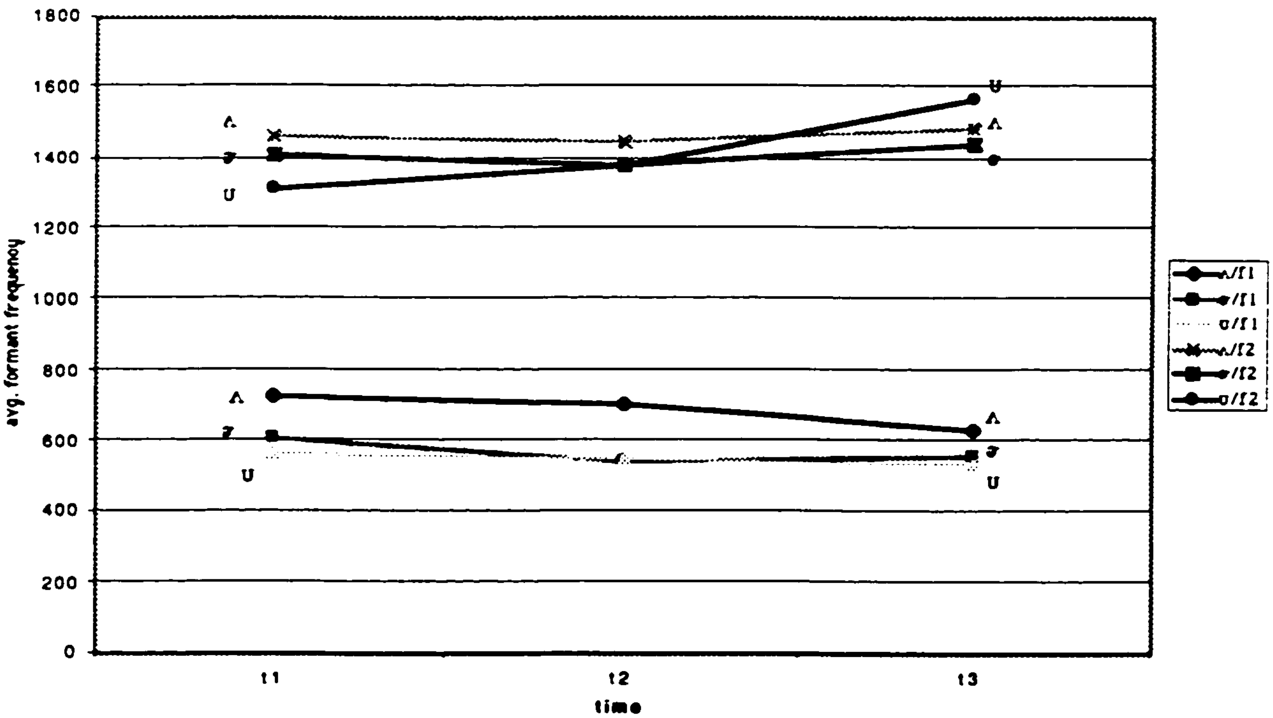


Figure 6.5.1 [ɚ] compared to /ʌ ʊ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.5.2 [ɚ] compared to /ʌ ʊ/ (Female Northern)

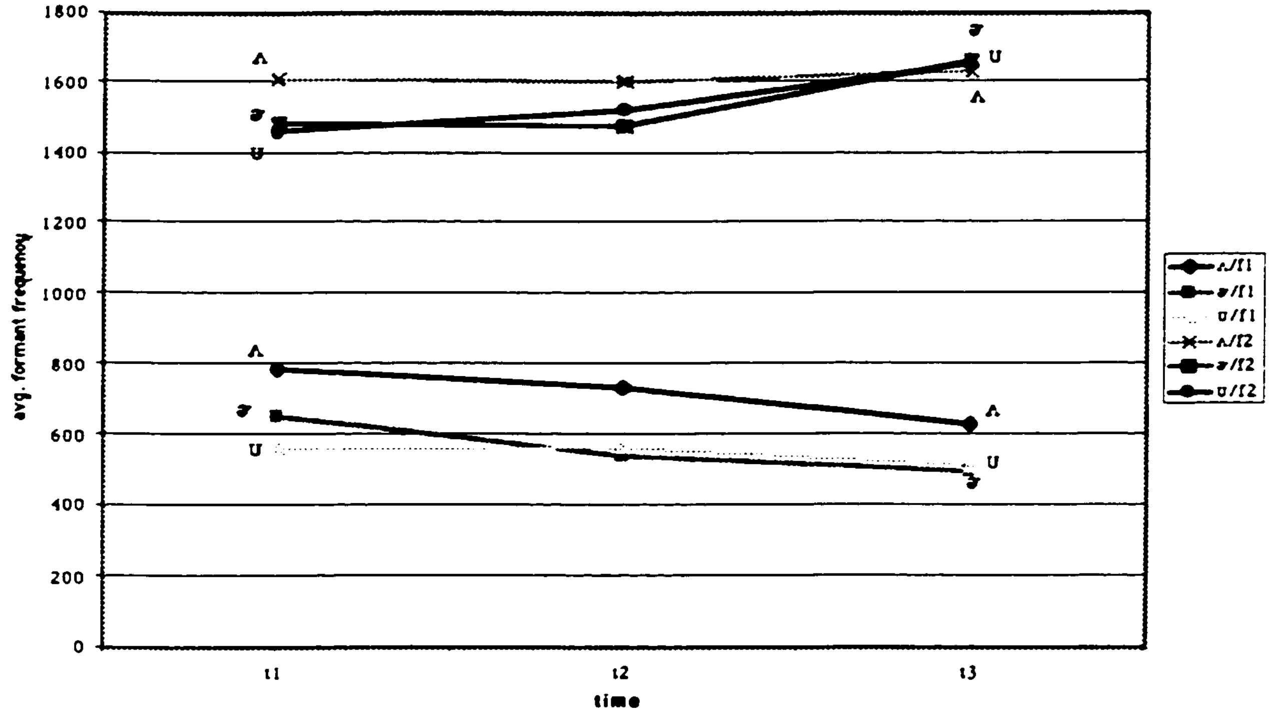
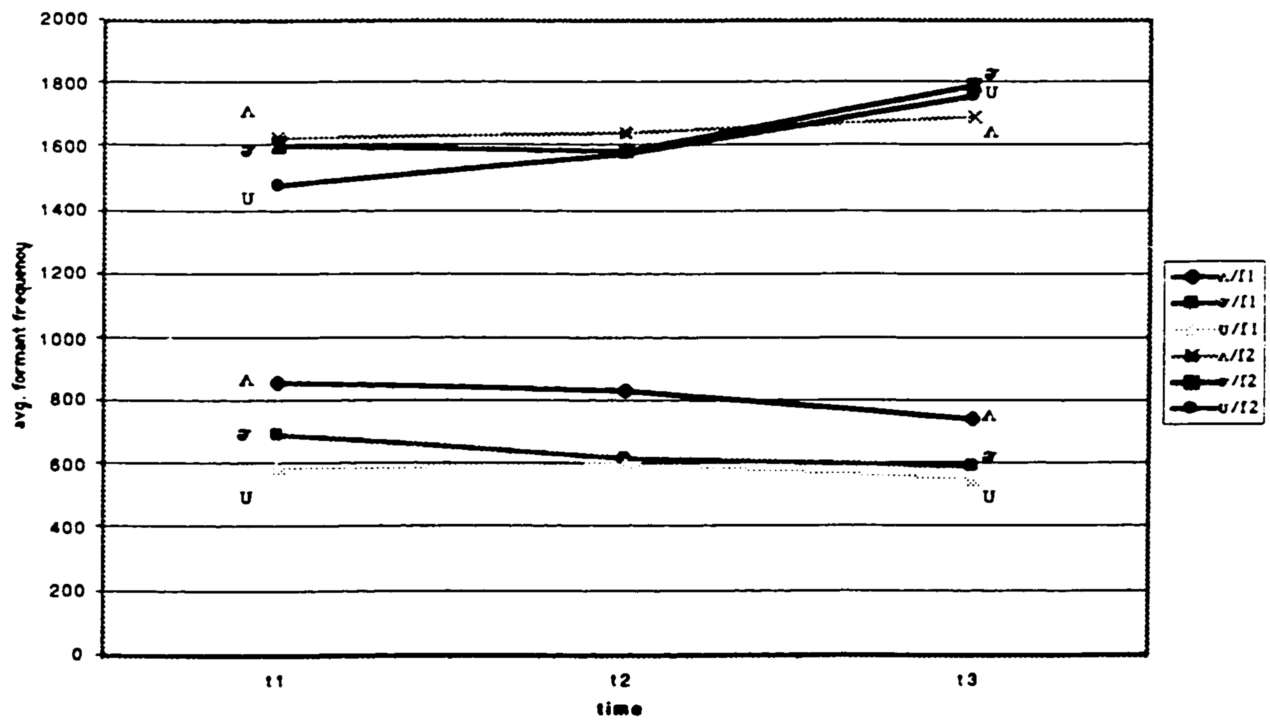


Figure 6.5.3 [ɚ] compared to /ʌ ʊ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

groups of speakers (a bit lower for Northern California Females). At T3 there are differences between groups. For Males, F2 of [ɚ] is lower than either that of /ʌ/ or /ʊ/, but closer to /ʌ/. For Southern California Females, F2 of [ɚ] is higher than that of /ʌ/ or /ʊ/ at T3. For Northern California Females, the F2 measurements of /ʌ/, /ʊ/, and [ɚ] at T3 are equivalent.

To summarize data on the F1 and F2 dynamics of the nuclei of the RGDs as compared to the averages of the canonical vowels:

1) The nucleus in [Ir] starts off like /i/ and ends up like /ɪ/.

2) The nucleus in [Er] starts off like /e/ and ends up like /ɛ/. It is not similar to /æ/.

3) The nucleus in [Or] is difficult to categorize. In terms of F1, it tends to start off like /u/ and end up like /ʊ/, but its F2 is not like that of any other vowel, indicating a high degree of roundness and/or backness.

4) The nucleus in [Ar] is much like /ɑ/.

5) The vowel [ɚ] is not like any other vowel.

6.2.2 Ranges of allophony (scatter graphs)

One weakness in presenting the data as it is in Figures 6.1 - 6.5 is that we don't get to see the wide range of positional variants of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vowels of American English as conditioned by following consonants. It would not be as interesting to say, for example, that F1 of [ɚ] is lower than that of /ʌ/ if the variant of /ʌ/ found before, say, /z/, also has this type of lowering. Therefore, formant measurements of all the consonantally conditioned allophones (and final allophones, where applicable) of all the vowels are needed. Such data is presented in Figures 6.6 - 6.15.

F1 and F2 measurements in Hz were averaged for all the speakers in each group and plotted on the graph, indicating which consonant they occur before. Separate charts are provided for each of the vowels /i ɪ e ɛ æ u ʊ o ɑ ʌ/ for each of the groups (Males, Northern California Females, Southern California Females). The x-axes and y-axes in Figures 6.6 through 6.15 do not all represent the same scale of F1 and F2 measurements. Different scales are used for the different groups and vowels in order to make maximally efficent use of space. Scatter graphs showing all the vowels for each group on a single graph are found in Appendix B.3.

The nucleus in [Ir] is on all the /i/ and /ɪ/ figures. The nucleus in [Er] is on all the /e/, /ɛ/, and /æ/ figures. The nucleus in [Or] is on the /u/, /ʊ/, and /o/ figures. The nucleus in [Ar] is on the /ɑ/ figures. The vowel [ɚ] is on the /ʌ/ and /ʊ/ figures. On the figures, the appropriate RGD nucleus is indicated by an "R", except for the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vowel [ɚ], which is simply indicated by "[ɚ]" on the /ʌ/ and /u/ figures.

For each of the scatter-graph figures, an ellipse is drawn. This ellipse represents confidence intervals (two standard deviations from the average) of F1 and F2 of the range of vowels found before all of the consonants except /r/, /l/, and /ŋ/.

For example, on Figure 6.13.2 (Northern California Female /o/), the average F1 measurement is 718 Hz with a Standard Deviation of 59. Two of these SDs equal 118, so the range of F1 is 600 to 836 (718 plus or minus 118). The average F2 measurement is 1618 Hz with a Standard Deviation of 104. Two of these SDs equal 208, so the range of F2 is 1410 to 1826 (1618 plus or minus 208). Thus, the ellipse is drawn with its center at (718, 1618) and its extreme values at (600, 1618), (836, 1618), (718, 1410) and (718, 1826). The average and extreme F1/F2 values used in the construction of the ellipses are marked on all the scatter graphs. The construction of the ellipses is used to determine whether the vowels found before /r/, /l/, and /ŋ/ are within the "normal range" of allophones of the canonical vowels, or whether they could be said to be outside this range.

The use of the ellipses lets us determine how similar phonetically the controversial vowels (those before /r/, /l/, or /ŋ/)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

are to the normal range of uncontroversial vowels. One could always gerrymander some kind of odd shape in order to include or exclude the vowels one wants. The use of objective criteria for the construction of the ellipses takes away this possibility.

One problem that must be considered is the question of whether to incorporate the vowels found before /r/, /l/, and /ŋ/ into the ellipses or not. We are assuming them to all be "controversial" and hence out of the ellipses. But this may not be right. Suppose, for example, the vowel in "eel" is definitely /i/. Should we not include it then in the ellipse for /i/ for the purposes of determining whether the nuclei in [Ir] and <ing> belong with /i/? This problem has no solution that is not question-begging. The question of how our categorizations would be different were we to include some of the supposedly "controversial" vowels within the "normal" ellipse will be brought up in discussion of the data. Specifically, we shall discuss how the inclusion of the vowels found before /l/, whose phonological categorization is the least controversial due to their complete range of contrast, within the range of "normal" vowels forming the ellipse might alter the data.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.6.1: /i/ - Males

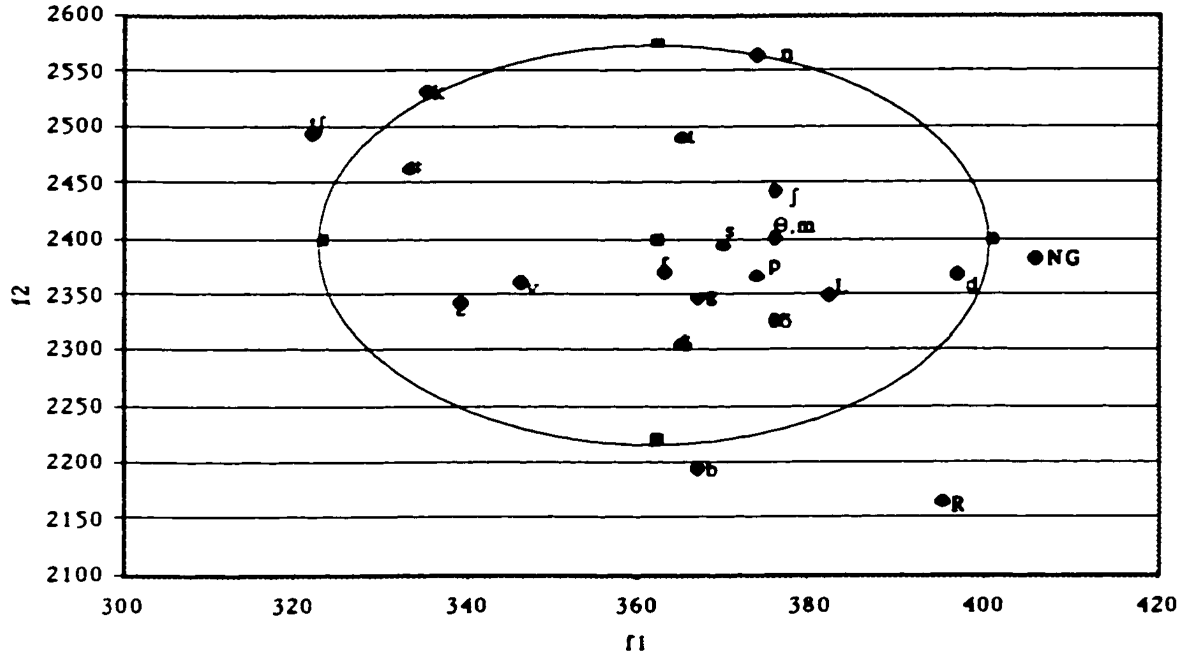
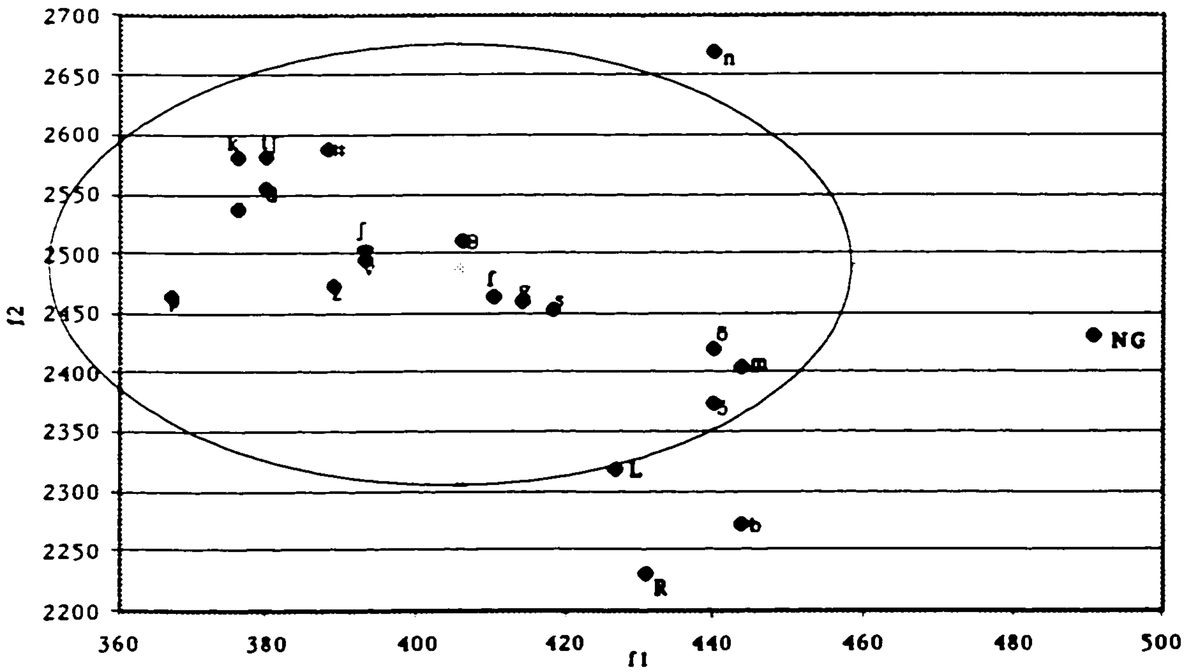


Figure 6.6.2: /i/ - Northern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.6.3: /i/ - Southern Females

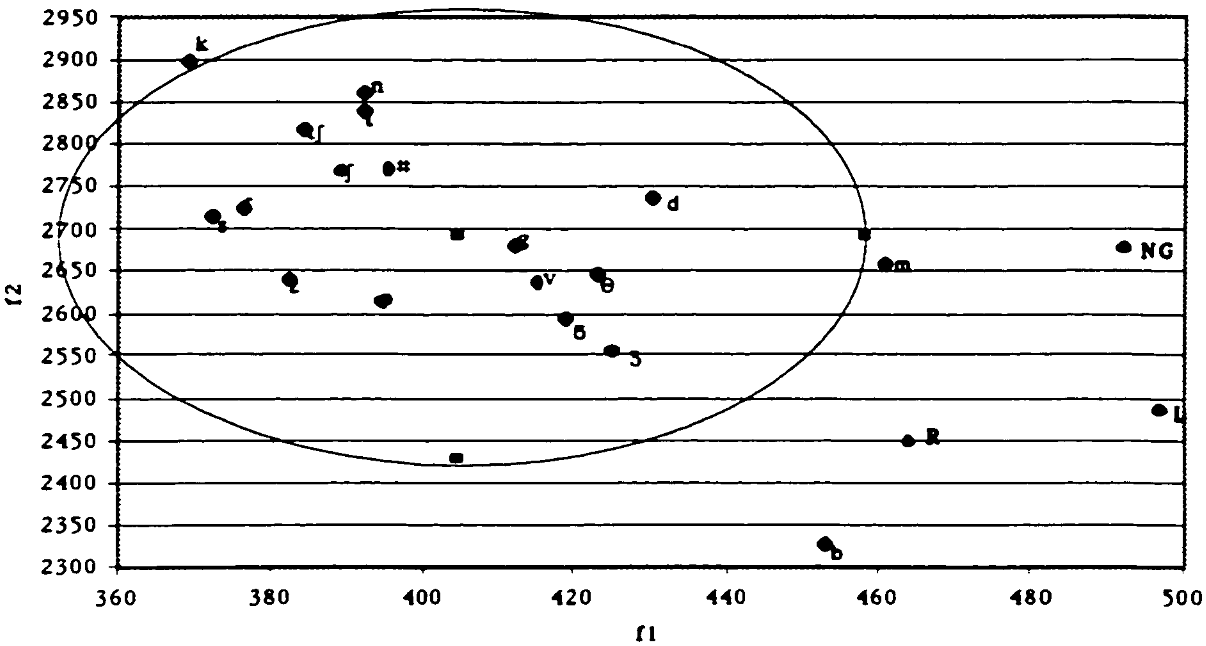
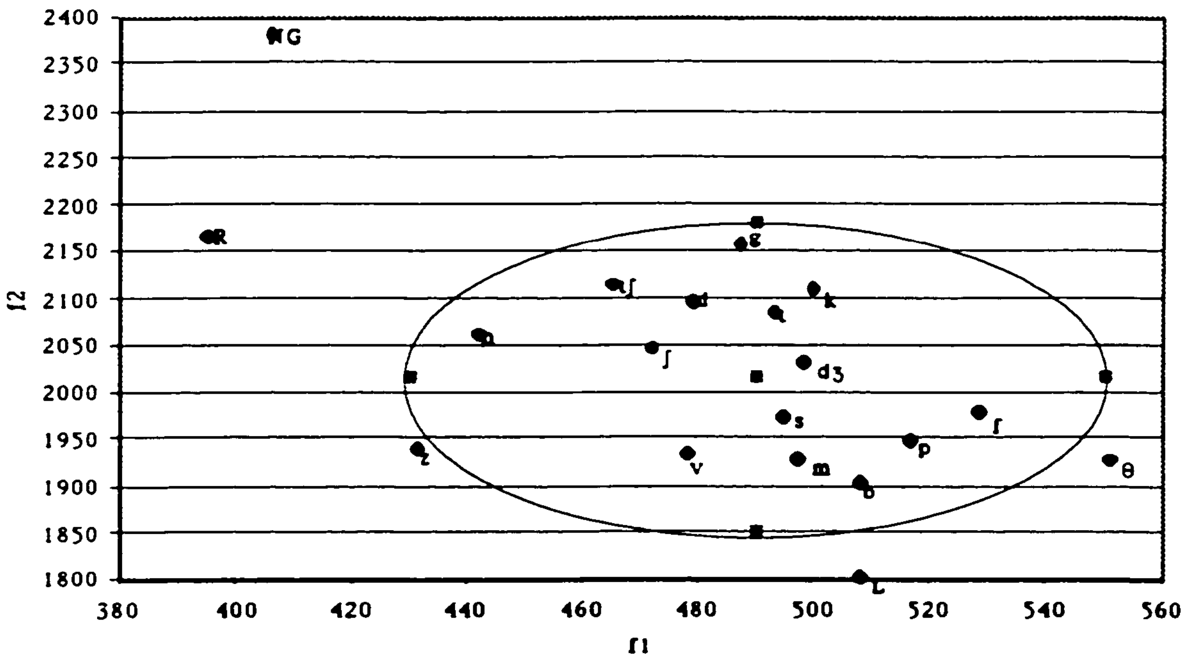


Figure 6.7.1: /ɪ/ - Males



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.7.2: /ɪ/ - Northern Females

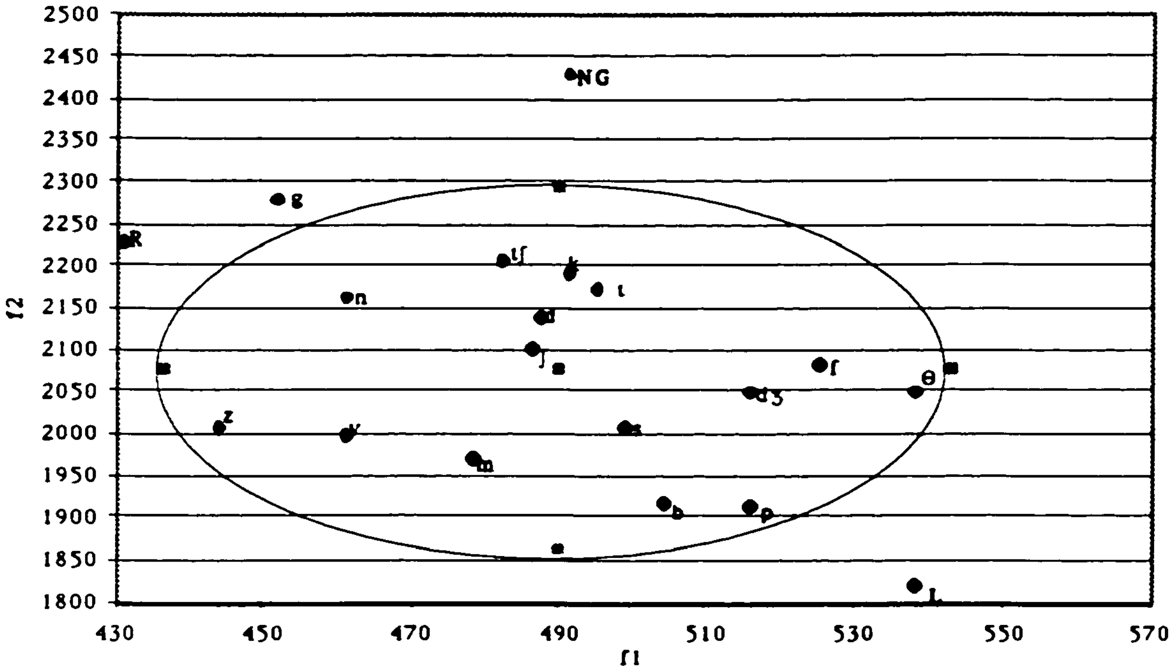
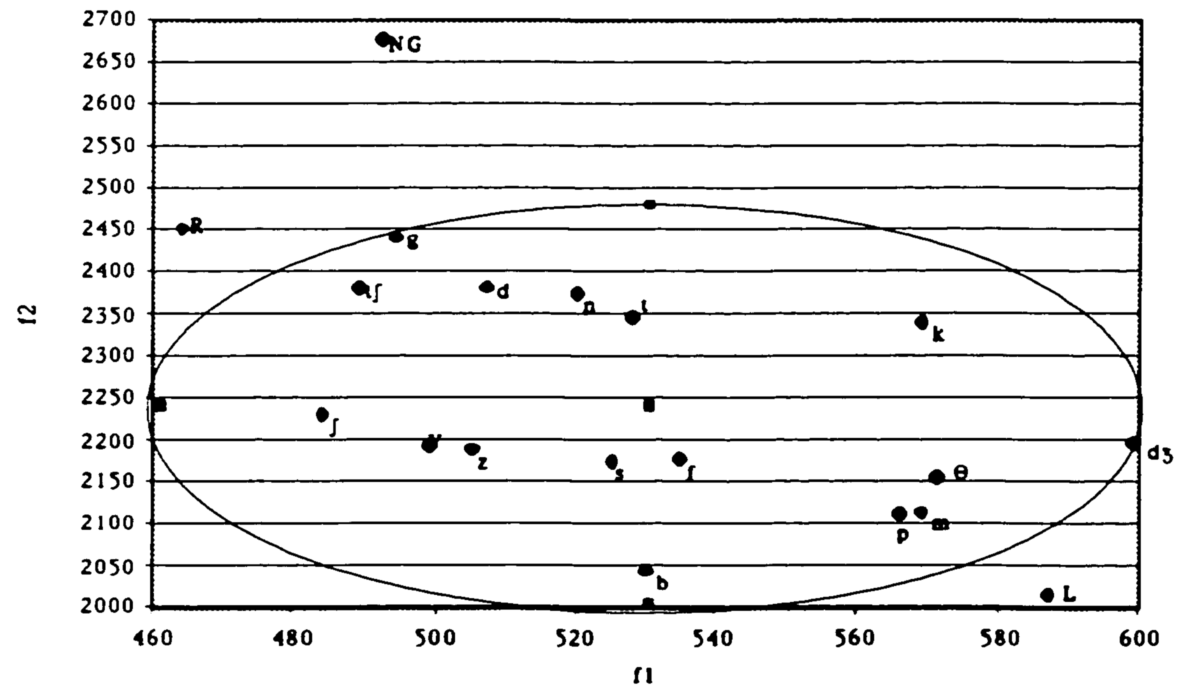


Figure 6.7.3: /ɪ/ - Southern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Examination of the charts for /i/ (Figures 6.6.1, 6.6.2, 6.6.3) show [Ir] to be outside the ellipse for all groups. If we include /l/ within the ellipse, this changes things for the Southern California Females, putting [Ir] within the ellipse of /i/. It doesn't change anything for Males and Northern California Females, for whom /l/ is in the ellipse anyway.

[Ir] is outside the ellipse of /ɪ/ for all groups. If we include /l/, the nucleus in [Ir] might be inside the ellipse for the two female groups.

[Er] is outside the ellipse of /e/ for all groups (Figures 6.8.1, 6.8.2, 6.8.3). Including /l/ in the ellipse doesn't change this.

[Er] is outside the ellipse of /ɛ/ for Males and Southern California Females, but inside the ellipse for Northern California Females. (Figures 6.9.1, 6.9.2, 6.9.3). Putting /l/ in the ellipse doesn't change the situation for the female group, but might put the nucleus in [Er] inside the ellipse for Males.

[Er] is firmly outside the ellipse of /æ/ for all groups (Figures 6.10.1, 6.10.2, 6.10.3).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.8.1: /e/ - Males

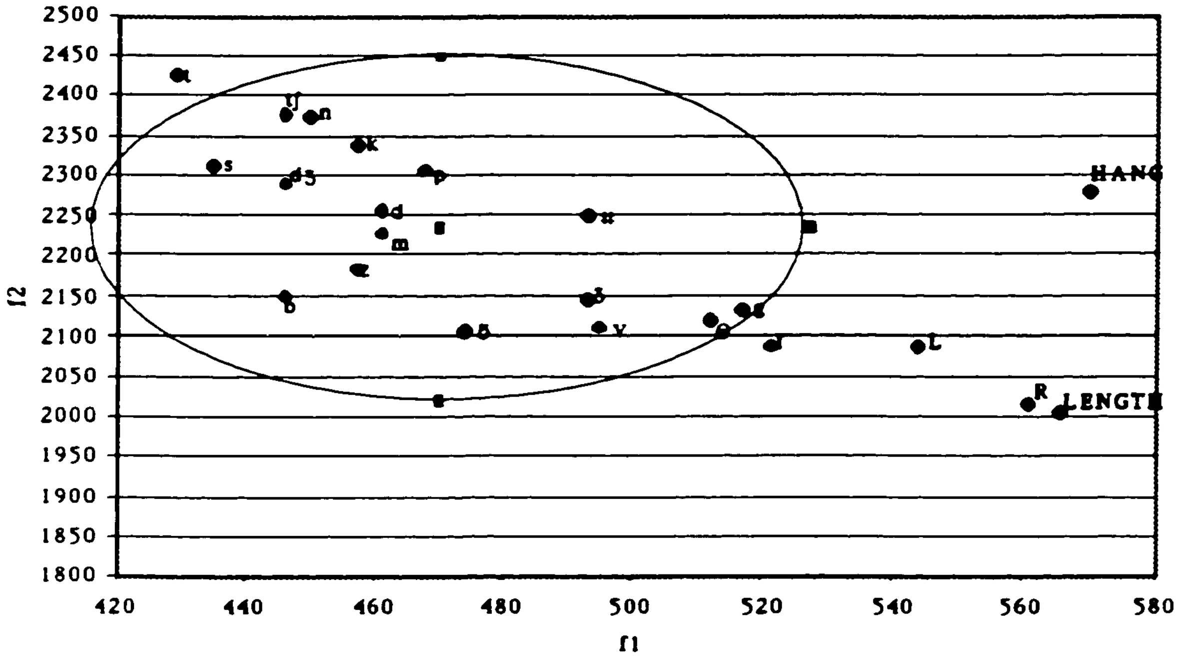
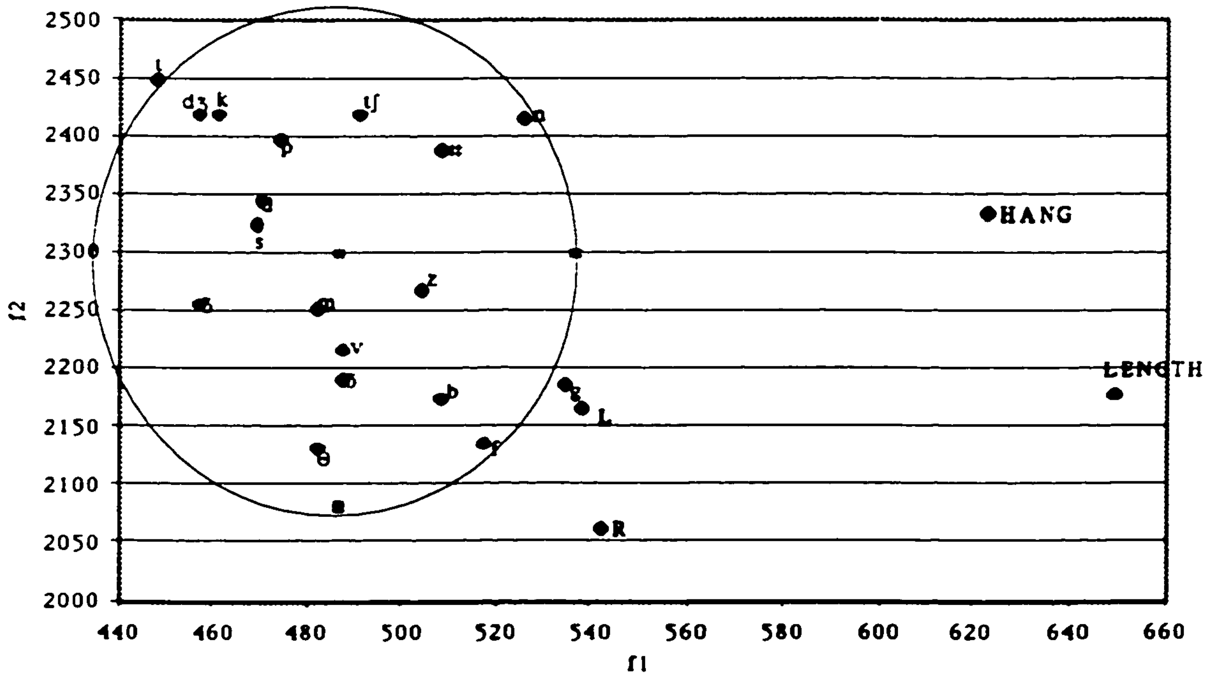


Figure 6.8.2: /e/ - Northern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.8.3: /e/ - Southern Females

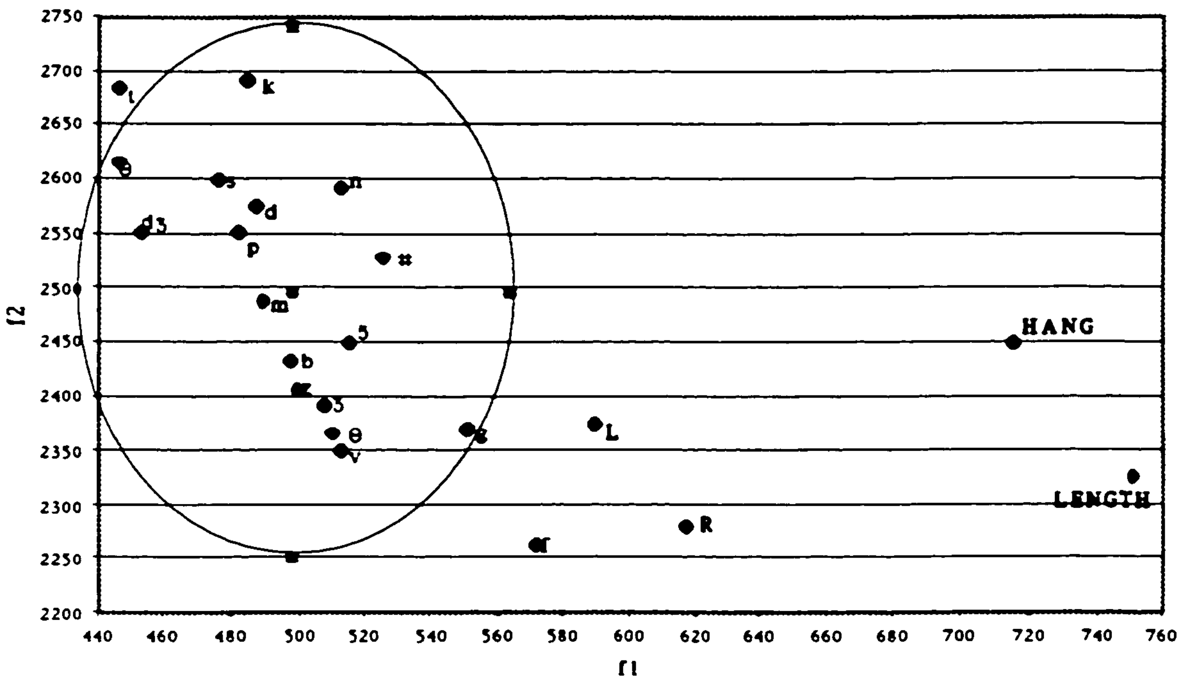
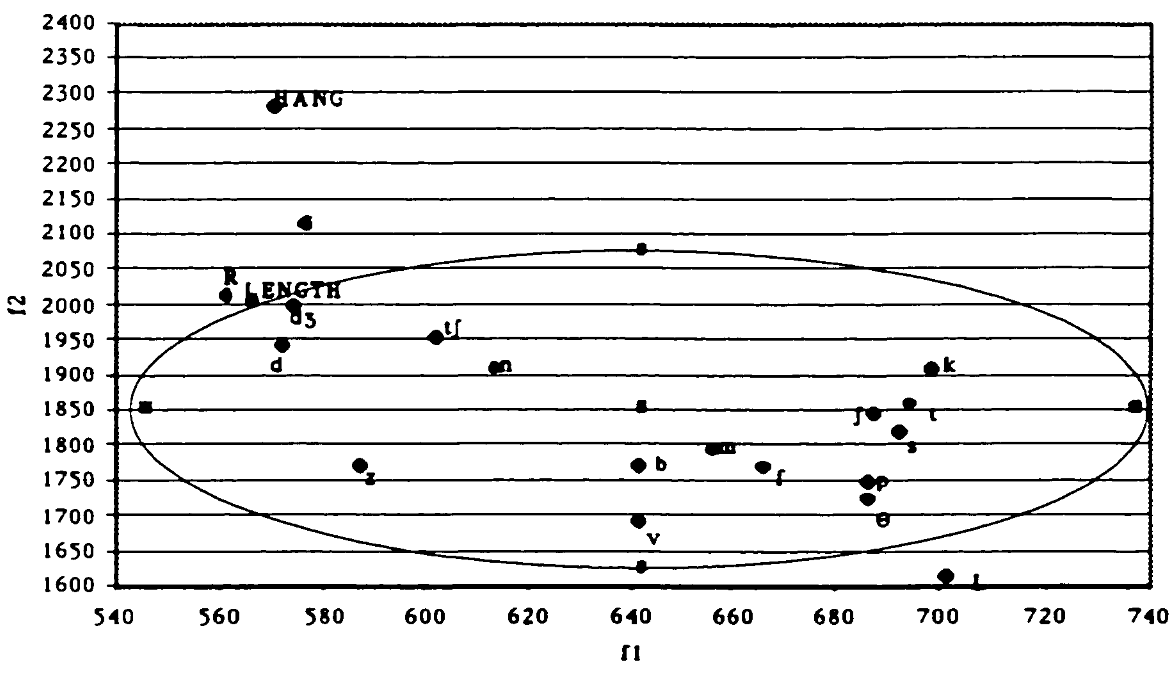


Figure 6.9.1: /e/ - Males



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.9.2: /ε/ - Northern Females

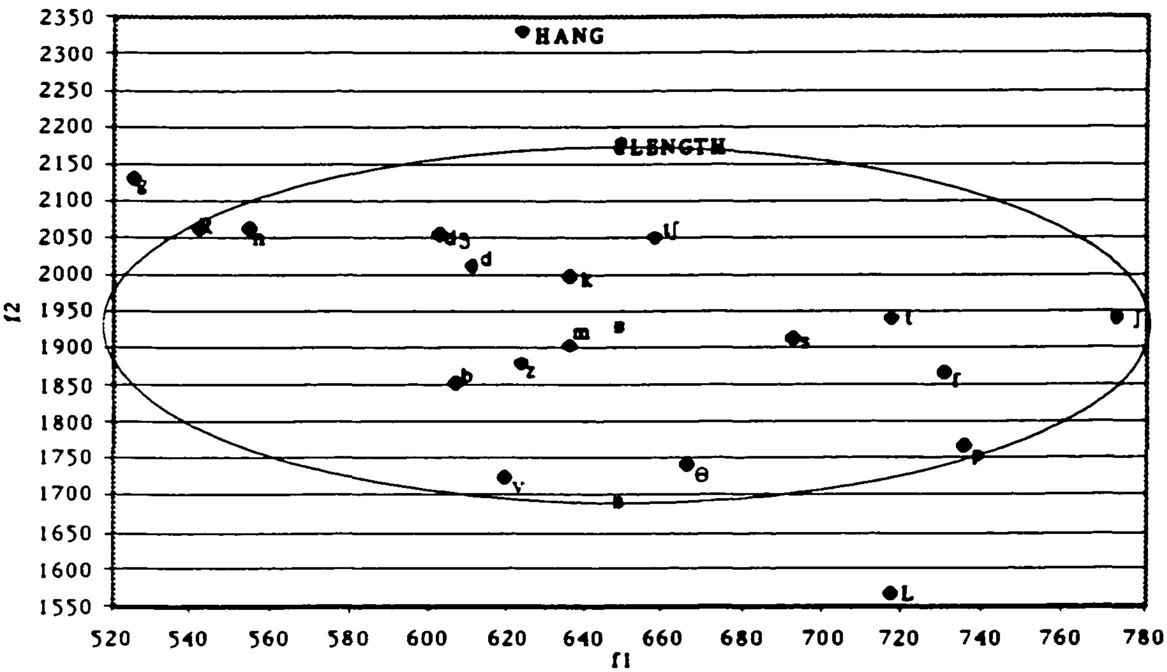
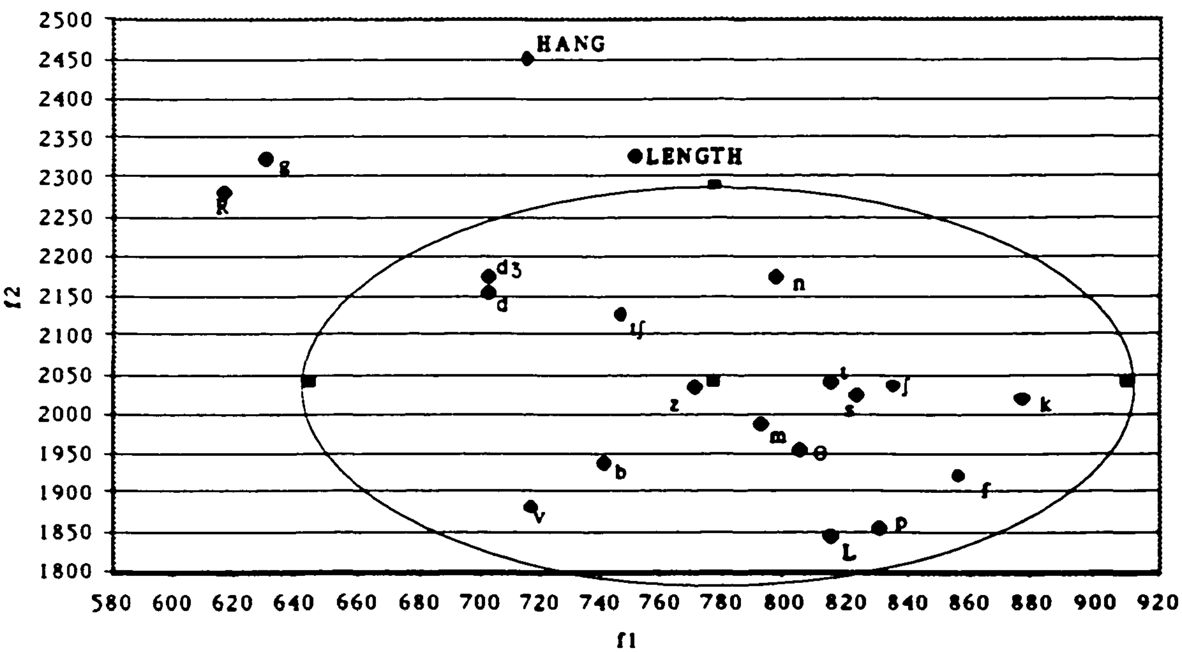


Figure 6.9.3: /ε/ - Southern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.10.1: /æ/ - Males

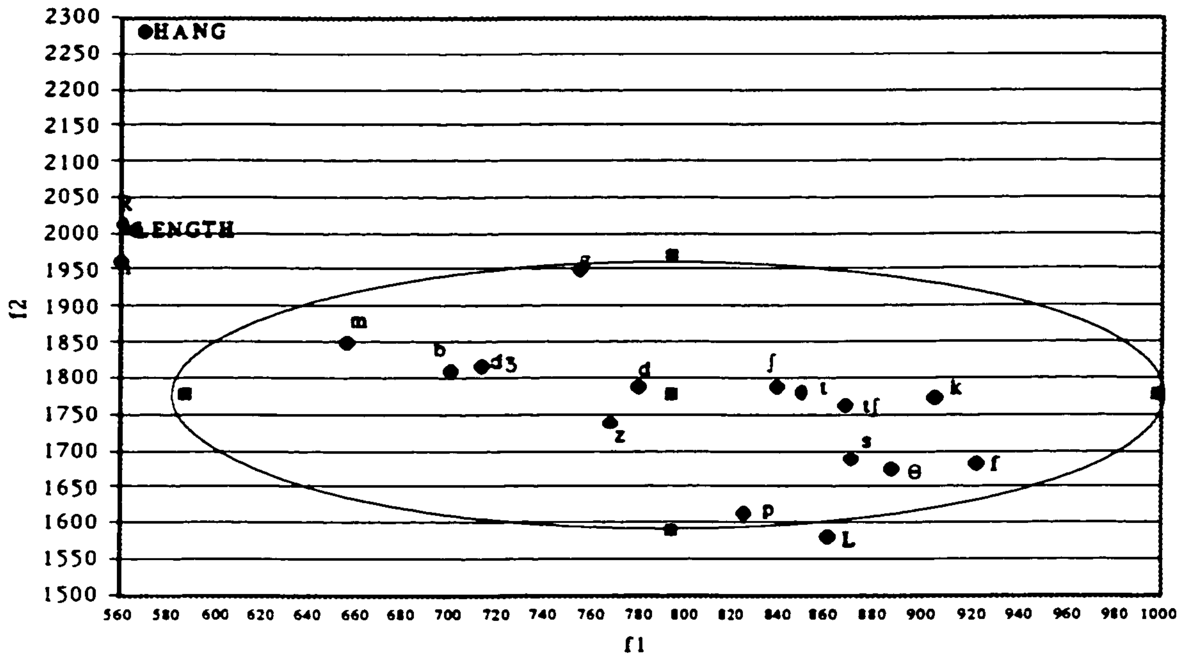
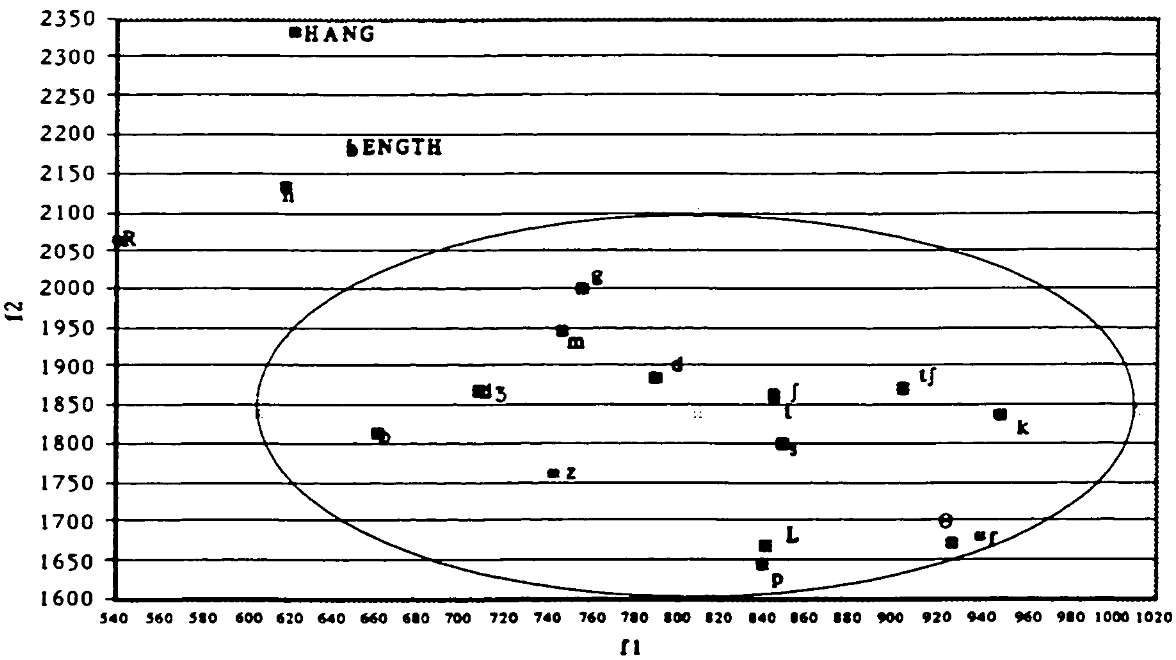


Figure 6.10.2: /æ/ - Northern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.10.3: /m/ - Southern Females

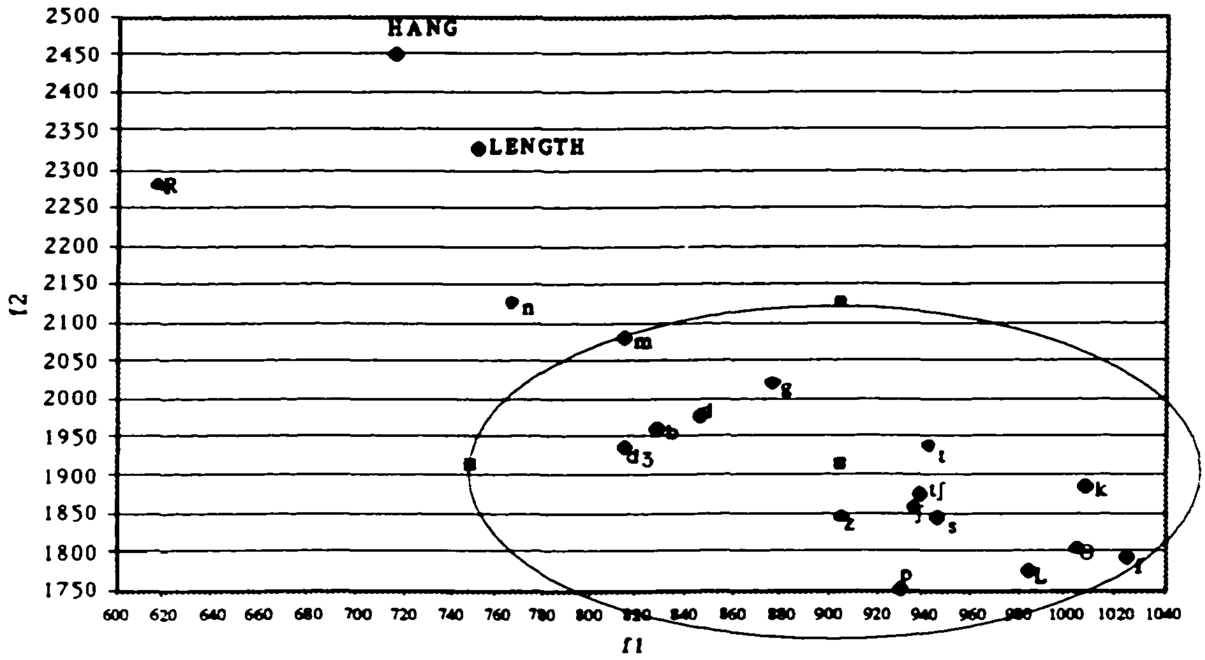
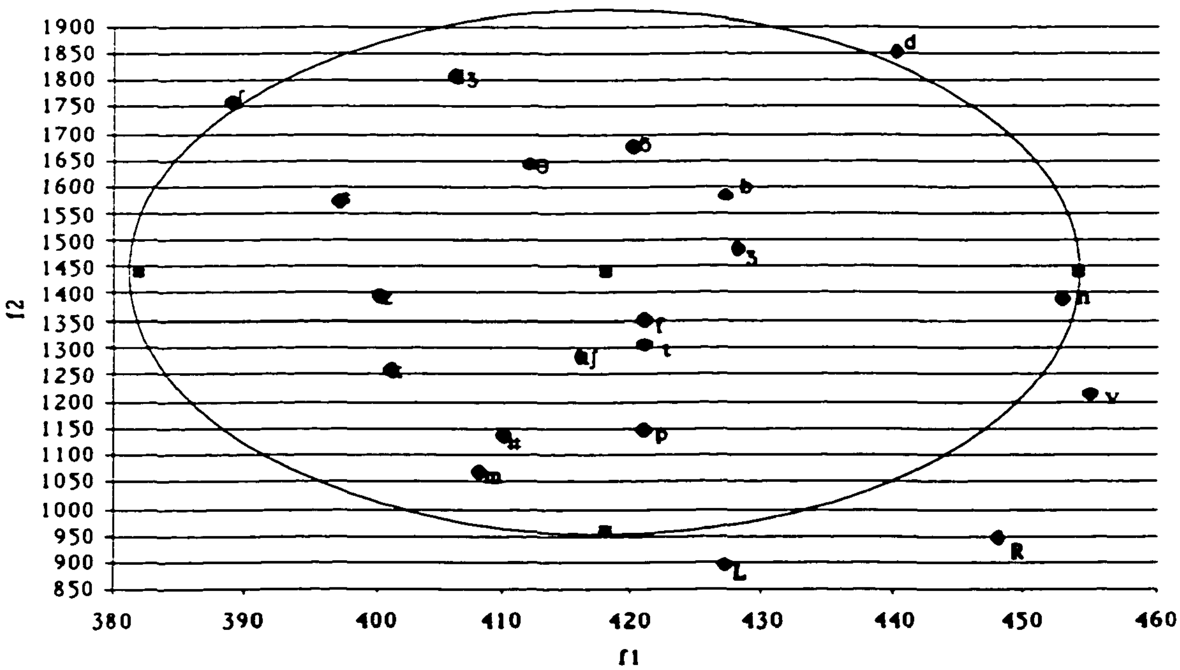


Figure 6.11.1: /u/ - Males



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.11.2: /u/ - Northern Females

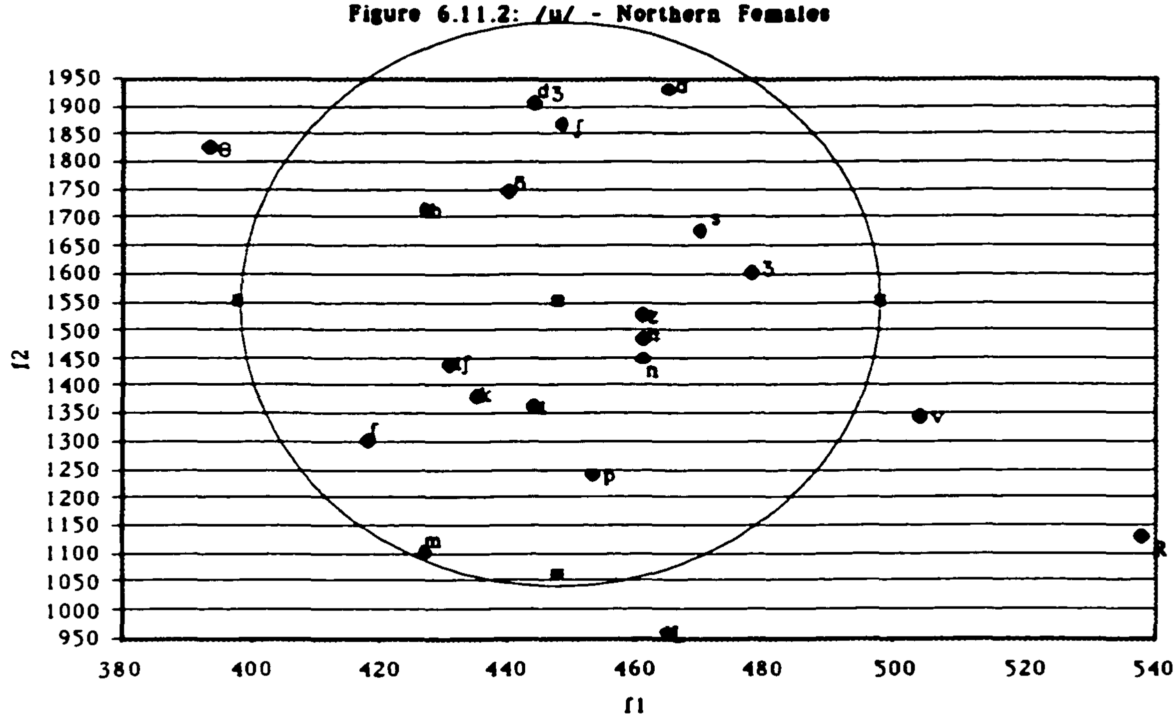
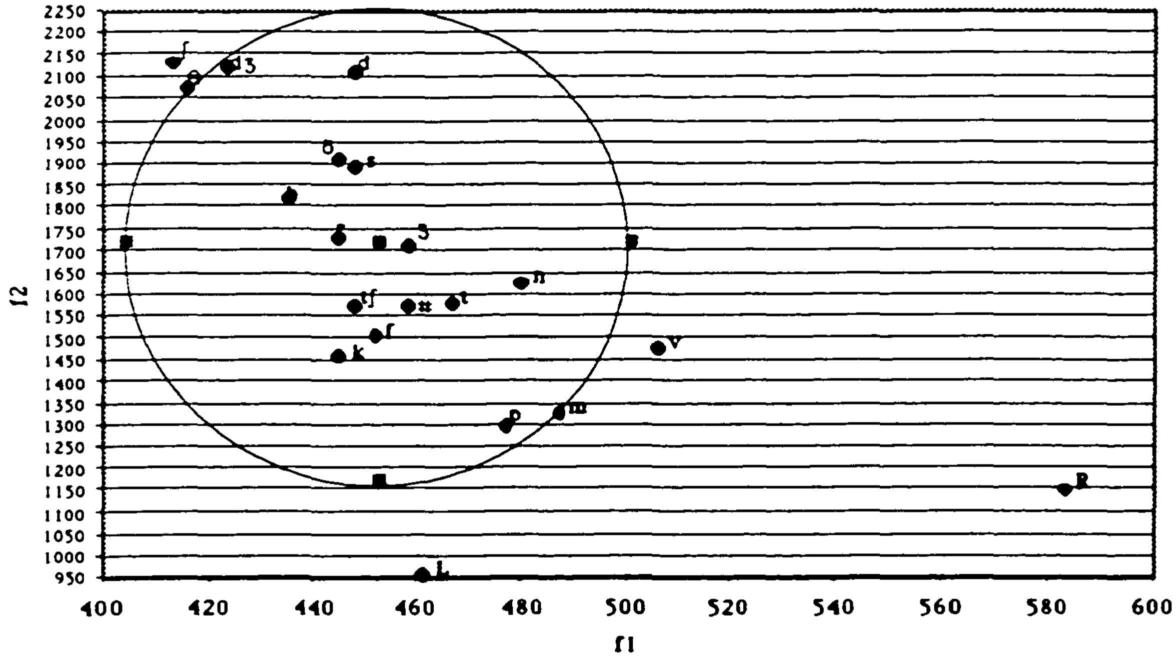


Figure 6.11.3: /u/ - Southern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[Or] is outside the ellipse of /u/ for all groups (Figures 6.11.1, 6.11.2, 6.11.3). If we include /l/, that puts [Or] in the /u/ ellipse for Males, but not Females.

[Or] is firmly outside the /ʊ/ ellipse for all groups (Figures 6.12.1, 6.12.2, 6.12.3). If we include /l/, [Or] is in the /ʊ/ ellipse for both Female groups. However, we shall see that there may be good reason not to include /l/ in the "normal" ellipse for /ʊ/.

[Or] is in the ellipse of /o/ for Northern California Females, extremely close to the ellipse for Southern California Females, and outside the ellipse for Males (Figures 6.13.1, 6.13.2, 6.13.3). The inclusion of /l/ puts [Or] inside the ellipse of /o/ for all groups.

[Ar] is in the ellipse of /ɑ/ for both Female groups and for Males (Figures 6.14.1, 6.14.2, 6.14.3).

[ɚ] is outside the /ʌ/ ellipse for all groups (Figures 6.15.1, 6.15.2, 6.15.3). If we include /l/, [ɚ] is likely within the /ʌ/ ellipse for all groups.

[ɚ] is outside the /ʊ/ ellipse for Southern California Females, but inside the ellipse for Males and Northern California Females. If we include /l/, [ɚ] will be inside the /ʊ/ ellipse for Southern California Females.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.12.1: /ʊ/ - Males

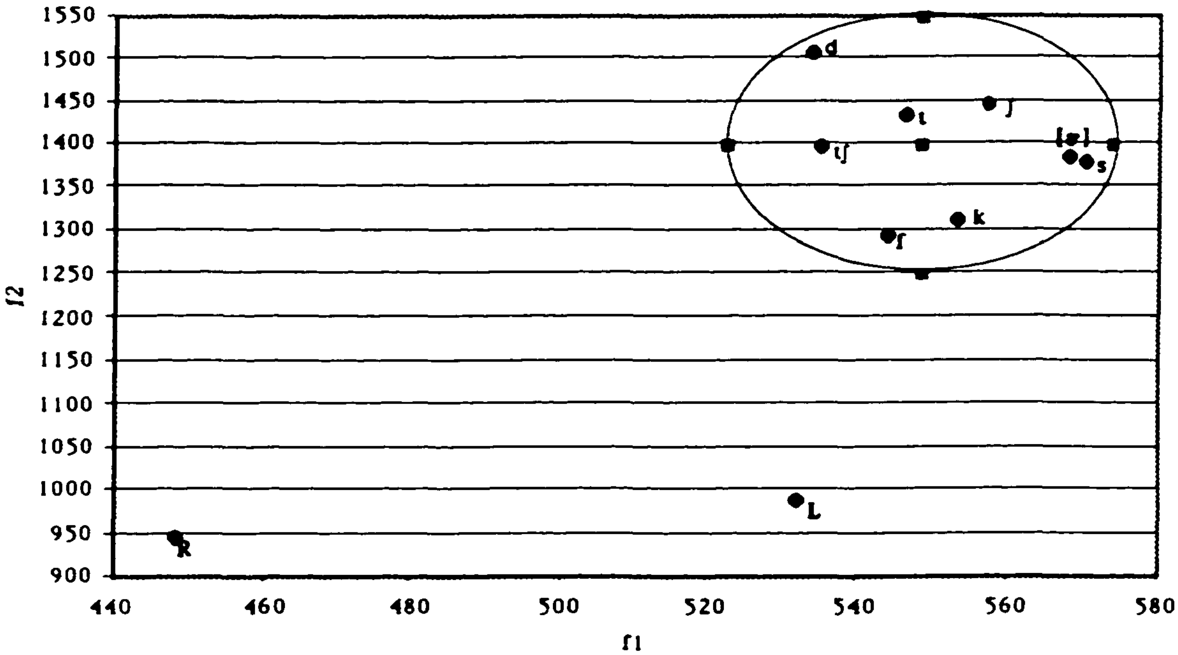
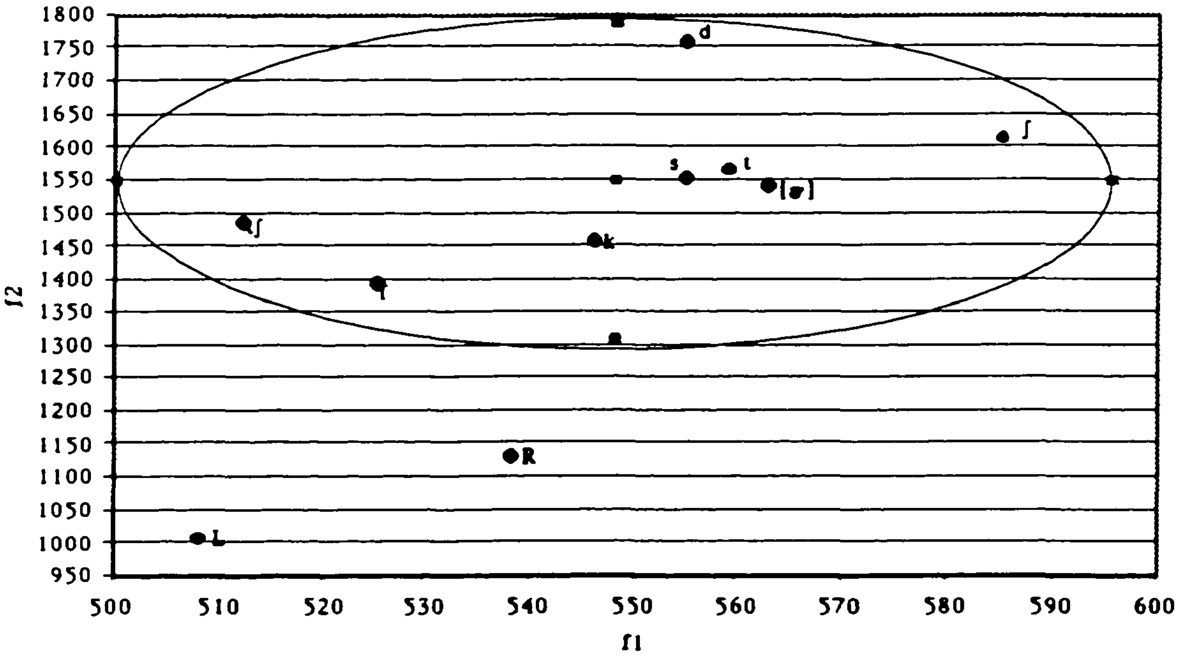


Figure 6.12.2: /ʊ/ - Northern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.12.3: /ʊ/ - Southern Females

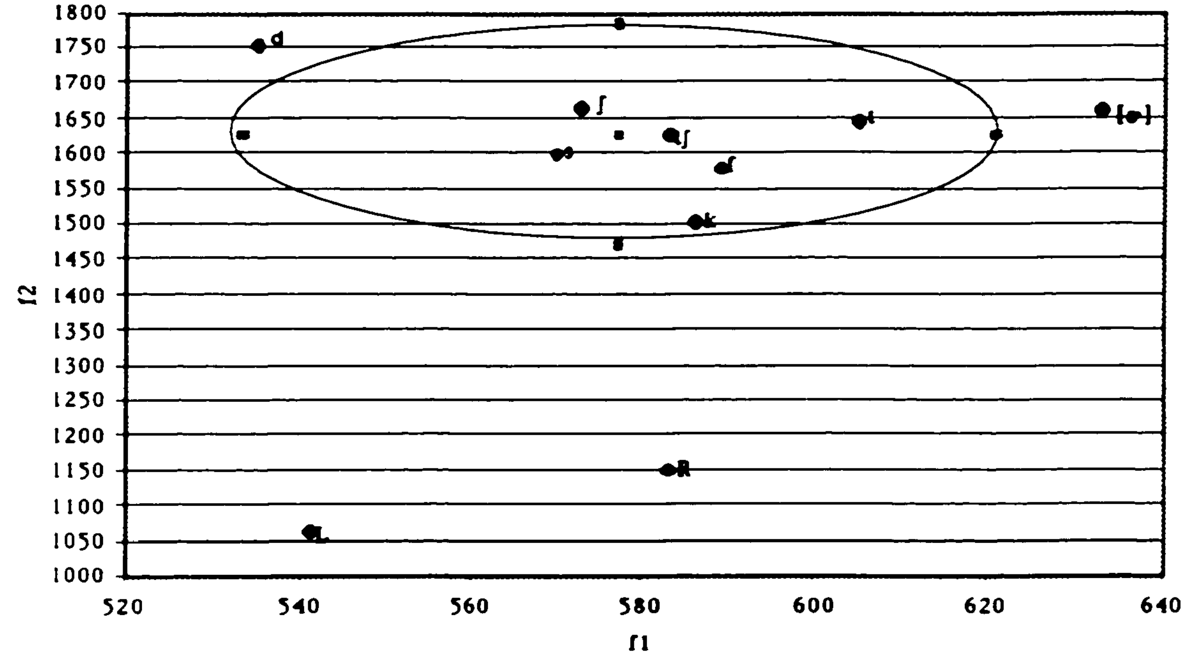
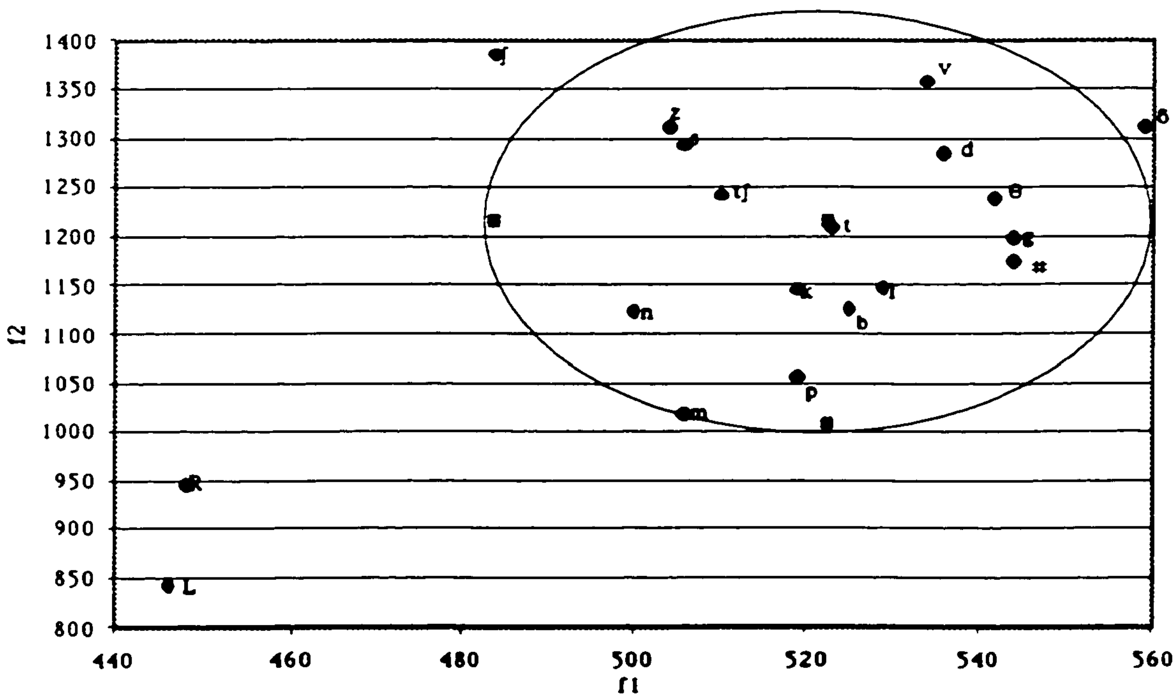


Figure 6.13.1: /o/ - Males



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.13.2: /o/ - Northern Females

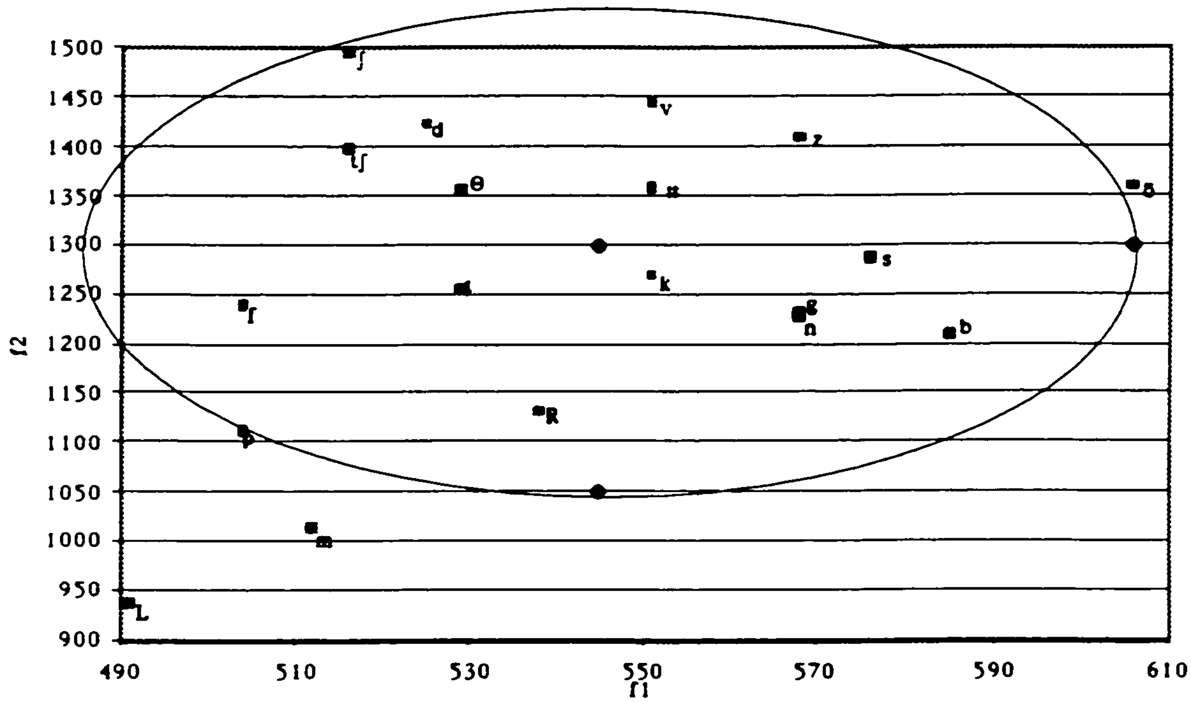
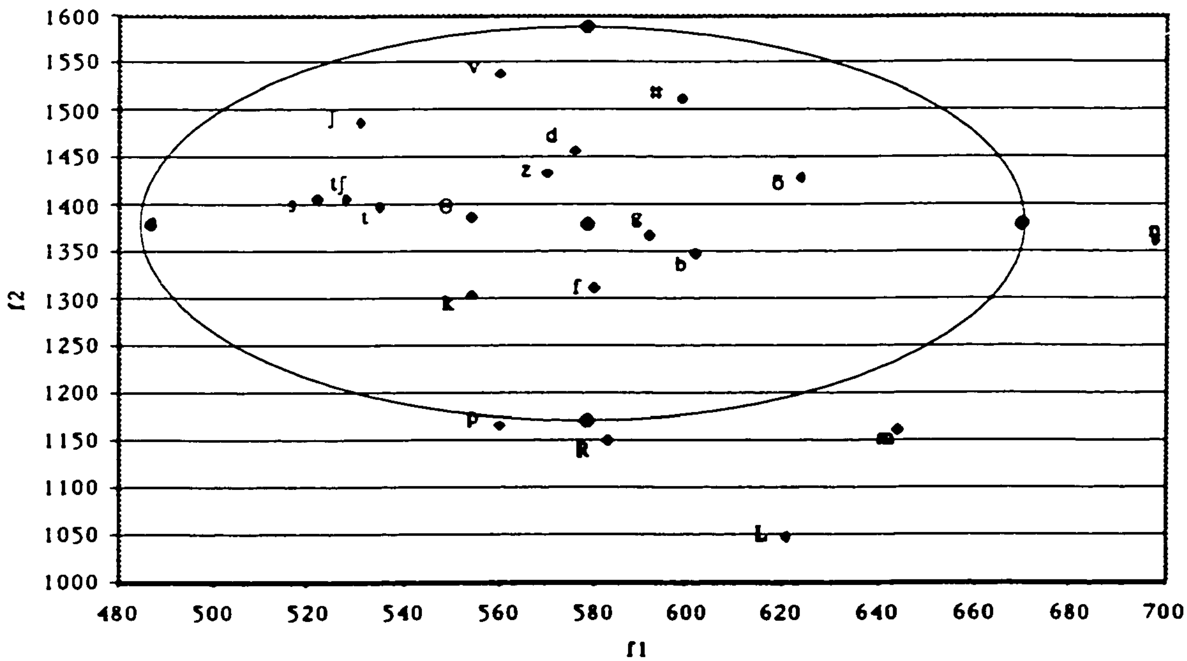


Figure 6.13.3: /o/ - Southern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.14.1: /a/ - Males

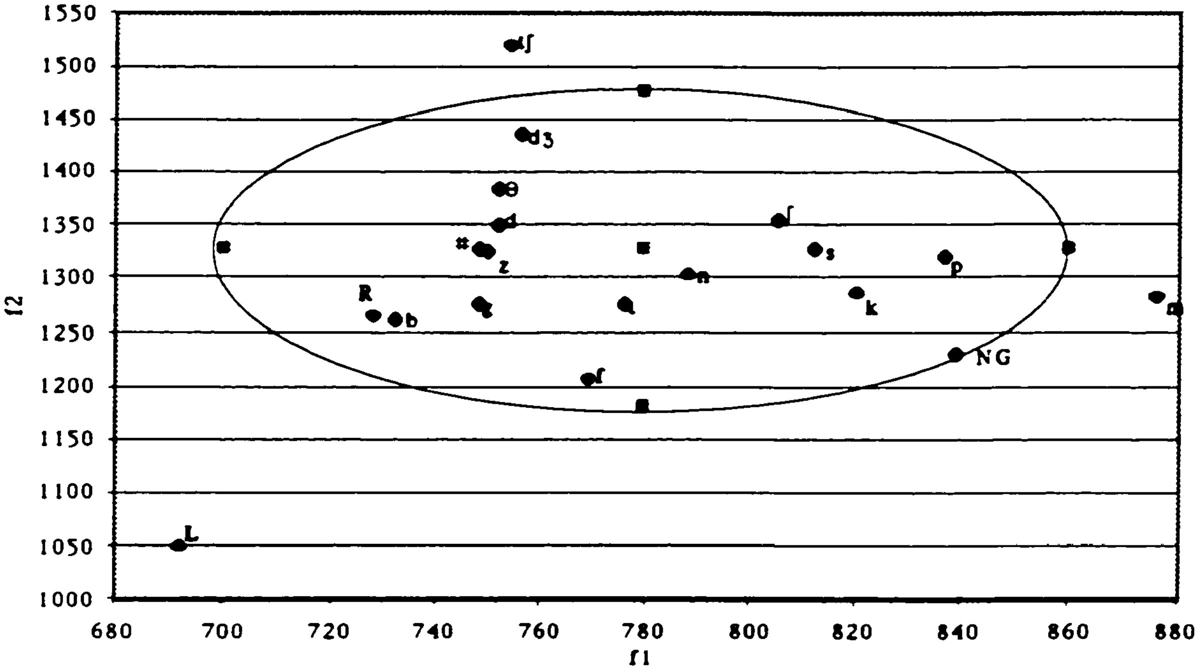
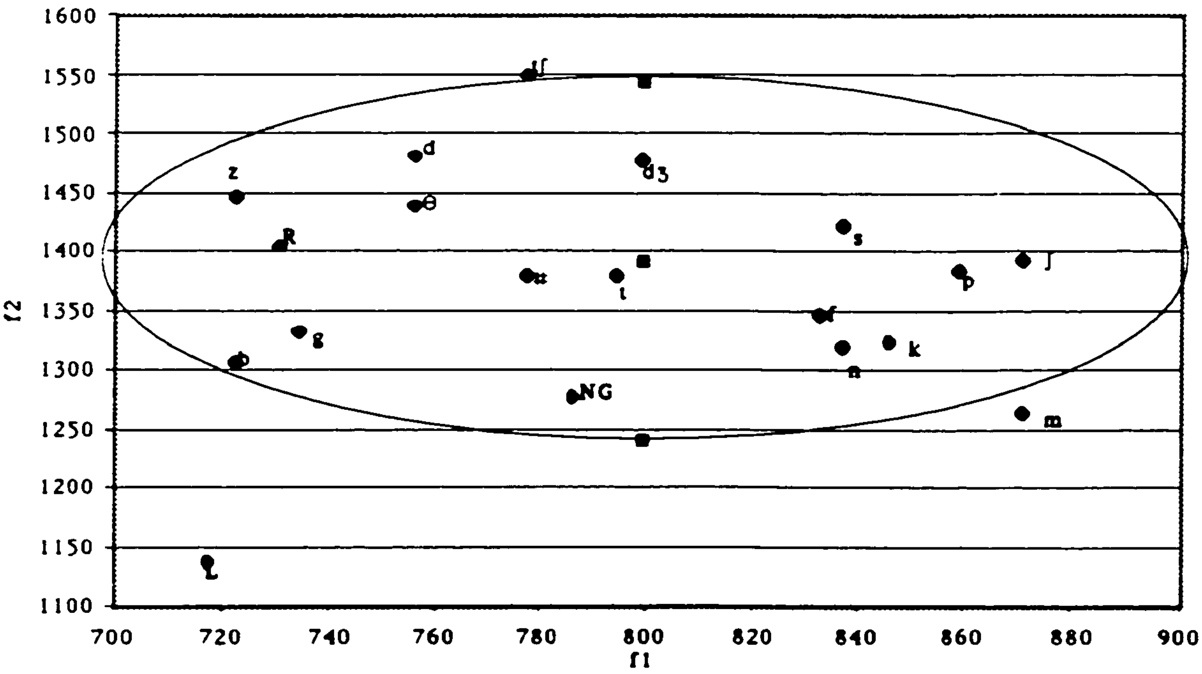


Figure 6.14.2: /a/ - Northern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.14.3: /a/ - Southern Females

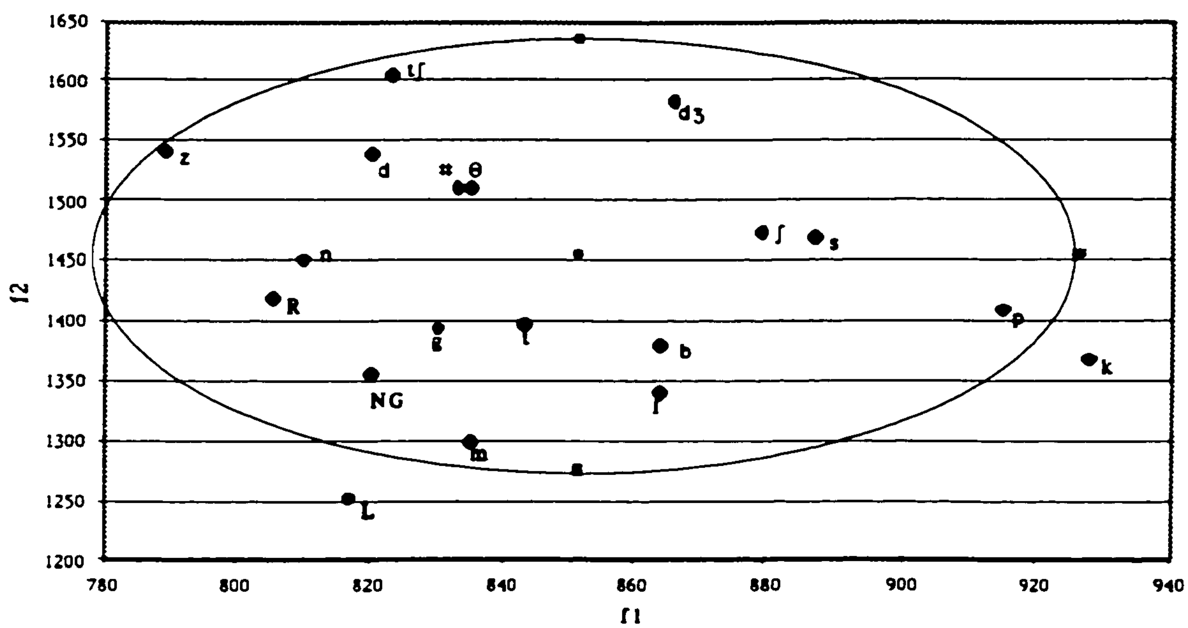
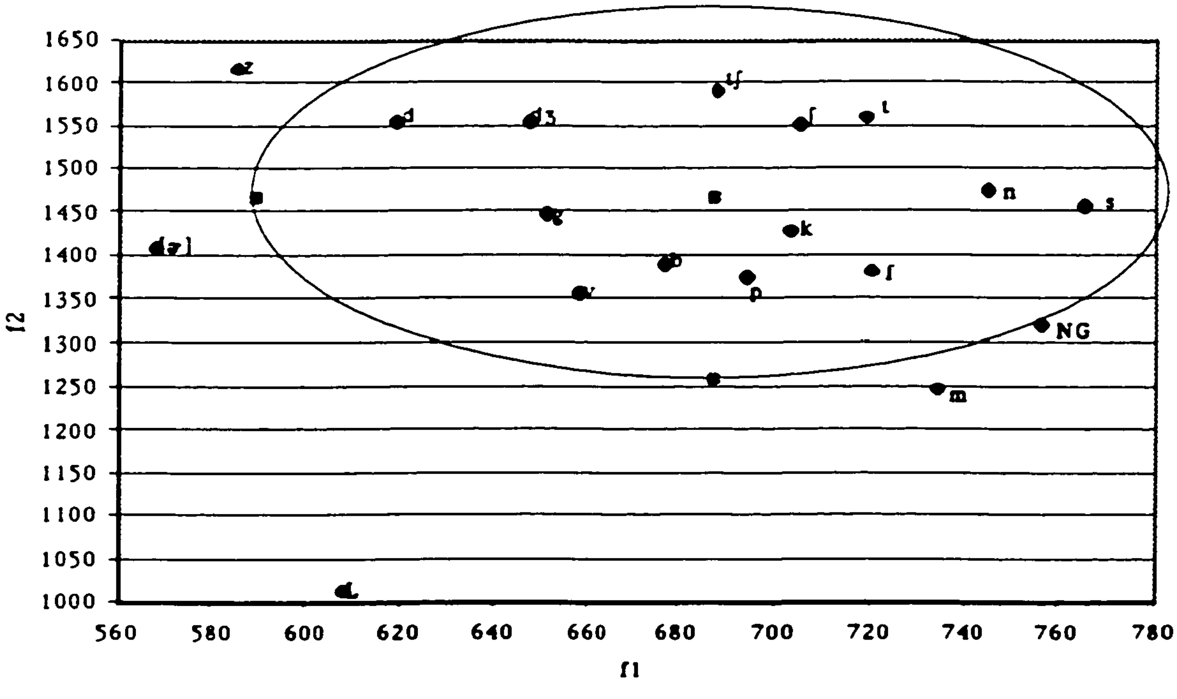


Figure 6.15.1: /ʌ/ - Males



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.15.2: /ʌ/ - Northern Females

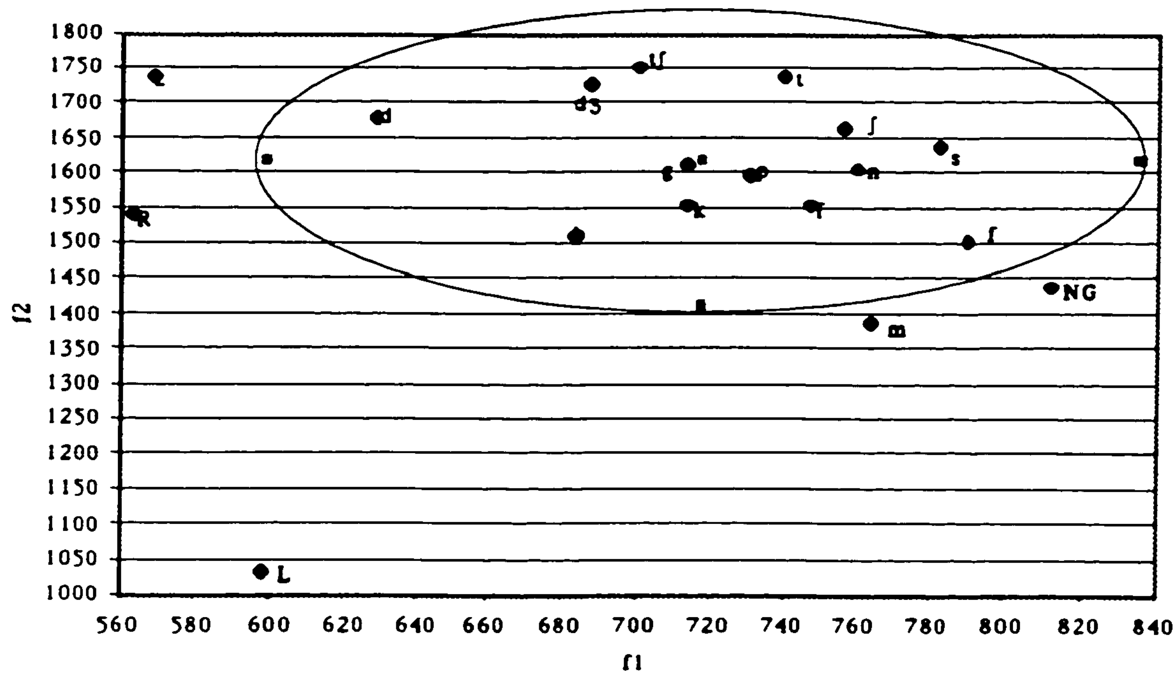
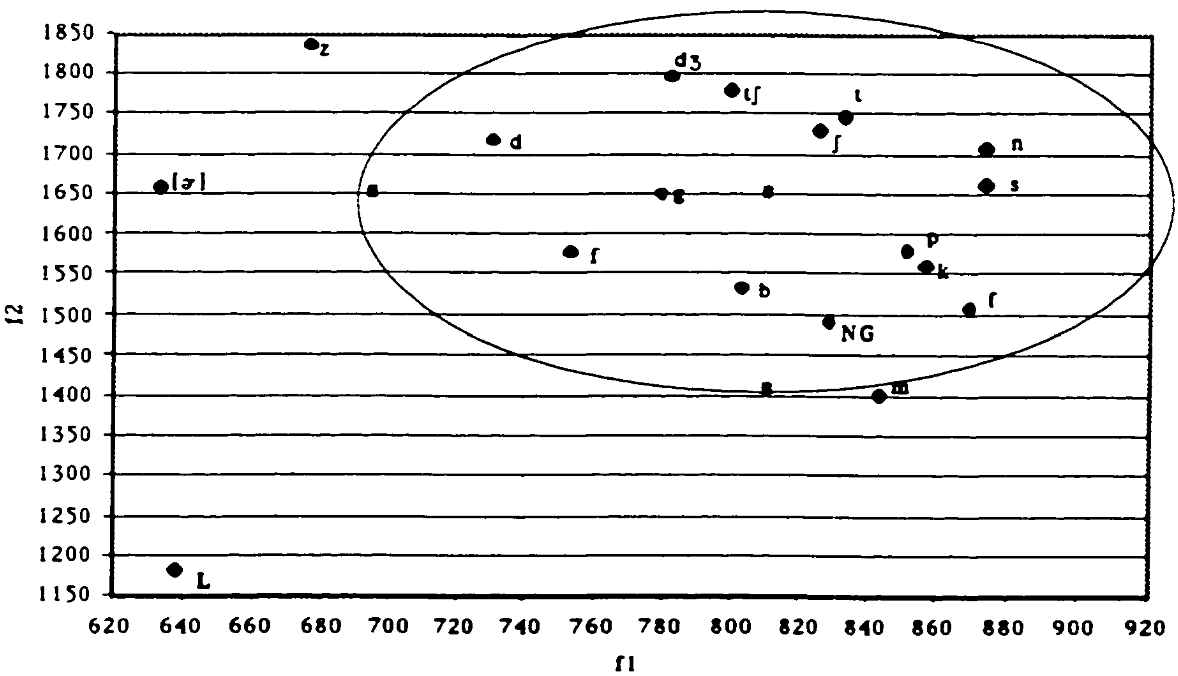


Figure 6.15.3: /ʌ/ - Southern Females



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

To summarize the findings from the scatter graphs: the nuclei in [Ir] and [Er] generally fall outside the allowable range of allophony for any of the canonical vowels. The nucleus in [Or] generally falls within the range of /o/, but not /u/ or /ʊ/. The nucleus of [Ar] is within the range of /ɑ/. The vowel [ɚ] is within the range of /ʊ/.

It cannot be argued that the use of these ellipses is a circular methodology, which automatically excludes the vowels found before /r/ from a standard range of allophony. Examination of the scatter graphs of the formants for /ɑ/ (Figures 6.14.1, 6.14.2, 6.14.3) show the nucleus in [Ar] to be firmly within the ellipse of /ɑ/ for two of the three groups. Hence, the methodology is falsifiable.

It must be remembered that there is no clear mechanism for determining whether a given nucleus of a diphthong occurs independently or not. Generally, though, the more the nucleus is within the normal range of a vowel, the more we can say that it does occur independently, and the more it is outside the normal range of any vowel, the more we can say it does not occur independently, and hence the diphthong in question might be monophonemic.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6.2.3. Conclusions: Vowels before /r/

Coupling the data from the line graphs with the data from the scatter graphs, we can say that:

1) The nucleus in [Ir] does not pattern like any canonical vowel in terms of formant dynamics or range.

2) The nucleus in [Er] does not pattern like any canonical vowel in terms of formant dynamics or range.

3) The nucleus in [Or] patterns like /o/ in terms of range but not like any canonical vowel in terms of formant dynamics.

4) The nucleus in [Ar] patterns like /ɑ/ both in terms of average formants and formant dynamics.

5) The vowel [ɚ] patterns somewhat like /ʊ/ in terms of range, but does not pattern like any canonical vowel in terms of formant dynamics.

To answer the question raised in section 3.3, namely "do the nuclei of the RGDs fit into Trubetzkoy's Rule VI, do they occur independently" or "does English allow the nuclei of the RGDs within its normal range of vowel allophony?", we can say that:

1) The nuclei in [Ir], [Er], and [ɚ] do not occur independently.

2) The nucleus in [Ar] does occur independently, as /ɑ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3) The status of the nucleus of [Or] is still ambiguous. It could occur independently, as /o/, or it might be distinct.

4) The inclusion of the vowels found before /l/ in any of the ellipses makes little difference.

In the case of [ɚ], the matter was never really in doubt. We have only measured F1 and F2 of the vowels in this study, excluding F3 because of its predictable lowering by the following /r/. However, the distinction in F3 between [ɚ] and /ʌ ʊ/ is relevant here. The vowel [ɚ] is different from the RGDs [Ir Er Ar Or] in that it has a lowered F3 throughout, instead of a gradually lowering F3. Hence, this must be considered a distinctive feature of the vowel rather than some sort of assimilation toward a following segment.

6.3. Vowels before /l/

In chapter 4, several questions were raised regarding the phonetics of vowels before /l/. Let us attempt to answer these questions first before moving on to a general discussion of vowels before /l/. The acoustic data for this section was gathered from the same speakers at the same time as the /vowel-r/ data. The words that are particularly relevant for this section are:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/i/:	*eel*
/ɪ/:	*ill*
/e/:	*ale*
/ɛ/:	*L*
/æ/:	*Al*
/u/:	*pool*
/ʊ/:	*pull*
/o/:	*hole*
/ɑ/:	*all*
/ʌ/:	*hull*

6.3.1. Phonetic classification of post-vocalic /l/

First Question: Is the post-vocalic /l/ a true consonant or a central approximant? If it is a true consonant, it is likely the velarized alveolar lateral [ɫ]. If it is a central approximant, it is likely a retracted one like the velar central approximant [ɰ][17]. The difference between these two sounds, [ɫ] and [ɰ], is slight, and not easily detectable by examination of formant frequencies. The acoustic cues of [ɫ] are a very low F2 and F1 (Ladefoged & Maddieson

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1996: 361), much the same as those for a high back vowel or velar central approximant. The main criterion used to distinguish between [ɫ] and [ɰ] here is amplitude. The lateral [ɫ], being a true consonant, should have lower amplitude than the central approximant [ɰ], and hence there should be a greater fall-off from the preceding vowel.

Measurements of amplitude dynamics of /Vl/ sequences in the words "eel", "ill", "ale", "L", "Al", "pool", "pull", "hole", "all", and "hull" show a relatively weak fall-off of energy (and hence, a central approximant instead of a true consonant) for six of the speakers. This can be illustrated by energy measurements (spectrograms of formants are also provided) of the word "L" spoken by speakers 04 and 08, respectively (Figures 6.36.1, 6.36.2, 6.36.3, 6.36.4)[18]. Energy calculations were made with a Frame Length of 20, a Display Range of 30-80 dB's, and no Smoothing Level. As we can see from the figures, there is a gradual decrease in the energy of Speaker 04's pronunciation of the word "L" throughout, indicating a transition from a vowel to a consonant. However, for Speaker 08, there is no such fall-off. The energy remains fairly steady throughout the pronunciation of the word "L." This indicates that there might not

[17]Thomas (2001: 32) claims that this central approximant variant of /l/ is rounded. I am still using the character [ɰ], however, to maintain a distinction with uncontroversial examples of [w].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

truly be a consonantal "l" after the vowel, but a central approximant. If this post-vocalic /l/ is truly a central approximant, then the /Vl/ sequence is a diphthong, and hence could possible be monophonemic according to Trubetzkoy's criteria (see section 3.1.).

6.3.2. Existence of stressed syllabic /l/

Second Question: Are stressed /Vl/ sequences /ɪl/, /ʌl/, and /ʊl/ pronounced as solely the syllabic lateral [ɫ], without any preceding vowel? If this is true, it would imply that there is a steady-state rhyme in the words "ill", "hull", and "pull." No steady state rhymes were found for the /ɪl/ and /ʌl/ sequences in "ill" and "hull." However, five of the speakers did indeed exhibit steady-state rhymes in the word "pull." Furthermore, it can be shown by comparison that this stressed rhyme is virtually identical to the unstressed syllable in the same speaker's pronunciation of the word "couple", the only difference being duration (82ms in the stressed syllable, 57ms in the unstressed syllable), as in Figure 6.32.1. Although this unstressed syllable in "couple" is usually assumed to be a syllabic [l], this does not necessarily mean that we have a

---

[18]These and all spectrograms mentioned in this section are at the end of the chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

stressed syllabic [l] out of /ʊl/ in "pull." It could be that both "pull" and the second syllable in "couple" have the same rhyme, but that this rhyme is some kind of steady state vowel, not a syllabic [l].

Even if this erstwhile /ʊl/ is not truly a syllabic /l/, what we have found here is still interesting: what was formerly a sequence of vowel + sonorant (in "pull") has now become for many speakers a steady state nucleus which is identical with former syllabic [l]'s (which may have been formerly sequences of unstressed [ə] with coda [l]).

6.3.3. Mergers of vowels before /l/

Third Question: Do we find reduction of vowel contrasts before /l/? No mergers of /i - ɪ/, /e - ɛ/, or /ɛ - æ/, which have been reported for some other dialects, were found in the California English data. However, some mergers of /u - ʊ/ and /o - ʌ/ were found such that the words "pool" and "pull" or "hole" and "hull" were homonyms.

Spectographic evidence of tokens may not be enough to determine true merger, since any two utterances of the same word by the same speaker may have significant differences. To test for merger, all fourteen examples of "pool", "pull", "hole", and "hull" (fifty-six tokens total) were played to a group of 13 judges in a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

random order (Guenter 2001). All the judges were trained phoneticians and/or native speakers of California English.[19] Judges were asked to choose by circling pre-printed words whether they heard "hole" or "hull", or "pool" or "pull". The results are shown in Table 6.3:

Table 6.3 Judges' identification of words as "pool/pull" or "hull/hole" (from Guenter 2001)

word read:	***pool***		***pull***		***hull***		***hole***	
word circled:	pull	pool	pull	pool	hull	hole	hull	hole
S01	1	12	13	0	3	10	10	3
S02	0	13	13	0	0	13	10	3
S03	1	12	9	4	4	9	13	0
S04	0	13	***1***	***12***	3	10	7	6
S05	1	12	***6***	***7***	2	11	***3***	***10***
S06	4	9	13	0	5	8	***1***	***12***
S07	1	12	13	0	3	10	***5***	***8***
S08	1	12	12	1	5	8	8	5
S09	5	8	12	1	6	7	13	0
S10	2	11	13	0	5	8	***6***	***7***
S11	2	11	12	1	2	11	9	4
S12	0	13	13	0	2	11	10	3
S13	4	9	13	0	5	8	***6***	***7***
S14	0	13	12	1	2	11	8	5

Data is listed by Speaker on the left-hand column. Bold face indicates words that the majority of speakers categorized "incorrectly."

In this situation, a merger could be considered to have happened when the majority of judges identified the word as the other word in the pair, i.e., identifying "hole" as "hull" or "pool" as "pull", etc. In reality, though, among thirteen judges, there is little difference between a 6/13 judgment (46%) and a 7/13 judgment (54%). For that matter, the only judgments in Table 6.3 which can be truly considered indicative of mergers are those where a large

[19] There was no significant difference between these two groups of judges, so their responses are grouped together.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

majority identified the word "incorrectly". Specifically, this means the judgments for Speaker 04's pronunciation of "pull", Speaker 05's pronunciation of "hole", and Speaker 06's pronunciation of "hole."

The /u-ʊ/ merger was found only for speaker 04, a Northern California. This merger can be demonstrated by spectrograms of the words "pull" and "pool" (see Figure 6.32.2). The formant measurements of speaker 04's production of the words "pull" and "pool" look almost identical. There is a difference is duration, however. The duration for the total rhyme in "pool" is 395 ms. compared with 330 ms for the total rhyme in "pull." We don't have enough data to tell whether this represents a consistent distinction in duration between these two words, or just between the two tokens. This situation may be contrasted with the pronunciation of the same two words by Speaker 14 (Figure 6.32.3), for whom the words "pool" and "pull" are clearly different. Speaker 14's vowel in "pull" has a clearly higher F2 than the one in "pool."

The /o-ʌ/ merger was found for two speakers: one Southern California Females (05) and one Northern California Male (06). This merger can be demonstrated by spectrograms of the words "hole" and "hull" (see Figure 6.32.3, here exemplified by speaker 06). The spectrograms of the words "hole" and "hull" here look almost identical. This situation may be contrasted with the pronunciation of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the same two words by Speaker 03 (Figure 6.32.5), for whom the words "hole" and "hole" are clearly different. Speaker 03's vowel in "hull" has a clearly higher F2 than the one in "hole."

Note that the direction of merger is always one-way. That is to say, "pull" was identified as "pool" and "hull" as "hole", but never "pool" as "pull" or "hole" as "hull." This strongly suggests that the mergers in question are the result of two sound changes:

1) ʊ > u / _ l

2) ʌ > o / _ l

These two sound changes are similar in that they both involve a shorter, "lax", less peripheral, less rounded, non-front vowel becoming more like its longer, "tense", more peripheral, more rounded[20] counterpart. This may be explained as a case of anticipatory assimilation to the following /l/. As we have seen, this post-vocalic /l/ is either a velarized lateral [ɫ] or a central approximant [ɰ]. In both cases, it has formant values similar to a high or higher-mid back vowel. The assimilation effects of this /l/

[20] At least before /l/. As we shall see, many of the supposedly "back round" vowels actually have more centralized, unrounded variants in other environments.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

on /ʊ/ or /ʌ/ would make them difficult to distinguish from their counterparts /u/ and /o/.

However, such an explanation cannot account for the reported mergers of /i-ɪ/, /e-ɛ/, or /ɛ-æ/ before /l/. Granted, none of those mergers were found in the dialect under study, but having a unified account of all mergers in vowels before /l/ would be helpful.

Let us recall from the discussion of the merger of vowels before /r/ in section 2.3 the hypothesis that these mergers were caused by the historical change of /r/ from a true consonant to a central approximant. This resulted in phonetic diphthongs from former sequences of /Vr/. Since it has been shown that transitions, not just steady states, are major cues in distinguishing diphthongs, sequences with similar transitions, such as [oɹ] and [ɔɹ], are likely candidates for merger.

This can also account for the loss of contrast in vowels before /l/. If post-vocalic /l/ changes from a lateral to a central approximant, or at least gets more vocalic, then we also have diphthongs or diphthong-like sequences coming from former [Vl] sequences. Hence, the same factors that resulted in loss of contrasts before /r/ would apply. Diphthongs with similar transitions, such as [iɰ] and [ɪɰ], [eɰ] and [ɛɰ], [ɛɰ] and [æɰ], or [oɰ] and [ʌɰ], would be difficult to distinguish, and could be merged.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The insertion of a post-vocalic [ə] after some vowels before /l/ (Bronstein 1960: 200, Cruttenden 1994: 188) could also help to explain the merger of front vowels we find in some dialects. The insertion of the [ə] creates a diphthong, hence the transition would be a major cue, and it would be difficult to distinguish [iə] and [ɪə], etc.

6.3.4. Acoustic categorization of vowels before /l/

Fourth Question: Are the vowels that occur before /l/ associable with any of the canonical vowel phonemes? As we have seen in section 4.1, based on the notion of contrast, the answer is "yes." We have no trouble assigning each vowel phoneme of American English to one of the vowels that occur before /l/. However, the mergers and other phonological changes that we have seen involving vowels before /l/ require a detailed account of the acoustics of the vowels before /l/. That is to say, certain phonetic and phonological changes suggest the possibility of monophonemic diphthongal analysis for former /Vl/ sequences, thus it is necessary to see if the vowels that occur before /l/ bear phonetic resemblance or not to the vowels that occur independently in English, in much the same manner as we did for the vowels before /r/ in Section 6.2, above.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6.3.4.1. Formant dynamics (line graphs)

Observation of the line graphs of the formant dynamics of the vowels before /l/ (Figures 6.16 - 6.25) show no major differences between the three population groups, so they can be discussed together as a whole.

The /i/ found before /l/ is very much like an average /i/ at T1 (Figures 6.16.1, 6.16.2, 6.16.3). As it moves on to T3, the F1 increases and the F2 decreases (sometimes severely). This indicates a degree of centering and lowering as the vowel approaches the following /l/. The same can be said of /ɪ/ and /e/ before /l/ (Figures 6.17.1, 6.17.2, 6.17.3, 6.18.1, 6.18.2, 6.18.3). They both begin very much like their non-lateral counterparts, but display a convergence of F1 and F2 as they move on toward T3, indicating a lowering and centralizing effect. The divergence of F2 from the average is always greater than that of F1, showing the centralizing effect to be greater than the lowering one.

The vowels /ɛ/ and /æ/ behave similarly to /i/, /ɪ/, and /e/ before /l/ (Figures 6.19.1, 6.19.2, 6.19.3, 6.20.1, 6.20.2, 6.20.3), the difference being that they show a distinctly lower F2 even at T1, this distinction continuing or even increasing as they move on toward F3.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.16.1 /i_l/ compared to /i/ (Males)

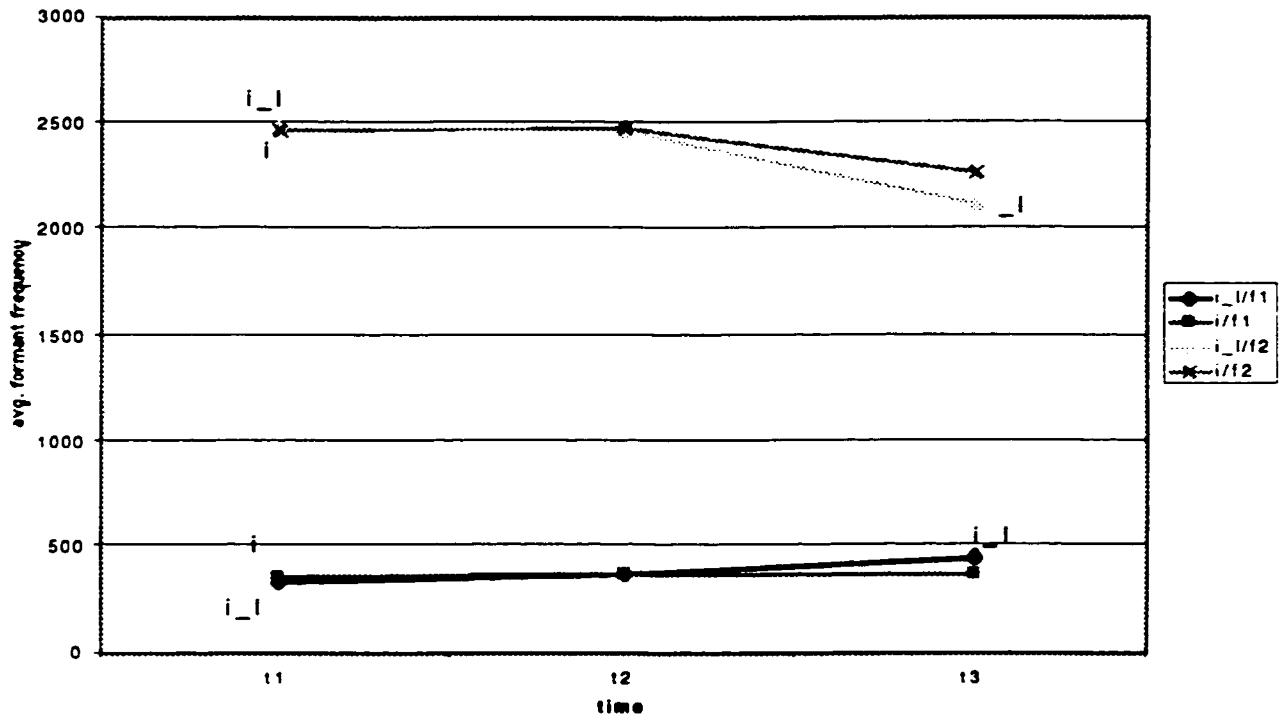
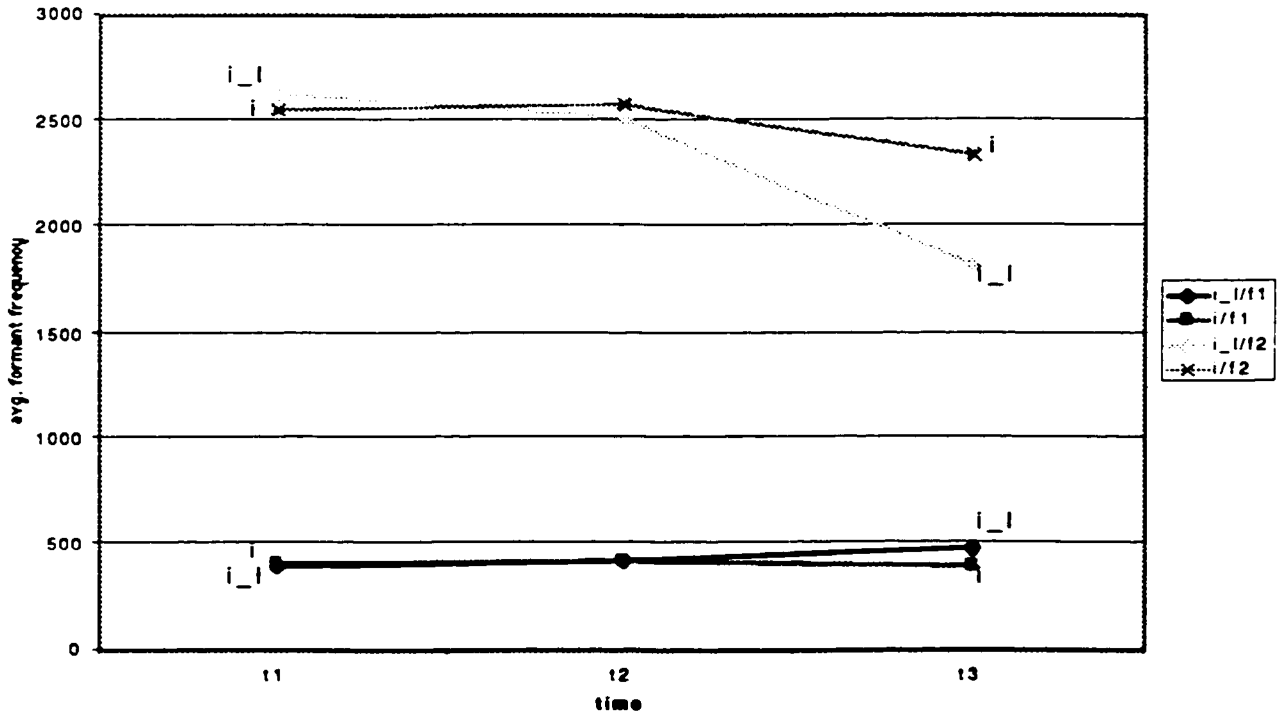


Figure 6.16.2 /i_l/ compared to /i/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.16.3 /i_l/ compared to /i/ (Female Southern)

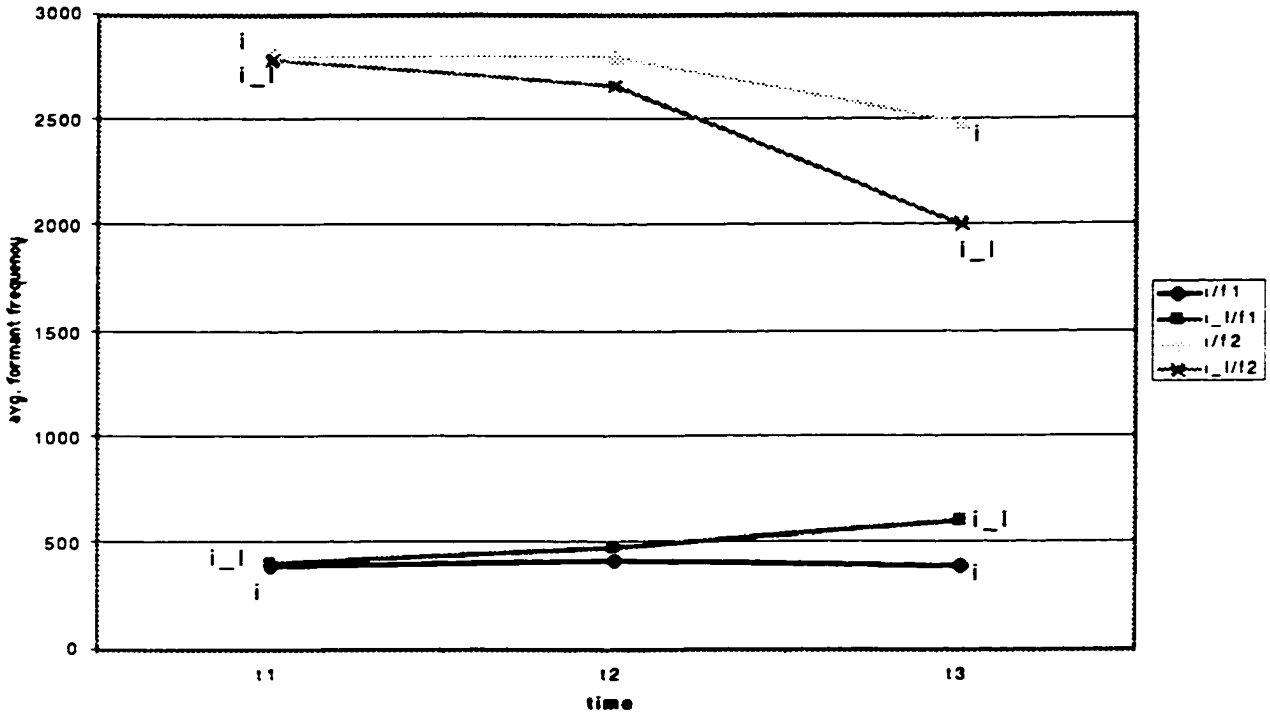
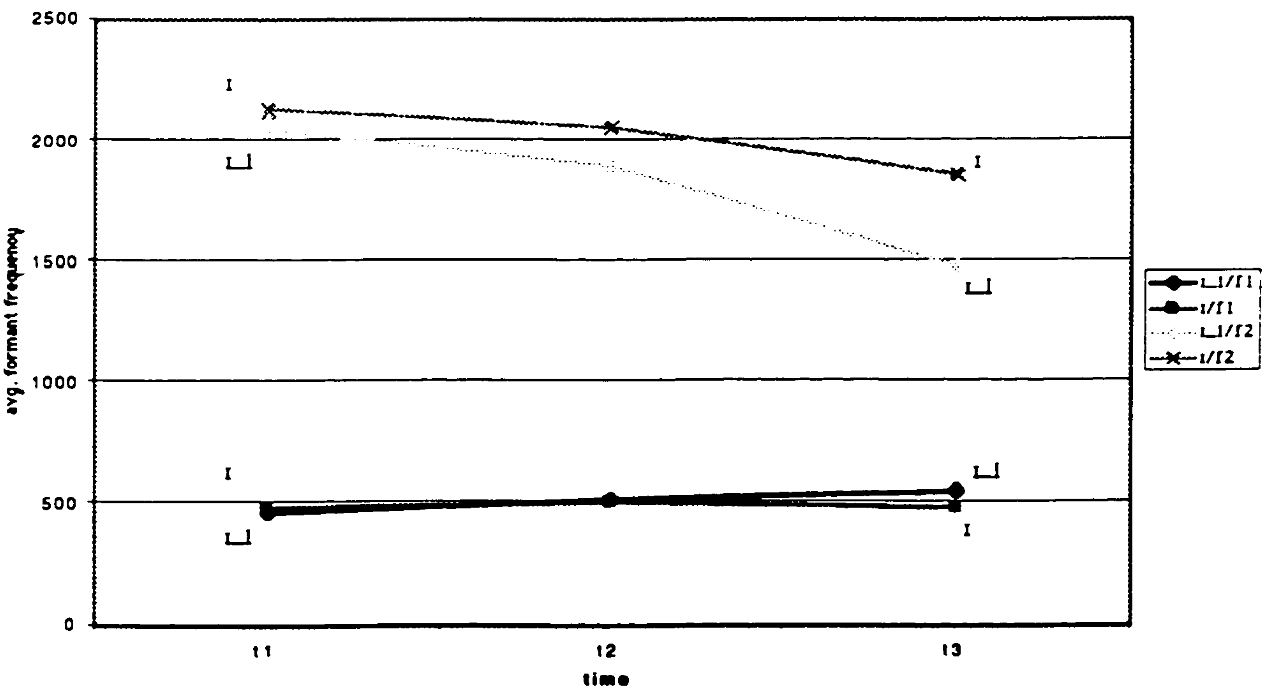


Figure 6.17.1 /ɪ_l/ compared to /ɪ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.17.2 /ɪ⊔l/ compared to /ɪ/ (Female Northern)

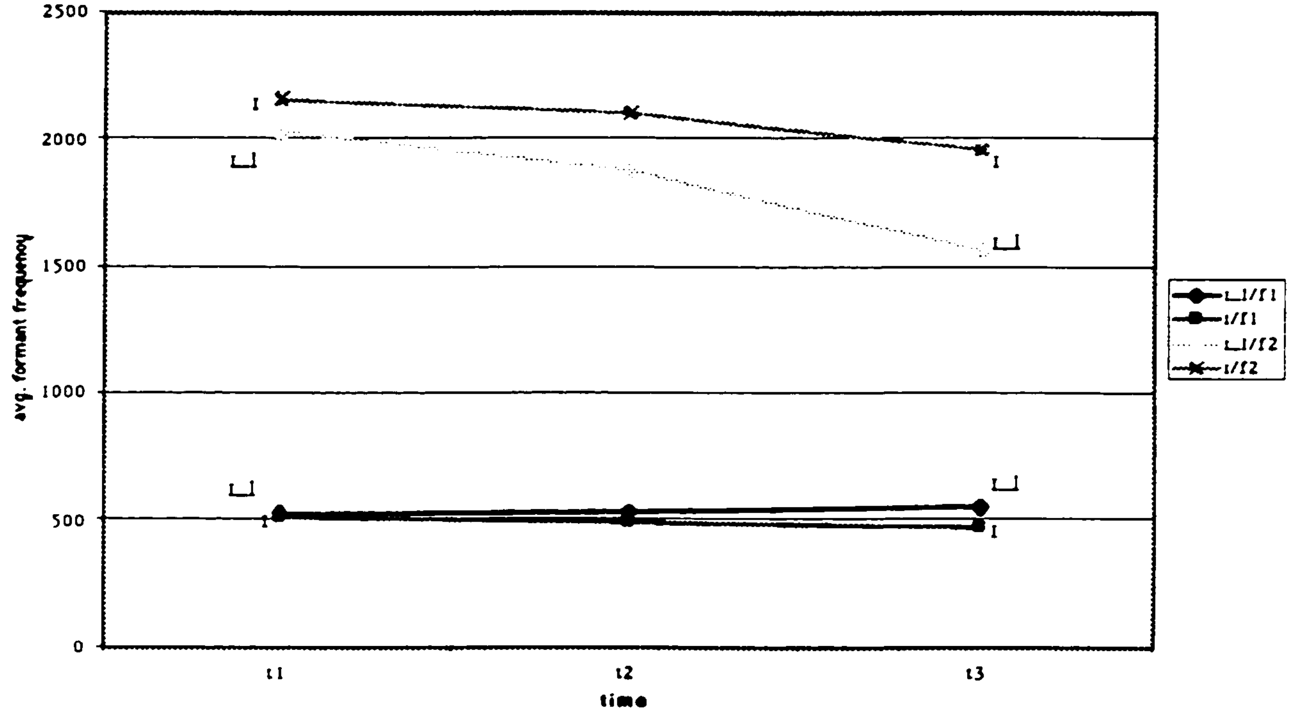
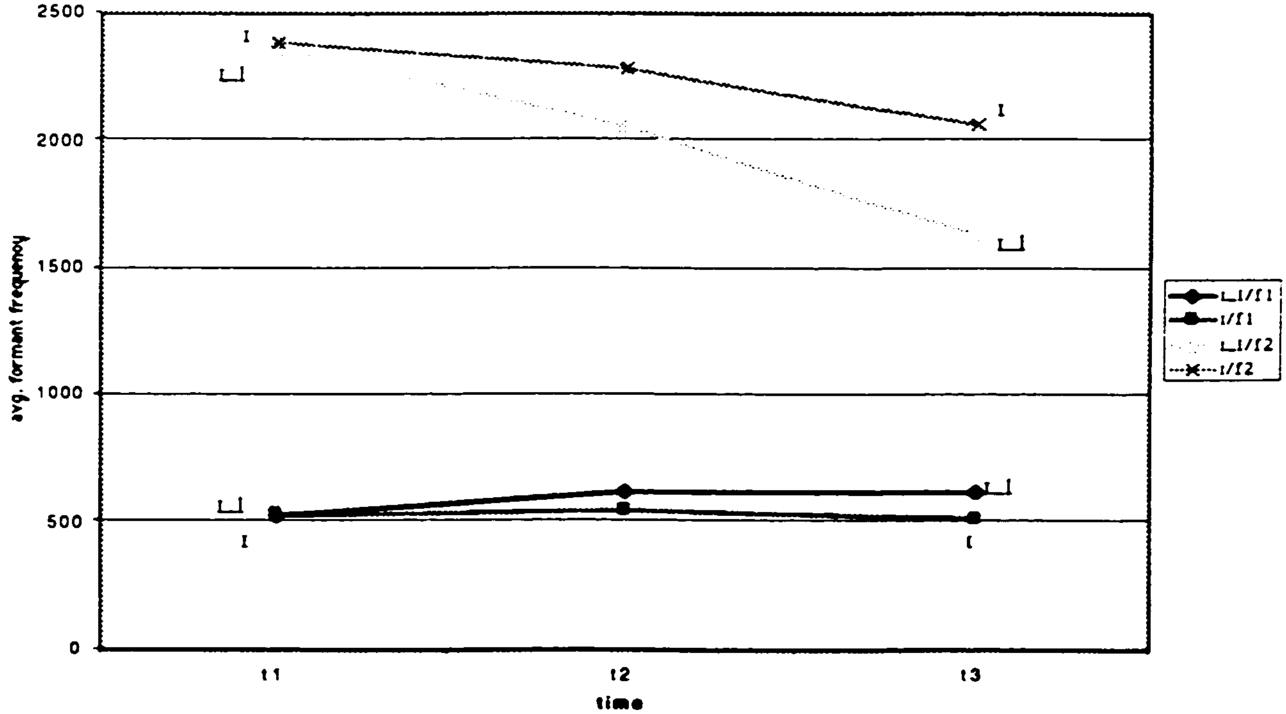


Figure 6.17.3 /ɪ⊔l/ compared to /ɪ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.18.1 /e_I/ compared to /e/ (Males)

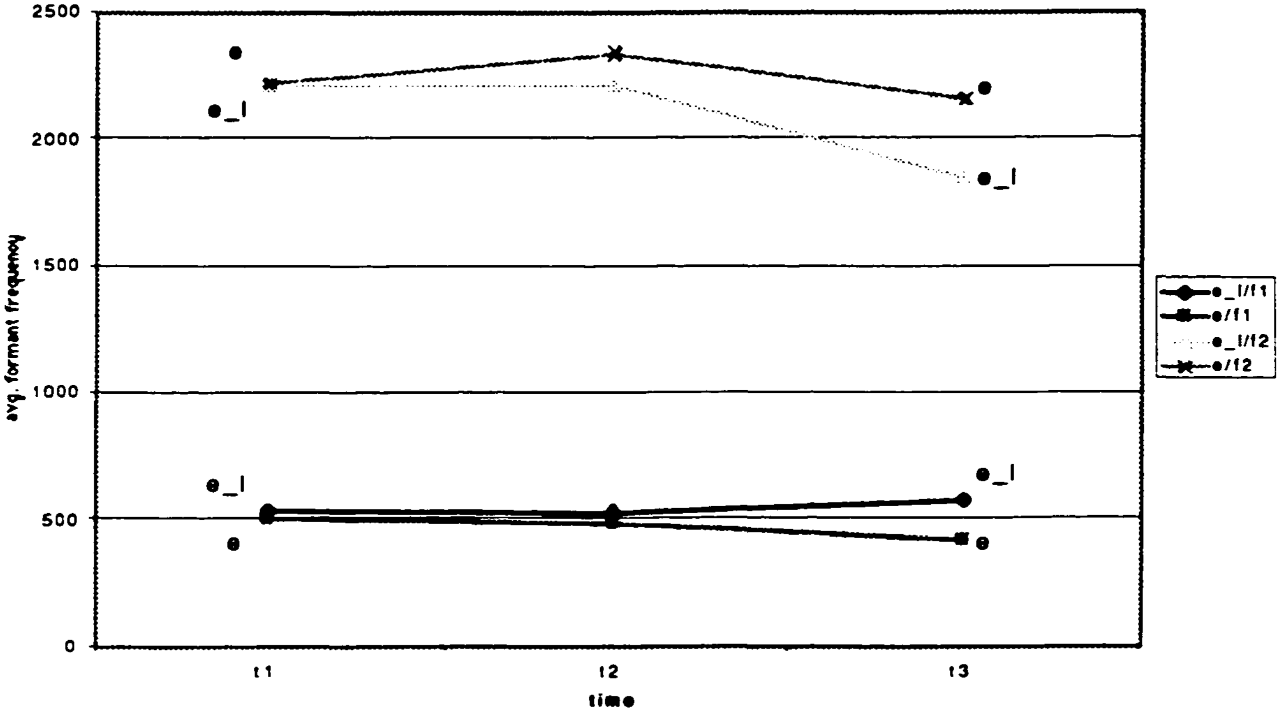
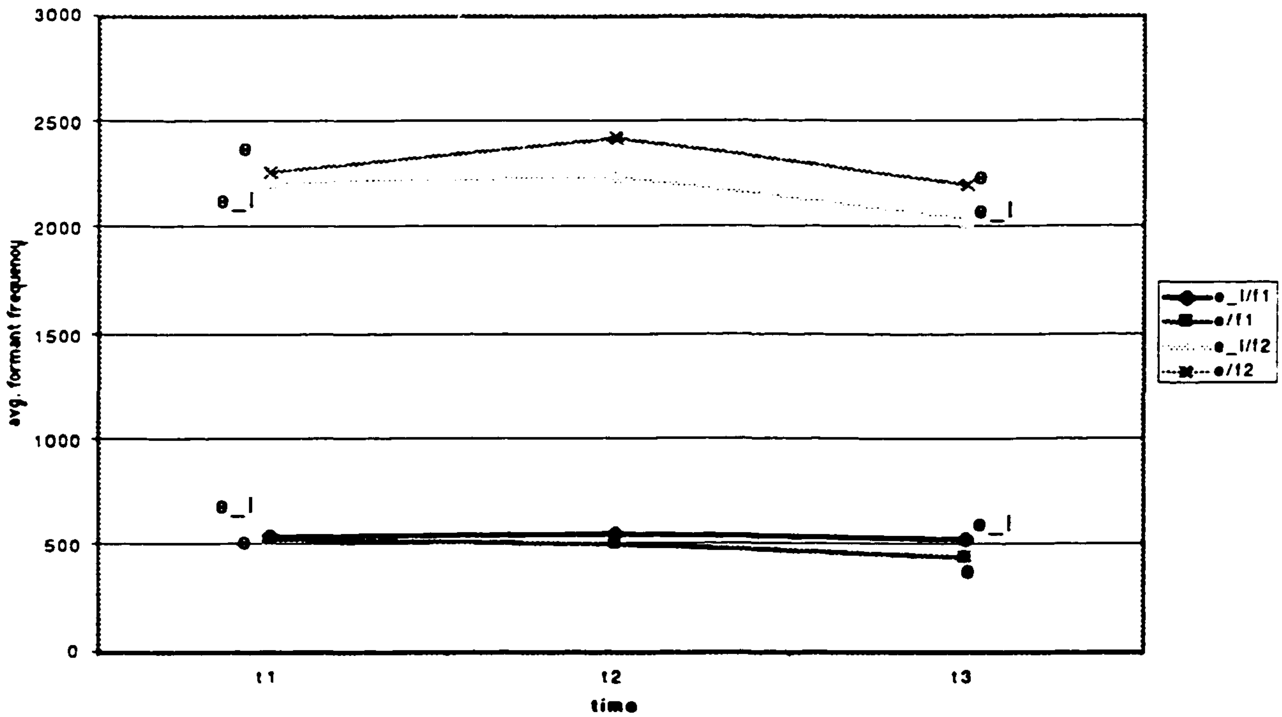


Figure 6.18.2 /e_I/ compared to /e/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.18.3 /e_I/ compared to /e/ (Female Southern)

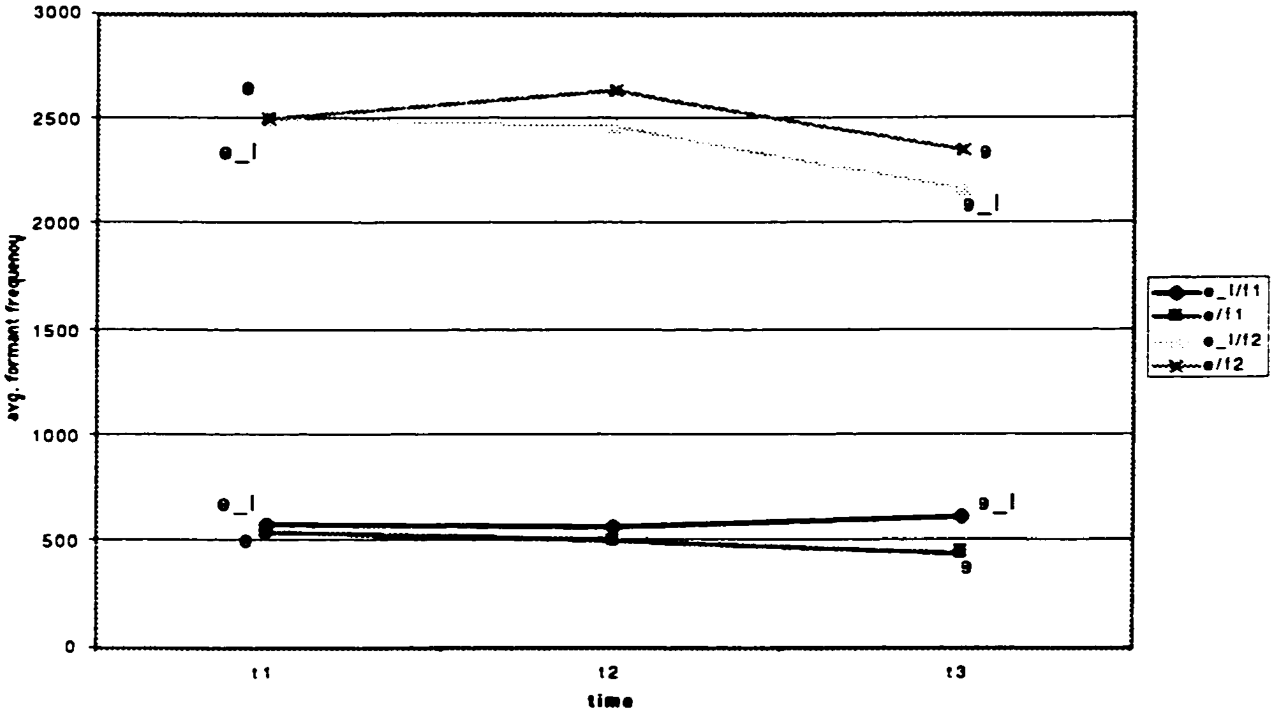
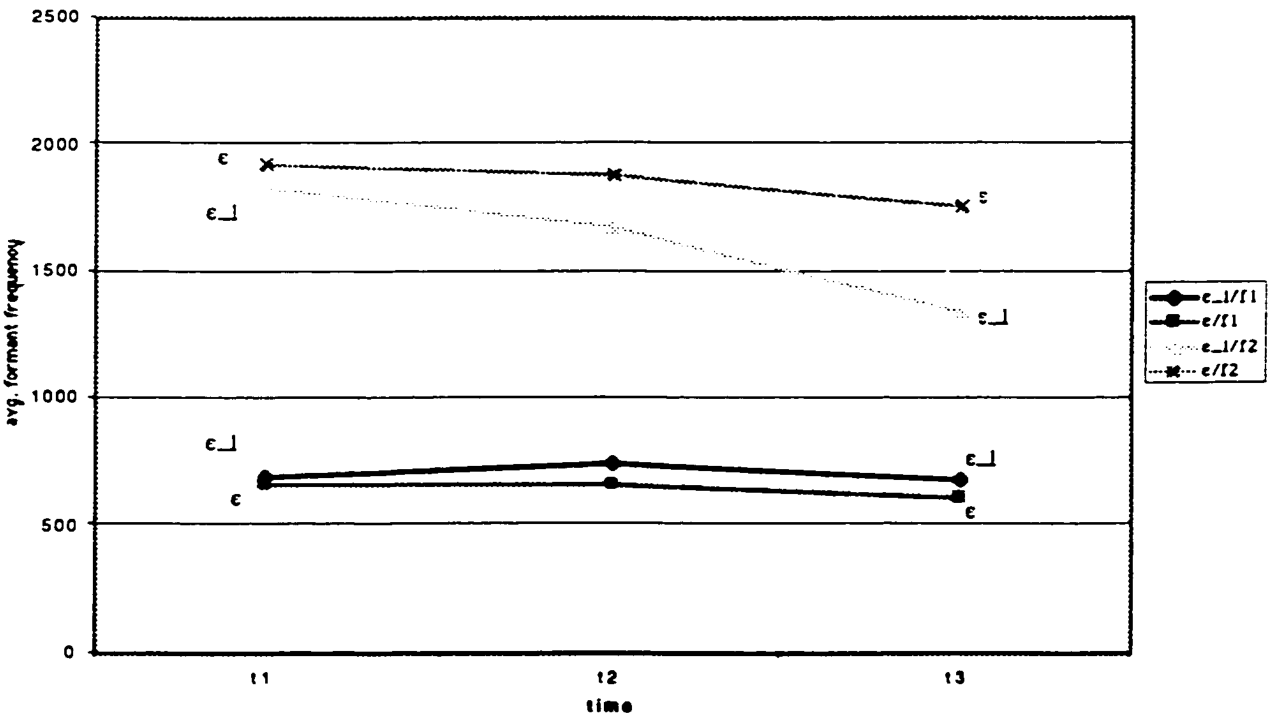


Figure 6.19.1 /ɛ_l/ compared to /ɛ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.19.2 /e_l/ compared to /e/ (Female Northern)

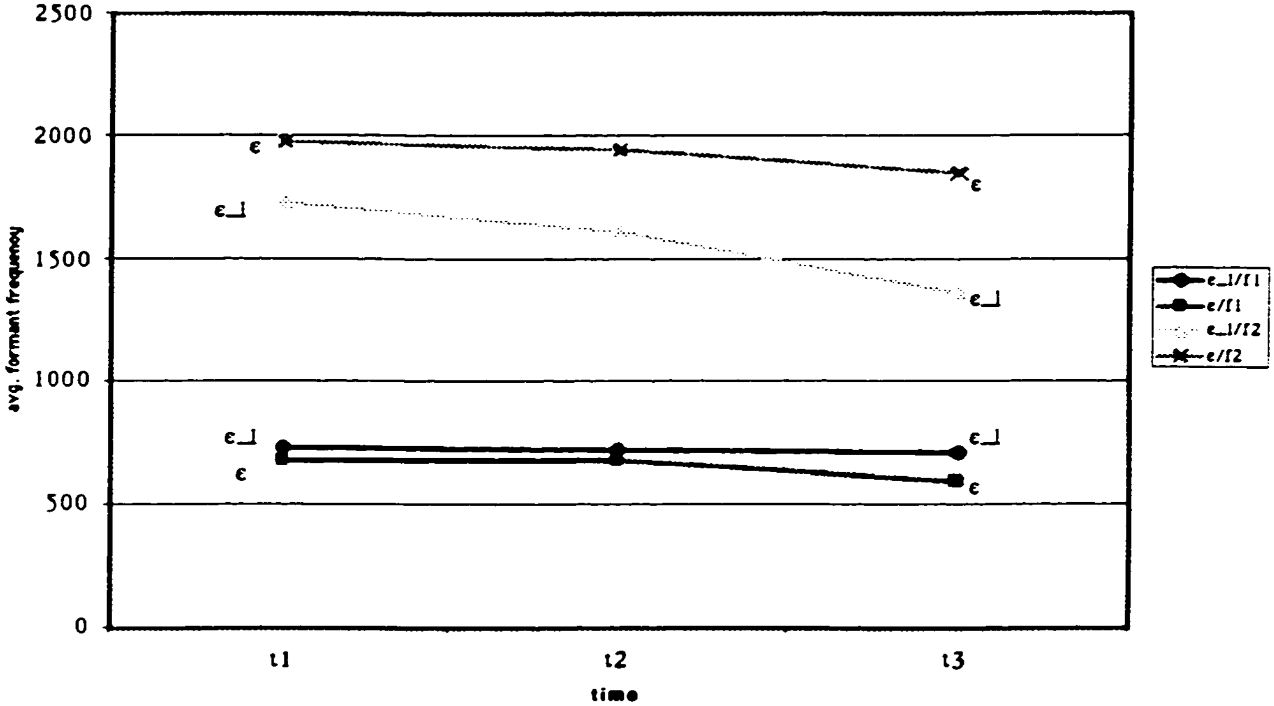
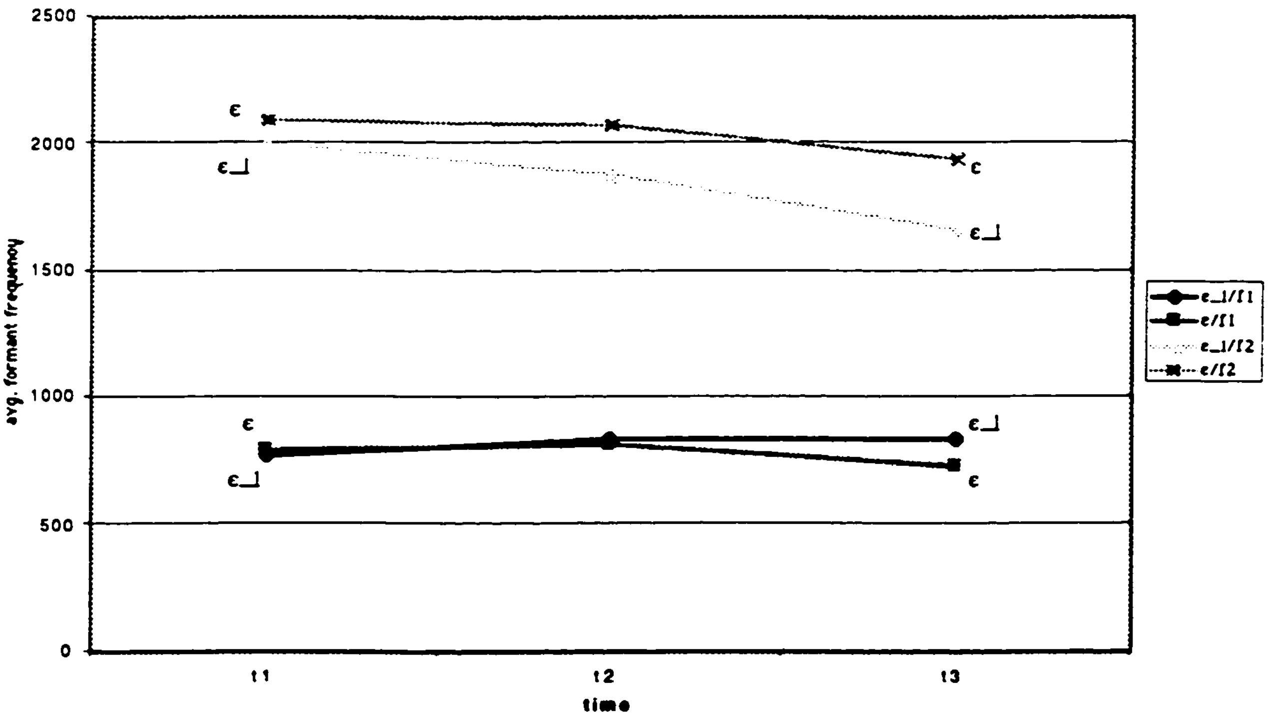


Figure 6.19.3 /e_l/ compared to /e/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Examination of the /u/ found before /l/ (Figures 6.21.1, 6.21.2, 6.21.3) shows an F1 identical to that of an average /u/, but an F2 which is much lower, indicating a high degree of backing or rounding influence by the following /l/. It has been remarked that American English, particularly California English, may display a very fronted and/or unrounded variant of /u/ (Ladefoged 1999: 43), as can be determined from the very high average F2 measurements. It may well be the case that a following /l/ exhibits a conservative effect on the preceding /u/, making it retain its back rounded position.

A similar effect can be seen on the /ʊ/ which precedes /l/[21] (Figures 6.22.1, 6.22.2, 6.22.3). The F1 is equivalent to the F1 of average /ʊ/, but the F2 is much lower. The divergence between the two F2s increases with time. The F2 of an average /ʊ/ increases, indicating movement to a fronter or less rounded position, while the F2 of the /ʊ/ before /l/ remain fairly constant. Unrounded pronunciations for /ʊ/ have also been reported (Ladefoged 1999: 43). Parallel to /u/, it may be that the following /l/ has a conservative effect on the preceding /ʊ/, preserving a more rounded

---

[21]Though, as we have seen in section 6.3.2, this erstwhile /ʊl/ sequence may actually be the syllabic lateral [ɫ̩].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.20.1 /æ_l/ compared to /æ/ (Males)

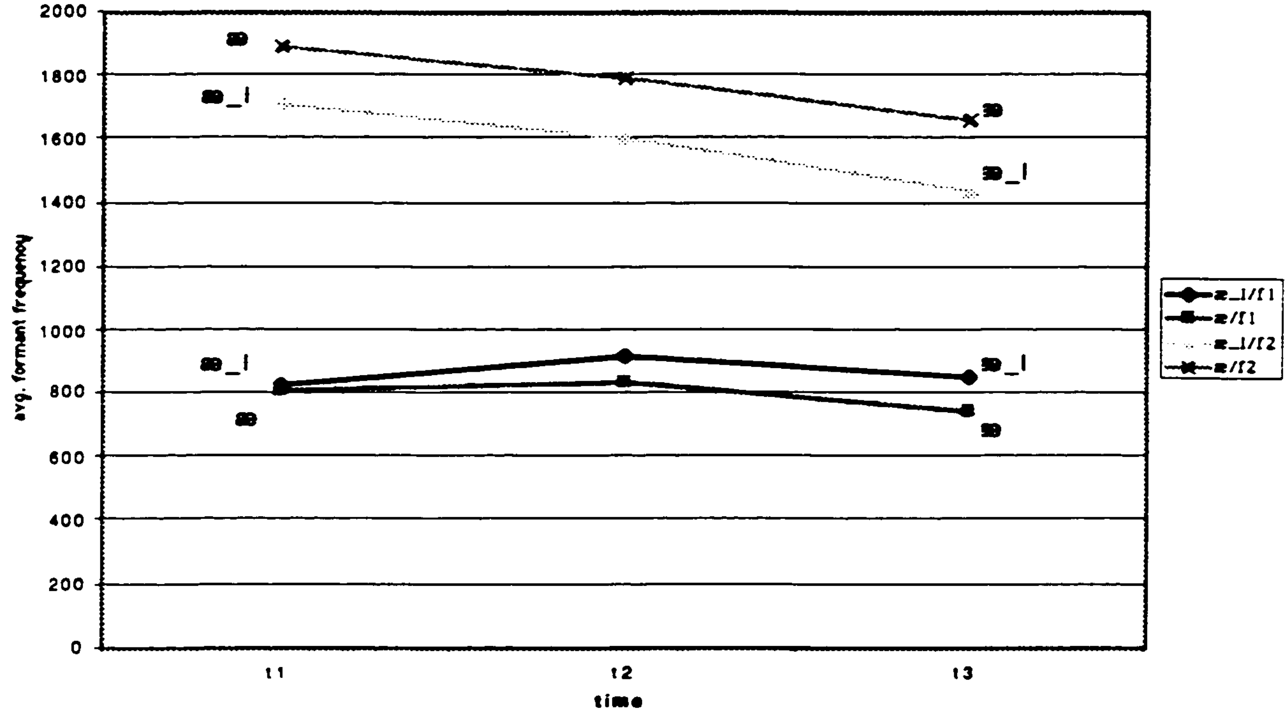
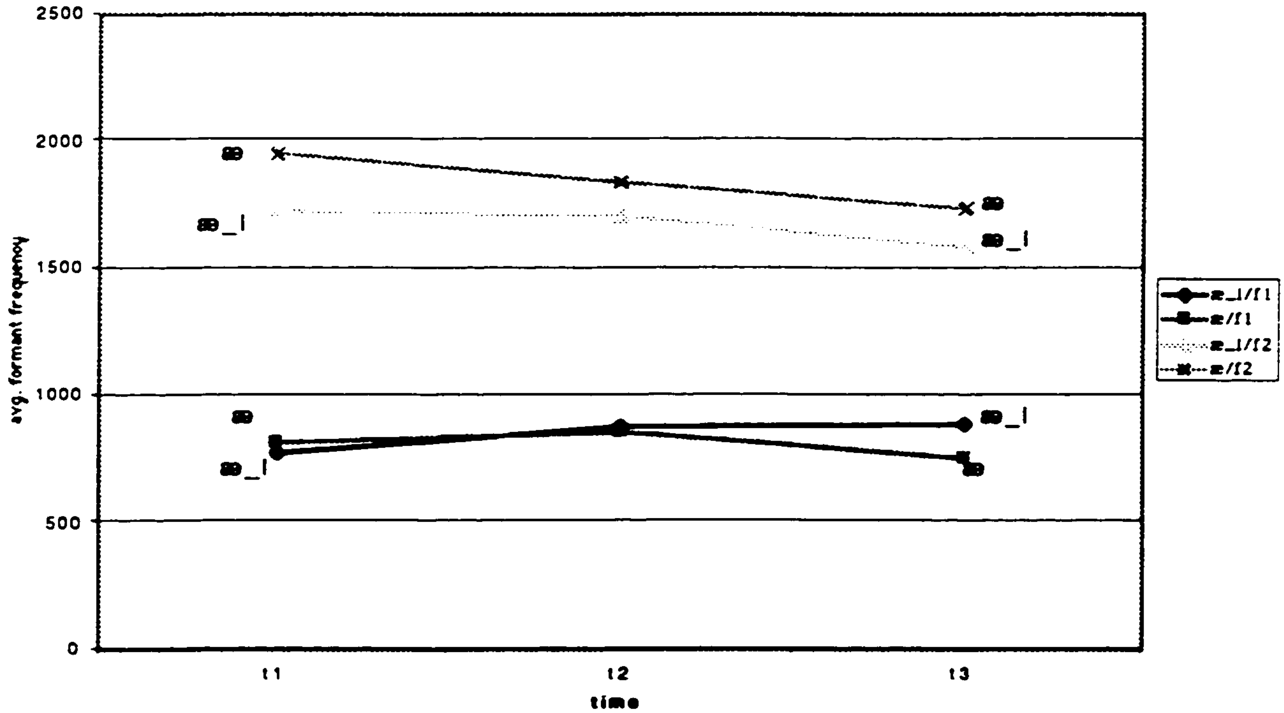


Figure 6.20.2 /æ_l/ compared with /æ/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.20.3 /æ_l/ compared with /æ/ (Female Southern)

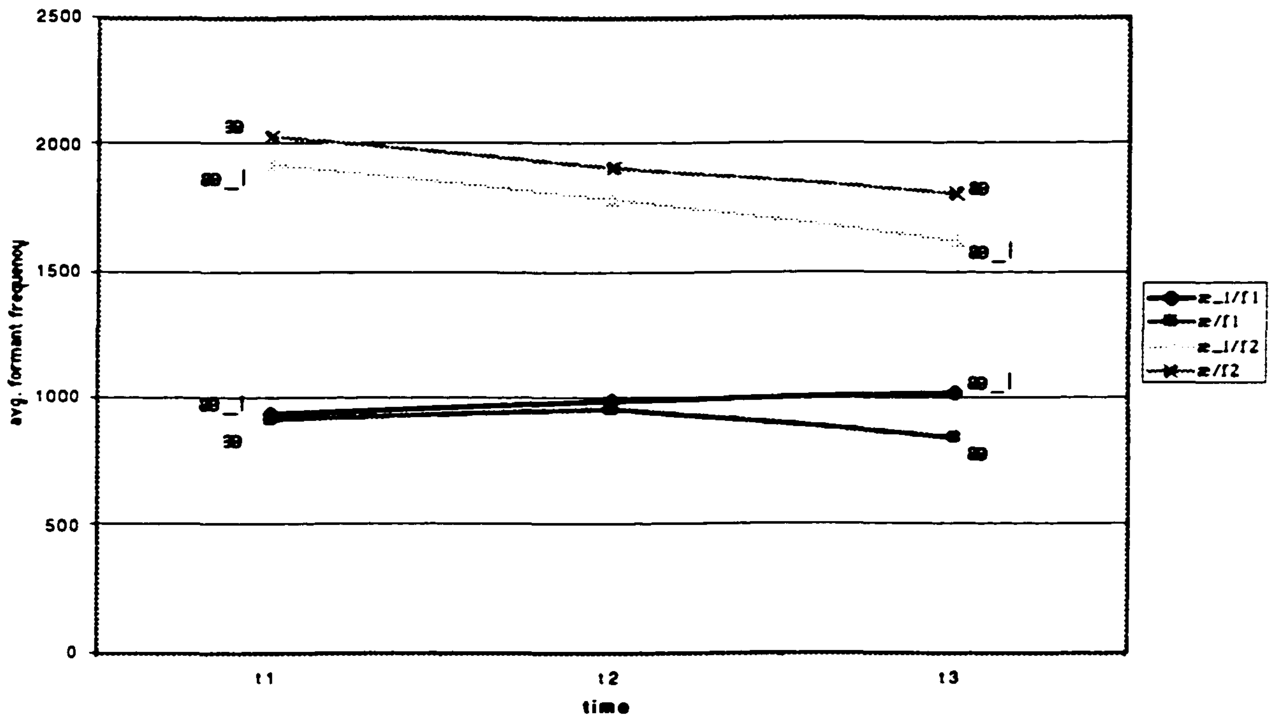
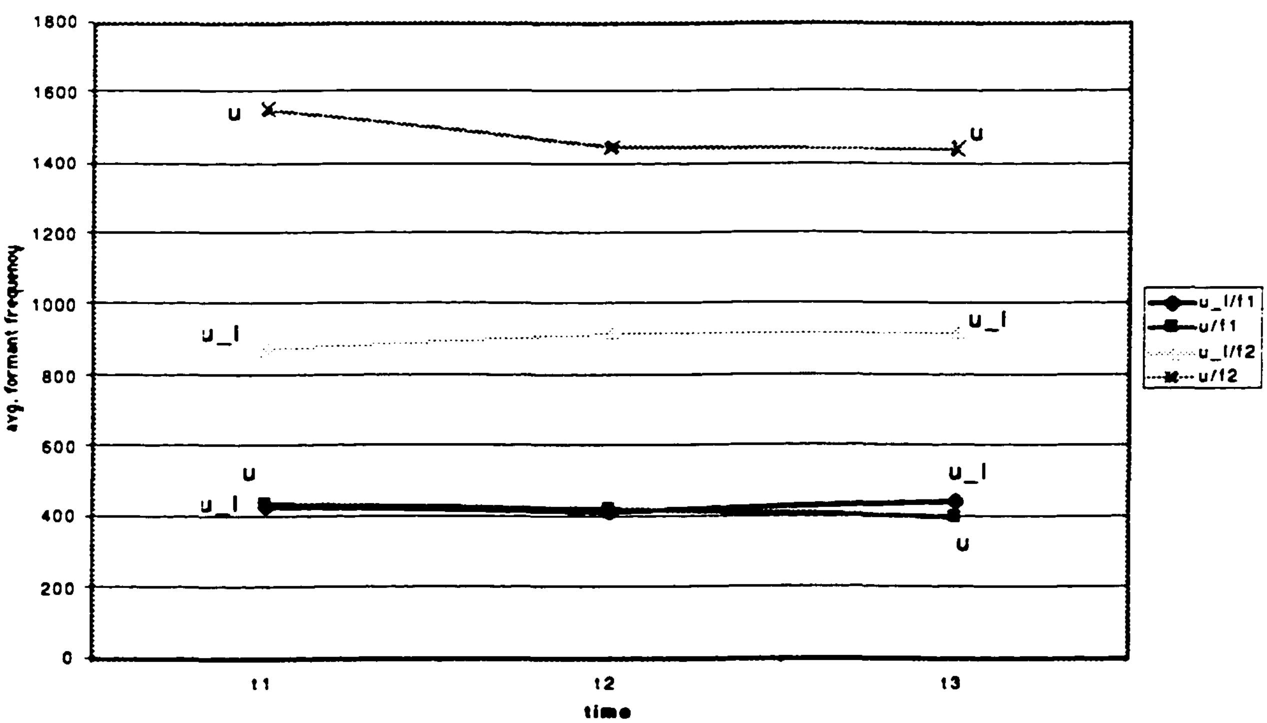


Figure 6.21.1 /u_l/ compared to /u/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.21.2 /u_l/ compared with /u/ (Female Northern)

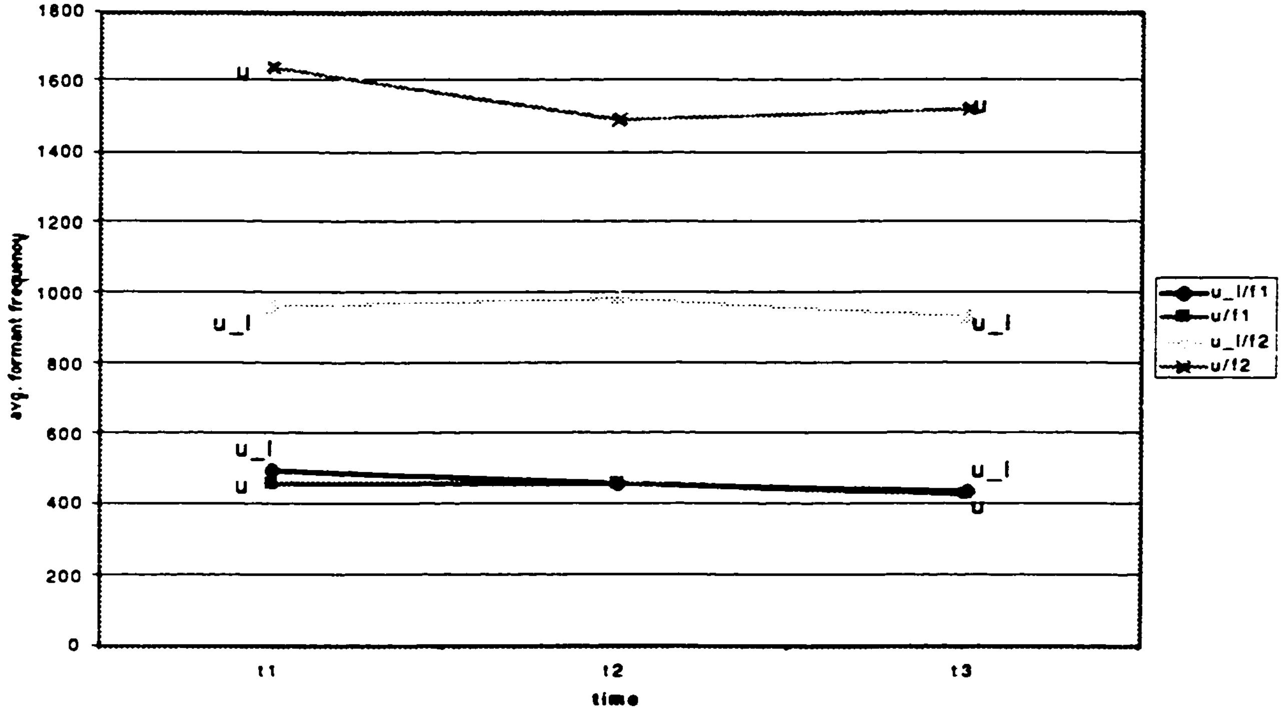
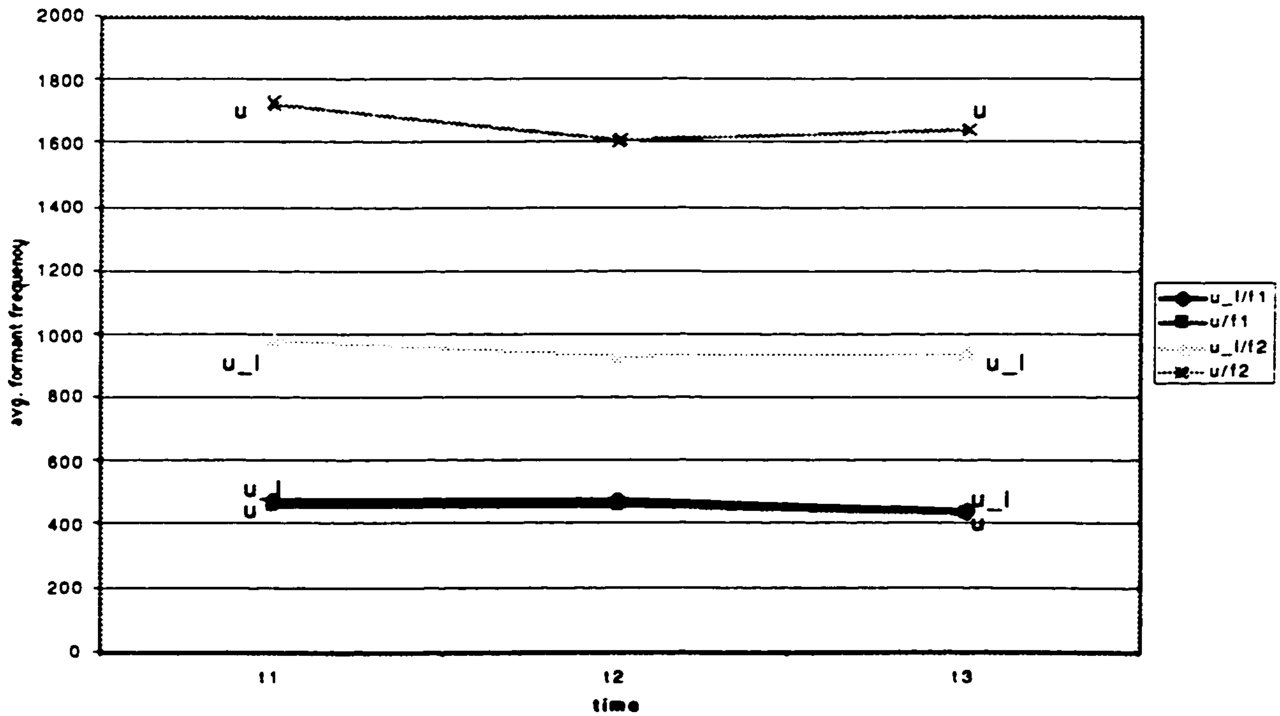


Figure 6.21.3 /u_l/ compared with /u/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

articulation. Even in dialects in which /ul/ is a syllabic lateral, it is claimed that lip rounding accompanies the production of this [ɫ] (Bailey 1985: 103).

The vowels /o/, /ɑ/, and /ʌ/ display similar effects before /l/ (Figures 6.23.1, 6.23.2, 6.23.3, 6.24.1, 6.24.2, 6.24.3, 6.25.1, 6.25.2, 6.25.3). For all of these vowels, the F1 of the vowel found before /l/ is basically the same as that of an average exemplar of that vowel, but there is a tendency for it to be lower. A possible reason for this would be velar constriction or approximation of the following /l/ (which could be [ɫ] or [ɰ]). The back of the tongue, which is used during production of the non-front vowels /u ʊ o ɑ ʌ/, could be assimilating to the higher tongue position required for the production of the [ɫ] or [ɰ]. This would explain why this lowering of F1 is not found for the front vowels /i ɪ e ɛ æ/, which do not require the back of the tongue during production, and why the lowering of F1 is not found for the higher non-front vowels /u ʊ/, for which the tongue back is already in a fairly constricted position.

Parallel to /u/ and /ʊ/, the vowels /o/, /ɑ/, and /ʌ/ all exhibit significant lowering of F2 before /l/. The average formant measurements of the vowel /o/ show a gradual decrease in F2, indicating diphthongal quality, perhaps beginning with a more

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

unrounded vowel, moving to something back and rounded, phonetically like [ɤʊ]. The variant of /o/ found before /l/ may parallel this diphthongal quality, but always preserves a more back and rounded position.

In non-lateral environments, the vowel /ɑ/ standardly shows an increase of F2, indicating a glide toward a higher, fronter position, phonetically like [ɑə]. The variety of /ɑ/ found before /l/ does not exhibit this centering glide, but remains fairly back, perhaps becoming even more retracted.

The vowel /ʌ/ has a much lower F2 before /l/ than in its average variants. This, coupled with the lower F1 of the lateral variant would suggest a higher, backer variety of /ʌ/ before /l/, perhaps phonetically much like [ɤ]. It is not surprising, then, that this lateral variety [ɤ] could become confused with the standard variety of the vowel /o/ ([ɤʊ]), resulting in merger of the two vowels before /l/ (see section 6.3.3).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.22.1 /ʊ_l/ compared to /ʊ/ (Males)

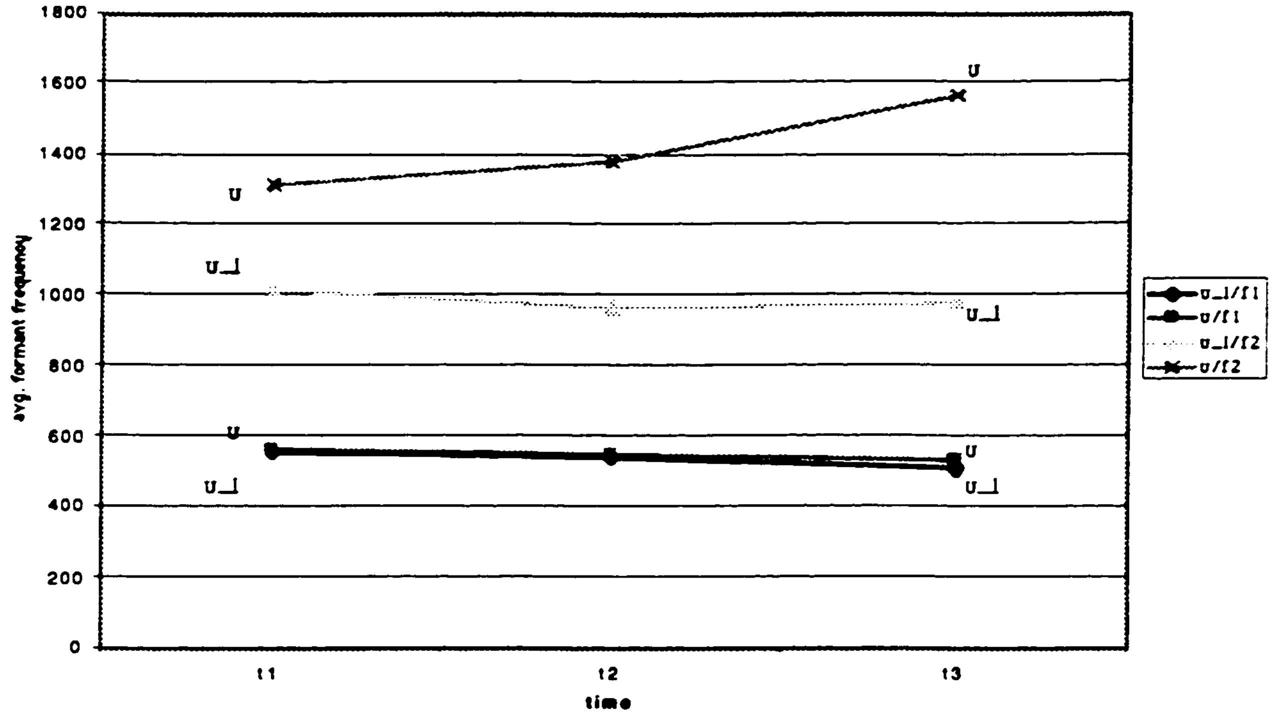
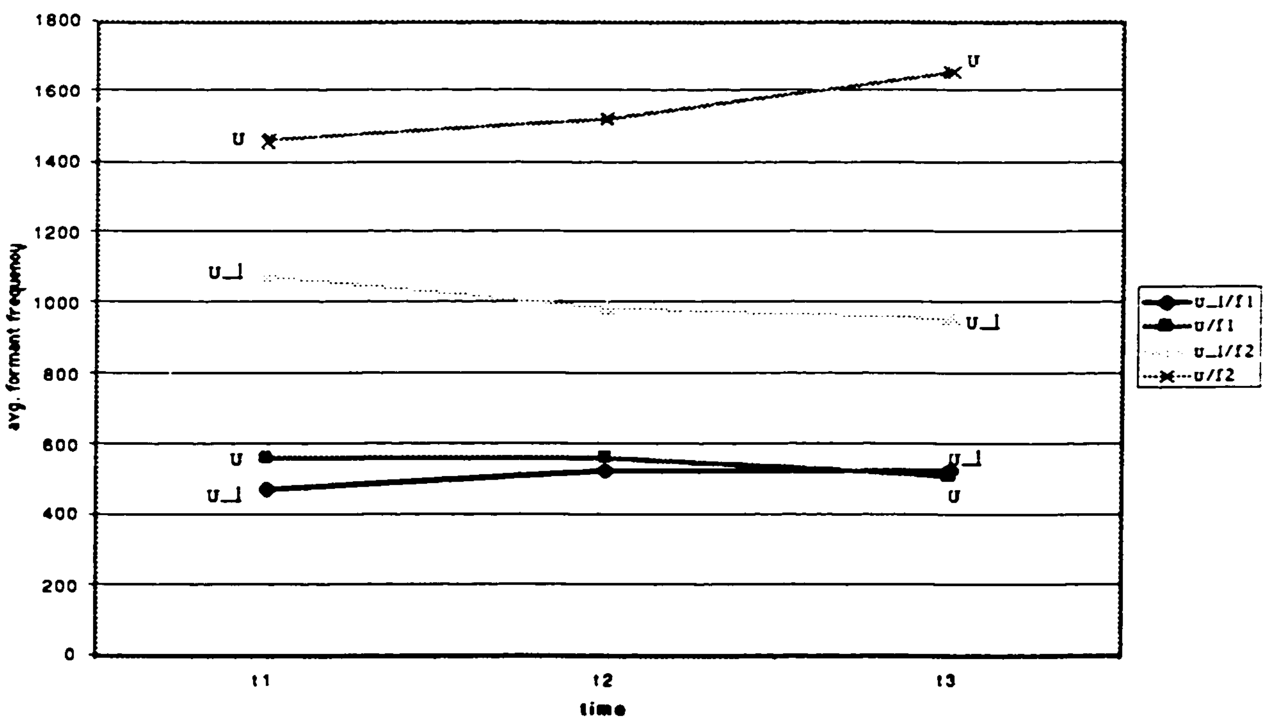


Figure 6.22.2 /ʊ_l/ compared with /ʊ/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.22.3 /ʊ_l/ compared to /ʊ/ (Female Southern)

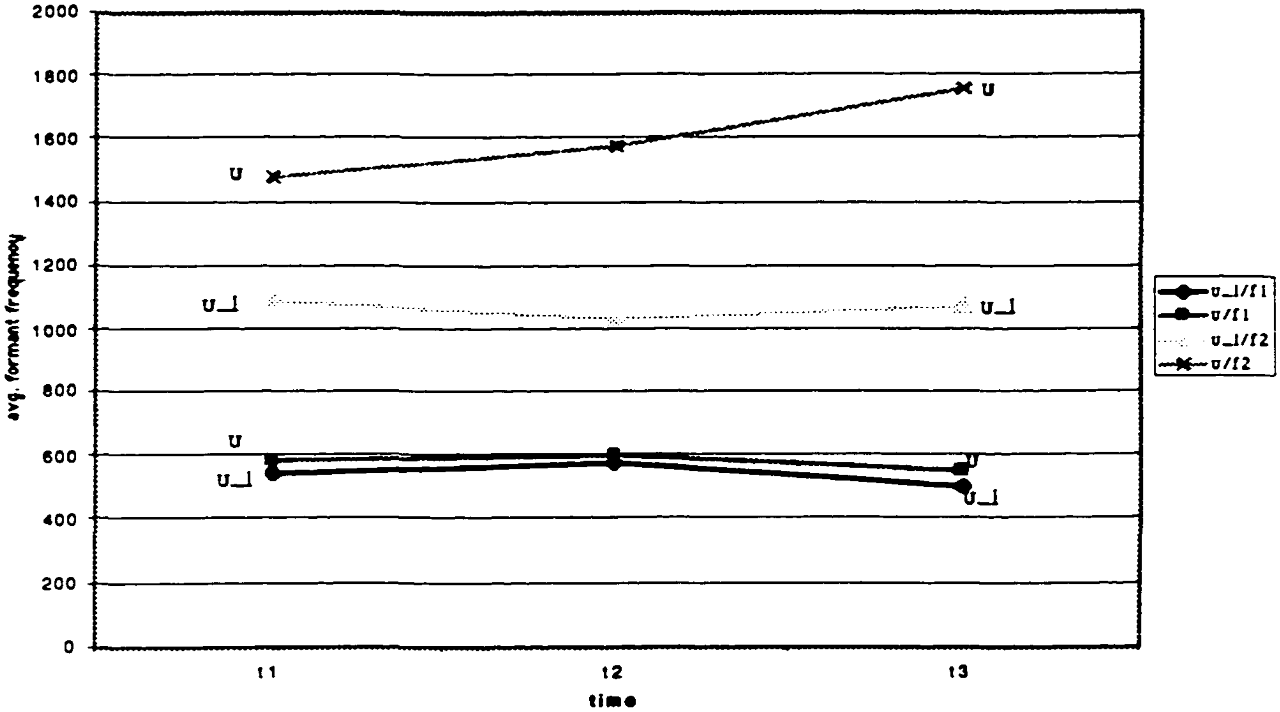
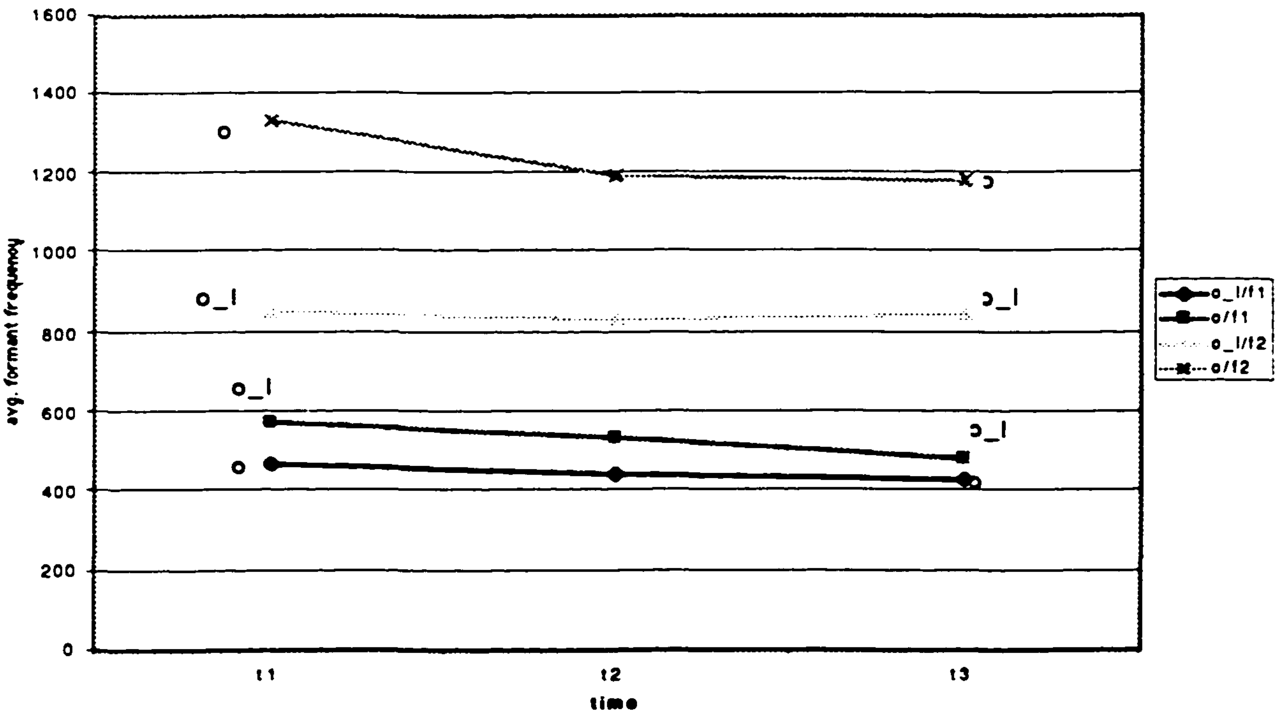


Figure 6.23.1 /o_l/ compared to /o/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.23.2 /o_l/ compared with /o/ (Female Northern)

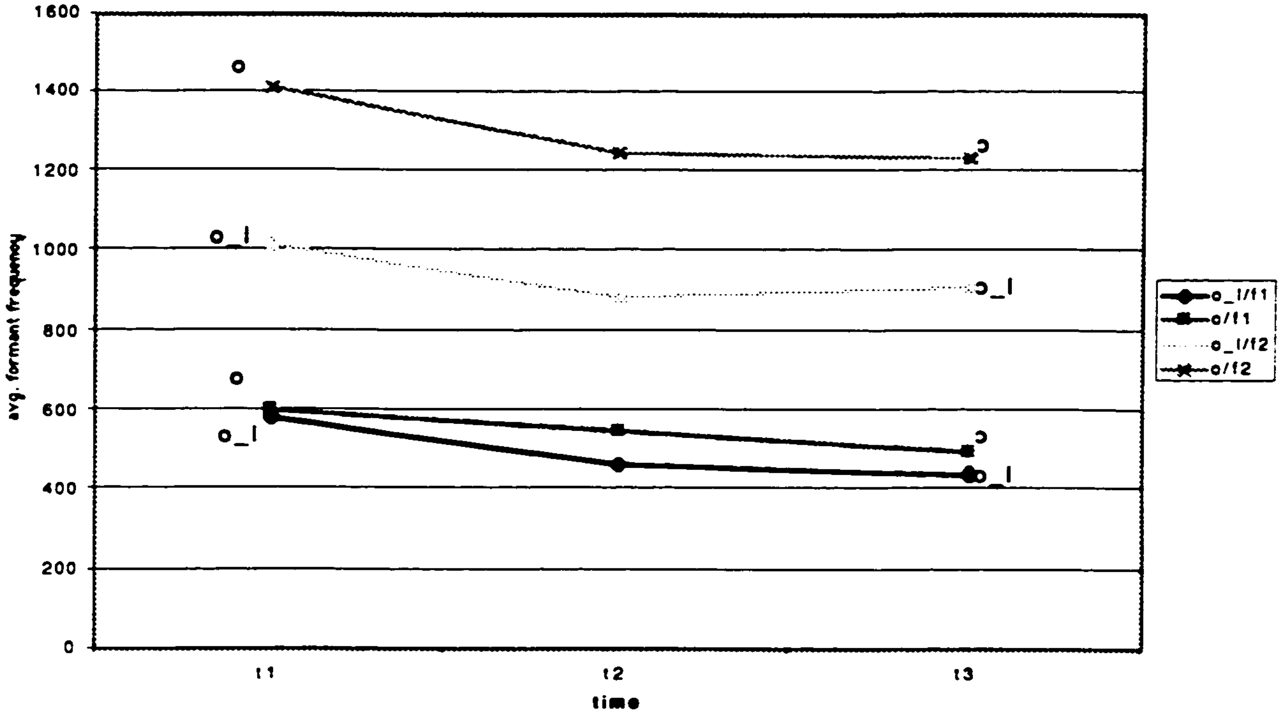
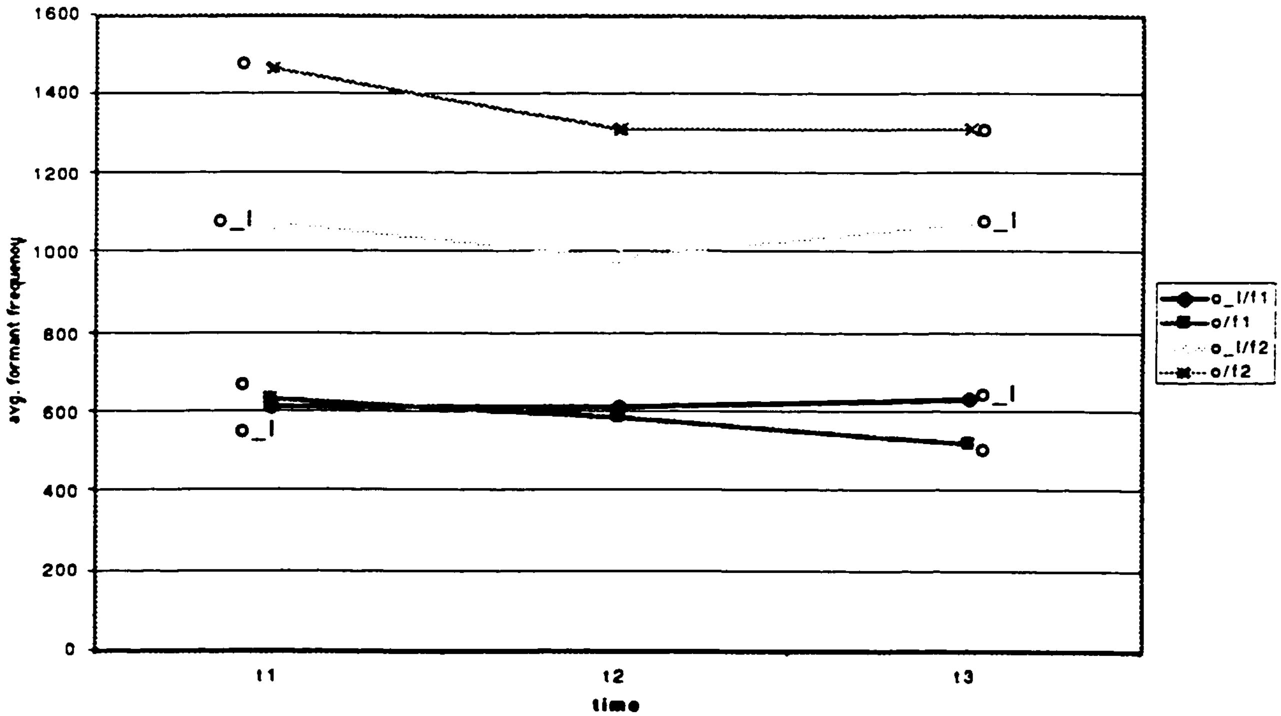


Figure 6.23.3 /o_l/ compared to /o/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.24.1 /a˩/ compared to /a/ (Males)

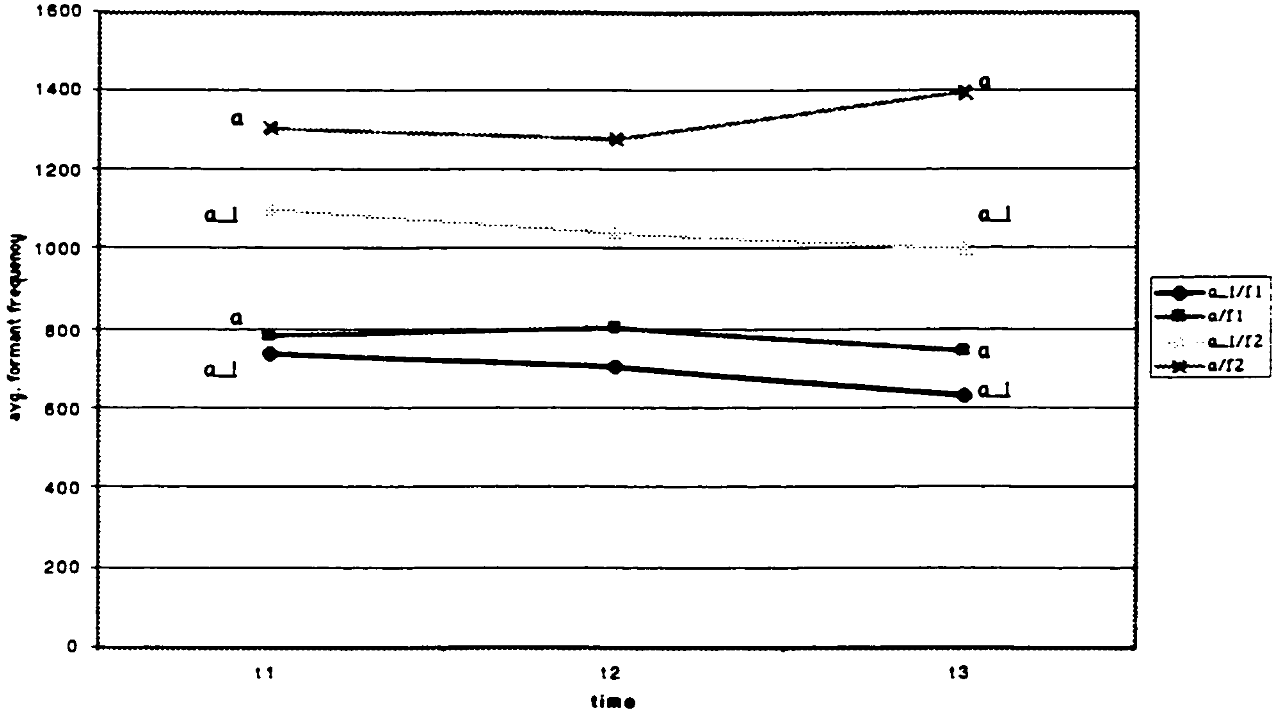
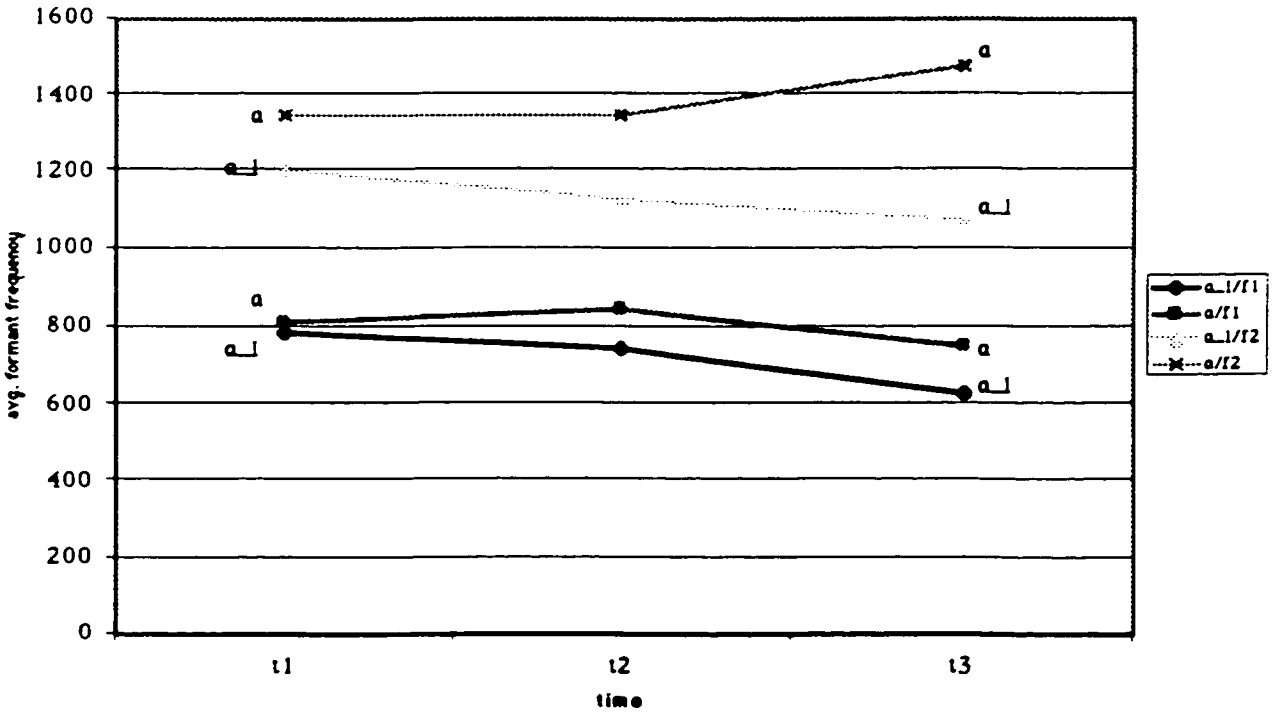


Figure 6.24.2 /a˩/ compared to /a/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.24.3 /ɑ_l/ compared to /ɑ/ (Female Southern)

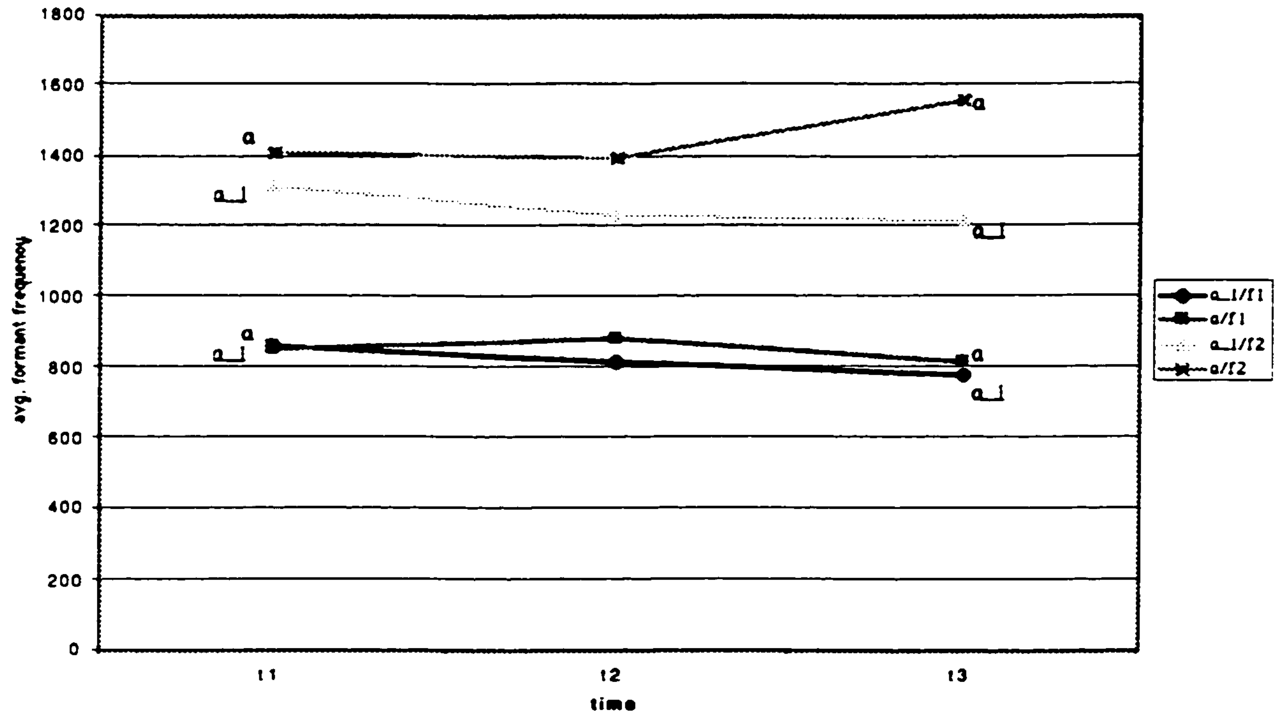
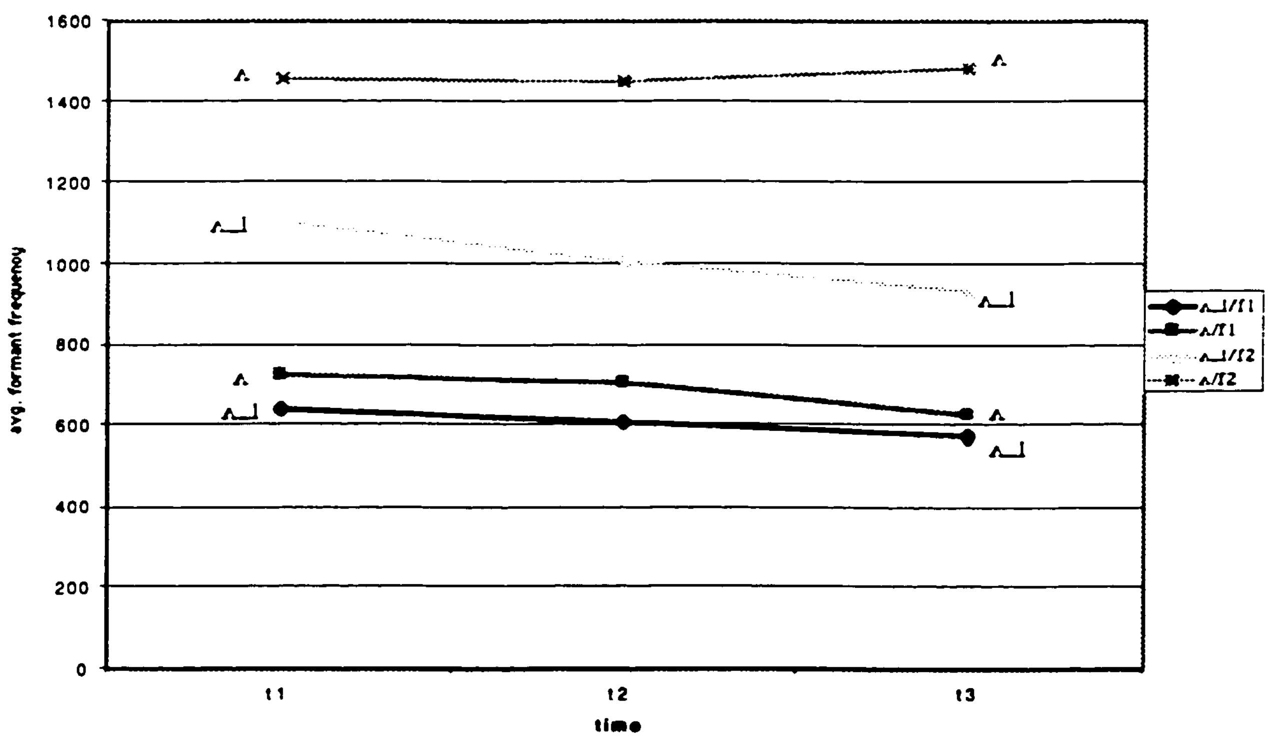


Figure 6.25.1 /ʌ_l/ compared to /ʌ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.25.2 /ʌ_l/ compared with /ʌ/ (Female Northern)

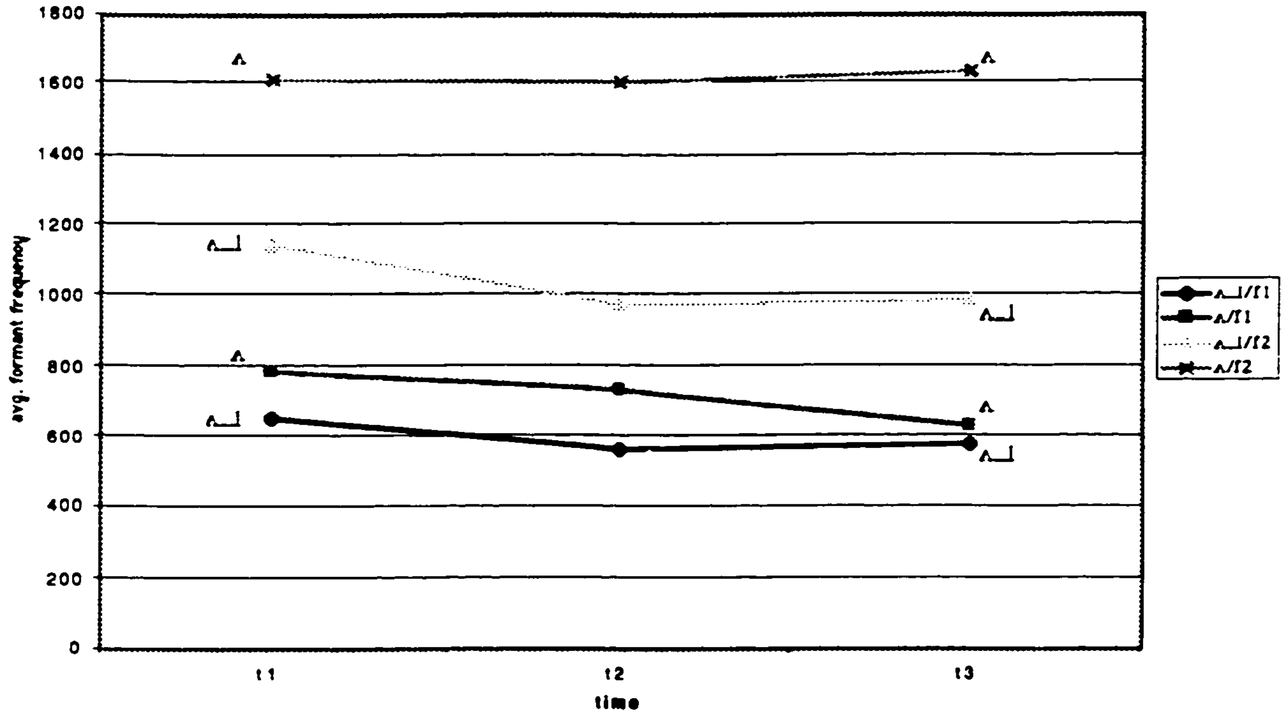
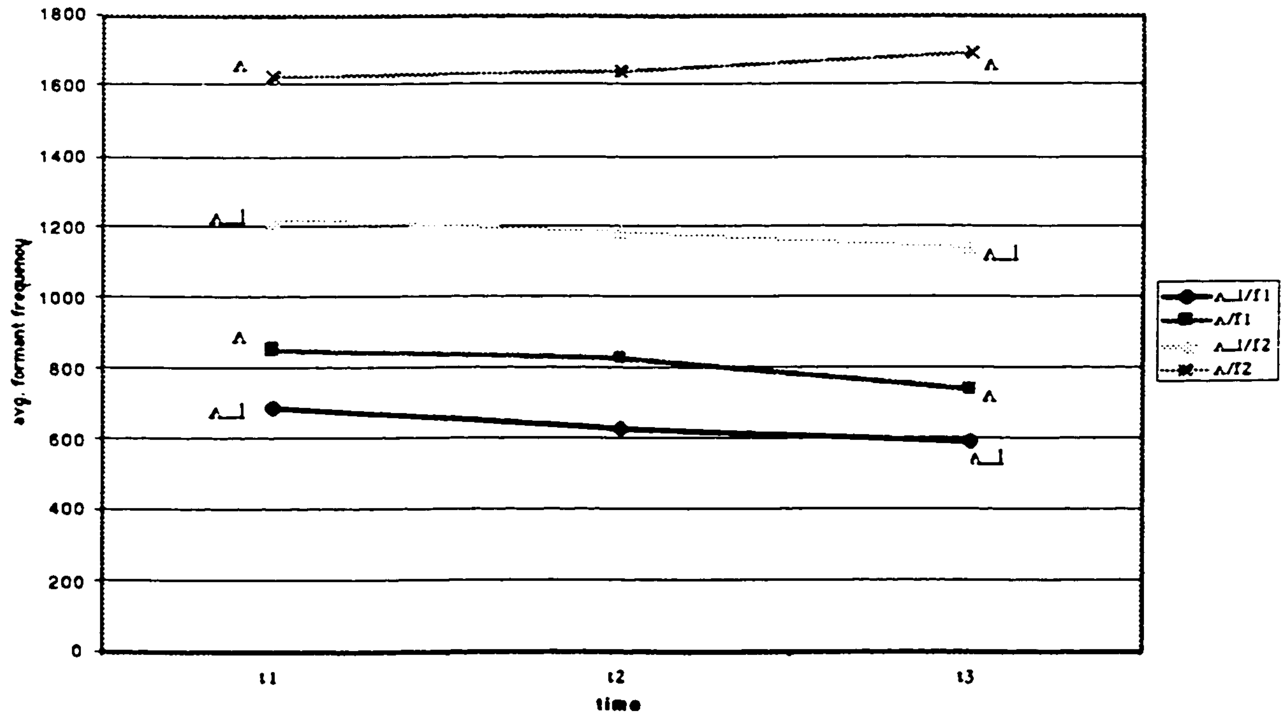


Figure 6.25.3 /ʌ_l/ compared to /ʌ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

To summarize: the front vowels /i ɪ e ɛ æ/ all begin very much like their non-lateral equivalents, but display a centralizing quality as they move toward the following /l/. It has been remarked upon (Section 4.2) that the vowel /i/ may have the allophone [iə] before /l/. This claim is certainly supported by the data, but it is equally true that the other front vowels /ɪ e ɛ æ/ could be claimed to have the allophones [ɪə eə ɛə æə] before /l/ as well.

The non-front vowels /u ʊ o ɑ ʌ/ all display significantly more retracted and/or rounded variants before /l/, being manifested in a much lower F2. We could say that the average phonetic values of the vowels /u ʊ o ɑ ʌ/ are respectively [ʉ ᵿ ɤʊ ɑə ʌ] in non-lateral environments, but [u ʊ oʊ ɑ ɤ] before /l/.

6.3.4.2. Ranges of allophony (scatter graphs)

On the F1/F2 scatter charts (Figure 6.6.-6.15), the formants of the vowels before /l/ are indicated by "L" on their appropriate chart. Examination of the F1/F2 scatter charts (Figures 6.6-6.15) to see how the vowels found before /l/ fit within the range of allophones allowed for English vowels before all consonants (and finally) shows that:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/i/ before /l/ is outside the /i/ ellipse for Southern California Females but inside the ellipse for Males and on the edge of the ellipse for Northern California Females (Figures 6.6.1, 6.6.2, 6.6.3).

/ɪ/ before /l/ is outside the /ɪ/ ellipse for all groups, due to its predictably lowered F2 (Figures 6.7.1, 6.7.2, 6.7.3).

/e/ before /l/ is outside the /e/ ellipse for all groups, due to a predictably higher F1 (Figures 6.8.1, 6.8.2, 6.8.3).

/ɛ/ before /l/ is outside the /ɛ/ ellipse for Males and Northern California Females, due mostly to a lower F2. For Southern California Females, /ɛ/ before /l/ is in the ellipse (Figures 6.9.1, 6.9.2, 6.9.3).

/æ/ before /l/ is inside the /æ/ ellipse for both Female groups, and only slightly outside the /æ/ ellipse for Males (Figures 6.10.1, 6.10.2, 6.10.3).

/u/ before /l/ is outside the /u/ ellipse for all groups (Figures 6.11.1, 6.11.2, 6.11.3).

/ʊ/ before /l/ is far outside the /ʊ/ ellipse for all groups (Figures 6.12.1, 6.12.2, 6.12.3), though as we have seen before (section 6.3.2), this /ʊl/ might actually be [ɫ]. There might not actually be a vowel [ʊ] present in the speech signal.

/o/ before /l/ is outside the /o/ ellipse for all groups (Figures 6.13.1, 6.13.2, 6.13.3).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɑ/ before /l/ is outside the /ɑ/ ellipse for all groups (Figures 6.14.1, 6.14.2, 6.14.3). Note that for Males and Northern California Females, both /ɑ/ and /o/ display lower F1 and F2 measurements before /l/, but for Southern California Females, only F2 is lowered.

/ʌ/ before /l/ is far outside the /ʌ/ ellipse for all groups, mostly due to a much lower F2 (Figures 6.15.1, 6.15.2, 6.15.3).

Of course, the question of whether vowels before /l/ are "outside" the normal range of allowed allophones might not be proper to ask. It might be that the variants before /l/ should just be considered part of the normal range to begin with, but it is still important to be able to make a detailed account of the types of allophony undergone by vowels preceding /l/.

6.3.4.3. Conclusion: Vowels before /l/

Coupling the data from the scatter charts with the data from the line charts, we can say that:

1) The nucleus in /il/ patterns like /i/ in terms of formant dynamics and range.

2) The nuclei in /ɪl el ɛl/ pattern like /ɪ e ɛ/ in terms of formant dynamics, but not in terms of range.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3) The nucleus in /æl/ patterns like /æ/ in terms of formant dynamics and range.

4) The nuclei in /ul ʊl ol ɑl ʌl/ do not pattern like /u ʊ o ɑ ʌ/ in terms of formant dynamics or range.

However, it can be observed from all the line charts and scatter charts that the deviations in vowels before /l/ are predictable and behave according to natural classes: front vowels glide toward a more central position, while non-front vowels are more rounded and/or backed (more "grave") throughout.

6.3.5. Syllabicity of /diphthong-l/ sequences

Fifth Question: Are words like "owl" or "Nile" monosyllabic or bisyllabic? It would be ideal if we could just look at the spectrographic data, count the number of syllables, and have an answer. Unfortunately, there has so far been nothing identified in a speech signal that can be objectively identified with the intuitive notion of a syllable. Here, a comparative and contrastive method will serve to help us find an answer.

The speakers were asked to say the words "line" and "lion." These words both have the diphthong [aj] but should differ in the number of syllables they have. The word "line" should have one

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

syllable, coming from Old English *līne*.[22] The final "e" would fall out, leaving us /līn/, which via the Great Vowel Shift would give us Modern English /lajn/. The word "lion" should have two syllables, coming from Middle English (from French) *lioun*, which was likely something like /lī.ən/, which would give us Modern English /lajən/. Thus, comparison of these two words should give us a good idea of what acoustic cues can be associated with contrastive syllabicity in Modern American English.

Comparison of the spectrographic dynamics of these two words (here, an example of Speaker 03 in Figure 6.33.1) should help illustrate what the difference between a one-syllable and a two-syllable word is. The two words look very similar. However, note that in the presumably monosyllabic "line" we have an increase in F2 toward a peak at the juncture with the following consonant /n/. In the presumably bisyllabic "lion", F2 rises to a peak, then falls for a period (95 ms) before we have the /n/.

Speakers were also asked to say the word "gown" and the name "MacGowan." The word "gown" should be monosyllabic, coming from Old French *goune*, which would give us Middle English /gūnə/. The final [ə] would drop out, leaving us /gūn/, which would become

---

[22]All etymologies are from Onions 1966 (ed.), *The Oxford Dictionary of English Etymology*, unless otherwise noted.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Modern English /gawn/ via the Great Vowel Shift. The name "MacGowan" should be bisyllabic after the "Mac", based upon the spelling. Examples of these two words are provided from speaker 11 (Figure 6.33.2). Parallel to the contrast between "line" and "lion", the words "gown" and "(Mac)Gowan" should be identical except for syllabicity. Note that in the presumably monosyllabic "gown" F2 lowers to a low point at the juncture with the following /n/, while in the presumably bisyllabic "(Mac)Gowan", F2 lowers to a low point, then rises for a period (80 ms) before we have the /n/. This situation is parallel to the difference in formant dynamics between "line" and "lion", as seen above.

Having determined this metric for measuring syllable count, we can now evaluate whether words like "owl" and "Nile" are monosyllabic or bisyllabic. Speakers were asked to say "owl" and "Nile", which are historically monosyllabic coming from Old English *ūle* and Latin *nīl* (‹*Nilus*)[23] respectively. They were also asked to say the words "avowal" and "denial", which are historically bisyllabic (after the prefixes "a-" and "de-"). The word "avowal" comes from Old French *avouer* plus the suffix *-aile*. The word "denial" comes from Middle English (from Old French) *denie* plus the same suffix -

[23]This etymology from *Webster's Geographical Dictionary* 1949.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

aile. The addition of this suffix, which clearly has vowels before the /l/, should result in another syllable added onto the end of the word.

Comparisons of the formant dynamics of these words show the following:

1) "Nile" and "(de)nial" have identical formant dynamics (example from speaker 03, Figure 6.34.1) for all the speakers. Furthermore, these dynamics are like those in "lion", not in "line" (see Figure 6.33.1) in that there is a period[24] after F2 rises to a peak. From this, we may conclude that "Nile" is a two-syllable word, and that tautosyllabic sequences of /ajl/ are not allowed synchronically but have been re-syllabified much like historical /ajr/ sequences (see section 2.2.3, above).

2) "Owl" and "(a)vowal" have identical formant dynamics for all but one speaker. For these thirteen speakers (exemplified by speaker 11, Figure 6.35.1), the dynamics of "owl" and "(a)vowal" are like those in "(Mac)Gowan", not "gown" in that they have an F2 which lowers to a low point, then rises for a period before the /n/.

For one speaker (speaker 06, Figure 6.35.2), the formant dynamics in "owl" and "(a)vowal" were different. For this speaker,

---

[24]145 ms in the case of "Nile", 132 ms in the case of "denial." The difference in duration here is not significant.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"owl" patterns like "gown", but "(a)vowal" patterns like "(Mac)Gowan."

From this we may conclude that "owl" is a two-syllable word for most speakers, coming from a re-syllabification of formerly monosyllabic /awl/. This change has not spread to all speakers yet, but is very common. I am not sure we can conclude yet that tautosyllabic sequences of /awl/ are not allowed at all in California English. It may be that "owl" is bisyllabic but other words with /awl/, like "howl" or "cowl" are still monosyllabic. However, the bisyllabic status of "owl" for most speakers does show that a sound change in which tautosyllabic sequences of /awl/ are not allowed, and hence re-syllabification occurs, has begun.

Unfortunately, I have no data concerning the resyllabification of /l/ after the diphthong /ɔj/, such that historically monosyllabic words like "oil" and "roil" would rhyme with historically bisyllabic words like "loyal" and "royal." Furthermore, finding good minimal pairs for the comparison of formant dynamics equivalent to "Nile"/"(de)nial" and "line"/"lion" might not be possible. I think it is pretty safe, though, to assume that /ɔj/ patterns like /aj/, given that they have similar off-glides. Thus, we could say that tautosyllabic sequences of /ɔjl/ are not allowed but have been re-syllabified much

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

like /ajr/ and /ajl/ sequences. It is also difficult to find any clear historical /ɔjr/ sequences which might show resyllabification[25].

6.3.6. Absence of Glides after Tense Vowels before /l/

Sixth Question: Are glides allowed before /l/ after the vowels /i e u o/? Examination of the formant dynamics of the vowel /i/ for all three groups (Figures 6.16.1, 6.16.2, 6.16.3) cast doubt on whether the vowel /i/ truly has an off-glide [j]. F1 remains steady throughout for all groups, not decreasing, as we would expect in the transition from a vowel to a [j]. F2 increases slightly at T2 for Males and Northern California Females, indicating a possible transition to a fronter vocalic position, which could be an indication of the glide [j]. F2 at T3 decreases for all groups, but this is likely due to transitions to the various following consonants. The increase in F2 at T2 is slight for production of average /i/, but it is completely lacking for the /i/ found before /l/. Rather, F2 decreases at T2 for the /i/ before /l/. Whether or not there is an off-glide [j] after /i/ normally is ambiguous, but it can be stated that there is no [j] after /i/ before /l/.

[25]There is the word "coir" which could be compared with "foyer." However, these are uncommon words whose elicitation might be difficult.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

All groups exhibit an off-glide [j] after /e/. This can be seen by the gradually decreasing F1 throughout and the sharp increase in F2 at T2 (Figures 6.18.1, 6.18.2, 6.18.3). The decrease in F2 at T3 is likely due to transitions to the various following consonants. However, the /e/ found before /l/ does not exhibit these formant dynamics. Indeed, the general pattern is for F1 to increase or hold steady and for F2 to decrease or hold steady before /l/. Only the Northern California Females display any increase in F2 at T2, and that is very slight. It pretty safe to say that there is no post-vocalic [j] after /e/ before /l/.

Examination of the formant dynamics of /u/ (Figures 6.21.1, 6.21.2, 6.21.3) show a distinct decrease in F2 at T2 for all groups, while F1 decreases or holds steady. This decrease in F2 can be associated with a backer, rounder position, and hence we do see evidence of a [w] off-glide after an average /u/. The variants of /u/ before /l/ do not display the same formant dynamics as average /u/. Their F1 remains steady. Their F2 remains relatively steady as well, increasing slightly for Males and Northern California Females and decreasing slightly for Southern California Females. To say that /u/ does not have a post-vocalic glide [w] before /l/ is not exactly accurate, because, as we have seen, the variety of /u/ found before /l/ already has a very back and round position, which would make

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

transitions to a following [w] hard to detect. The [u] already achieves a minimal F1 and F2 position and cannot lower these frequencies any farther. We can say that the variety of /u/ found before /l/ does not display the same formant dynamics as an average /u/, but this has already been observed (section 6.3.4)

The vowel /o/ exhibits a clear off-glide [w] as can be seen by the decreasing F1 and F2 values for all three groups (Figures 6.23.1, 6.23.2, 6.23.3). The variant of /o/ found before /l/ shows different formant dynamics for the three groups, however. For the Males, F1 and F2 remain fairly steady throughout, indicating a lack of off-glide. For both Female groups, F2 sharply decreases at T2, indicating that there might be an off-glide [w], but then it increases again at T3, particularly for the Southern California Females. For the Northern California Females, F1 of the /o/ before /l/ decreases in a manner parallel to that of a normal /o/. For the Southern California Females, it actually increases slightly. We may conclude that the off-glide [w] does exist after /o/ before /l/ for Northern California Females, but may or may not exist for Southern California Females.

In summary, we can say that:

1) The off-glide [j] does not exist after /i/ before /l/, but it might not really exist after /i/ in other environments.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2) The off-glide [j] does not exist after /e/ before /l/, but does exist in other environments.

3) It is difficult to determine whether there is an off-glide after /u/ before /l/ due to the very back and round position of this variant.

4) The off-glide [w] does not exist after /o/ before /l/ for the Male speakers, but may exist for some of the Female speakers.

6.4. Vowels before /ŋ/

The relevant data for this section consisted of the following words:

‹ing›: *Ping-Pong* (first syllable)

‹eng›: *length*

‹ang›: *hang*

‹ong›: *Ping-Pong* (second syllable)

‹ung›: *hung*

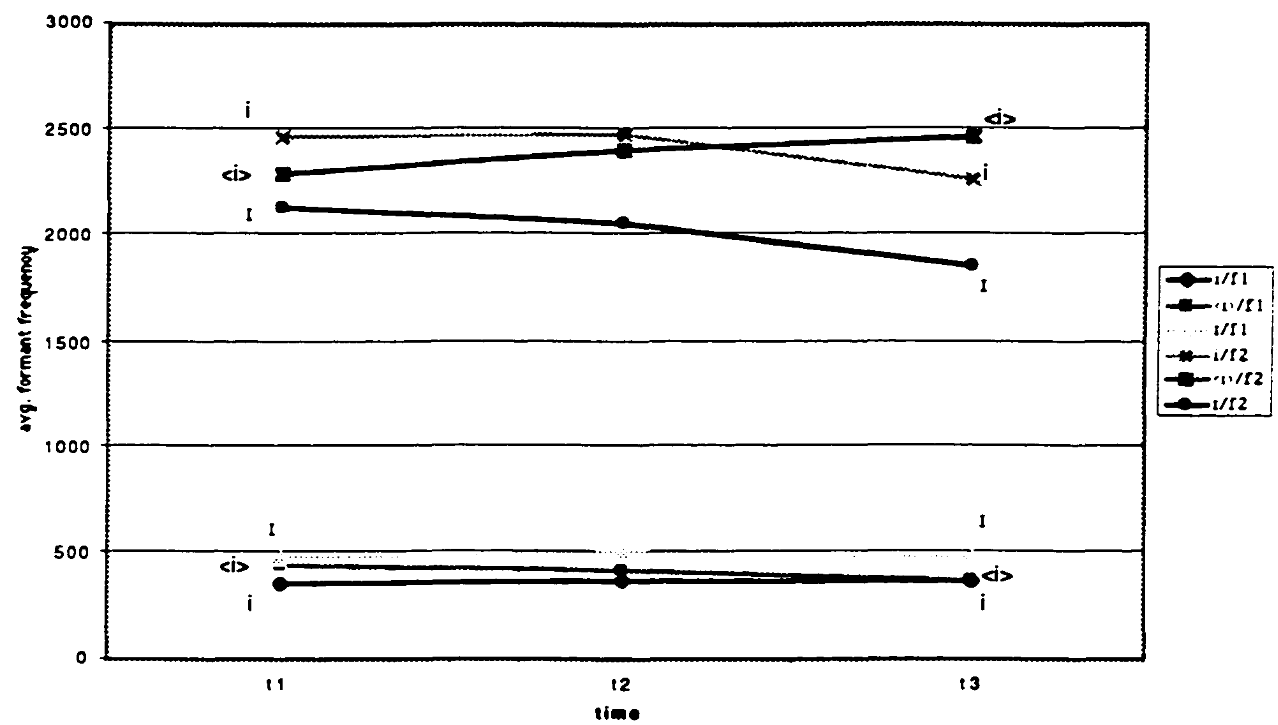
Figures 6.26-6.30 show the formant dynamics of the various vowels found before /ŋ/ in California English. The vowel in ‹ing› is compared to /i/ and /ɪ/. The vowel in ‹eng› is compared to /e/, /ɛ/, and /æ/. The vowel in ‹ang› is also compared to /e/, /ɛ/, and /æ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The vowel in ‹ong› is compared to /ɑ/, and the vowel in ‹ung› is compared only to /ʌ/.

6.4.1. Formant dynamics (line graphs)

Figure 6.26.1 ‹i› compared to /i/ and /ɪ/ (Males)



Examination of Figures 6.26.1, 6.26.2, and 6.26.3 shows F1 of the vowel in ‹ing› to pattern much like /ɪ/ for Southern California Females. For Northern California Females, it begins between /i/ and /ɪ/, then approximates /ɪ/ at T2 and T3. For Males, the vowel in ‹ing› begins much like /ɪ/, then gradually lowers in the vowel space to being much like /i/. For all three groups, F2 of the vowel in ‹ing› begins between /i/ and /ɪ/, but then gradually increases, being even

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.26.2 ‹i› compared to /i ɪ/ (Female Northern)

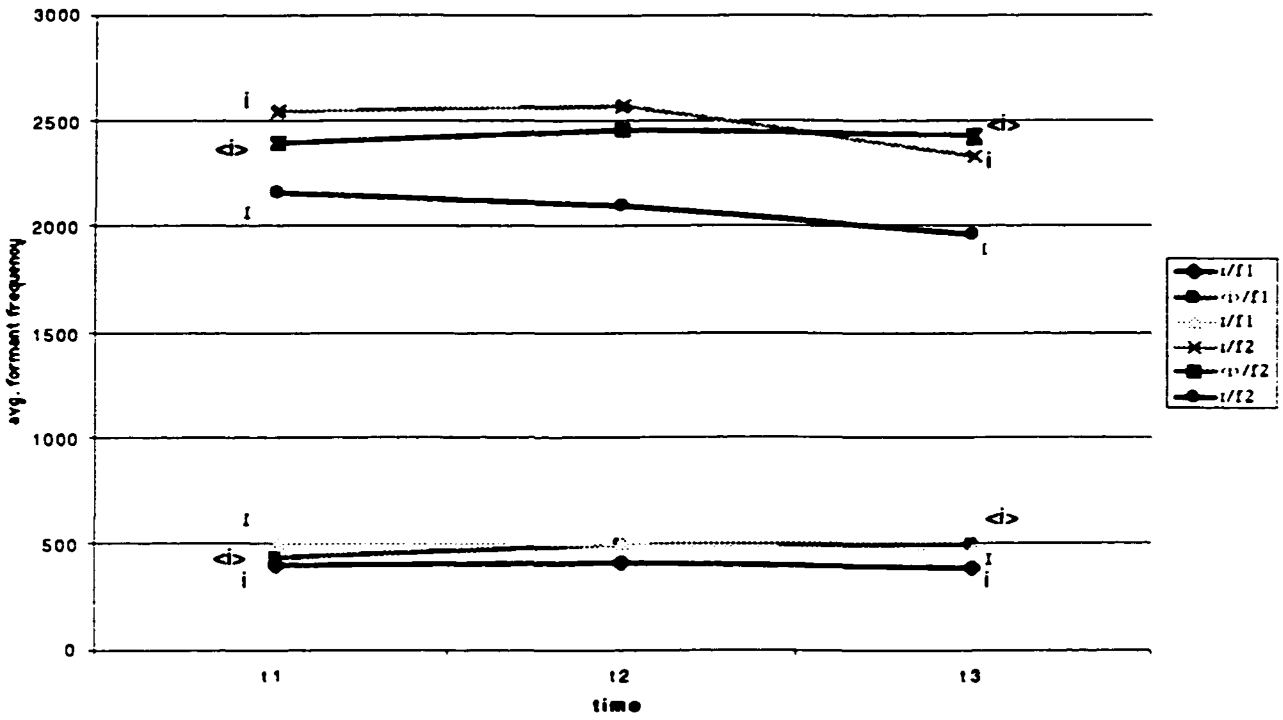
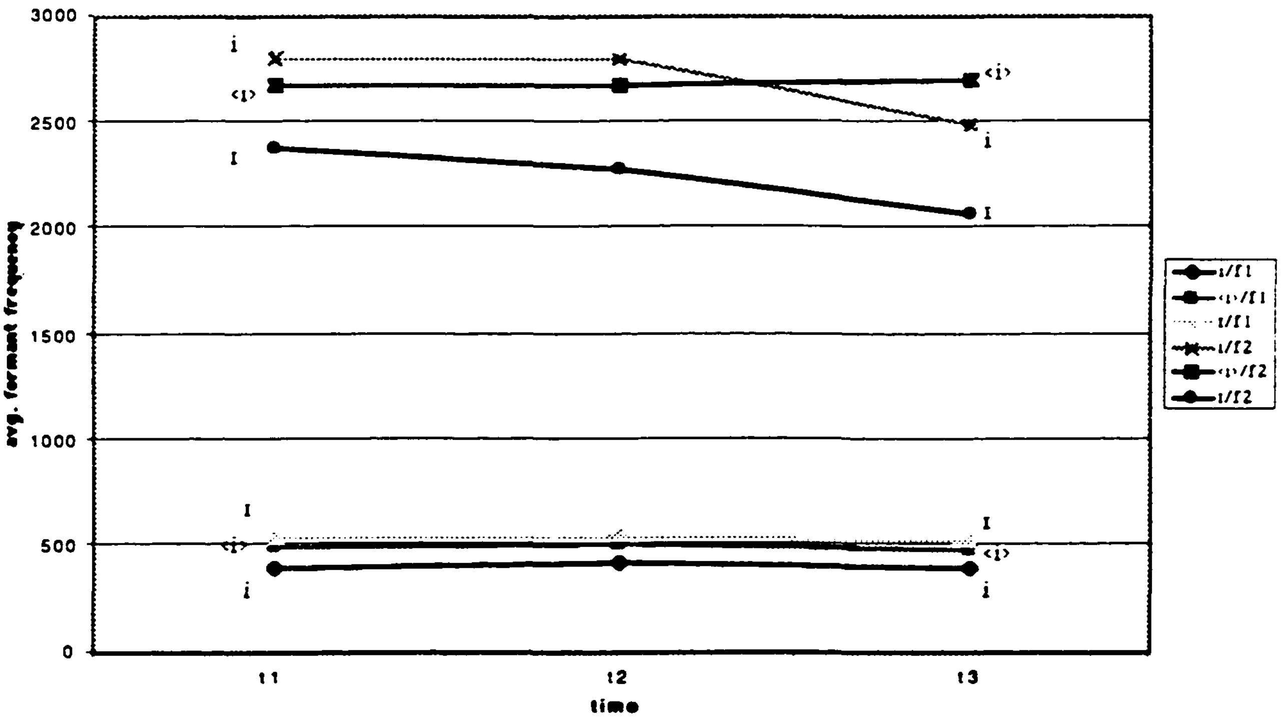


Figure 6.26.3 ‹i› compared to /i ɪ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.27.1 ‹e› compared to /e ɛ æ/

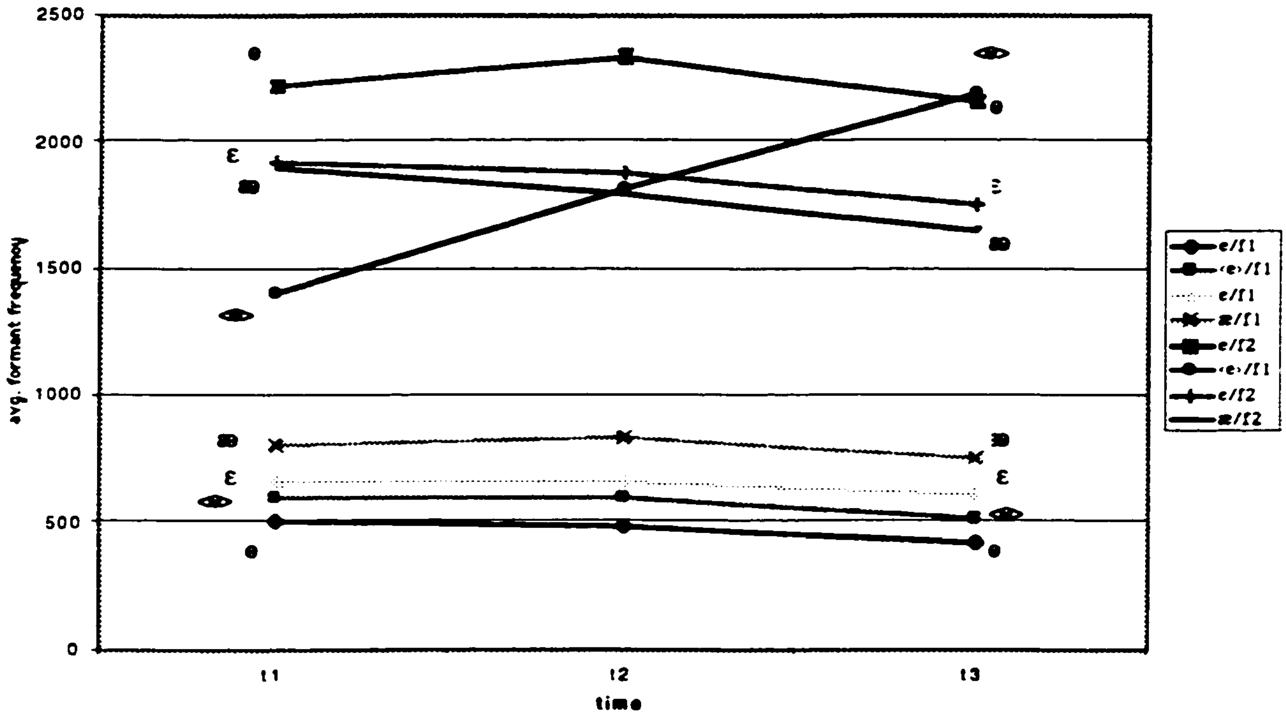
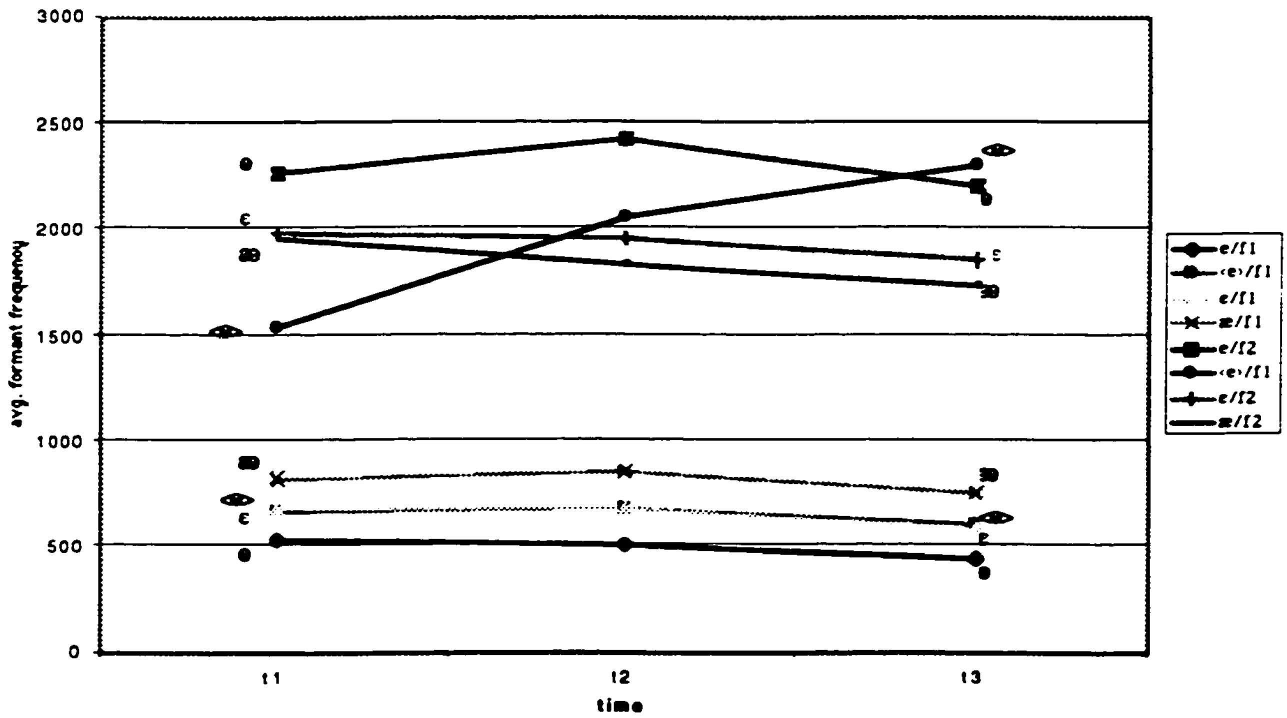


Figure 6.27.2 ‹e› compared with /e ɛ æ/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.27.3 ‹e› compared to /e ɛ æ/ (Female Southern)

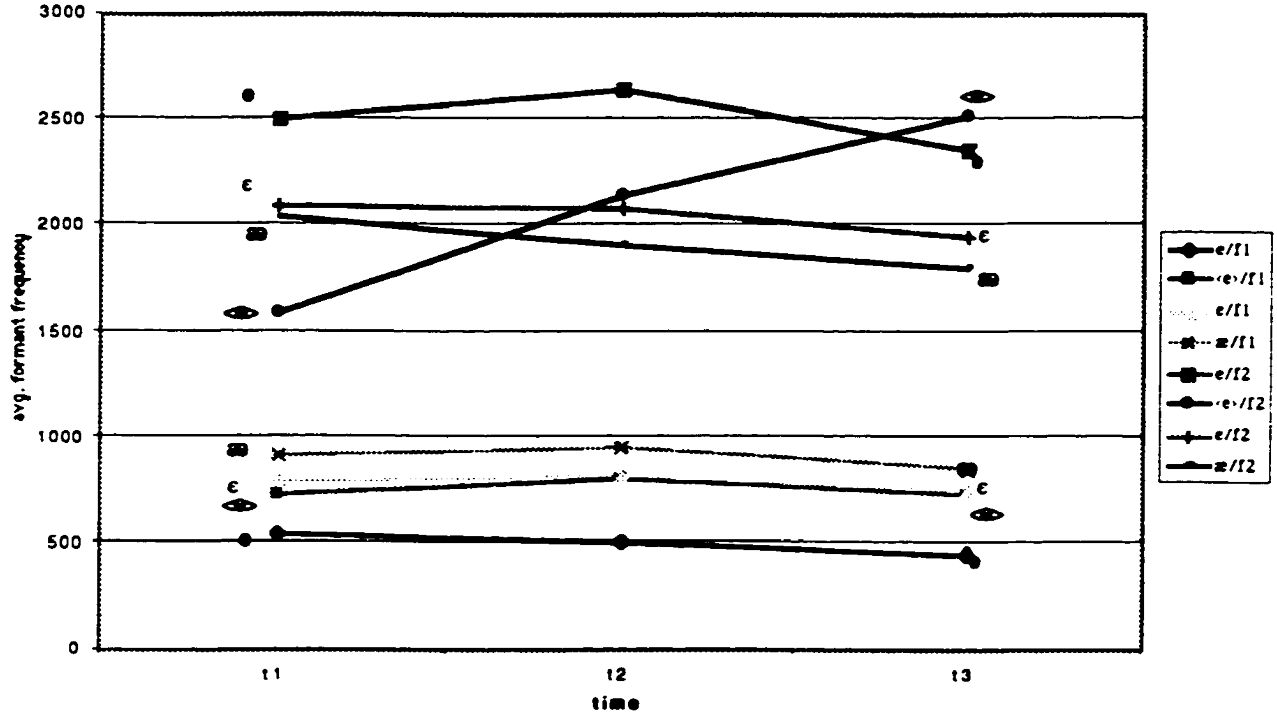
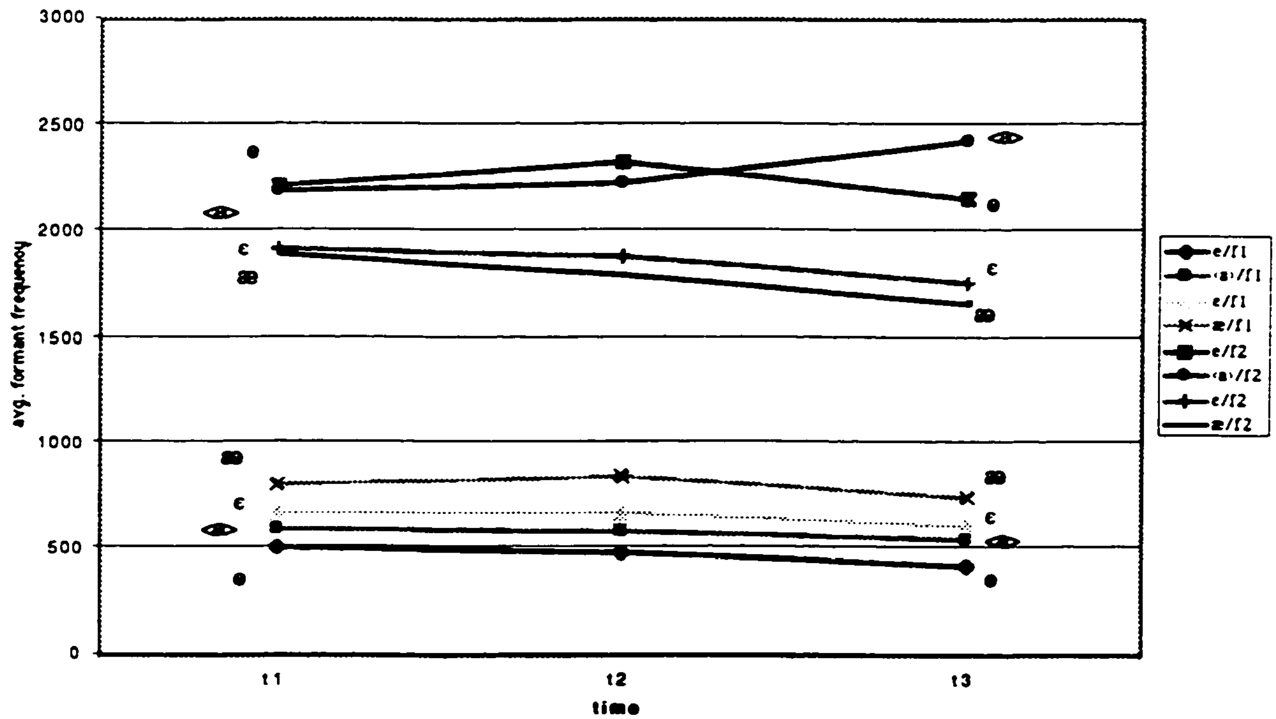


Figure 6.28.1 ‹a› compared to /e ɛ æ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.28.2 ‹a› compared to /e ɛ æ/ (Female Northern)

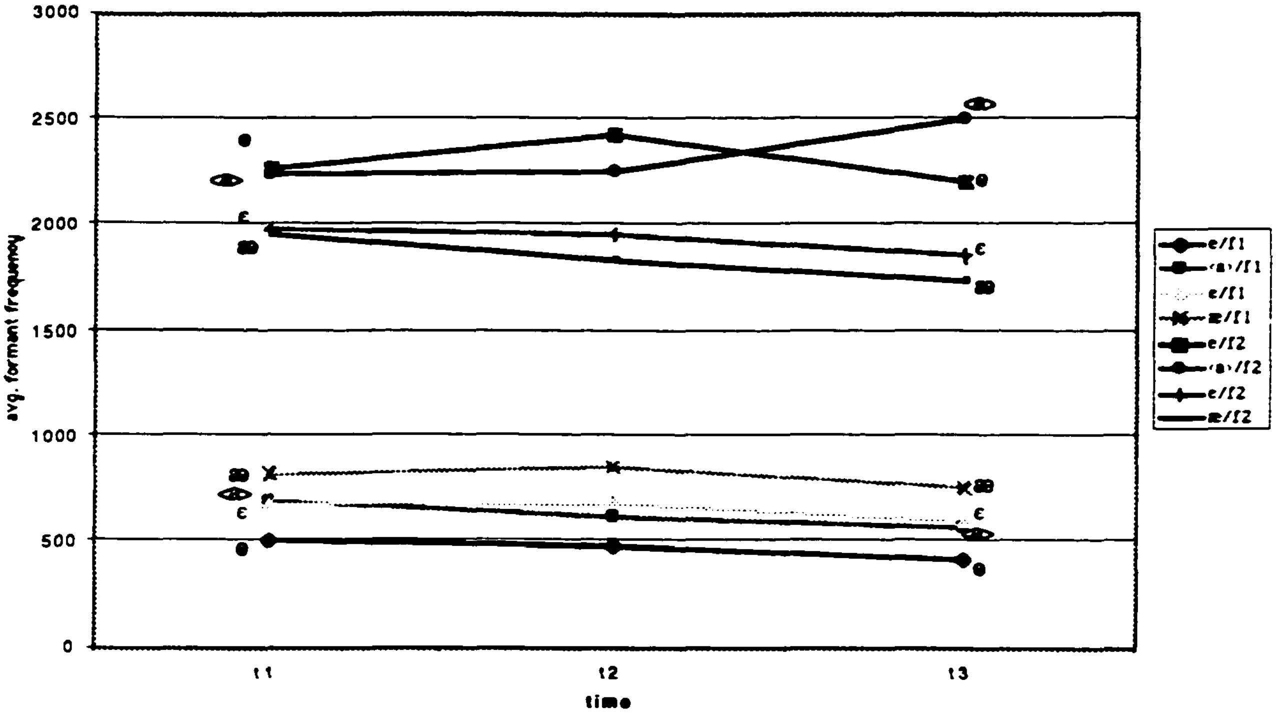
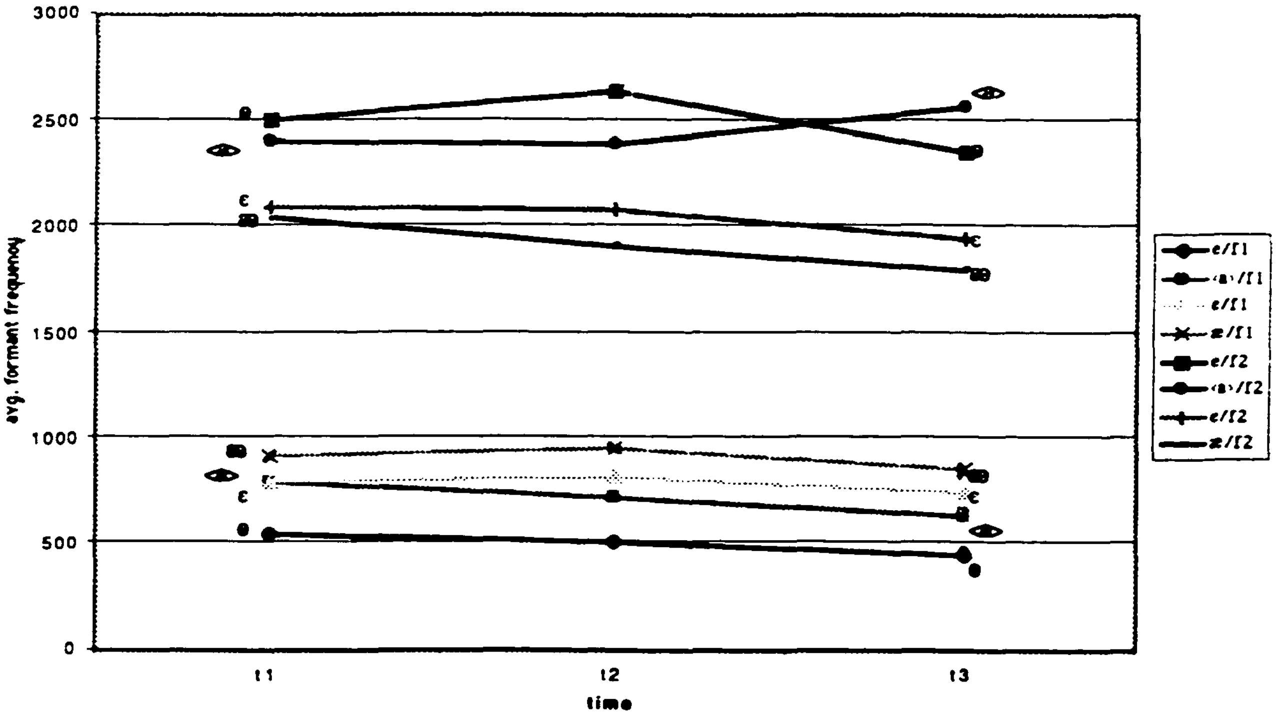


Figure 6.28.3 ‹a› compared to /e ɛ æ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.29.1 ‹o› compared to /a/ (Males)

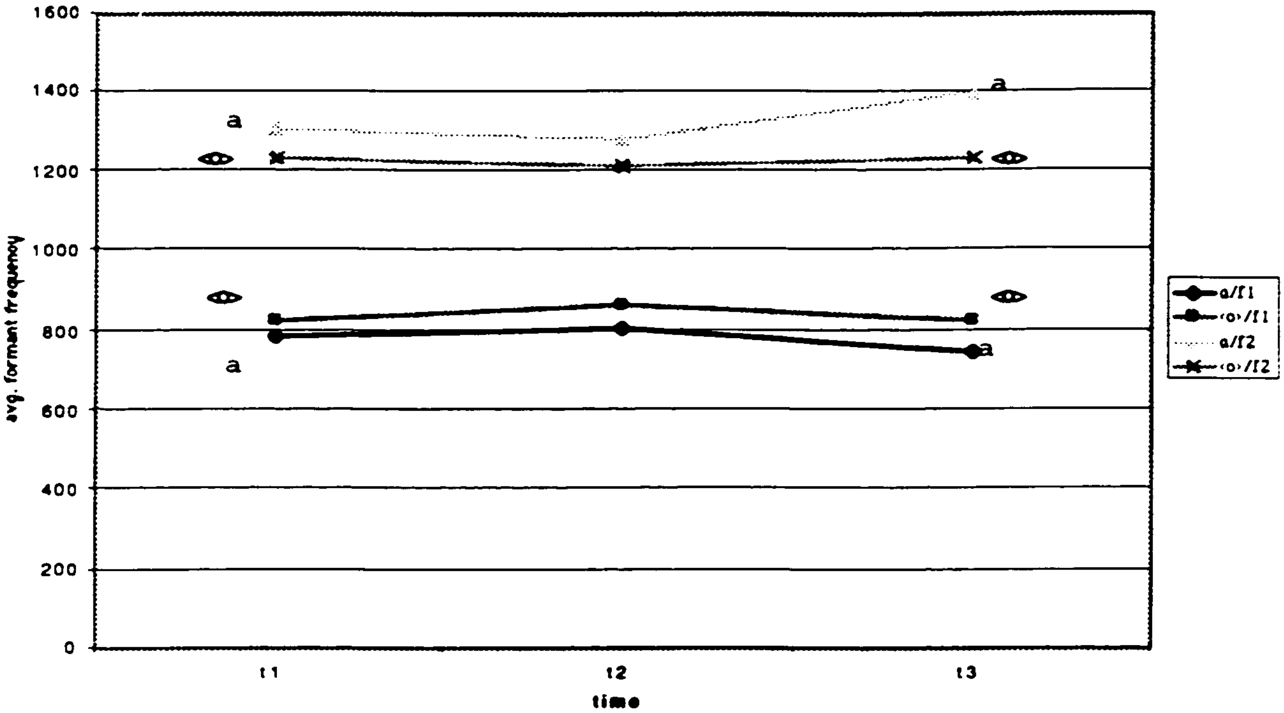
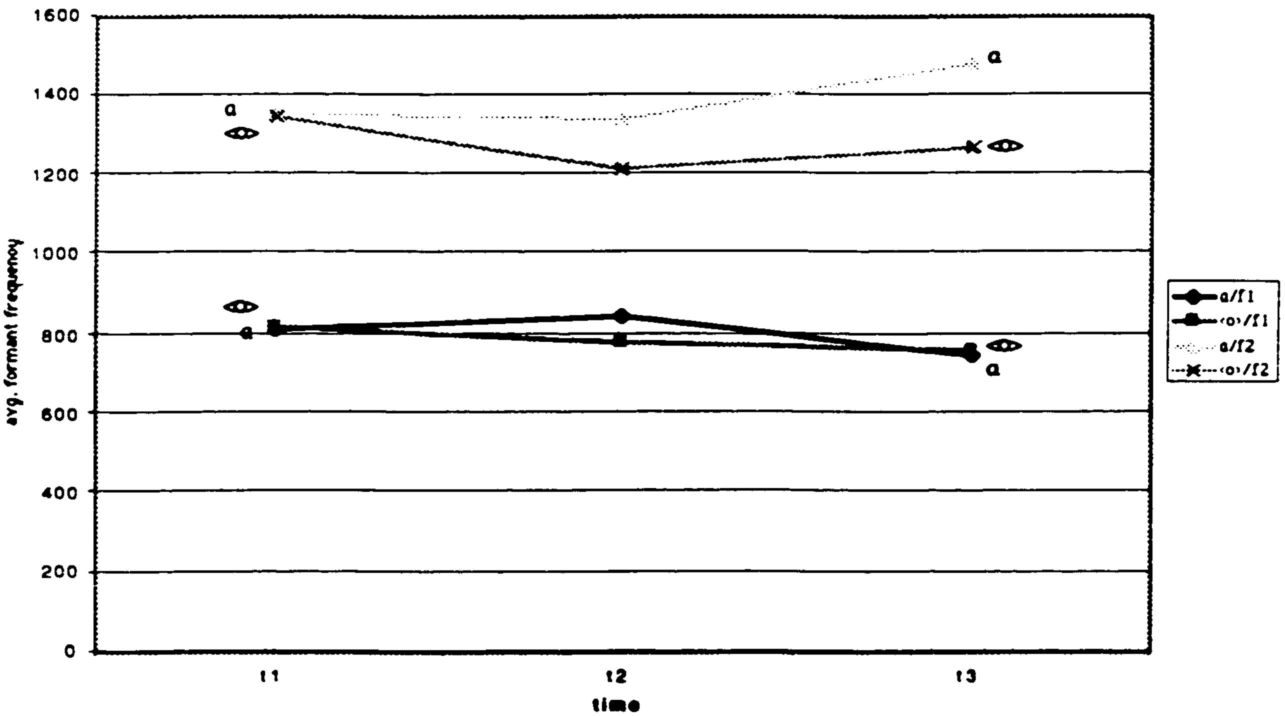


Figure 6.29.2 ‹o› compared with /a/ (Female Northern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.29.3 ‹o› compared to /a/ (Female Southern)

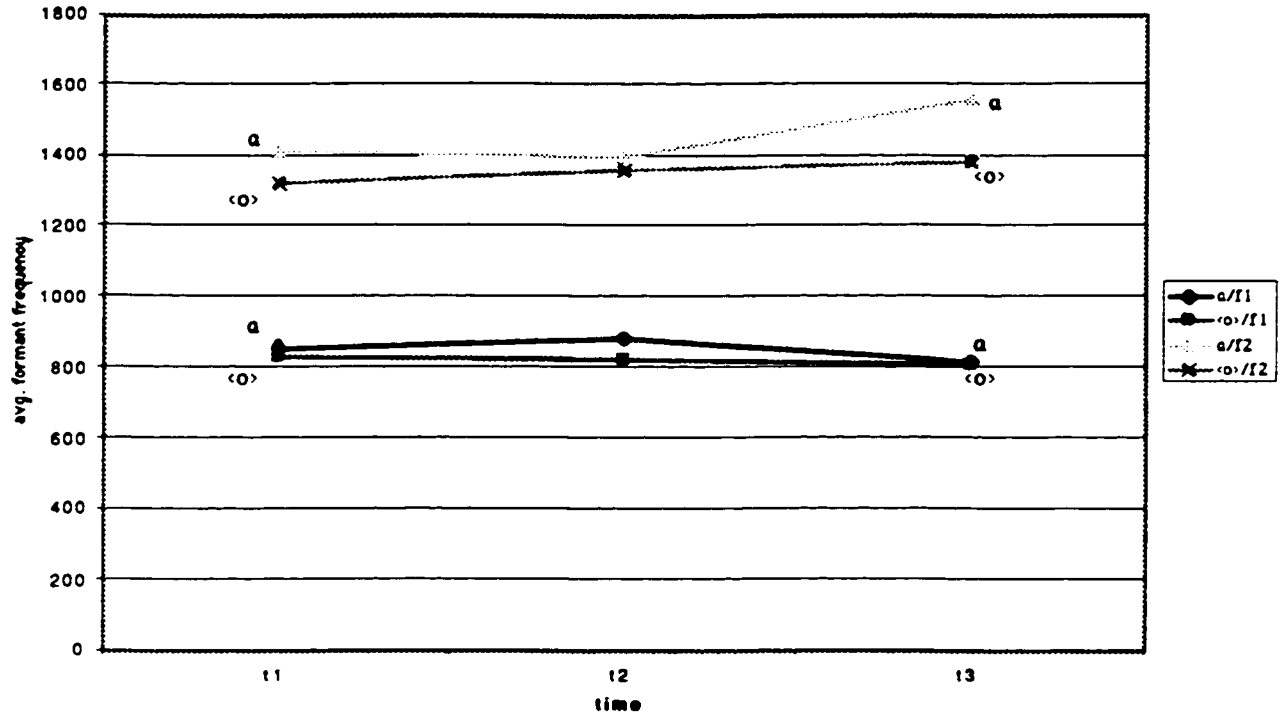
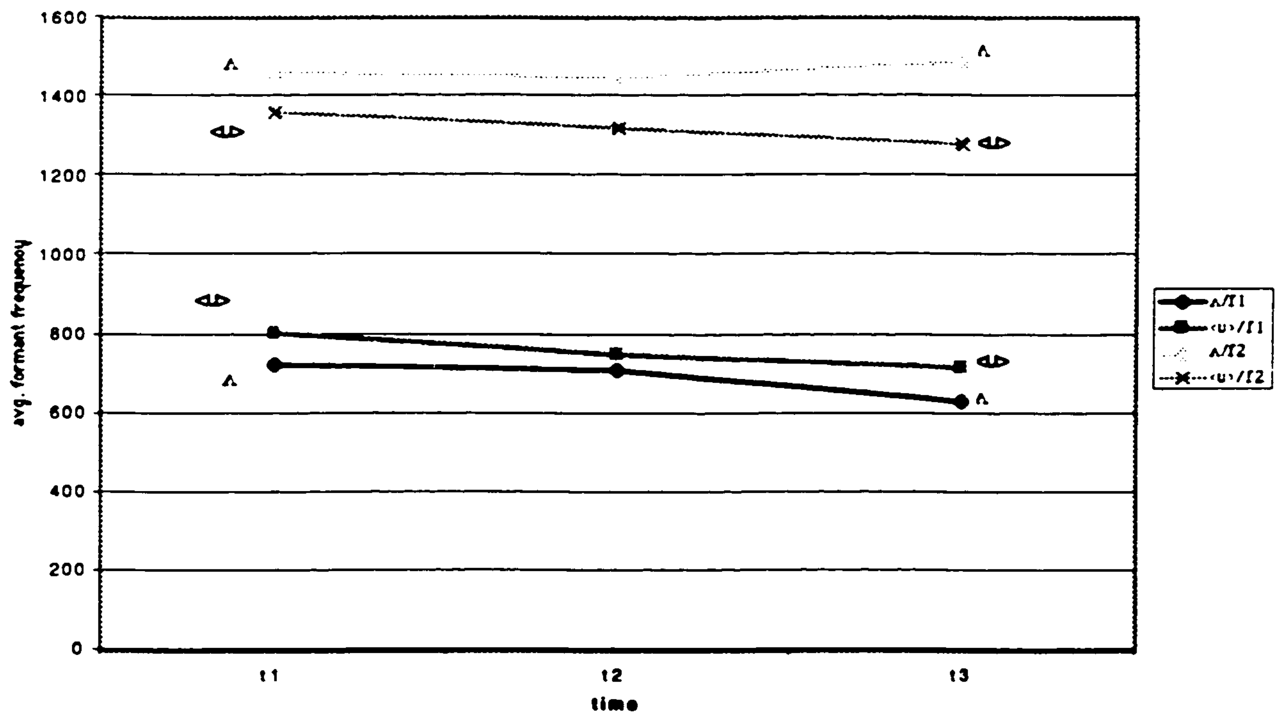


Figure 6.30.1 ‹u› compared to /ʌ/ (Males)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.30.2 ‹u› compared with /ʌ/ (Female Northern)

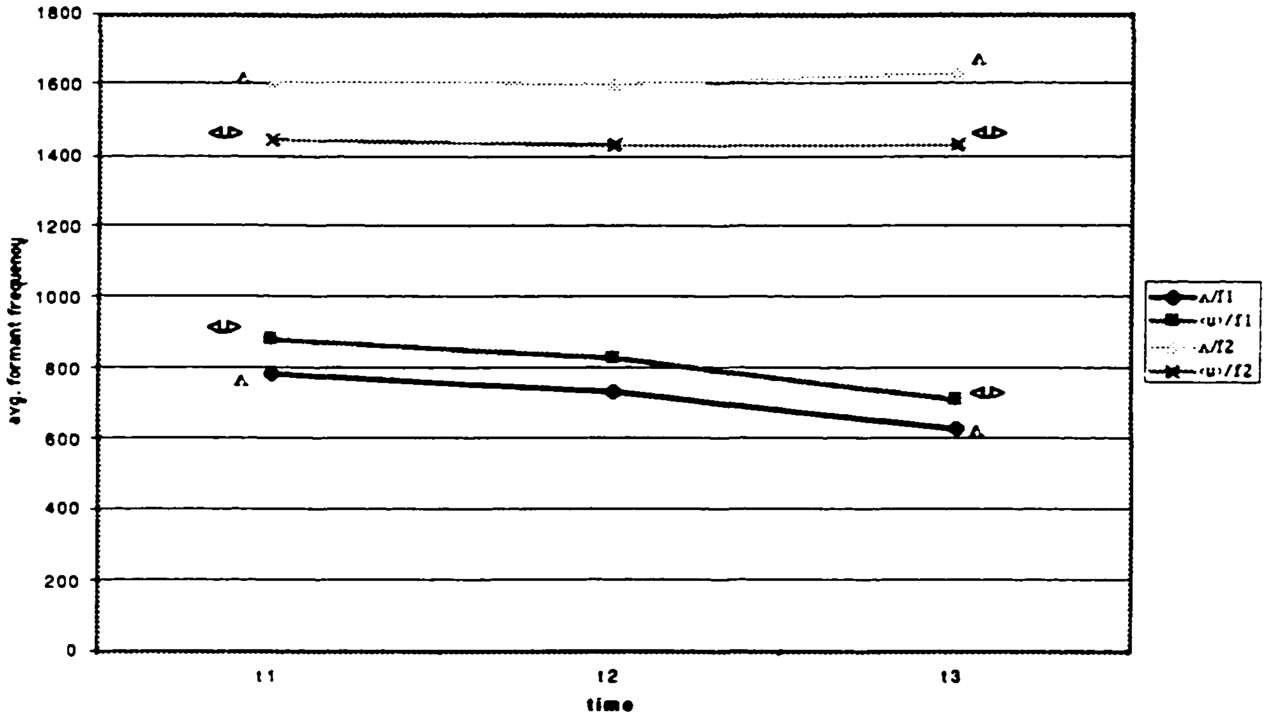
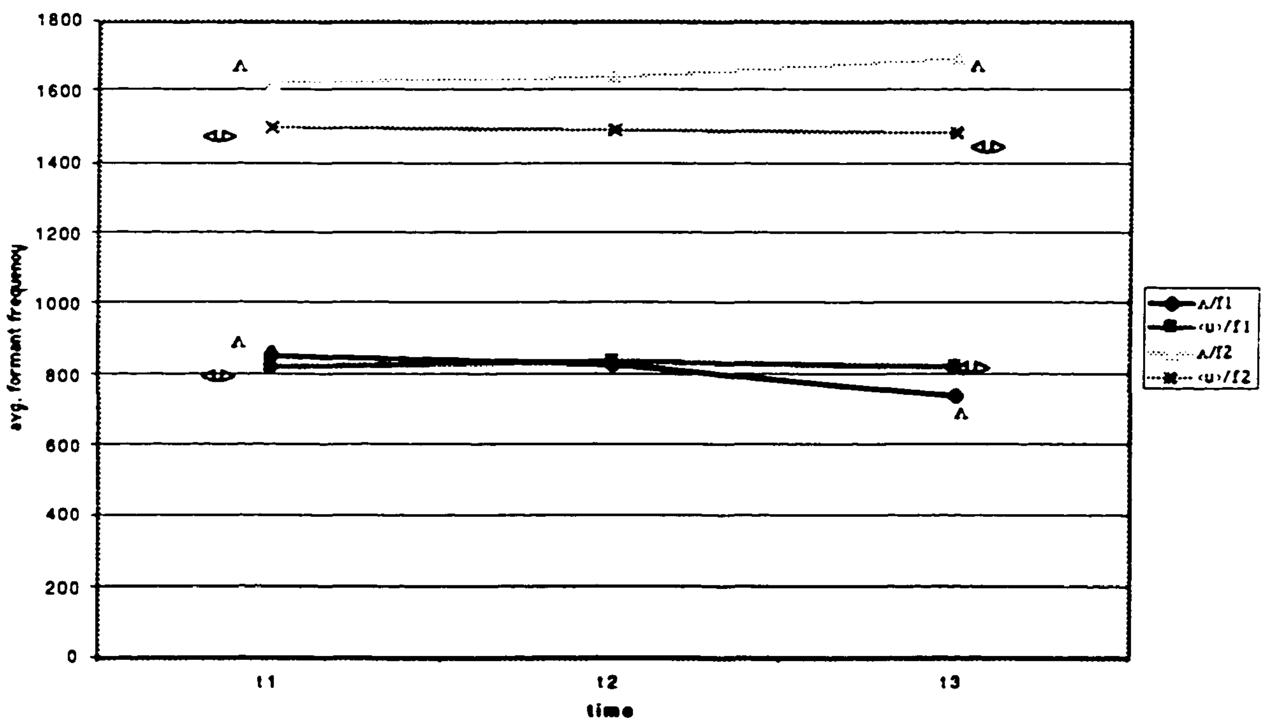


Figure 6.30.3 ‹u› compared to /ʌ/ (Female Southern)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

higher than that of /i/ at T3. A reasonably accurate transcription of the vowel in ‹ing› would be [ɪj]: something which begins much like /ɪ/, but raises to a higher, fronter position.

Examination of Figures 6.27.1, 6.27.2, and 6.27.3 show F1 of the vowel in ‹eng› to be much like /ɛ/ for all groups. For Males, it is actually slightly lower, being between /e/ and /ɛ/. There is little difference in the F2 of the vowel in ‹eng› between the three groups. The F2 of the vowel in ‹eng› seems to begin in a very low position, much lower than the position of any of the F2s of /e/, /ɛ/, and /æ/. We must remember, however, that all of these examples of ‹eng› come from utterances of the word "length." The preceding /l/ would serve to lower the F2 of the vowel significantly. Unfortunately, the sequence ‹eng› occurs in very few words, the only two common ones of which are "length" (with preceding /l/) and "strength" (with preceding /r/). There is no way to find an exemplar word for the vowel in ‹eng› without a preceding consonant that makes things difficult. To account for this, we have to ignore the F2 measurement at T1 for the vowel in ‹eng› and make do with the other measurements.

For the Female speakers, F2 of the vowel in ‹eng› at T2 is slightly higher than that of /ɛ/. For the Males, it is between /ɛ/ and /æ/. We cannot tell if the F2 lowering effect of the preceding /l/ is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

still a contributing factor at T2 or not. At T3, F2 is very high, higher than /e/ for all speakers. The closest transcription for the vowel in <eng> would be [ɛj], with the off-glide [j] reflecting the increase in F2 at T3.

Examination of Figures 6.28.1, 6.28.2, and 6.28.3 show the F1 of the nucleus in <ang> to be much like that of /ɛ/, but slightly lower, especially for Males, where it is between /ɛ/ and /e/. F2 of the vowel in <ang> is the same for all three groups, beginning much like /e/, holding fairly steady at T2 (not exhibiting the sharp increase in F2 that /e/ does), and increasing at T3, being higher than that of /e/.

Phonetic transcription of the vowel in <ang> is difficult. Its F1 is most like /ɛ/, but its F2 is most like /e/. Note that it is not at all like /æ/, to which it is related historically (see Chapter 5). We could transcribe it as [ɛ̣j], a raised variant of [ɛ] that glides toward a fronter position.

This brings up the question, raised earlier in Chapter 5, whether the vowel in <eng> and the vowel in <ang> are different vowels or not. They are historically derived from different vowels, ME /ĕ/ and /ă/ respectively, but they are extremely similar phonetically in the data. F1 measurements of the vowel in <eng> and the vowel in <ang> are identical for the male speakers, but Female speakers do have lower F1 for the vowel in <ang> than for the vowel

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

in <eng>. The F2 lowering effect of the preceding /l/ in "length" obscures comparison of the F2 measurements of the vowel in <eng> and the vowel in <ang>, but we can observe that at T2, the vowel in <ang> displays a higher F2 than the vowel in <eng>. This difference is even more pronounced at T3, especially for Males and Northern California Females. I think it is best to say that the vowel in <eng> and the vowel in <ang> are distinct vowels, though very similar to each other phonetically. It is not unlikely that they would be merged in some dialects, especially given the rarity of <eng>.

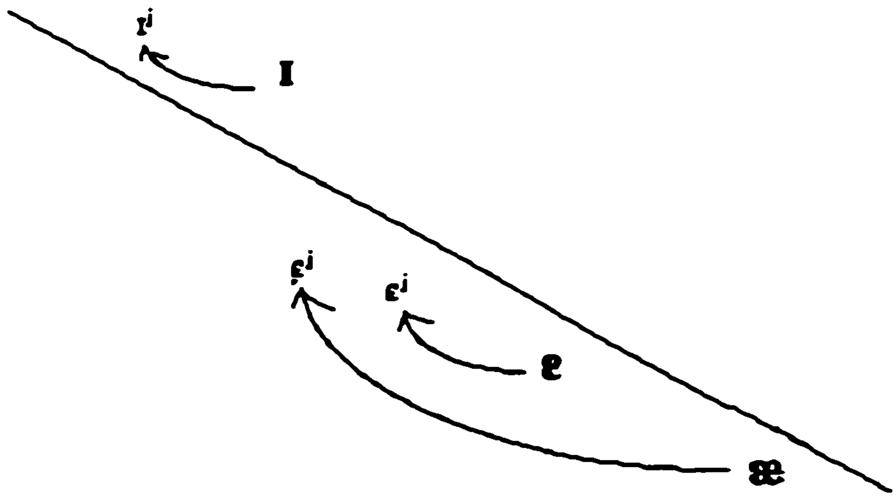


Figure 6.31 Historical raising of vowels before /ŋ/.

As noted, the vowel in <ang> is somewhat fronter and higher than that in <eng>, which is interesting considering that the vowel in <ang> is historically cognate with /æ/, a vowel which is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

lower and backer than /ɛ/, the vowel which the vowel in <eng> is related to historically. It appears that the raising effects of the following /ŋ/ have caused the historical /æ/ to "leap over" /ɛ/ on its way to [ɛ̣] (see Figure 6.31).

This matter only seems strange if we regard the vowels on a two-dimensional vowel chart such as Figure 6.31, above, and don't pay attention to other features such as duration. Let us examine data on the comparative durations of American English vowels (from Peterson and Lehiste 1960):

Table 6.4 Durations of syllabic nuclei in American English (Peterson and Lehiste 1960)

vowel	average duration for five speakers (ms)
i	240
ɪ	180
e	270
ɛ	200
æ	330
ʌ	230
ɑ	260
ɔ	310
o	220
ʊ	200
u	260
aw	300
aj	350
ɔj	370
ɚ	240

We can see from the table that, although the vowel /ɛ/ is closer to /æ/ in terms of F1 and F2, /e/ is more like /æ/ in terms of duration. A vowel /æ/ when caused to raise due to the effects of a following /ŋ/ would not necessarily "pass through" the place of /ɛ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

but could exhibit sound changes of its own. The relatively long vowel /æ/, coupled with its off-glide [j] (due to the transition to the following /ŋ/), could be something like [æ:j], which would help explain why the raised version of /æ/ is more similar to /e/, which also shares a relatively long duration, and could be something like [e:j]. This could also explain why the vowel in ‹ang› is frequently identified with /e/ by Di Paolo's subjects (in Chapter 5) and, as we shall see, by the subjects in this study as well.

It should be pointed out that the off-glides I am transcribing in ‹ing›, ‹eng›, and ‹ang› are not necessarily the same as the off-glides found in the vowel /e/. Regarding Figures 6.27 and 6.28, we can see that F2 of /e/ increases sharply at T2, while the increase in F2 of the vowel in ‹eng› and the vowel in ‹ang› doesn't happen until T3. It may be accurate to say that the [j] found in ‹ing›, ‹eng›, and ‹ang› is a true "off-glide", while that in /e/ is part of the dynamics of the vowel itself. A phonetic transcription that would reflect this would be to transcribe the vowels in ‹ing›, ‹eng›, and ‹ang› as [ɪʲ], [ɛʲ], and [ɛ̝ʲ][26], respectively, while that in /e/ is [ej].

---

[26]This use of a superscript [ʲ] is not completely consistent with IPA usage, but I am using it here to distinguish a short off-glide which might be just due to the transition from a glide which is part of the vowel nucleus.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Comparison of the formant dynamics of the vowel in <ong> to /ɑ/ (Figures 6.29.1, 6.29.2, 6.29.3) show the F1 of the nucleus in <ong> to be much like that of /ɑ/ for all groups. The F2 measurements of the vowel in <ong>, however, begin much like /ɑ/ at T1, but thereafter remain steady or decrease, not showing the centering off-glide characteristic of /ɑ/. This may be due to the effect of the following /ŋ/, which after back vowels is a true velar.

Examination of Figures 6.30.1, 6.30.2, and 6.30.3 show the F1 of the vowel in <ung> to be much like /ʌ/. F2 of the vowel in <ung>, however, is considerably lower throughout, which could also be accounted for by the retracting influence of the velar /ŋ/.

6.4.2. Range of allophony (scatter graphs)

On the ellipse charts (Figures 6.6-6.15), the appropriate vowel before /ŋ/ is indicated by "NG" on the chart. The vowel in <ing> is found on the /i/ and /ɪ/ charts, the vowel in <ung> on the /ʌ/ chart and the vowel in <ong> on the /ɑ/ chart. The vowels in <eng> and <ang> are both found on the /e/, /ɛ/, and /æ/ charts. In these latter cases, the vowels are indicated on the chart by the actual words they were pronounced in: "LENGTH" or "HANG". Re-examination of the ellipse charts (Figures 6.6-6.15) shows the following:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The vowel in ‹ing› is outside the /i/ ellipse for all groups. If we include /l/, the vowel in ‹ing› is inside the /i/ ellipse for Southern California Females (Figures 6.6.1, 6.6.2, 6.6.3).

The vowel in ‹ing› is outside the /ɪ/ ellipse for all groups. The inclusion of /l/ does not change anything (Figures 6.7.1, 6.7.2, 6.7.3).

The vowel in ‹ang› is outside the /e/ ellipse for all groups. The inclusion of /l/ does not change this (Figures 6.8.1, 6.8.2, 6.8.3). the vowel in ‹eng› is also outside the /e/ ellipse for all groups, this being unchanged by the inclusion of /l/. For the creation of the ellipse groups, I did not include the F2 measurements of /eng/ at T1. The F2 measurements of the vowel in ‹eng› only reflect T2 and T3. This is due to the very strong lowering effect of the preceding /l/ in "length", the word used in the study.

The vowel in ‹ang› is outside the /ɛ/ ellipse for Males and Southern California Females, but inside the /ɛ/ ellipse for Northern Females (Figures 6.9.1, 6.9.2, 6.9.3), as is the vowel in ‹eng› (though only slightly so for Males). This situation does not change if we include /l/. Likewise, the vowel in ‹ang› and the vowel in ‹eng› are outside the /æ/ ellipse for all groups, regardless of the inclusion of /l/ (Figures 6.10.1, 6.10.2, 6.10.3).

The vowel in ‹ong› is inside the /ɑ/ ellipse for all groups (on the border for Males) (Figures 6.14.1, 6.14.2, 6.14.3).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The vowel in <ung> is inside the /ʌ/ ellipse Southern California Females, on the border for Males, but outside the ellipse for Northern California Females. The inclusion of /l/ likely puts it inside the ellipse for Northern Females.

6.4.3. Conclusion: Vowels before /ŋ/.

Coupling the data from the scatter graphs with the data from the line charts, we may conclude that:

1) The vowel in <ing> patterns like no other vowel in terms of formant dynamics or range.

2) The vowel in <eng> patterns like no other vowel in terms of formant dynamics or range.

3) The vowel in <ang> patterns like no other vowel in terms of formant dynamics or range.

4) The vowel in <ong> patterns much like /ɑ/ in terms of formant dynamics and range.

5) The vowel in <ung> patterns somewhat like /ʌ/ in terms of formant dynamics, and much like /ʌ/ in terms of range.

Since /Vŋ/ sequences are not diphthongs, and hence cannot be evaluated according to the criteria explained in section 3.1, we cannot answer the question of whether the nuclei occur

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

independently or not. We can make the following observations, though:

1) The nuclei in ‹ong› and ‹ung› are pretty much [ɑ] and [ʌ] respectively. They can probably be assigned phonologically to the vowels /ɑ/ and /ʌ/.

2) The nuclei in ‹ing›, ‹eng›, and ‹ang› are something like [ɪi], [ɛi], and [ɛ̣i] respectively. Their phonological assignment is not obvious. Psychological data based on native speakers' categorizations of these vowels and other vowels examined in this chapter is needed to aid in their classification. This matter will be pursued in the next chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.32.1. Speaker 09's pronunciation of "pull" and "couple"

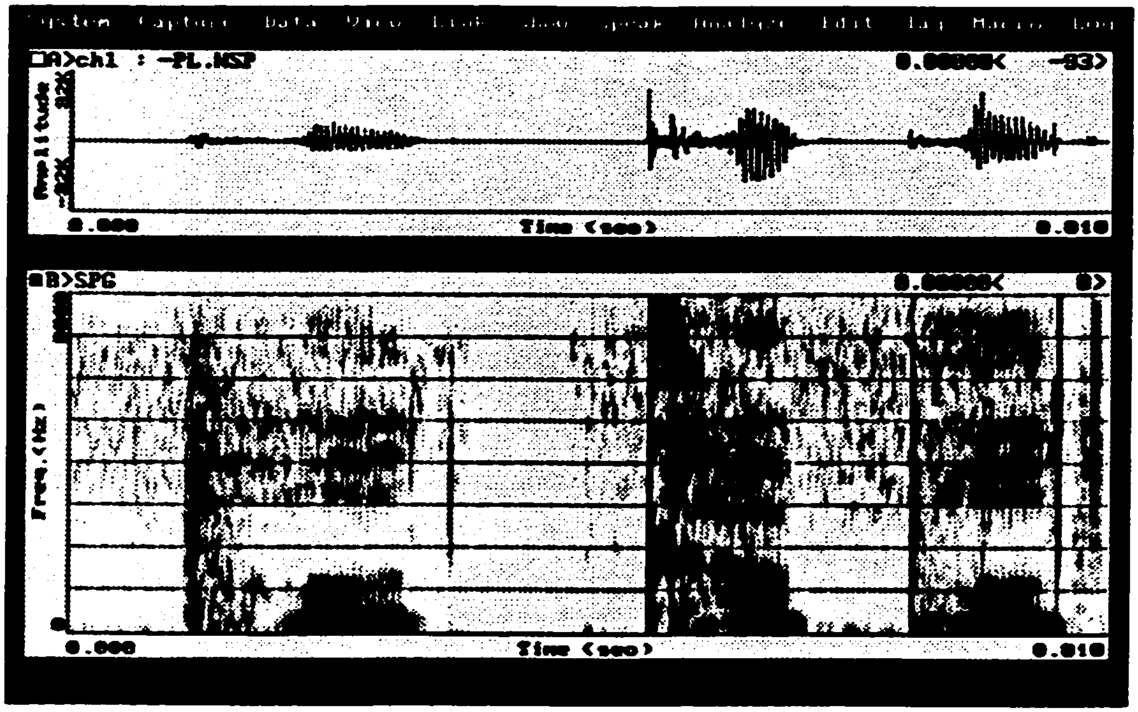
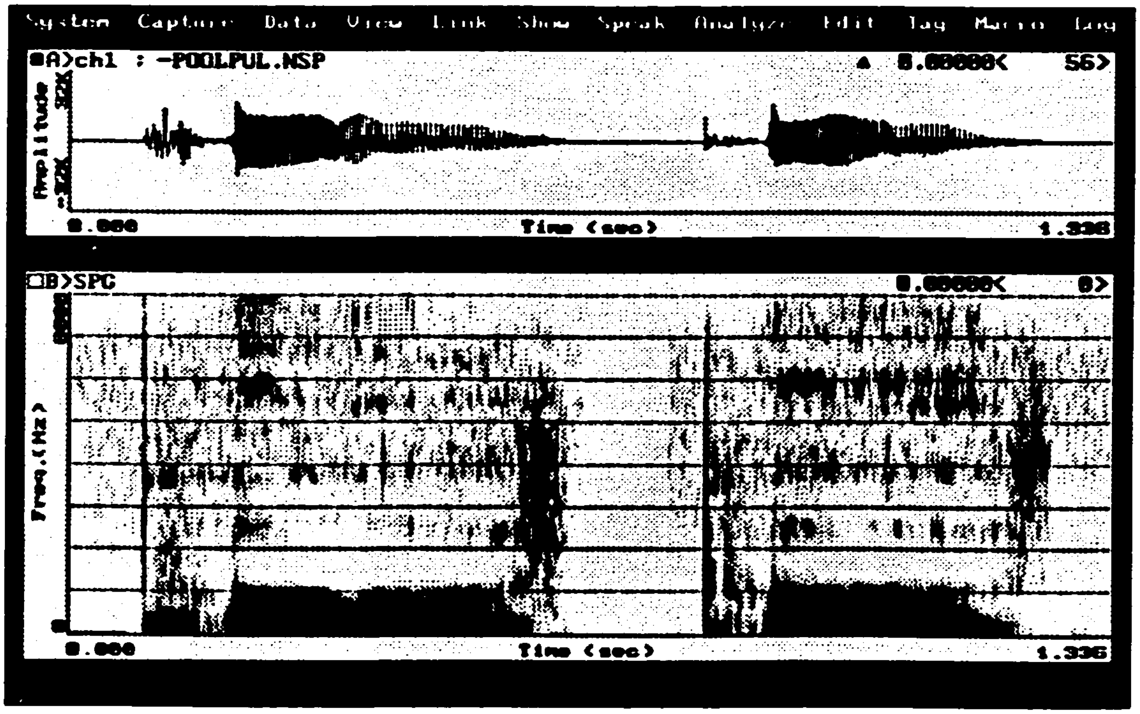


Figure 6.32.2 Speaker 04's pronunciation of "pull" and "pool."



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.32.3 Speaker 14's pronunciation of "pool" and "pull.'

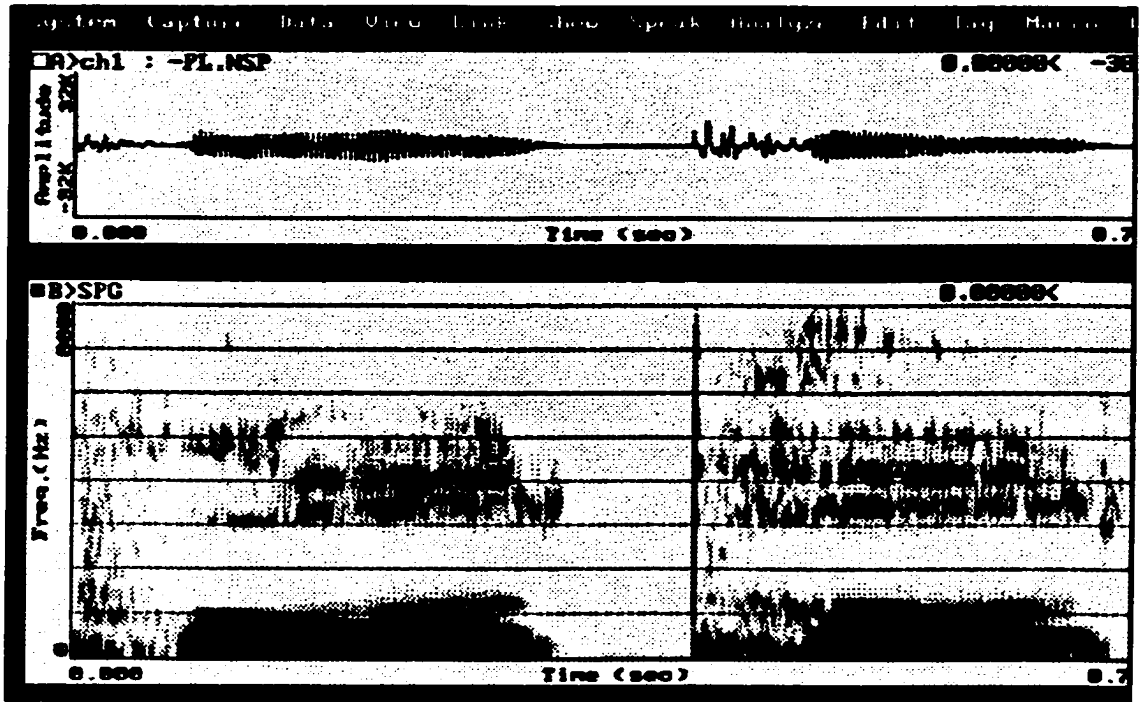
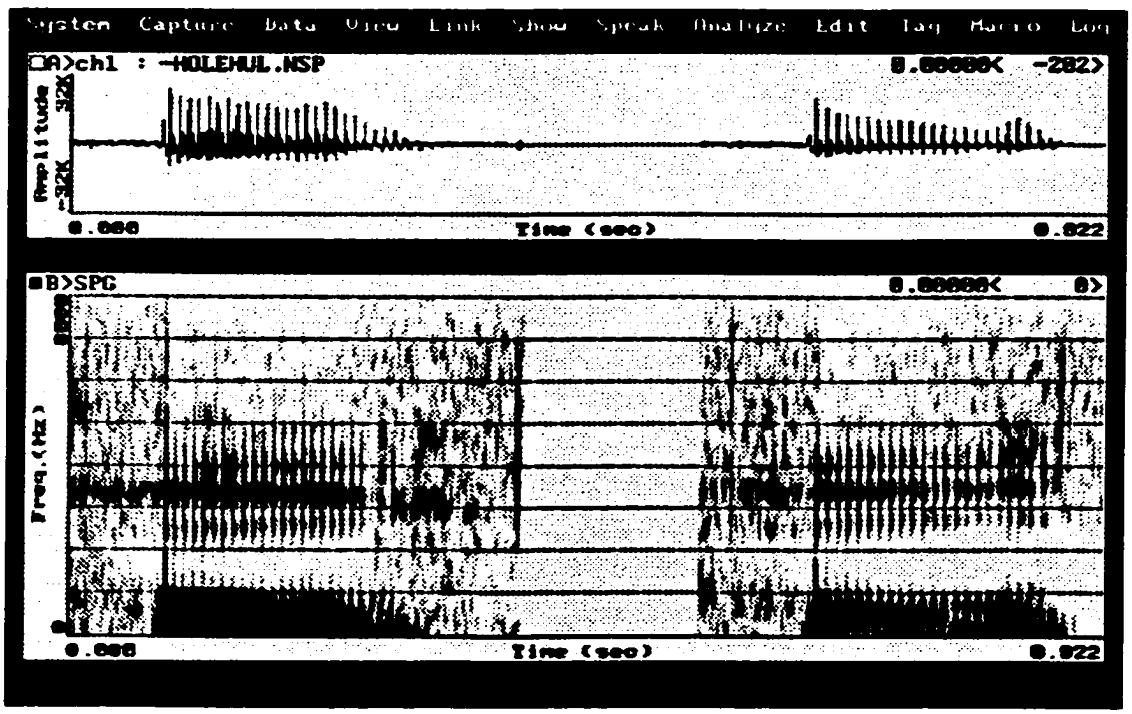


Figure 6.32.4. Speaker 06's pronunciation of "hole" and "hull"



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.32.5. Speaker 03's pronunciation of "hole" and "hull."

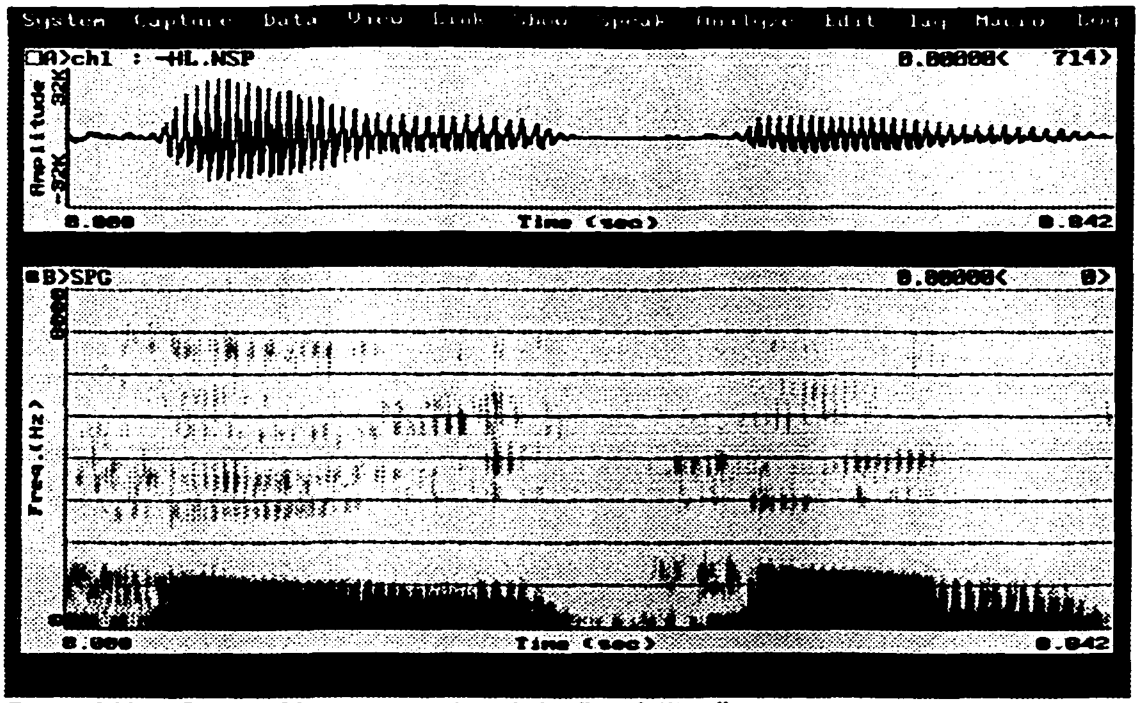
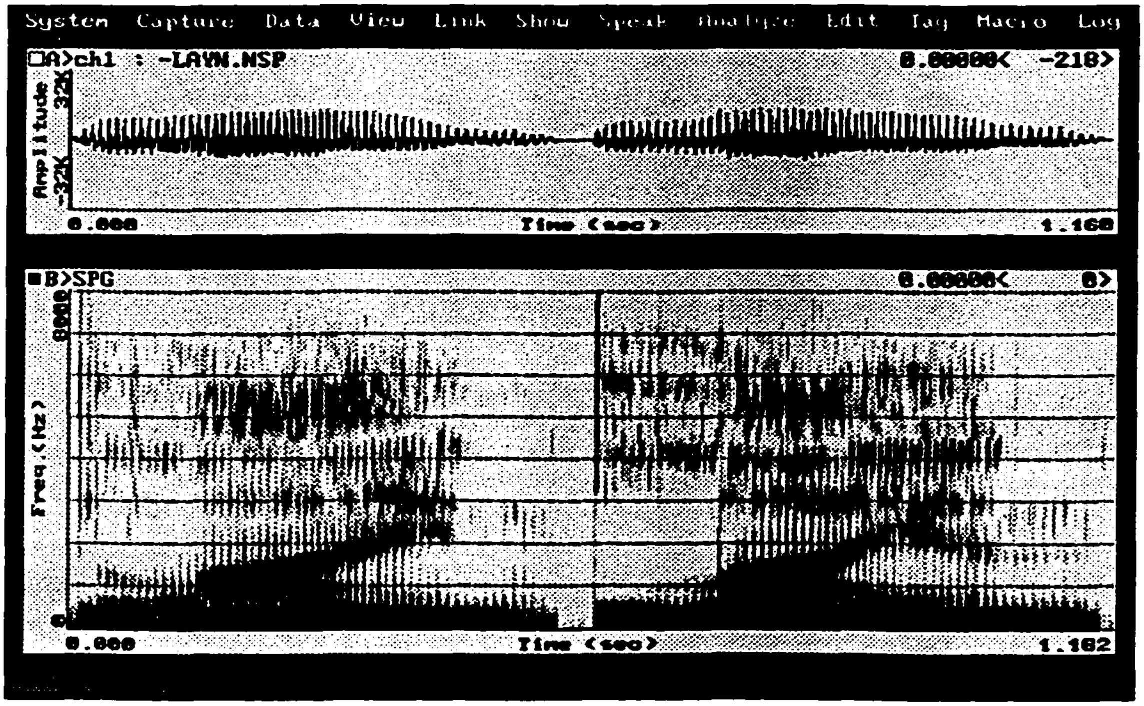


Figure 6.33.1. Speaker 03's pronunciation of "line" and "lion."



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.33.2. Speaker 11's pronunciation of "gown" and "MacGowan."

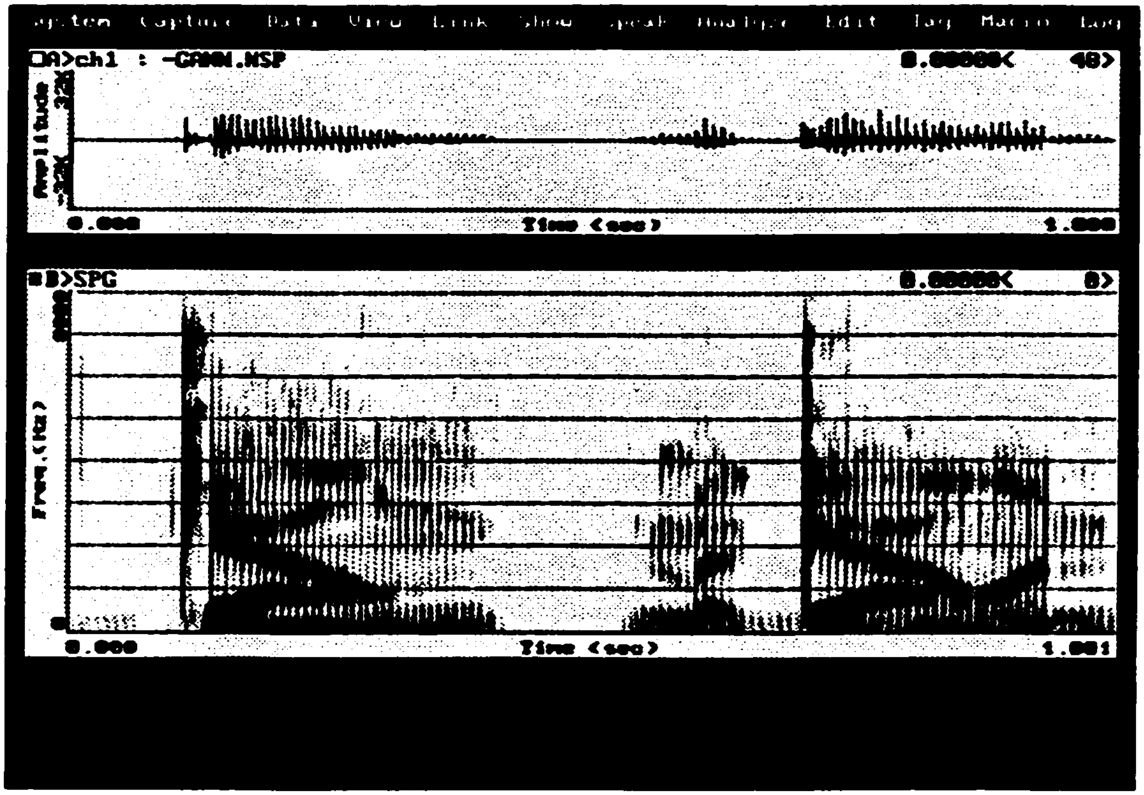
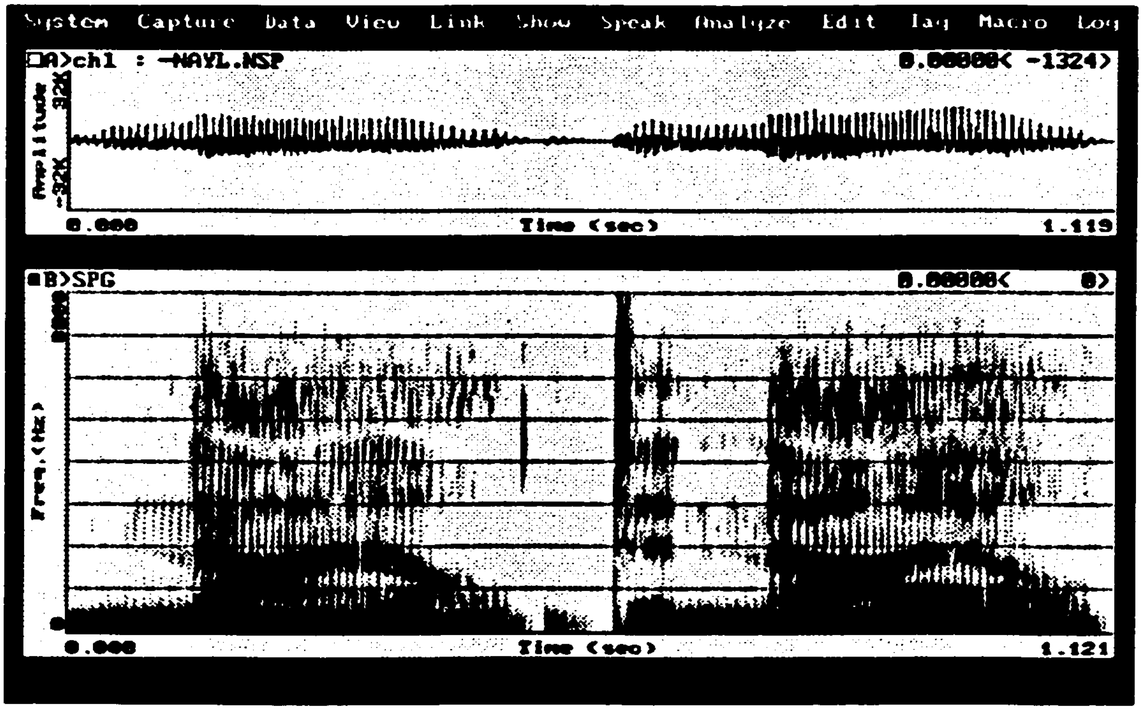


Figure 6.34.1. Speaker 03's pronunciation of "Nile" and "denial."



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.35.1. Speaker 11's pronunciation of "owl" and "avowal."

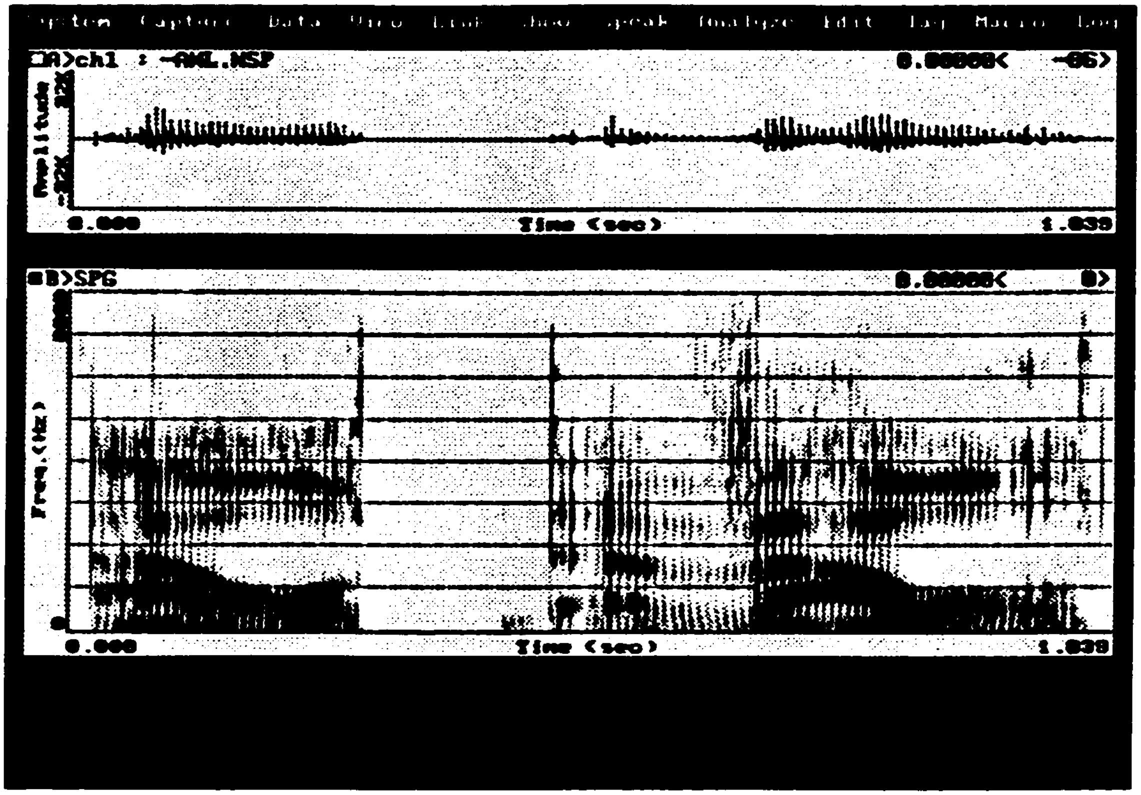
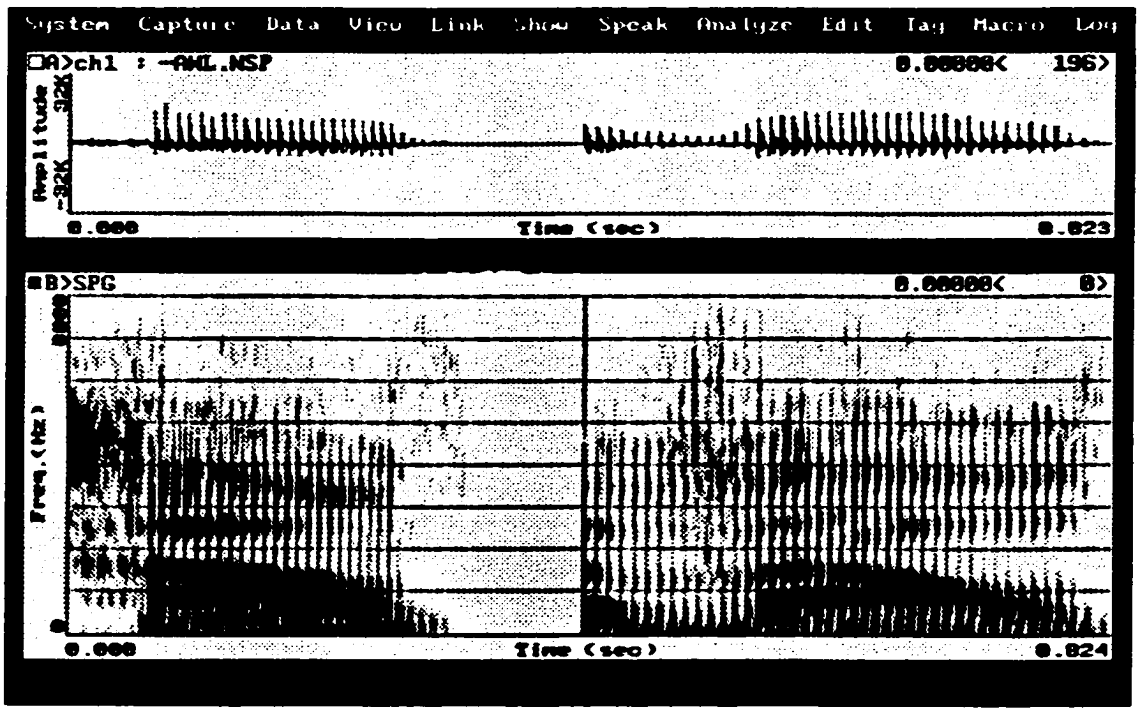


Figure 6.35.2. Speaker 06's pronunciation of "owl" and "avowal."



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.36.1. Speaker 04's pronunciation of "L" (amplitude)

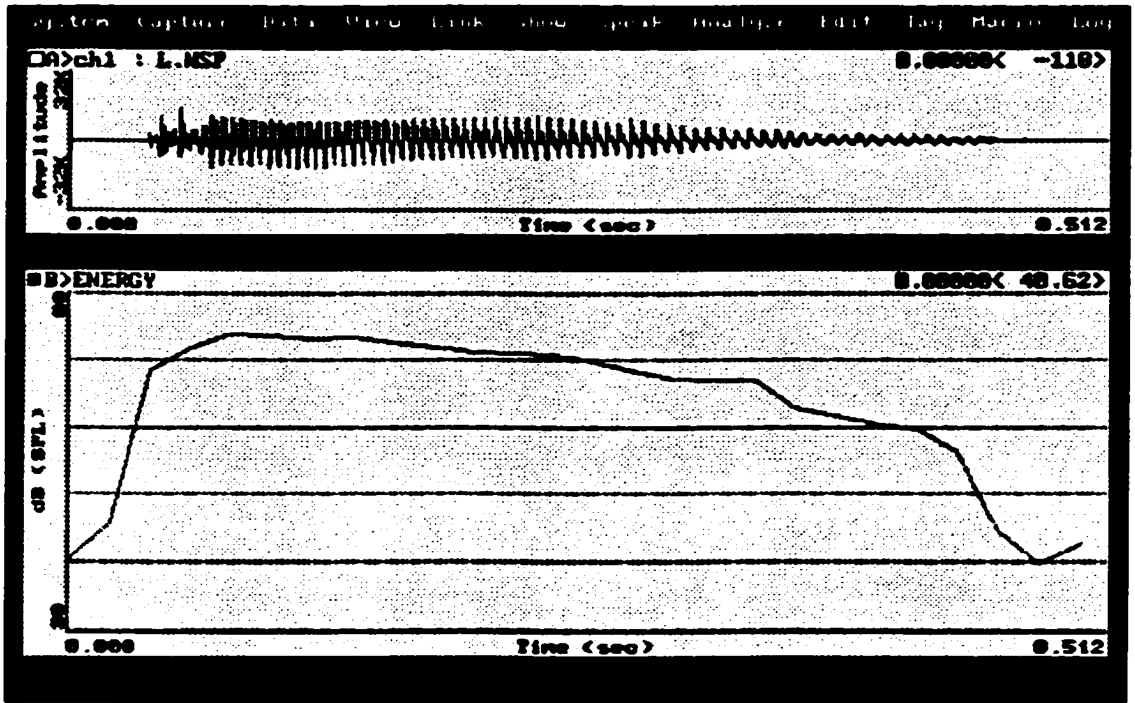
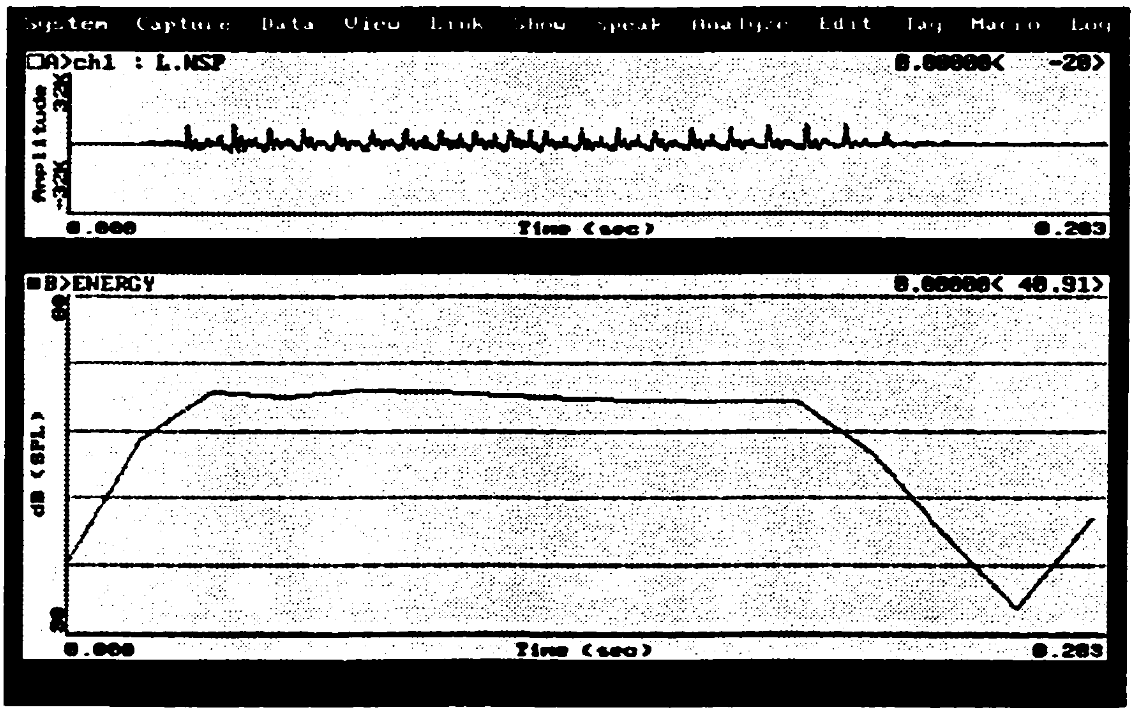


Figure 6.36.2 Speaker 08's pronunciation of "L" (amplitude)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 6.36.3. Speaker 04's pronunciation of "L" (formants)

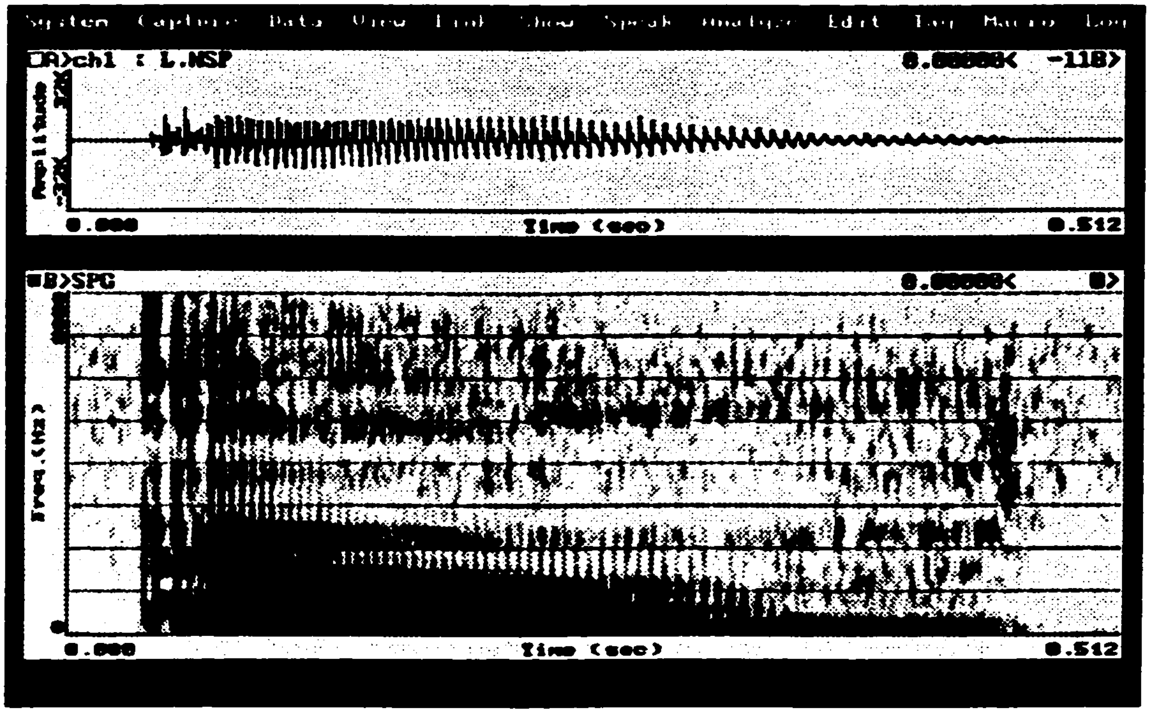
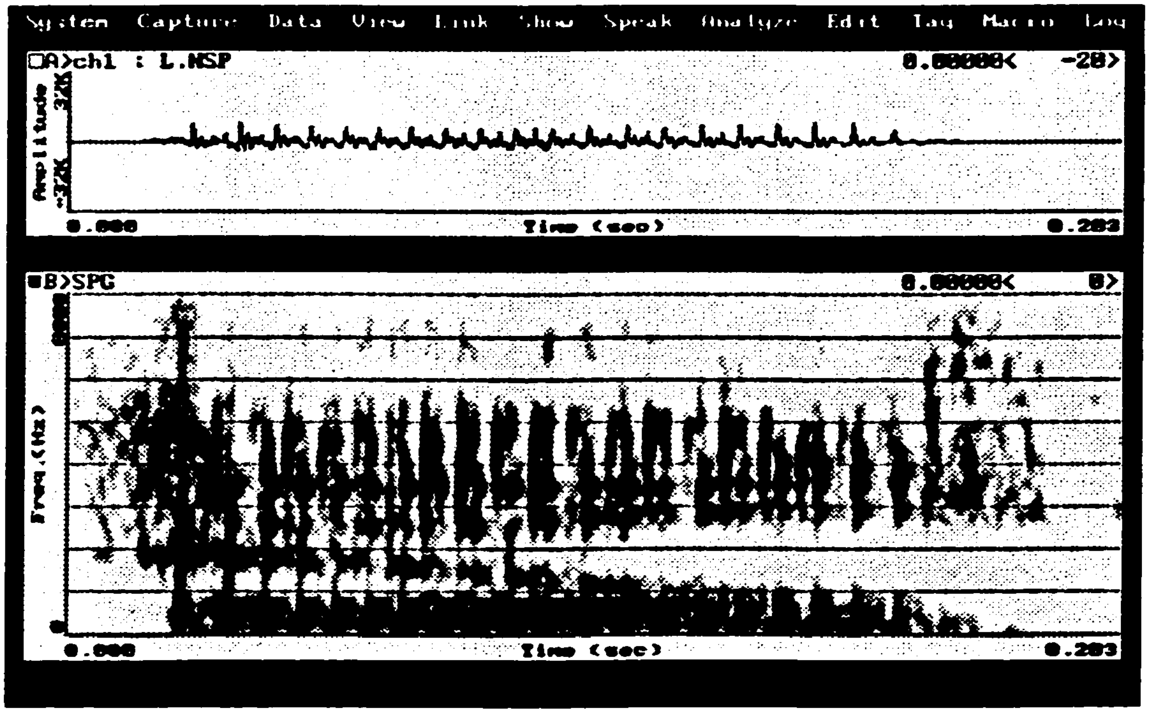


Figure 6.36.4. Speaker 08's pronunciation of "L" (formants).



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 7. Psycholinguistic Evidence

7.1. Introduction.

In addition to the phonetic evidence presented in Chapter 6, it would be helpful to have some psycholinguistic evidence which could support one claim or another made with respect to the vowels found before /r/ (and /l/ and /ŋ/).

The purpose of this chapter is to provide psycholinguistic evidence as to how native speakers of California English categorize the vowels found before /r/, /l/, and /ŋ/ with respect to the canonical vowels (those found in other environments)[1]. The use of a psycholinguistic test does not necessitate that the phenomena tested be psychological phenomena (though they may be), any more than the use of a litmus strip means that pH is measure of color.

The basic idea of the experiment was to play subjects pairs of monosyllabic English words and ask them if the two words had the same vowel or not. A big hurdle that can come up in such an experiment is the matter of orthographic bias. Subjects may be basing their responses not on the phonetics or phonology of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

words, but on the spelling of the words in question, or on general spelling conventions of Modern English. One way to control for this is to present the data orally, not graphically. Other attempts to control for orthographic bias were made. They will be discussed later in the chapter.

One question that the performing of such an experiment raises is: What exactly are the subjects basing their responses on? There are several possibilities:

1) The subjects are using the stimuli as triggers and are basing their responses on their own internal phonological categorizations.
2) The subjects are listening to the stimuli objectively and are basing their responses on the phonetics of the words they hear.
3) The subjects are using the stimuli as triggers, which they then use to evoke their own phonetics and then are basing their responses on their own surface phonetics.

---

[1]The experiment was performed with Julie A. Lewis and Margaret Urban. Many of the results have already been presented in Guenter, Lewis, and Urban 1999.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

4) The subjects are focusing on the speaker's pronunciations but are basing their responses on what they believe the speaker's internal phonological representations to be.

5) The subjects are using the words as triggers to evoke the general phonological system of their speech community rather than just themselves or the speaker.

6) The subjects are using the words as triggers to evoke the general phonetics of their speech community rather than just themselves or the speaker.

Of course, it is possible that some subjects may be using one strategy while other subjects use different strategies. Or, it is possible that a single subject may use on strategy for one pair of words, and another for the next pair of words, etc.

The hope is the subjects will be using the first strategy, above. We are interested in determining how native speakers of California English represent some of these controversial vowels internally. We already have detailed phonetic information gathered in Chapter Six. We hoped to induce the first strategy by:

1) Using stimuli from a speaker who belonged to the same age and dialect group as the subjects. This was done based on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the belief that listening to a speaker with a different accent might have a distracting effect on the subjects, causing them to focus more on the phonetics they hear.

2) Asking the subjects to respond to the stimuli as quickly as they could. This would hopefully inhibit the use of the third, fourth, fifth, and sixth strategies above, which would seem to require a greater deal of reflection on behalf of the subjects.

Ultimately, however, we do not know which strategies were being used. Given that, we can make the following qualifications:

1) A large number of subjects must be used in the experiment (we used eighteen). Hopefully, this will reduce the effect of individual variation in strategies and let general patterns be recognized.

2) It will not be claimed that the results of the experiment directly represent the underlying forms of the vowels in question. Rather, the results of the experiment (provided the results pattern in a meaningful way, which, as we shall see, they do) will be used as evidence in conjunction with

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

other types of evidence gathered (phonetic, phonological, historical) in order to make final conclusions.

7.2. The Experiment

Subjects:

There were 18 subjects[2]. All subjects were native speakers of California English between the ages of 18 and 25. Both male and female subjects were used. Most (but not all) subjects were undergraduate students drawn from linguistics classes. Some were drawn from an introductory-level survey class in American languages in which the topic of phonetics and phonology were not discussed much. Some were drawn from an introductory-level general linguistics class. However, the experiment was conducted at the beginning of the school semester before the topics of phonetics and phonology were introduced to the class. Some subjects were enrolled in an upper-division general linguistics class and may have had prior exposure to the topics of phonetics and phonology. None had had extensive classroom exposure to phonetics (such as in

[2]More than 18 tests were run, but some data had to be eliminated for various reasons.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

specialized phonetics classes) or to any discussion of the problem at hand.

Speaker/Recording:

The test consisted of pairs of common monosyllabic English words. The words were spoken by a 26-year-old female native speaker of California English.

Words were recorded in a frame sentence of "Say (word) again" using high quality audio recording equipment. The words were then digitized using a Kay CSL Model 4300 at a sampling rate of 16000 Hz and spliced into pairs. Between the words in each pair was a gap of .5 seconds. The pairs of words were played to subjects on a computer over headphones. The words were randomized, but all subjects heard the words in the same order. The experiment was conducted using the MATLAB program.

Instructions:

Subjects were read the following script:

We are studying vowel sounds in English words. We would like to find out how quickly vowels in different words can be recognized.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

You will hear a pair of words. If the two words have the same vowel, press "h" on the keyboard. If the two vowels are different, press "k." In between each answer, please rest your finger on the key between "h" and "k" ("j"). Please answer as quickly as you can, and respond to all the pairs. If you're not sure, give your best guess, but again, answer quickly. We are interested in how the words sound, not how they are spelled. More specifically, we are interested in the vowel sounds, not whether or not the word pairs rhyme. There will be a short pause between your answer and the next pair.

You will first hear a training set of word pairs, so you can become familiar with the format. Press enter only when you are ready to begin. Let the experimenter know when you are finished with the training set.

Any questions?

Thank you for your participation.

The sentence "We are interested in how the words sound, not how they are spelled" was included in the script in order to (hopefully) reduce the possibility of orthographic bias.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Training Test:

The subjects were first given a training test consisting of thirty pairs of words. The thirty pairs consisted of three categories with the following pairs:

Set 1 (same sound/different spelling)

sigh/dye	code/toad
boy/moist	pod/odd
date/wait	shy/buy
choose/dues	guide/side

Set 2 (same sound/same spelling)

cat/flash	cheat/neat
cow/now	fat/vat
bed/fed	met/pet
sip/zip	tip/nip
mad/pad	knee/tree
mow/show	fate/date

Set 3 (different sound/same spelling)

pose/lose	good/booze

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

head/lead[3]	soup/doubt
though/through	grout/group
lost/most	niece/sieve
moth/both	tow/how

The words were played to subjects in a non-meaningful order. The purpose of the training test was twofold: to familiarize the subjects with the procedure, and to determine if there were any strong orthographic biases. This was the reason for Sets 1 and 3. If orthography, not phonetics or phonology were being used as the basis for judgment, subjects would judge the words in Set 1 as having different vowels, and the words in Set 3 as having the same vowels. Though not many mistakes were made by subjects in Sets 2 and 3, one of the subjects did identify the majority of the words in Set 1 as being different. Hence, we did not include that subject's responses for the main test in the data. That left us with 18 subjects total.

The Main Test:

The main test was conducted by the same procedure as the training test. In the main test, both Yes/No responses and response

[3]The verb [lid].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

times were recorded. Response times (RT) were measured from a tag 0.2 seconds from the end of the second word in each pair. All of the second words in each pair ended with a stop: [t], [d], or [k]. The "end of the word" was considered to be the end of the noise burst following the release of the stop. All of the final stops (voiced or voiceless) were released and contained some noise burst afterwards (voiced or voiceless)[4]. Response times automatically determined by the computer based on the interval between the tag on the audio file and the detection of the keystroke by the subject.

The test consisted of 129 pairs of words divided into the following sets (Pairs were played in a non-meaningful order).

It will be noticed from looking at the pairs used that there is a lot less variation in the second word in each pair than in the first word. The second word in each pair came from a limited inventory of words. This was done in order to minimize differences in response time that might result from varying durations of words. At any rate, it must be stated that the shortest response time of any subject (0.31275 secs, Subject 31's response for the pair "food/spade") was longer than the 0.2secs between the tag and the end of the word.

[4]Since the words were all citation forms spoken in a frame sentence, it is not surprising that all the final stops would be released and that there would always be some noise following the release. This noise resembled aspiration following the voiceless stops and a short [ə] vowel following the voiced stops.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

This indicates that all subjects responded after hearing both words in each pair completely.

Set SS (Same/Same). This set consisted of words with the same vowel phoneme nucleus and the same consonant phoneme in the coda. It comprised the following eleven pairs:

<u>words</u>	<u>phonemic transcription</u>
freight/gate	/fret/, /get/
debt/bet	/dɛt/, /bɛt/
braid/spade	/bred/, /sped/
head/bed	/hɛd/, /bɛd/
blood/bud	/blʌd/, /bʌd/
could/hood	/kʊd/, /hʊd/
said/bed	/sɛd/, /bɛd/
coat/boat	/kot/, /bot/
clock/dock	/klɑk/, /dɑk/
node/load	/nod/, /lod/
prod/pod	/prɑd/, /pɑd/

The purpose of this set was to have a control group in which the vowels in both words in the pair belong unambiguously to the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

same vowel phoneme. Since the coda consonants are also the same, the vowels in both words in each pair do not have different allophones conditioned by the following consonant either.

Set SD (Same/Different): This set consisted of words with the same vowel phoneme but different consonant codas. It comprised the following 28 pairs:

words	phonemic transcription
grief/beet	/grif/, /bit/
weep/beet	/wip/, /bit/
myth/bit	/mɪθ/, /bɪt/
grieve/bead	/griv/, /bid/
weep/bead	/wip/, /bid/
fizz/bid	/fɪz/, /bɪd/
rough/luck	/rʌf/, /lʌk/
pup/luck	/pʌp/, /lʌk/
put/look	/pʊt/, /lʊk/
breath/deck	/brɛθ/, /dɛk/
pup/bud	/pʌp/, /bʌd/
smoke/boat	/smok/, /bot/
dot/dock	/dɑt/, /dɑk/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

robe/load	/rob/, /lod/
dog/pod	/dɑg/, /pɑd/
beam/beet	/bim/, /bit/
beam/bead	/bim/, /bid/
dim/bit	/dɪm/, /bɪt/
game/gate	/gem/, /get/
game/spade	/gem/, /sped/
stem/bet	/stɛm/, /bɛt/
stem/bed	/stɛm/, /bɛd/
comb/boat	/kom/, /bot/
comb/load	/kom/, /lod/
mom/dock	/mɑm/, /dɑk/
some/luck	/sʌm/, /lʌk/
some/bud	/sʌm/, /bʌd/

The purpose of this set was to account for any allophonic effects the coda consonant might have on the preceding vowel, in order to see if subjects were basing their Yes/No responses on the allophone or the phoneme, and also to see if subjects were basing their responses on the whole rhyme of the word, or just the nucleus. Set SD contains 13 pairs in which one of the words has the coda consonant /m/. This was done in order to have a coda consonant

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that conditions an uncontroversially variant allophone of the previous vowel. We selected /m/ as this consonant because it triggers both nasalization due to its nasal character and a lowering of both the second and third formants of the preceding vowel due to its bilabial character (Ladefoged 1993, Lehiste and Peterson 1961).

Set D (Different):

This set consisted of words with different vowel phoneme nuclei. Consonant codas might be the same or different. It comprised the following 41 pairs:

words	phonemic transcription
bit/beet	/bɪt/, /bit/
beet/bit	/bit/, /bɪt/
bide/bead	/bajd/, /bid/
bid/bead	/bɪd/, /bid/
bad/bid	/bæd/, /bɪd/
bead/bid	/bid/, /bɪd/
bite/gate	/bajt/, /get/
boot/gate	/but/, /get/
hit/bet	/hɪt/, /bɛt/
foot/bet	/fʊt/, /bɛt/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

bread/spade	/brɛd/, /sped/
food/spade	/fud/, /sped/
lid/bed	/lɪd/, /bɛd/
hood/bed	/hʊd/, /bɛd/
look/luck	/lʊk/, /lʌk/
deck/luck	/dɛk/, /lʌk/
duck/look	/dʌk/, /lʊk/
deck/look	/dɛk/, /lʊk/
luck/deck	/lʌk/, /dɛk/
look/deck	/lʊk/, /dɛk/
hood/bud	/hʊd/, /bʌd/
bed/bud	/bɛd/, /bʌd/
bud/hood	/bʌd/, /hʊd/
bed/hood	/bɛd/, /hʊd/
bide/bed	/bajd/, /bɛd/
bud/bed	/bʌd/, /bɛd/
bit/boat	/bɪt/, /bot/
deck/dock	/dɛk/, /dɑk/
bed/load	/bɛd/, /lod/
bed/pod	/bɛd/, /pɑd/
bike/beet	/bajk/, /bit/
bath/bit	/bæθ/, /bɪt/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

lit/luck	/lɪt/, /lʌk/
lap/look	/læp/, /lʊk/
dot/deck	/dɑt/, /dɛk/
big/bud	/bɪg/, /bʌd/
bike/boat	/bajk/, /bot/
bed/dock	/bɛd/, /dɑk/
have/load	/hæv/, /lod/
bed/load	/bɛd/, /lod/
bug/pod	/bʌg/, /pɑd/

The purpose of this set was to have a control group in which the vowel phonemes in both words in each pair were unambiguously different. A few of the pairs in Set D were reversals of each other (bit/beat, beat/bit; bid/bead, bead/bid; deck/luck, luck/deck; deck/look, look/deck; hood/bud, bud/hood; bed/bud, bud/bed). There weren't many large differences in Yes/No response rates or reaction times for the reversed pairs, as we can see:

Pair	Yes%	No%	avg. RT (secs.)
bid/bead	0	100	1.81
bead/bid	0	100	1.94
deck/luck	11	89	1.63
luck/deck	0	100	1.81

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

deck/look	6	94	2.00
look/deck	6	94	1.43
hood/bud	22	78	2.13
bud/hood	28	72	2.18
bed/bud	6	94	1.60
bud/bed	6	94	1.93

This suggests that the order the words in each pair were placed in was not significant.

Set R:

This set consisted of pairs in which one of the words had an RGD or [ɚ], and the other word had a phonetically similar vowel but a non-r coda consonant.

[Ir] was compared to /i/ and /ɪ/.

[Er] was compared to /e/ and /ɛ/.

[Or] was compared to /o/ and /ɑ/. Since there is no contrastive phoneme /ɔ/ in California English, we could not compare [Or] to /ɔ/. The phoneme /ɔ/ has merged with the vowel phoneme /ɑ/. Hence, the vowel phoneme /ɑ/ might include any actual phonetic realizations of [ɔ] that are found in California English.

[Ar] was compared to /ɑ/.

[ɚ] was compared to /ʌ/, /ɛ/, and /ʊ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The set was broken up into the following groups comprising the following 20 pairs:

group	words	phonemic transcription
/Ir-i/	beer/beet	/bIr/, /bit/
	beer/bead	/bIr/, /bid/
/Ir-ɪ/	beer/bit	/bIr/, /bɪt/
	beer/bid	/bIr/, /bɪd/
/Er-e/	bear/gate	/bEr/, /get/
	bear/spade	/bEr/, /sped/
/Er-ɛ/	bear/bet	/bEr/, /bɛt/
	bear/bed	/bEr/, /bɛd/
/Or-o/	bore/boat	/bOr/, /bot/
	bore/load	/bOr/, /lod/
/Or-ɑ/	bore/dock	/bOr/, /dɑk/
	bore/pod	/bOr/, /pɑd/
/Ar-ɑ/	car/dock	/kAr/, /dɑk/
	car/pod	/kAr/, /pɑd/
/ɚ-ʌ/	lurk/luck	/lɚk/, /lʌk/
	bird/bud	/bɚd/, /bʌd/
/ɚ-ʊ/	lurk/look	/lɚk/, /lʊk/
	bird/hood	/bɚd/, /hʊd/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɚ-ɛ/	lurk/deck	/lɚk/, /dɛk/
	bird/bed	/bɚd/, /bɛd/

The purpose of this set is the purpose of this dissertation: to determine how subjects categorize vowels found before /r/ with respect to the vowels found in other environments.

Set L:

This set consisted of words with the (presumably) same vowel phoneme, but different consonant codas. The coda in one of the words in each pair was /l/, while the coda in the other word in each pair was a different consonant. Set L consisted of the following 8 groups comprising the following 15 pairs:

group	words	phonemic transcription
/il-i/	peel/beet	/pil/, /bit/
	peel/bead	/pil/, /bid/
/ɪl-ɪ/	will/bit	/wɪl/, /bɪt/
	will/bid	/wɪl/, /bɪd/
/el-e/	pail/gate	/pel/, /get/
	pail/spade	/pel/, /sped/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɛl-ɛ/	well/bet	/wɛl/, /bɛt/
	well/bed	/wɛl/, /bɛd/
	bell/deck	/bɛl/, /dɛk/
/ol-o/	bowl/boat	/bol/, /bot/
/ɑl-ɑ/	hall/dock	/hɑl/, /dɑk/
/ʌl-ʌ/	dull/luck	/dʌl/, /lʌk/
	dull/bud	/dʌl/, /bʌd/
/ʊl-ʊ/	pull/look	/pʊl/, /lʊk/
	pull-hood	/pʊl/, /hʊd/

The purpose of this set was to determine how subjects categorize the vowels found before /l/ with respect to the vowels found before other consonants. As we have seen in Chapters Four and Six, above, there are ways in which the vowels found before /l/ in American English are deviant phonetically and phonologically. Hence, their phonemic status might be in doubt, and psycholinguistic evidence would help inform any categorization.

Set NG:

This set consisted of pairs in which one of the words had a /Vŋ/ sequences, and the other word had a phonetically similar vowel with a non-ŋ coda consonant.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

<ing> was compared to /i/ and /ɪ/.

<eng> was compared to /e/ and /ɛ/.

<ang> was compared to /e/, /ɛ/, and /æ/.

<ong> was compared to /ɑ/.

<ung> was compared to /ʌ/.

The set was broken up into the following nine groups comprising the following 11 pairs:

group	words	phonemic transcription
/ing-i/	sing/bead	/s<ing>/, /bid/
/ing-ɪ/	sing/bid	/s<ing>/, /bɪd/
/eng-e/	length/gate	/l<eng>kθ/, /get/
	length/spade	/l<eng>kθ/, /sped/
/eng-ɛ/	length/bet	/l<eng>kθ/, /bɛt/
	length/bed	/l<eng>kθ/, /bɛd/
/ang-e/	hang/spade	/h<ang>/, /sped/
/ang-ɛ/	hang/bed	/h<ang>/, /bɛd/
/ang-æ/	hang/sad	/h<ang>/, /sæd/
/ong-ɑ/	song/pod	/s<ong>/, /pɑd/
/ung-ʌ/	lung/bud	/l<ung>/, /bʌd/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The purpose of this set was to determine how subjects categorize the vowels found before /ŋ/ with respect to the vowels found before other consonants, particularly with regards to the front vowels <ing>, <eng>, and <ang>, whose phonemic categorization is not obvious from the phonetic data (see section 6.4.3).

Diphthongs:

This set consisted of pairs in which one of the words had a diphthong rhyme of /aj/ or /aw/, and the other had a rhyme of /ɑC/. The set comprised the following two pairs:

/aj-ɑ/	buy/pod	/baj/, /pɑd/
/aw-ɑ/	cow/pod	/kaw/, /pɑd/

The purpose of this set was to see how complex diphthongal rhymes like /aj/ and /aw/ are categorized when compared to rhymes with a phonetically similar vowel nucleus (in this case, /ɑ/), but a true consonantal coda, instead of a central approximant like [j] or [w].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We also tested the following pair:

bee/bead /bi/, /bid/

The purpose of this pair was to evaluate one interpretation of Harris's claim (see section 3.2.1) that the reduction in contrast of vowels before /r/ is caused by a rule allowing only tense vowels in open syllables. This rule accounts for why /bi/ (as in "bee") is a possible English word, but not /bɪ/. If this interpretation of Harris's claim is correct, then the vowel in "bee" should have the same relation to the vowel in "bead" as the vowel in "beer" has to the vowel in "bead." The pair "beer/bead" is included in Set R. Comparing how subjects respond to the pair "bee/bead" with how they response to the pair "beer/bead" will let us see if there is any psycholinguistic basis for Harris's claim.

It should be pointed out that many of the words in the test have common (or fairly common) homonyms with different spellings, namely:

word	pronunciation	homonym(s)
peel	/pil/	peal
beet	/bit/	beat
pail	/pel/	pale

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

gate	/get/	gait
spade	/sped/	spayed
hall	/hal/	haul
load	/lod/	lode
some	/sʌm/	sum
pod	/pad/	pawed
bear	/bEr/	bare
bore	/bOr/	boar
rough	/rʌf/	ruff
bee	/bi/	be, B
buy	/baj/	by, bye

The spellings given in the previous lists are only one possible interpretation. Specifically, they are the words written down for the speaker to say when she recorded the words. We have no idea which words the subjects thought they were hearing. This is relevant only in that it points to the chance of orthographic bias working in more than one possible direction for many of the words used in the test.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

7.2.1. Expectations

It was expected that Yes/No responses for the sets SS and SD would be near 100% positive, and that Yes/No responses for Set D would be near 0% positive.

It was also expected that response times for sets SS, SD, and D would be short, since subjects should know clearly whether the vowels in the words in these sets belong to the same phoneme or not.

It was expected that responses for Set L would pattern much like those in Set SD, since the vowels in each pair should belong to the same phoneme; only the final consonant is different.

It was expected that subjects would have difficulty categorizing the vowel pairs in Set R, and that this categorization might manifest itself in longer response times for these pairs.

It was expected that the pairs in Set NG with ‹ong› and ‹ung› would pattern like those in Set SD as well.

No firm expectations were set for the vowels in Set R and the front vowels in Set NG. We were as unsure as to how to classify these vowels as anybody else who has researched the problem, though we did believe that the vowel in [Ar] might pattern well with /ɑ/, since this seems to be the least controversial of any of the vowels in the RGDs.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

If the vowels in the RGDs are just allophones of some of the canonical vowels, then the pairs in Set R should pattern like those in Set SD. If the RGDs themselves constitute distinct monophonemic diphthongs like /aj/ and /aw/, then the pairs in Set R should pattern like those in Set D. This latter expectation, however, is based on the presupposition that the diphthongs /aj/ and /aw/ themselves are distinct monophonemes. If the diphthongs /aj/ and /aw/ are sequences of one of the canonical vowels followed by /j/ and /w/, then the pairs in the diphthong set should pattern like those in Set SD. If the diphthongs /aj/ and /aw/ are monophonemic, then the pairs in the diphthong set should pattern like those in Set D.

7.3. Results and Discussion.

Complete results for each subject, including Yes/No responses and response times are given in appendix C. The total data for all subjects are presented by set in Table 7.1. The data are also represented in graph form in Figure 7.1, with the response times in the x-axis, and the percentage of "Yes" responses in the y-axis. The variables used in the test are not arbitrary categories. "Yes" and "No" indicate whether the subjects considered the vowels in the two words to be the same or not. Response times can be reasonably

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

linked to subjects' certainty of response: a low response time indicating a greater degree of certitude, and a high response time indicating a lesser degree of certitude.

7.3.1. Control Sets.

We can see from Table 7.1 that pairs of words in Set SS (those with identical nuclei and codas) were categorized with a 97% "Yes" response rate, and a very quick response time.

We can also see that pairs of words in Set D (those with different nuclei) were categorized with a 4% "Yes" response rate, and a very quick response time. Hence, the results of the test are basically consistent with the categorizations predicted by standard phonemic theory. Words containing vowels of the same phoneme were associated together at a very high rate. Words containing vowels of different phonemes were associated together at a very low rate.

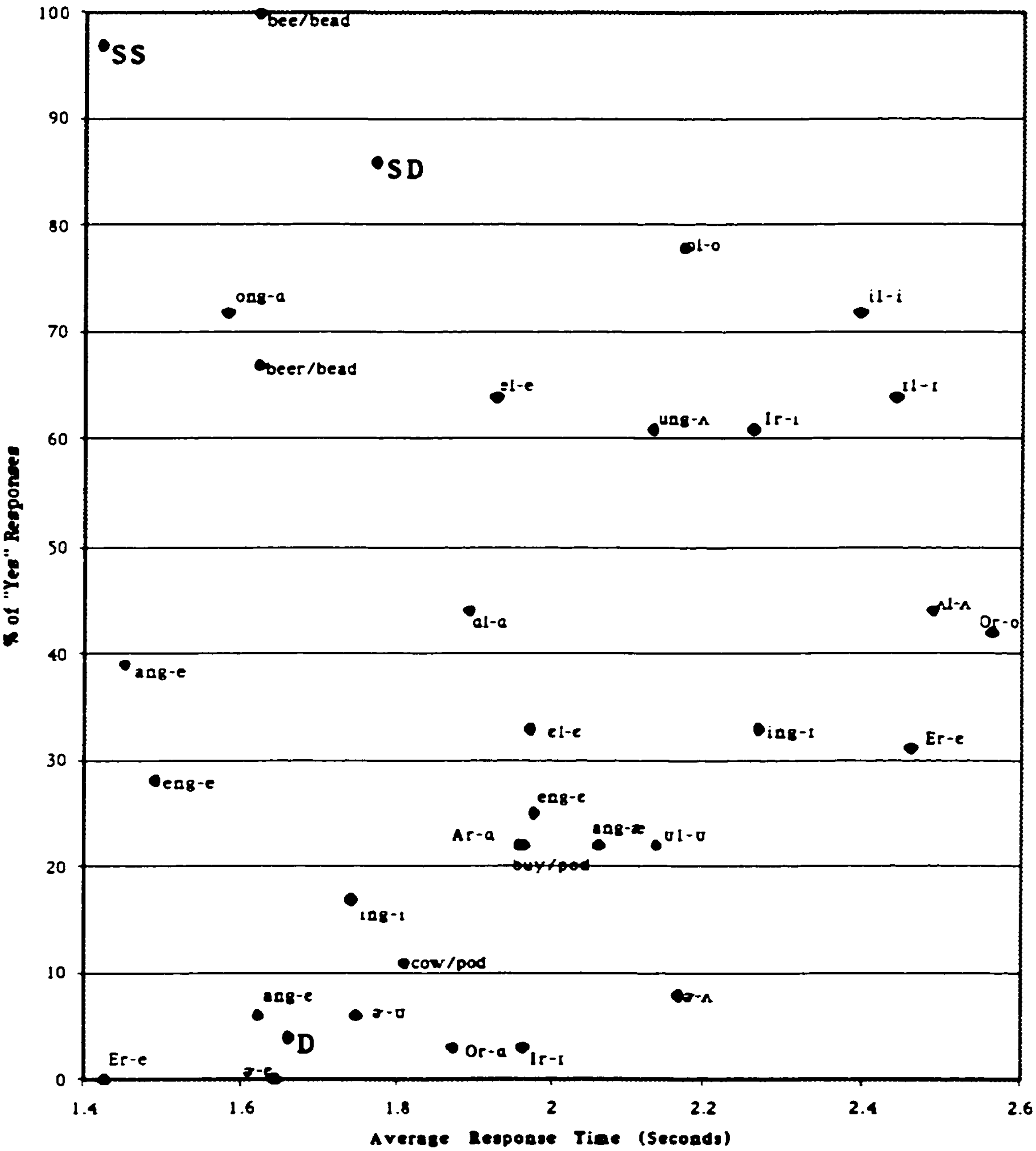
Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 7.1. Percentage of Yes/No and Response Times by vowel-pair category.

	Set	Group	Responses	*Yes*	*No*	RT (Seconds)
1	SS	all	198	97	3	1.42
1a	*diff. sp*	*all*	*126*	*95*	*5*	
2	SD	all	504	86	14	1.769
2a	*diff. sp*	*all*	*252*	*81*	*19*	
3	D	all	738	4	96	1.658
4	R	{Ir-i}	36	61	39	2.26
5	"	{Ir-ɪ}	36	3	97	1.96
6	"	{Er-e}	36	0	100	1.425
7	"	{Er-ɛ}	36	31	69	2.46
8	"	{Or-o}	36	42	58	2.56
9	"	{Or-ɑ}	36	3	97	1.87
10	"	{Ar-ɑ}	36	22	78	1.955
11	"	{ɚ-ʌ}	36	8	92	2.165
12	"	{ɚ-ʊ}	36	6	94	1.745
13	"	{ɚ-ɛ}	36	0	100	1.64
14	L	{il-i}	36	72	28	2.395
15	"	{il-ɪ}	36	64	36	2.44
16	"	{el-e}	36	64	36	1.925
17	"	{ɛl-e}	54	33	67	1.97
18	"	{ol-o}	18	78	22	2.17
19	"	{ɑl-ɑ}	18	44	56	1.89
20	"	{ul-u}	36	22	78	2.135
21	"	{ʌl-ʌ}	36	44	56	2.485
22	NG	{ing-i}	18	17	83	1.74
23	"	{ing-ɪ}	18	33	67	2.27
24	"	{eng-e}	36	28	72	1.49
25	"	{eng-ɛ}	36	25	75	1.975
26	"	{ang-e}	18	39	61	1.45
27	"	{ang-ɛ}	18	6	94	1.62
28	"	{ang-æ}	18	22	78	2.06
29	"	{ong-ɑ}	18	72	28	1.58
30	"	{ung-ʌ}	18	61	39	2.13
31	Pairs:	Buy/Pod	18	22	78	1.96
32	"	Cow/Pod	18	11	89	1.81
33	"	Beer/Bead	18	67	33	1.62
34	"	Bee/Bead	18	100	0	1.62

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 7.1. Relation of Yes/No% to Response Time



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Pairs of word in Set SD (those with identical nuclei, but different codas) were categorized with an 86% "Yes" response rate. This is lower than the 97% "Yes" response rate of Set SS. In addition, the response time for Set SD is somewhat higher than that of Set SS. There does appear to be some difference in how subjects respond to pairs of words with the same nucleus, depending on whether the coda is the same or different. Whether this effect is due to subjects' phonetic sensitivity to a different allophone of the vowel, or due to the response being based on the whole rhyme, instead of just the vowel, is not known. The "Yes" response rate for Set SD is still very high, close to 90%, and this is basically consistent with a phonemic model. The difference between the Yes/No response rates for Sets SD and SS is significant though. Discussion of the meaning of this difference will be found in Section 7.4.

Row 1a on Table 7.1 shows the data for the subset of Set SS in which the two words in the pair have different vowel spellings (freight/gate, braid/spade, head/bed, blood/bud, could/hood, said/bed/, node/load). Row 2a shows the data for the subset of Set SD in which the two words in the pair have different vowel spellings (grief/beet, myth/bit, grieve/bead, weep/bead, rough/luck, put/look,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

breath/deck, smoke/boat, robe/load[5]). The purpose of these two subsets is to see the effect of orthographic bias on the subjects' responses. The subset of Set SS has a 95% "Yes" response rate (compared to 97% total). The subset of Set SD has an 81% "Yes" response rate (compared to 86% total). There does appear to be an effect of orthographic bias, but a small one at best. Is it not being claimed that orthographic bias has been eliminated completely in the test. However, these comparisons at least give us some idea as to how large a factor we should expect it to be.

The high Yes/No response rates for the control sets SS, SD, and D is extremely important, though. Since the responses are consistent with phonemic theory, the responses for other pairs can be evaluated in this framework as well. If the vowels in a given pair of words belong to the same phoneme, we should expect the results to pattern much like Set SD (since we will have different coda consonants in the two words in the pair). If the vowels in a given pair of words belong

[5]Pairs are included in the subsets if they have empirically different vowel spellings. There still might be similarity in the spellings in the words in the pairs though. For example, "smoke" and "boat" have empirically different spellings, but they both contain the letter <o>. The vowels in "myth" and "bit" are represented by different letters, but the letters <i> and <y> are to a certain extent allographs in English orthography, since they can be interchanged in names like "Brian/Bryan", and participate in morphological alternations in pairs like "puppy/puppies", and "die/dying." There also is the question of whether orthographic bias here would come from the particular words used, or from the general spellings of the sound. The question of what constitutes orthographic bias is still an open one.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to different phonemes, we should expect the results to pattern much like Set D.

The ranges of responses to the various sets are also compared to each other statistically by the use of T-tests. Both the range of response times and Yes/No responses were compared in this manner. The Yes/No responses were compared by converting all instances of a "Yes" response to the number 1 and all instances of a "No" response to the number 0. The results of these T-tests are shown in Table 7.2. Each T-test returns a P-value, or the probability that the range of responses in the two groups tested could come from the same population. Since so many groups are being tested (44 in all), the P-value must be "very highly significant" (< .001) for it to be of interest.

If a T-test of two sets returns a P-value of less than .001, this suggests that the response times and Yes/No response rates of the two groups in question are very highly unlikely to come from the same population, and that there must be some factor which contributes to the difference in response times and Yes/No response rates between these two groups. If a T-test of two sets returns a P-value of greater than .001, it is more possible that the response times and Yes/No response rates of the two groups in question come from the same population, their difference being due to chance.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Since the response times and Yes/No response rates of the control sets D, SS, and SD are all at extremes in the range (low response times for all the control groups, extremely high "Yes" response rates for sets SS and SD, extremely low "Yes" response rates for Set D), the T-tests are single-tailed. The maximum P-value that can be returned is .50.

The usage of statistical analysis tools here is not intended to take precedence over any other consideration of the matters at hand. It merely gives us some metric to support assertions that two tested groups pattern alike or differently. A thorough discussion of the results of this experiment is still necessary.

7.3.2. Set R

[Ir] Pairs:

Group /Ir-ɪ/: On Table 7.1, row 5, we can see that responses for the /Ir-ɪ/ pairs "beer/bit" and "beer/bid" were 97% negative, comparable to set D.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 7.2. P-values (rounded to eight significant digits) for Response Times and Range of Yes/No Responses for various vowel groups compared in Chapter 7.
Very Highly Significant P-values (p < .001) are in bold.

	Set 1	Set 2	P-Value (Response Time)	P-Value (Yes/No Response)
1.	SS	SD	**0**	**0**
2.	SD	D	0.00328991	**0**
3.	SD	SS	**0**	
4.	Ir-ɪ	D	0.00916694	0.2578145
5.	Ir-i	SD	**0.00074848**	0.00341471
6.	Er-e	D	0.03060987	**0.00000118**
7.	Er-ɛ	SD	**0.00022278**	**0.00000002**
8.	Er-ɛ	D	**0.00003683**	**0.00059291**
9.	Or-ɑ	D	0.10798303	0.47173079
10.	Or-o	SD	**0.00016976**	**0.00000453**
11.	Or-o	D	**0.00003436**	**0.00002446**
12.	ɚ-ʌ	D	0.00411246	0.13183311
13.	ɚ-ʊ	D	0.41544688	0.2578145
14.	ɚ-ɛ	D	0.20391395	**0.00000118**
15.	Ar-ɑ	D	0.02007696	0.00490378
16a.	aj-ɑ	D	0.07742435	0.03694904
16b.	aw-ɑ	D	0.27496643	0.15131305
16c.	Ar-ɑ	aj-ɑ	0.49766187	0.5
17.	ong-ɑ	SD	0.084972	0.12770489
18.	ung-ʌ	SD	0.06212064	0.0296893
19.	ung-ʌ	Ir-i	0.31791281	0.5
20.	ing-i	D	0.32671335	0.07464227
21.	ing-ɪ	D	0.01645736	0.00840692
22.	ing-i	ing-ɪ	0.04964518	0.13064792
23.	eng-e	D	0.25198657	0.00122854
24.	eng-ɛ	D	**0.00068672**	0.00245517
25.	eng-e	eng-ɛ	0.02795605	0.39636032
26.	ang-e	D	0.06441622	0.00375574
27.	ang-æ	D	0.09869606	0.03694904
28.	ang-ɛ	D	0.37588223	0.32549791
29.	ang-e	ang-æ	0.03604383	0.14562581
30.	bee-bead	SD	0.11070732	**0**
31.	il-i	SD	**0.00028787**	0.12770489
32.	ɪl-ɪ	SD	**0.00042584**	0.00717153
33.	el-e	SD	0.12697446	0.00717153
34.	ol-o	SD	0.01287002	0.24061993
35.	ɑl-ɑ	SD	0.24953057	0.00179778
36.	ɑl-ɑ	D	0.10653758	0.00157673
37.	ʌl-ʌ	SD	**0.00010531**	**0.00001407**
38.	ʌl-ʌ	D	**0.00001518**	**0.00001012**
39.	ɛl-ɛ	SD	0.0287328	**0**
40.	ɛl-ɛ	D	0.00197218	**0.00002197**
41.	ʊl-ʊ	D	0.00167098	0.00490378
42.	ʊl-ʊ	SD	0.01057999	**0**

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

On Table 7.2, line 4 we can see that the responses for the /Ir-ɪ/ group are not significantly different from those of Set D.

Orthography would be biased toward the negative in these pairs, since [Ir] comes from ME /ē/ and is usually spelled with <ee>, <ea>, or <eCV>[6], and /ɪ/ comes from ME /ī/ and is usually spelled with <i>, but 97% is still a very high negative response rate.

Conclusion: Subjects do not categorize the vowel in [Ir] with /ɪ/.

Group /Ir-i/: On Table 7.1, row 4, we can see that responses for the /Ir-i/ pairs "beer/beet" and "beer/bead" were 61% positive. This number is between those of sets SD and D, but much closer to Set SD.

On Table 7.2, row 5, we can see that the difference in Yes/No response rates between the /Ir-i/ group and set SD is not significant, but the difference in response time is, indicating a degree of uncertainty on behalf of the subjects.

Orthography would be biased toward the positive in these pairs, since both [Ir] and /i/ come from the same ME sources: /ẹ̄/ and /ę̄/ and hence share the same common spellings with <ee>, <ea>,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

and <eCV>. An interesting thing to note in this group is the very long response time, indicating a high degree of uncertainty on the part of the subjects as to whether the vowel in [Ir] is /i/ or not. The ramifications of this uncertainty will be discussed later in section 7.4.

Conclusion: Subjects generally categorize the vowel in [Ir] with /i/, but are somewhat uncertain about it.

[Er] pairs:

Group /Er-e/: On Table 7.1, row 6, we can see that responses for the /Er-e/ pairs "bear/gate" and "bear/spade" were 100% negative, comparable to Set D.

We can see from Table 7.2, row 6, that the response times for Group /Er-e/ are not significantly different from those of Set D, but that the Yes/No response rates are. However, in this particular case, this is because the Yes/No response rate for Group /Er-e/ is actually lower than that of Set D (0% vs. 4%). Group /Er-e/ still patterns like Set D for our purposes.

This is particularly interesting, because orthography would be strongly biased toward the positive in these pairs, since both [Er] and

---

[6] By <xCV> I mean any spelling where the vowel <x> is followed by a single orthographic consonant and then an orthographic vowel. This would include

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/e/ come from ME /ā/ and hence share common spellings like <ai> and <aCV>. Though the word "bear" does not have the same vowel orthography as "gate" or "spade", the subjects might also have heard the word as "bare", which does share the same vowel orthography as "gate" and "spade." Additionally, the <ea> spelling we have in "bear" can spell /e/ in some words like "break", "steak", or "great", so orthographic bias could still be toward the positive.

In addition, the response time for this group is extremely quick. What we have for the /Er-e/ pairs is the most extreme negative categorization for any group on the test. Subjects quickly and unanimously decided that the vowel in "bear (bare)" is not the same as that in "gate (gait)" or "spade (spayed)." No orthographic bias could account for a negative judgment this strong.

Conclusion: Subjects do not categorize the vowel in [Er] with /e/.

Group /Er-ɛ/. On Table 7.1, row 7, we can see that responses for the /Er-ɛ/ pairs "bear/bet" and "bear/bed" were 69% negative. This number is between those of sets D and SD, but closer to Set D.

It can be seen from Table 7.2, rows 7 and 8, that both the response times and Yes/No response rates for Group /Er-ɛ/ are

---

words like "penal" and also "silent 'e'" words like "eke."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

signficantly different from both Set D and Set SD. Group /Er-ɛ/ does not pattern with either Set D or Set SD.

Orthography would be generally biased toward the negative in these pairs, since [Er] usually comes from ME /ā/ and is usually spelled with <ai> or <aCV>, while /ɛ/ comes from ME /ĕ/ and is usually spelled with an <e>. However, the <ea> spelling we find in "bear" can spell /ɛ/ in some words like "head", "deaf", and "threat." An interesting thing to note in this group is the long response time, indicating a high degree of uncertainty on the part of the subjects as to whether the vowel in [Er] is /ɛ/ or not. The ramifications of this uncertainty will be discussed in Section 7.4

Conclusion: Subjects generally do not categorize the vowel in [Er] with /ɛ/, but are uncertain about it.

[Or] pairs:

Group /Or-ɑ/: On Table 7.1, row 9, we can see that responses for the /Or-ɑ/ pairs "bore/dock" and "bore/pod" show a 97% negative rate, comparable to that of Set D.

On Table 7.2, Row 9, we can see that the differences between Group /Or-ɑ/ and Set D with regards to response times and Yes/No response rates are not significant.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Orthography could actually be biased toward the positive in these pairs, since both [Or] and /ɑ/ can come from ME /ŏ/ and are usually spelled with <o>, so the very high negative response rate is significant. Actually, we wouldn't really expect the vowel in [Or] to be categorized with /ɑ/, since the two are not phonetically similar. The reason this comparison was done was because the vowel in [Or] is frequently categorized with GA /ɔ/, which has merged into /ɑ/ in California English.

Conclusion: subjects do not categorize the vowel in [Or] with /ɑ/.

Group /Or-o/. On Table 7.1, row 8, we can see that responses for the /Or-o/ pairs "bore/boat" and "bore/load" show a 42% positive rate, nearly equidistant between those of sets SD and D. The actual mid-point between the two control sets would be 45%.

On Table 7.2, rows 10 and 11, we can see that Group /Or-o/ is significantly different from both Set D and Set SD with regard to both response times and Yes/No response rates.

Orthography could be biased toward the positive in these pairs, since both [Or] and /o/ can come from ME /ǭ/ and share common spellings with <oa> and <oCV>. The issue of orthographic bias becomes less interesting however, when we look at the response

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

time for this group, which is very high, indicating a high degree of uncertainty on the part of the subjects as to whether the vowel in [Or] is /o/ or not. Like the results for the /Er-ɛ/ and /Ir-i/ groups we have seen previously, a long response time corresponds to a middling degree of positive/negative responses. The ramifications of this uncertainty will be discussed in section 7.4.

Conclusion: Subjects are unsure as to whether to categorize the vowel in [Or] with /o/ or not.

[ɚ] pairs:

On Table 7.1, rows 11, 12, and 13, we can see that responses for the /ɚ-ʌ/ pairs "lurk/luck" and "bird/bud" show a 92% negative rate, responses for the /ɚ-ʊ/ pairs "lurk/look" and "bird/hood" show a 94% negative rate, and responses for the /ɚ-ɛ/ pairs "lurk/deck" and "bird/bed" show a 100% negative rate. All these negative response rates are comparable to that of Set D.

We can see from Table 7.2, rows 12, 13, and 14, that there is no significant difference between these three [ɚ] groups and Set D with regard to response times. We can also see that there is not significant difference between two of these groups (/ɚ-ʌ/ and /ɚ-ʊ/) and Set D with regard to Yes/No response rates.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There is a significant difference between Group /ɚ-ɛ/ and Set D with regard to Yes/No response rates. However, in this particular case, the Yes/No response rate for Group /ɚ-ɛ/ is actually lower than that of Set D (0% vs. 4%). Group /ɚ-ɛ/ still patterns like Set D for our purposes.

Orthography could be biased toward the positive or negative in these cases, since the vowel [ɚ] has multiple sources. It can come from ME /ĭ/, /ĕ/, or /ŭ/, which give us Modern English /ɪ/, /ɛ/, and /ʌ/ or /ʊ/, respectively in non-rhotic environments. Hence, [ɚ] is usually spelled with <i>, <e> and <u>, the same letters usually used for /ɪ/, /ɛ/, and /ʌ/, respectively. The /ɚ-ʊ/ and /ɚ-ɛ/ group pattern very strongly with Set D in terms of negative response rate and reaction time. The /ɚ-ʌ/ group has a slightly lower (but still greater than 90%) negative response rate, and a longer reaction time. The difference in negative response rate might be due to the slight positive orthographic bias in the pair "lurk/luck", which are both spelled with a <u>. Confusion due to the orthography might also account for the uncertainty manifested in a longer response time. The /ɚ-ʌ/ pairs still pattern very similarly to Set D at any rate.

Conclusion: Subjects do not categorize [ɚ] with /ɛ/, /ʊ/, or /ʌ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[Ar] Pairs:

On Table 7.1, row 10, we can see that the responses for the /Ar-ɑ/ pairs "car/dock" and "car/pod" show a 78% negative rate. This number is between those of Set D and Set SD, but much closer to Set D.

We can see from Table 7.2, row 15, that Group /Ar-ɑ/ is not significantly different from Set D with regard to response times and Yes/No response rates.

Orthography would generally be biased toward the negative in these pairs, since [Ar] comes from ME /ă/, while /ɑ/ comes from ME /ŏ/. Hence, /ɑ/ is usually spelled with ‹o›, but the vowel in [Ar] is usually spelled with ‹a›. This could in part account for the strong negative response rate, but see below for another explanation.

This group seems to be in the "uncertain" zone of the /Er-ɛ/, /Or-o/, and /Ir-i/ groups, but to a lesser extent. The positive/negative response rates are more extreme than those of any of the aforementioned pairs, while the response time is shorter, hence subjects were more certain of their responses. Although the orthography would bias responses toward the negative in this group, it should be remembered that of all the RGDs, the nucleus in [Ar] was the most similar to a canonical vowel phoneme, being within the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

normal range of /ɑ/ for most speakers. The group which the /Ar-ɑ/ pairs pattern most similarly to are the diphthong groups, which are discussed below.

7.3.3 Diphthongs:

On Table 7.1, rows 31 and 32, we can see that the responses for the /aj-ɑ/ pair "buy/pod" show a 78% negative response rate and the responses for the /aw-ɑ/ pair "cow/pod" show an 89% negative response rate. These numbers are between those of Set D and Set SD, but much closer to Set D, especially for the "cow/pod" pair.

We can see from Table 7.2, rows 16a and 16b, that there is no significant difference between the /aj-ɑ/ and /aw-ɑ/ groups and Set D with regard to response times and Yes/No response rates.

Orthography would be biased toward the negative in the "buy/pod" pair since the diphthong /aj/ shares no common spellings with /ɑ/, but might be actually biased toward the positive in the "cow/pod" pair, since both contain the letter <o> followed by another single letter.

Subjects do not generally categorize the nucleus in /aj/ with /ɑ/, either. There does appear to be a sort of "diphthong effect", in which some subjects identify a diphthong with a vowel which is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

phonetically similar to the initial state of the nucleus of the diphthong in question. That is to say, since the diphthong /aj/ begins somewhat like /ɑ/, some subjects identified it with /ɑ/[7]. Orthographic bias cannot account for the degree of positive identification, because /aj/ and /ɑ/ have very different origins and do not share similar spellings. The "diphthong effect" might also account for the slight degree of uncertainty reflected in the longer response time. Note, however, that most subjects do not show this "diphthong effect" and did not categorize /aj/ with /ɑ/.

Conclusion: Subjects do not categorize the nucleus in /aw/ with /ɑ/. Generally speaking, subjects do not categorize the nucleus of /aj/ with /ɑ/, but there is a bit of a "diphthong effect" which raises the positive response rate and creates a degree of uncertainty.

The positive/negative response rates and response times for the /Ar-ɑ/ pairs are extremely similar to those of the /aj-ɑ/ pair. On Table 7.1, we can see that the response times and Yes/No response rates for these two groups are nearly identical (1.955 secs and 22% vs. 1.96 secs and 22%).

[7]It might actually begin with a vowel more like the front vowel [a], which doesn't appear independently in the dialect under study. The vowel [ɑ] would still be the closest independently appearing vowel to the initial element in the diphthong [aj], though.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We can see from Table 7.2, row 16c, that the difference in response times and Yes/No response rates between these two groups is not significant.

The "diphthong effect" that we saw with the /aj-ɑ/ pair seems to be at work with the /Ar-ɑ/ pairs as well. This cannot be a coincidence. In both cases, we have a diphthong (one ending in [j], one ending in [ɹ]) being compared to a vowel that is similar to the initial state of the diphthong in question. In both cases, the judgment is generally negative, but slightly higher than when comparing two completely distinct vowels, and with a higher degree of uncertainty as manifested in subjects' longer response times. In neither case can the increase in positive identification be explained by orthographic bias.

A conclusion can then be made: in terms of subjects' categorizations, [Ar] is to /ɑ/ as /aj/ is to /ɑ/. Or, the nucleus in [Ar] is to /ɑ/ as the nucleus in /aj/ is to /ɑ/. This data would thus support an analysis which treats the RGDs parallel to the diphthongs which end in /j/ and /w/. This will be discussed in Chapter 8. It might be asked why there is such a low positive response rate for the /Ar-ɑ/ pairs, given that the nucleus in [Ar] is phonetically very much like /ɑ/ (see section 6.2.3). The effects of negative orthographic bias are one possible reason. Another reason, and one

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

consistent with some of the independently-derived phonological analyses discussed in Chapter 3, is that the whole [Ar] diphthong in a word like "car" is being categorized as a single unit which contrasts paradigmatically with /ɑ/ in the same manner as vowels like /e/ and /o/ would. This matter will also be returned to in Chapter 8.

7.3.4 Set NG

The results of the test for the various vowels found before /ŋ/ are particularly interesting because, as we have seen in Chapter 5, the phonemic classifications of some of these vowels are not obvious.

‹ong› Pairs:

On Table 7.1, row 29, we can see that the responses for the /ong-ɑ/ pair "song/pod" show a 72% positive response rate. This number is between those of sets D and SD, but much closer to Set SD.

This might seem to put the /ong-ɑ/ pair in the "uncertain" zone with the /Er-ɛ/, /Ir-i/, and /Or-o/ pairs, but on Table 7.2, row 17, we can see that there is no significant difference between Group /ong-ɑ/ and Set SD with regard to response times and Yes/No response rates. The slightly lower rate of positive responses can perhaps be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

accounted for by the allophonic variance caused by the following /ŋ/, or it could be just a factor of there only being one pair in this group, hence more variance is likely.

Conclusion: Subjects categorize the vowel in ‹ong› with /ɑ/.

‹ung› Pairs:

On Table 7.1, row 30, we can see that the response for the /ung-ʌ/ pair "lung/bud" show a 61% positive response rate. This number is between those of sets D and SD, but closer to Set SD.

We can see from Table 7.2, row 18, that there is no significant difference between Group /ung-ʌ/ and Set SD with regard to response times and Yes/No response rates.

Like the /ong-ɑ/ pair, this one is somewhere in the middle. Furthermore, the response times are higher than those of Set SD, perhaps showing a degree of uncertainty on the part of the subjects as to whether the vowel in ‹ung› is /ʌ/ or not, though not the degree of uncertainty found with the /Er-ɛ/ and /Or-o/ sets.

On Table 7.2, row 19, we can see that there is no significant difference in response times and Yes/No response rates between Group /ung-ʌ/ and Group /Ir-i/. This indicates that the degree of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

uncertainty found in Group /ung-ʌ/ may be akin to that found in Group /Ir-i/ (see discussion of this, above).

Conclusion: Subjects generally categorize the vowel in <ung> with /ʌ/, but are a bit uncertain.

<ing> Pairs:

On Table 7.1, rows 22 and 23, we can see that the responses for the /ing-i/ pair "sing/bead" show a 17% positive response rate, and the responses for the /ing-ɪ/ pair "sing/bid" show a 33% positive response rate. Both of these numbers are between those of sets D and SD, but closer to Set D, especially for the /ing-i/ pair.

We can see from Table 7.2, rows 20 and 21, that there is no significant difference between both the /ing-i/ and /ing-ɪ/ groups and Set D with regard to response times and Yes/No response rates.

Orthography would bias responses toward the negative in the /ing-i/ pair and toward the positive in the /ing-ɪ/ pairs, since both <ing> and /ɪ/ come from ME /ī/, and are usually spelled with <i>.

The response times of the /ing-i/ pair show this group to be comparable to Set D, despite the higher positive response rate. The response times of the /ing-ɪ/ pairs are higher than those of Set D,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

and near the "uncertain" area of the /Er-ɛ/, /Ir-i/, and /Or-o/ groups.

Conclusions: Subjects generally do not categorize the vowel in .<ing> with either /i/ or /ɪ/, but are somewhat uncertain. Generally, the vowel in <ing> is believed to have the same relation to both /i/ and /ɪ/, but a bit closer to /ɪ/. This might be the result of orthographic bias. We can see from Table 7.2, row 22, that there is no significant difference between the two <ing> groups /ing-i/ and /ing-ɪ/ with regard to response times and Yes/No response rates.

<eng> Pairs:

On Table 7.1, rows 24 and 25, we can see that the responses for the /eng-e/ pairs "length/gate" and "length/spade" show a 28% positive rate, and the responses for the /eng-ɛ/ pairs "length/bed" and "length/bet" show a 25% positive response rate. Both these figures are between those of sets D and SD, but much closer to Set D. The figures for the /eng-e/ and /eng-ɛ/ groups are also very close to each other.

We can see from Table 7.2, row 23, that there are no significant differences in response times and Yes/No responses between Group /eng-e/ and Set D. We can also see from Table 7.2, row 24, that

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

there is so significant difference between Group /eng-ɛ/ and Set D with regard to Yes/No response rates but that there is a significant difference between the two groups with regard to response times. This shows a degree of uncertainty on behalf of the subjects as to whether the vowel in <eng> is /ɛ/ or not.

Orthography would bias responses toward the negative in the /eng-e/ pairs and toward the positive in the /eng-ɛ/ pairs, since both <eng> and /ɛ/ come from ME /ĕ/ and are usually spelled with <e>, while /e/ comes from ME /ā/ and is usually spelled with <ai> or <aCV>.

Both <eng> groups behave most similarly to Set D of any of the control sets, but the positive response rates are higher, and the response times are longer for the /eng-ɛ/ pairs. The /eng-ɛ/ pairs tend toward the "uncertain" area of the /Ir-i/, /Er-ɛ/, and /Or-o/ groups. What's most interesting to note, though, is the fact that the /eng-ɛ/ and /eng-e/ groups behave similarly to each other. We can see from Table 7.2, row 25, that there are no significant differences between the two groups with regard to response times and Yes/No response rates.

Conclusion: Subjects do not generally categorize the vowel in <eng> with either /e/ or /ɛ/, but do show a degree of uncertainty.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The vowel in ‹eng› is believed by subjects to have the same sort of relationship to /e/ as it does to /ɛ/.

‹ang› Pairs:

On Table 7.1, rows 26, 27, and 28, we can see that the responses for the /ang-e/ pair "hang/spade" show a 39% positive response rate, and the responses for the /ang-æ/ pair "hang/sad" show a 22% positive response rate. Both these numbers are between those of sets D and SD, but closer to Set D. The responses for the /ang-ɛ/ pair "hang/bed" show a 94% negative response rate, comparable to that of Set D.

We can see from Table 7.2, rows 26, 27, and 28, that none of the ‹ang› groups differ significantly from Set D with respect to response times or Yes/No responses. Orthography would bias responses toward the positive in the /ang-æ/ pairs, and toward the negative in the /ang-ɛ/ pairs, since both ‹ang› and /æ/ come from ME /ă/ and share the spelling ‹a›, while /ɛ/ comes from ME /ē/ and is usually spelled with ‹e›. The direction of orthographic bias is difficult to predict in the /ang-e/ pair since these vowels do not have the same historical origin, but do share spellings containing the letter ‹a›, coming from ME /ā/ and /ă/, respectively.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The positive/negative response rates for the /ang-e/ and /ang-æ/ pairs might seem to put them in the "uncertain" category with the /Ir-i/, /Er-ɛ/, and /Or-o/ groups, but the response times are lower (especially for the /ang-e/ pair), suggesting the degree of certainty is higher. It is interesting to note that the /ang-e/ and /ang-æ/ groups are fairly similar to each other in terms of positive/negative responses, parallel to the similarities between the /ing-i/ and /ing-ɪ/ groups and the /eng-e/ and /eng-ɛ/ groups.

We can see from Table 7.2, row 29, that there are no significant differences between the /ang-e/ and /ang-æ/ groups with regard to Yes/No responses and response times.

Conclusion: Subjects do not categorize the vowel in ‹ang› with /ɛ/. Subjects generally do not categorize the vowel in ‹ang› with either /e/ or /æ/. The vowel in ‹ang› is believed to have the same relationship to /æ/ as it does to /e/, but perhaps a bit more like /e/.

7.3.5 bee/bead

On Table 7.1, row 34, we can see that the responses for the pair "bee/bead" show a 100% positive rate. This number is even higher than that of Set SD. Furthermore, the response times are very quick, indicating a high degree of certainty on the part of the subjects.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We can see from Table 7.2, row 30, that the "bee/bead" pair does not differ significantly from Set SD with regard to response time. These two groups do differ significantly from each other with regard to Yes/No response rates. However, in this particular case, the Yes/No response rate for "bee/bead" is actually higher than that of Set SD (100% vs. 86%). Group "bee/bead" still patterns like Set SD for our purposes.

In Table 7.1, row 33, we can see that the responses for the pair "beer/bead" (a subset of the /Ir-i/ group on row 4) show a 67% positive rate and a long response time, going into the "uncertain" zone. The purpose of comparing the pairs was to test Harris's claim that neutralization of vowels before /r/ is caused by the same rule that only allows tense (long) vowels in open syllables in English (see section 3.2.1.1). If this rule were supported by this experiment, we would expect subjects to categorize the vowel in "beer" with the vowel in "bead" the same way as they categorize the vowel in "bee" with the vowel in "bead."

Conclusion: Subjects unanimously and quickly categorize the vowel in "bee" with the vowel in "bead" (/i/). Subjects generally categorize the vowel in "beer" with that in "bead", but are somewhat uncertain (see section 7.3.2, above). The vowel in "beer" does not

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

have the same relationship to the vowel in "bead" as the vowel in "beer" does.

7.3.6 Set L:

/il ɪl el ol/ Pairs:

On Table 7.1, rows 14-21, we can see that the responses for the various pairs in Set L vary a great deal. The /il-i/ pairs "peel/beet" and "peel/bead" show a 72% positive response rate. The /ɪl-ɪ/ pairs "will/bit" and "will/bid" show a 64% positive response rate. The /el-e/ pairs "pale/gate" and "pale/spade" show a 64% positive response rate. The /ol-o/ pair "bowl/boat" show a 78% positive response rate. The positive response rates for these four groups are all between those of sets D and SD, but much closer to set SD.

We could conclude that subjects generally do categorize the vowels in /il/, /ɪl/, /el/, and /ol/ with /i/, /ɪ/, /e/, and /o/, respectively, but there is the matter of response times to consider. The response times for three of these groups: /il-i/, /ɪl-ɪ/, and /ol-o/, are very high, in the "uncertain" range of /Ir-i/, /Er-ɛ/, and /Or-o/. The response times for the /el-e/ group are somewhat lower, closer to those of Set SD.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We can see from Table 7.2, rows 31 through 34, that there are no significant differences between any of these groups and Set SD with regard to Yes/No responses and no significant differences between the /el-e/ and /ol-o/ groups and Set SD with regard to response times. However, there are significant differences between the response times of the /il-i/ and /ɪl-ɪ/ groups and Set SD with regard to response times.

Conclusion: Subjects categorize the vowel in /el/ with /e/ and the vowel in /ol/ with /o/. Subjects generally do categorize the vowels in /il/ and /ɪl/ with /i/ and /ɪ/, respectively, but show a high degree of hesitation before making their positive categorizations.

/ɑl/ and /ʌl/ Pairs:

The /ɑl-ɑ/ pair "hall/dock" and the /ʌl-ʌ/ pairs "dull/luck" and "dull/bud" (Table 7.1, rows 19 and 21) both show 44% positive response rates. This number is almost exactly between those of sets D and SD, thus we cannot classify the /ʌl-ʌ/ or /ɑl-ɑ/ groups with either D or SD. The positive/negative response rates are close to chance.

The two groups /ʌl-ʌ/ and /ɑl-ɑ/ may have similar positive/negative response rates, but they do not pattern together in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

terms of response times. The /ʌl-ʌ/ pairs exhibit very long response times, which would put them in the "uncertain" area alongside the /Ir-i/, /Er-ɛ/, and /Or-o/ groups. The /ɑl-ɑ/ pair, however, has a relatively short response time, closer to that of Set SD.

We can see on Table 7.2, rows 35 and 36, that Group /ɑl-ɑ/ is not significantly different from either Set D or Set SD with regard to response times and Yes/No responses. We can also see on Table 7.2, rows 37 and 38, that Group /ʌl-ʌ/ does differ significantly from Set D and Set SD with regard to both response times and Yes/No responses. This is a perplexing matter.

A further perplexing matter is that the positive/negative response rates for the two /ʌl-ʌ/ pairs "dull/luck" and "dull/bud" are very different:

pair	Yes	No
dull/luck	72	28
dull/bud	17	83

This cannot be explained by saying that the allophone of /ʌ/ found before /l/ is closer to the one found before /k/ than to the one found before /d/. As we have seen in Figures 6.15.1, 6.15.2, and 6.15.3 in Chapter 6, the allophone of /ʌ/ before /l/ is very deviant, and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

equally distinct from the variants found before /d/ and /k/. It is more likely the case that the initial /l/ in "luck" may affect the following /ʌ/, making it more similar to the vowel in "dull." This would still not explain the very large differential in positive/negative responses between the "dull/luck" and "dull/bud" pairs.[8]

Conclusion: I am not sure what to make of these two groups. Subjects seem uncertain as to how to categorize /ʌl/ and /ɑl/, and I don't know how to account for this. It must be remembered from Chapter 6, section 6..3.3 that some speakers have merged the variant of /ʌ/ historically found before /l/ into /o/. The speaker in the experiment does not have this merger, and contrasts /ʌ/ with /o/ before /l/. However, if some of the subjects themselves lack /ʌ/ before /l/, and are basing their responses on their own categorizations rather than what they have heard, that could explain why they would not categorize the vowel in "dull" with that in "luck" or "bud."[9] We cannot account for the unclear categorizations of the /ɑl-ɑ/ pair in the same way, however.

---

[8]The three tokens "dull", "luck" and "bud" were re-examined and the vowels in each were found not to be aberrant, with the exception that the word "bud" had a detectably slightly lower amplitude than the others. However, it is not expected that this difference in amplitude would account for the difference in Yes/No response rates.

[9]This would require a separate study in which subjects' acoustics were also measured and compared to their responses.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɛl/ and /ʊl/ Pairs:

On Table 7.1, row 17, we can see that the /ɛl-ɛ/ pairs "well/bet", "well/bed", and "bell/deck" show a 33% positive response rate. On row 20, we can see that the /ʊl-ʊ/ pairs "pull/look" and "pull/hood" show a 22% positive response rate. Both of these numbers are between those of sets D and SD, but closer to Set D. The response times for these two groups are somewhat high, pushing the groups toward the "uncertain" area of the /Ir-i/, /Er-ɛ/, and /Or-o/ sets.

We can see from Table 7.2, rows 39 and 40, that the /ɛl-ɛ/ group is not significantly different from Set D and Set SD with regard to response times, but is significantly different from either group with regard to Yes/No responses, indicating a degree of unanimity on behalf of the subjects.

We can also see from Table 7.2, rows 41 and 42, that Group /ʊl-ʊ/ does not differ significantly from Set D with regard to response times and Yes/No responses, but it does differ from Set SD significantly with regard to Yes/No responses. Hence, we can say that Group /ʊl-ʊ/ patterns like Set D, not Set SD, since sets D and SD have similar response times anyway.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The low positive response rates for the /ʊl-ʊ/ pairs can perhaps be explained by the fact that for many speakers, /ʊl/ contains no [ʊ], but is the syllabic lateral [ɫ̩]. Also, some speakers do not contrast /ʊ/ with /u/ before /l/, but have merged both to /u/. (see chapter 6, section 6.3.3) If some of the subjects lack a true /ʊ/ before /l/, and are basing their responses on their own internal categorizations, that could explain why they would not categorize the vowel in "pull" with that in "look" or "hood."

The low positive response rates for the /ɛl-ɛ/ pairs is more difficult to explain. Two of the /ɛl-ɛ/ pairs have the word "well." It has been remarked upon (Moon and Lindblom 1994) that the vowel in "well" is very different from a typical /ɛ/, approaching /ʌ/.

It can be seen from Figures 6.9.1, 6.9.2, and 6.9.3. in Chapter 6 that the allophone of /ɛ/ found before /l/ is very deviant. In terms of F1 and F2, it does indeed fit into or approach the range of /ʌ/ for all three groups (see Table 7.3). However, we can see a similar degree of retraction for other front vowels before /l/. For example, the variant of /ɪ/ found before /l/ approaches the range of /u/ or /ʊ/ for all three groups of speakers (see Table 7.3), but the /ɪl-ɪ/ pairs, which both include the word "will", do not show the same low positive response rate, but rather high positive response rates.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 7.3. Allophones of /ɛ/ and /ɪ/ before /l/ and ranges of /ʌ/, /u/, and /ʊ/ for all three groups of speakers:

	F1 (Hz)	F2 (Hz)
Males		
/ʌ/ range	585-765	1248-1617
/ɛ/ before /l/	701	1613
/ʊ/ range	534-570	1295-1508
/u/ range	389-455	1070-1854
/ɪ/ before /l/	508	1803
Northern Females		
/ʌ/ range	568-790	1389-1752
/ɛ/ before /l/	717	1568
/ʊ/ range	512-585	1393-1760
/u/ range	393-504	1102-1931
/ɪ/ before /l/	538	1820
Southern Females		
/ʌ/ range	676-874	1402-1838
/ɛ/ before /l/	815	1846
/ʊ/ range	535-605	1503-1756
/u/ range	413-506	1298-2134
/ɪ/ before /l/	587	2015

Conclusion: Subjects generally do not categorize the vowels in /ɛl/ and /ul/ with /ɛ/ and /u/, respectively, and show a large degree of uncertainty.

Making any general conclusion about the pairs in Set L is difficult. Generally speaking, the pairs involving front vowels before /l/ show higher positive response rates than those involving back vowels. This might be expected, since as we have seen in Chapter 6, front vowels found before /l/ begin much like their standard counterparts, gliding to a more central position, while the back vowels found before /l/ display highly deviant allophones (much lower F2s) throughout their production. However, this generalization of front/back vowels is not absolutely true, since pairs involving the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

front vowel /ɛ/ have a low positive response rate, while those involving the back vowel /o/ have a high positive response rate.

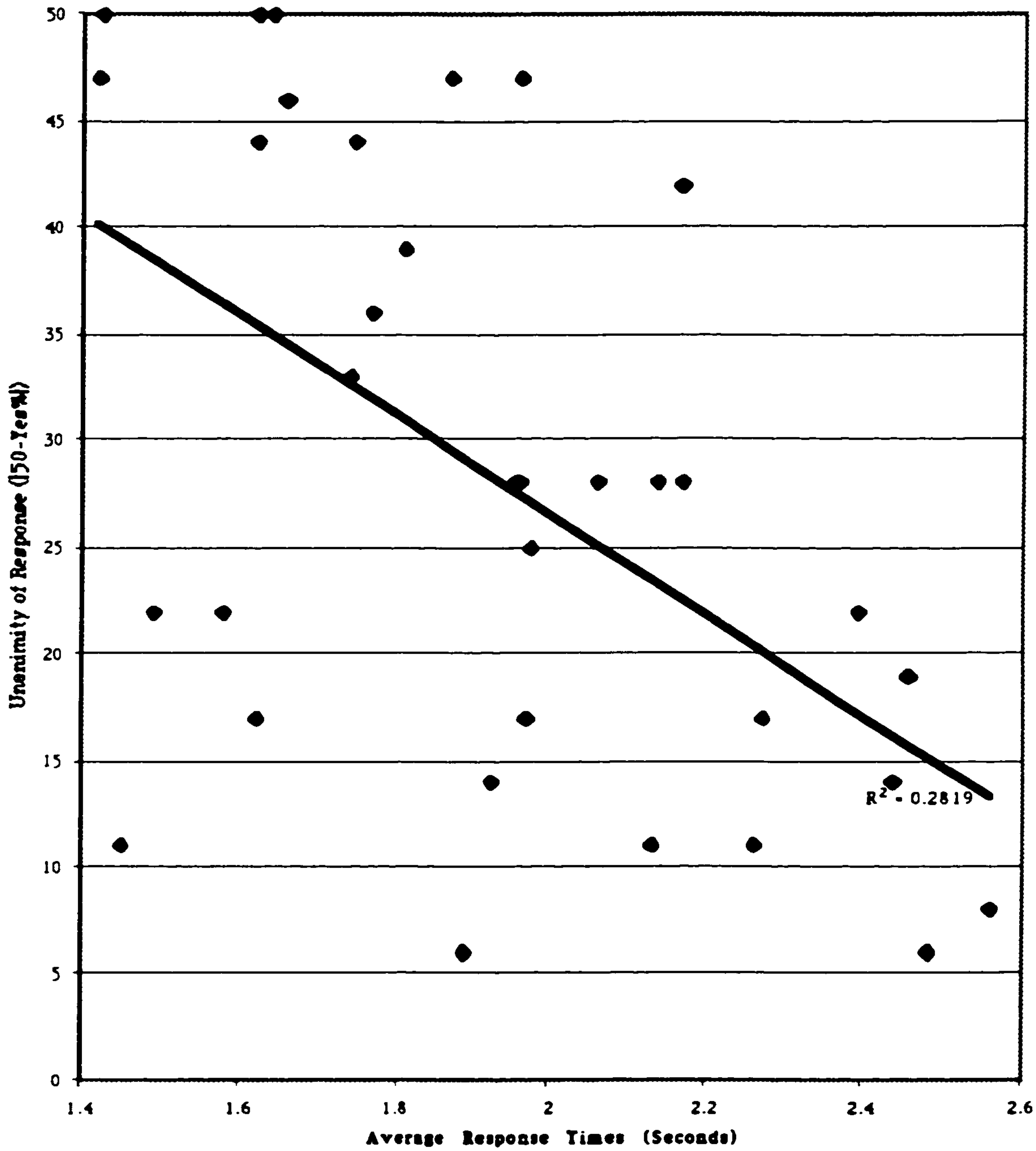
Most of the pairs involving vowels before /l/ have long response times. Exceptions to this are the /al-a/ and /el-e/ groups. These long response times can be explained as representing a high degree of uncertainty on the part of the subjects. The meaning of this uncertainty will be discussed below.

7.4. Uncertainty

An interesting thing to note from Table 7.1 and Figure 7.1 is that there is in general an inverse relation between the length of the response times and the extremes of Yes/No responses. That is to say, that pairs with positive response rates close to 100% or 0% have shorter response times, while those with positive response rates closer to 50% have longer response times. This can be more easily illustrated in Figure 7.2, in which the Yes/No response rates are converted to a "unanimity of response rate." This number is simply the absolute value of the positive response rate subtracted from 50 ($|50-x|$), so that positive response rates of 100% or 0% come out equal (a value of 50), while a positive response rate of 50% would come out to be a "unanimity of response rate" of 0. The relationship between

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 7.2. Relation of Response Time to Unanimity of Response



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

response time and the unanimity of response on Figure 7.2 had a regression rate (R) of -0.5309 (R^2 = 0.2819, as indicated on the Figure). This regression rate is shown by a trendline on Figure 7.2. An R of −1 would indicate that there was a complete inverse relationship between response rate and unanimity of response. An R of 0 would indicate that the two figures are not related at all.

7.4.1. Comparison with Semantic Prototypes

There have been other categorization studies that exhibit similar phenomena of variable response times in fields outside of phonology. One such study is found in Rosch (1973). The experiment is very similar to the one done for this chapter, but involved semantic rather than phonological categorizations. In Rosch's experiment (done in collaboration with Richard Millward), subjects (24 adult undergraduate students of mixed gender, 20 male children between the ages of 9 and 11) were played 96 sentences of the forms "A (word) is a (category)." and asked to evaluate the statement as true or false by pressing appropriate keys on a computer keyboard. Sentences consisted of both true statements and false statements, for example "A pear is a fruit" and "A pear is a metal."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Prior to the experiment, words were rated by a separate pool of subjects for goodness of membership in the appropriate categories. Based on these rankings, "central" and "peripheral" members of categories were determined. For example, a carrot was determined to be a "central" member of the category "vegetable", and an onion was determined to be a "peripheral" member of the category vegetable. The complete list of categories and members used is on Table 7.4.

Table 7.4. Categories and Members Used in Reaction Time Experiment (from Rosch 1973)

	Member	
Category	Central	Peripheral
Toy	Doll	Skates
	Ball	Swing
Bird	Robin	Chicken
	Sparrow	Duck
Fruit	Pear	Strawberry
	Banana	Prune
Sickness	Cancer	Rheumatism
	Measles	Rickets
Relative	Aunt	Wife
	Uncle	Daughter
Metal	Copper	Magnesium
	Aluminum	Platinum
Crime	Rape	Treason
	Robbery	Fraud
Sport	Baseball	Fishing
	Basketball	Diving
Vehicle	Car	Tank
	Bus	Carriage
Science	Chemistry	Medicine
	Physics	Engineering
Vegetable	Carrot	Onion
	Spinach	Mushroom
Part of the body	Arm	Lips
	Leg	Skin

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The results of Rosch's experiment show a definite correlation between reaction time and central/peripheral status, in Table 7.5.

Table 7.5. Response Times and Error Proportions for Central and Peripheral Category Members (from Rosch 1973):

	Response			
	True Sentences		False Sentences	
Category Member	Reaction time (msec)	Error proportion	Reaction time (msec)	Error proportion
Adults				
Central	1011.67	.028	1089.94	.024
Peripheral	1071.45	.071	1115.52	.032
Children				
Central	2426.45	.056	2692.40	.038
Peripheral	2703.45	.228	2799.30	.029

For both Adults and Children, true statements with central members, for example "Basketball is a sport" took less time to judge true than true statements with peripheral members, for example "Diving is a sport." The difference in response times was only significant for the true sentences. Although there do appear to be differences in the response times for central/peripheral false sentences, these were not significant[10].

Thus, even though a robin and a chicken are both birds, subjects took longer to decide that a chicken was a bird than to decide that a robin was a bird. According to Rosch, this indicates a type of internal structure for the category. A robin is a "better" or more prototypical example of a bird than a chicken is, which is

[10]This makes sense. Whether a pear is a central or peripheral member of the category "fruit" should have no bearing on how quickly subjects classify it in categories like "metal" or "sport."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

reflected in subjects' response times. Subjects can identify prototypical membership quicker than they can identify less prototypical membership.

The variance in response times that we have seen in the phonological categorization experiment in this chapter could also be explained by category-internal prototype effects. For example, the vowel in "bowl" might be definitely a member of the phoneme /o/, as shown by the 78% positive response rate, but it might be a peripheral member of the phoneme /o/, as shown by the high response time (see Table 7.1, row 18). This peripheral status could be attributed to phonetic factors, as we have seen in Chapter 6, section 6.3.4. The variety of /o/ found before /l/ is significantly different phonetically from the varieties found before other consonants.

With respect to the pairs that show very long response times, and positive response rates near 50%, such as /Er-ɛ/, /Or-o/, and /ʌl-ʌ/ (see Table 7.1), we could say that these are very peripheral members of their appropriate categories. For example, the nucleus in "bear" is a very peripheral /ɛ/, the nucleus in "bore" is a very peripheral /o/, and the nucleus in "dull" is a very peripheral /ʌ/.

There are some differences between the experiment conducted in this dissertation and Rosch's experiment, however. Namely:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1) In Rosch's experiment, category membership was known in advance, and was not the subject of the test. In our test, we could not make *a priori* claims to membership with respect to the vowels found before /r/ and /ŋ/, though this was done with the SS, SD, D, and L sets. Hence, we cannot say for sure that any vowel is a less prototypical member of any particular category. We can only interpret it as such based on the test results.

2) Rosch's experiment included classifying words ("pear", "robin", "basketball", etc.) with the superordinate categories to which they belong ("fruit", "bird", "sport", etc.). In our test, no item in the pair was superordinate to the other, but subjects were being asked essentially whether the vowels belonged to the *same* superordinate category or not. This difference is a necessity of the nature of the test. Using superordinate phonological categories, such as phonemes (for example, asking "Is the vowel in *bear* an /ɛ/?") would be difficult to do in a test such as ours (though see the discussion of Jaeger and Ohala 1984, below), and could only be done with trained linguists, who might have prior theoretical biases, as subjects. It is also difficult to see how Rosch's test could have been done without superordinate categories.

3) With the exception of Set D, we only included in test pairs vowels that we had reason to believe could be categorized together.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There were no negative comparisons equivalent to asking whether a mushroom was a bird, for example comparing [Er] with /ɑ/. There did turn out be some strongly negative comparisons involving peripheral vowels though, such as /Ir-ɪ/ and /Er-e/.

4) Rosch's category members are only judged to be central or peripheral. Degree of centrality is not considered. Our results, however, do show a cline of category membership on both the Yes/No response rate and response time scales (remembering, of course, that we could not always assign membership or centrality beforehand. The degrees of membership and centrality are interpreted due to the results of the experiment).

5) We can see a difference in response times among negative category judgments, something that Rosch did not find to a significant degree in her experiment. Here, once again, "negativity" is not a matter of *a priori* assignment (except in the case of Set D), but a result of the experiment. By "negative" categorization, I simply mean groups in which the positive response percentage was less that fifty percent. That is to say, that positive response rates in our experiment varied from 0% (for Groups /Er-e/ and /ɚ-ɛ/) to 100% (for "bee/bead") with a wide variety of response rates in-between. We had significant variation in positive response rate for vowel pairs that the majority of subjects did not identify as being the same. For

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

example, the positive response rate for Group /Ir-ɪ/ was 3%, the positive response rate for Group /ing-i/ was 17%, the positive response rate for Group /Er-ɛ/ was 31%, and the positive response rate for Group /Or-o/ was 42%. All of these category judgments could be considered "negative", in that the majority of subjects did not consider the vowels in the pairs to be the same, but there is still wide variation in the degree of negativity within these various groups.

6) Although Rosch recognizes an *a priori* distinction between central and peripheral category members, all categories are still assumed to be discrete and unambiguous. A chicken may be a less prototypical bird than a robin but it is nevertheless a bird. There is a factor in the results of Rosch's experiment that does point to the possibility of non-discrete category membership, the factor of "error proportion." There does appear to be a higher degree of error proportion for the peripheral category members than for the central category members in the results of Rosch's experiment (Table 7.5). The labeling of these judgments as "errors" comes from a prior assumption of discrete category membership. This variation in "error proportion" could be akin to the Yes/No judgments from our test, however. It could be the case not that subjects are making "errors" but that there is less agreement of category membership for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

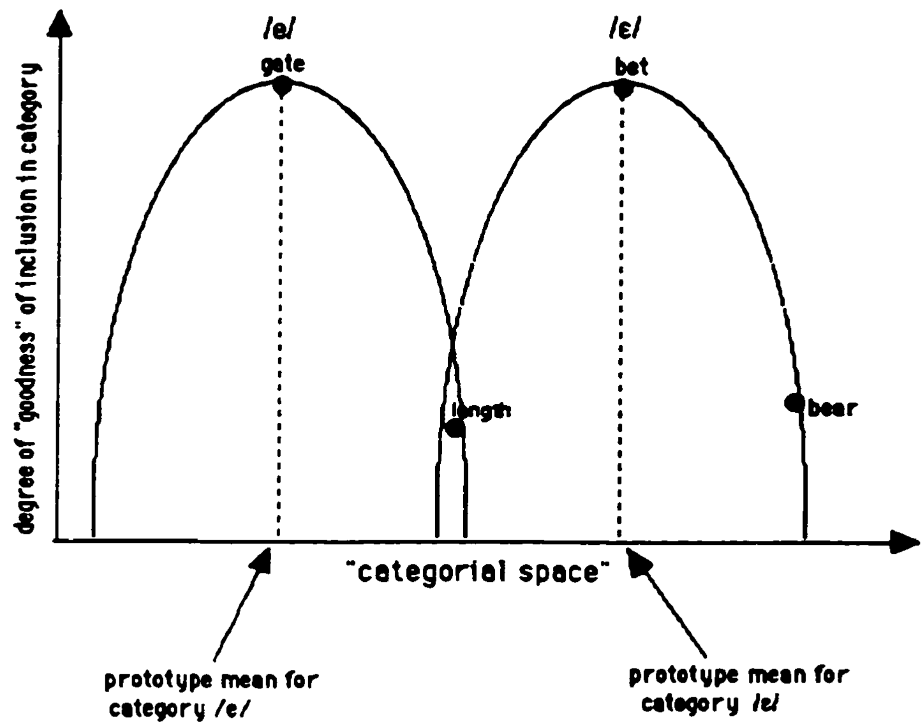
the peripheral members. However, the difference in error proportions for the central and peripheral category members was found to not differ significantly in Rosch's experiment for the adult subjects. It was found to be significantly different for the children, but this could be accounted for by unfamiliarity with words like "rheumatism" and "magnesium" for 9-11 year-olds.

The differences between the two tests may be because the categories under consideration in our test, vowel phonemes, are never discrete, as opposed to, say, the category "bird." There are situations where a vowel is a good example of one of the categories tested, such as those in Set SS. There are situations in which a vowel is not a good example of any of the categories tested, but is a peripheral example of more than one of the categories tested, such as the vowel in <eng>, which is a peripheral member of both the category /e/ and the category /ɛ/. Lastly, there are situations in which a vowel is a peripheral example of one of the categories tested, but not of any other tested categories. For example, the vowel in [Er] is a peripheral member of /ɛ/, but not a member or /e/ at all.

These situations are illustrated in Figure 7.3. In the figure, the categories (phonemes) are represented by arcs, here for the vowels /e/ and /ɛ/. More central membership in the category, as judged by high positive Yes/No response rates and/or short response times, is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 7.3 Prototype representations for /e/ and /ɛ/



indicated by a high position on the category arc. More peripheral membership in a category, as judged by low positive Yes/No response rates and/or long response times, is indicated by a lower position on the category arc[11]. Note that the two categories: /e/ and /ɛ/, are shown as overlapping. This may not be true for all categories. Note also that category overlap is only possible at points where category membership is peripheral for both categories. Something cannot be a prototypical member of two categories, at least in the matter of vowel phonemes.

[11]The basic idea for this type of representation of category membership comes from Givón (1984: 16).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thus, the vowel in "gate" is shown as being a central member of the category /e/ on Figure 7.3. The vowel in "bet" is a central member of the category /ɛ/. The vowel in "length" is both a peripheral member of the category /e/ and a peripheral member of the category /ɛ/. The vowel in "bear" is a peripheral member of the category /ɛ/, but not any kind of member of the category /e/.

7.4.2 Prototypes and Sound Change

The discovery of prototype effects in phonological categorization has implications for the study of sound change. For example, we have noted the historical sound change which raised the variant of /æ/ before /ŋ/ to [ɛ̣ʲ] (section 6.4.). We have also seen evidence from Di Paolo (1988) to show that speakers may indeed categorize this vowel not as /æ/ but as /e/. The results of our test (Table 7.1) show speakers to be categorizing this vowel as both a peripheral /æ/ and a peripheral (though somewhat more central) /e/. We could say that the variant of /æ/ found before /ŋ/ historically has undergone a historical shift from being at one point presumably a good example of the category /æ/, to undergoing a sound change which made it a more peripheral member of /æ/, to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

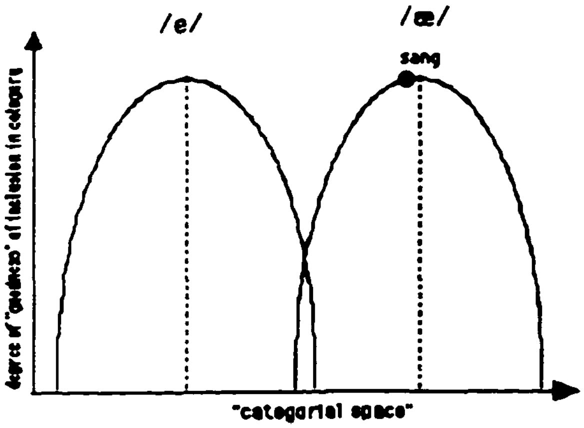
undergoing further sound change[12] which made it a peripheral example of /æ/ which is also peripherally within the range of /e/, to perhaps eventually being a better example of /e/, at which point we can say that the sound change has been completed. These stages are shown in Figures 7.4-7.7. Note that in our data, the vowel in ‹ang› is a peripheral member of both /e/ and /æ/, but a better example of /e/ than it is of /æ/. This difference cannot be shown on the figures as drawn.

Peripheral membership in a category does not necessarily mean shift to another pre-existing category. It could mean the creation of a new category. We can see this in the categorization of [Ar]. It is a peripheral member of the category /ɑ/, but not a member of any other vowel phoneme. The closest parallel to this is the categorization of /aj/, which bears the same relationship to /ɑ/ that [Ar] does. The diphthong /aj/ is usually categorized as monophonemic (see Section 3.1). However, the nucleus of /aj/ is fairly similar to /ɑ/, so it gets categorized as a peripheral member of /ɑ/. The parallel may hold for the nucleus in [Ar]. As the nucleus in

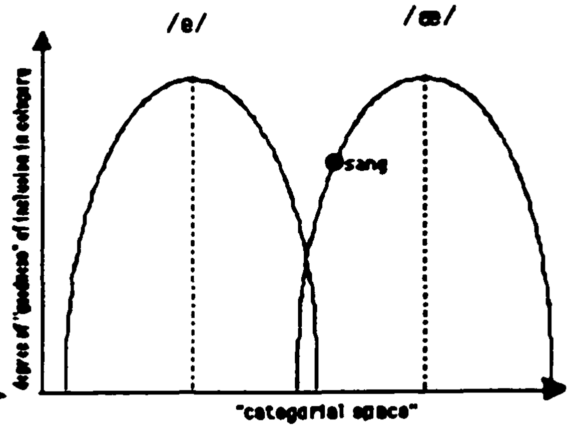
[12]The lack of contrast of vowels before /ŋ/ in English should by no means be overlooked as a contributing factor in the phonological re-analysis being described here. The fact that there is no contrast between, for example /i/ and /ɪ/ before /ŋ/ makes it more possible that a peripheral /ɪ/ before /ŋ/ could be interpreted as /i/, since the listener has no clear /i/ before /ŋ/ to contrast it with.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

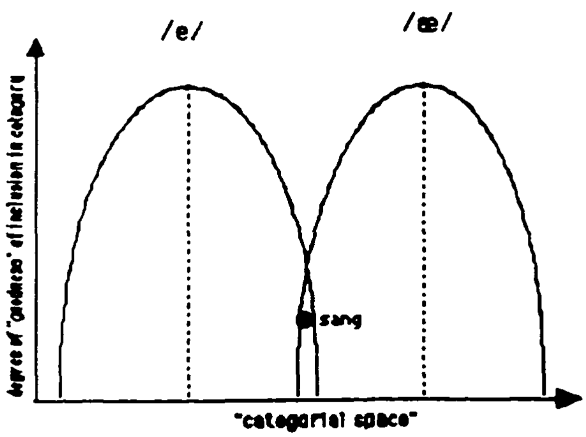
Figures 7.4-7.7 Possible Stages for the Raising of /æ/ before /ŋ/.



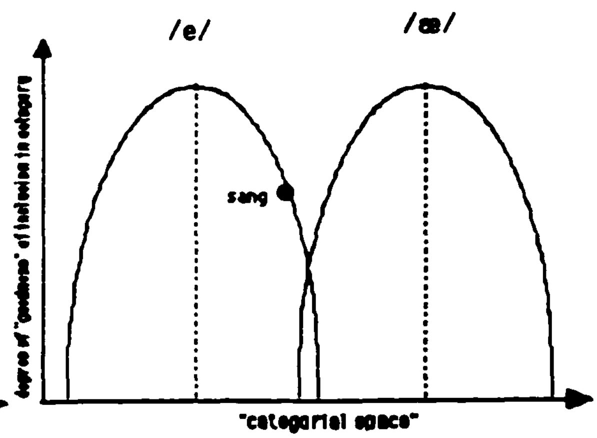
Stage 1: The vowel in "sang" is a central example of /æ/



Stage 2: The vowel in "sang" is a less central example of /æ/



Stage 3: The vowel in "sang" is a peripheral example of /æ/ and a peripheral example of /e/ (Modern California English).



Stage 4: The vowel in "sang" is a peripheral example of /e/, and no longer an example of /e/. (Hypothetical)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[Ar] moves out of the periphery of /ɑ/, it does not move into the periphery of another vowel phoneme, but it approaches the point of not being categorized at all, as per the pairs in Set D. The fact that /aj/ and [Ar] are phonetically diphthongs makes it possible for their nuclei and off-glides to form a category of their own, as monophonemic diphthongs.

As a note of clarification, it should be said that it has never been assumed that the nucleus in /aj/ was historically a member of /ɑ/. Peripheral membership in a category is not only due to historical sound change from a more central position. Here, it may just be due to phonetic similarity. Likewise, the nucleus in [Ar] is not historically cognate with /ɑ/ (see section 2.2.2). It is frequently considered to be /ɑ/, though, so it may have been a more central member of /ɑ/ historically. Its peripheral membership in /ɑ/ synchronically would not come from its phonetic characteristics (which, as we have seen in section 6.2, are well within the range of /ɑ/), but due to the fact that [Ar] is a diphthong, and hence may have monophonemic status of its own.

Another example of peripheral membership in a category not being due to historical sound change from a more central position is the case of the nucleus in [Er]. This vowel is historically cognate with /e/, but does not even constitute a peripheral member of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

category /e/ anymore, according to the results of our experiment. It is now a peripheral member of /ɛ/, but there is no reason to believe it was ever a central member of /ɛ/ historically[13]. The fact that the vowel in [Er] can be considered a peripheral member of /ɛ/ now does not necessarily mean that it is moving toward being a central member of the category /ɛ/. The sequence [Er] is a diphthong, and the relationship of [Er] to /ɛ/ bears some similarity to the relationships of /aj/ and [Ar] to /ɑ/. Hence, the possibility of [Er] forming its own category, as a monophonemic diphthong, still has to be considered.

7.4.3 Other Phonological Tests

JAEGER & OHALA 1984

The possibility of prototype effects in phonological categorization was demonstrated by Jaeger and Ohala (1984), who performed category-formation tests for a number of phonological features of American English. In this study, 28 subjects were first played words whose first phonemes were unambiguous positive or

[13]Unlike the situation with [Ar], the phonological categorization of the nucleus in [Er] has never been agreed on, and transcriptions vary (see Section

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

negative exemplars of the categories in question, which were ±anterior, ±sonorant, and ±voice. Subjects were not initially told whether the initial phonemes of the words contained the feature or not. Then they were told to make Yes/No judgments on their own. Once it was apparent that a subject had figured out what phonemes belonged correctly in which category (by responding to 15 tokens in a row with two or fewer errors), subjects were played words containing test phonemes and control phonemes. Their Yes/No responses were recorded. Results for the category [+sonorant] are shown in Table 7.6 below:

Table 7.6: Results for [+sonorant] (from Jaeger and Ohala 1984)

Tokens	%Positive	%Negative[14]
nasals	95	5
glides	93	4
[r]	91	6
[l]	86	14
[h]	36	64
voiced fricatives	23	73
voiced affricate	17	83
voiceless affric.	13	87
voiceless fric.	10	87
voiced stop	9	88
[z]	4	93
voiceless stop	3	94

3.2.).

[14]Subjects could also not respond, thus positive and negative answers don't necessarily add up to 100%.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There is a rather large gap between the Positive response percentages for [l] and for [h]. This suggests that inclusion in the category [+sonorant] may be discrete: nasals, glides, [r], and [l] are definitely within the category. All the other groups tested are definitely outside of the category. However, there is sufficient variation in the Positive response rates for the various categories (especially those which are [-sonorant]) to show prototype effects. A voiceless stop appears to be the best exemplar of a [-sonorant] segment (that is to say, an obstruent), followed by [z], then voiced stops, then voiceless fricatives, etc. The segments that are the most peripheral members of the category [-sonorant] are [h] and voiced fricatives (excluding [z]).

Jaeger and Ohala attribute this prototype effect to phonetic factors such as continuancy, lack of turbulence, an open vocal tract position, and voicing. For example, voiceless stops and fricatives are considered to be better examples of the category [-sonorant] than their voiced counterparts. Similar effects were also found for the categories [+anterior], [-anterior], and [+voice]. One interesting difference between Jaeger and Ohala's experiment and the one conducted in this chapter is the fact that Jaeger and Ohala are overtly testing superordinate phonological categories rather than comparing two different items which are at the same level.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

DERWING, NEAREY, & DOW 1986

Another study showing possible prototype effects in phonological categorization is found in Derwing, Nearey, and Dow (1986). In their study, subjects were read a "probe" word and then a list of real and nonsense words. The subjects were asked whether the test words contained the same sound as the first sound in the "probe" word or not. For example, subjects were asked "Does 'tree' contain the first sound of the word 'tough'?" Derwing *et al.* decided to test the phonemes /t/ and /d/, since they both have many allophonic variants in Modern English. Hence, the "probe" words were "tough" and "duck." The results of the experiment for the probe word "tough" are shown in Table 7.7 below.

Though Derwing *et al.* do not provide response times for the experiment, the variation in the percentage of "Yes" responses does show a cline similar to the results of the vowel experiment in Table 7.1. Some allophones of /t/ appear to be central exemplars, such as the [t^h] in "tub." Others are somewhat weaker, but still fairly central, such as the unreleased [t˺] after a fricative in "best." Some have weak membership, but can still be considered in the category of /t/,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

such as the dental [t̪] in "eighth." Some sounds are clearly not in the category, such as the [dʒ] in "jig", while some sounds have a high enough percentage of "Yes" responses to show peripheral membership, such as the [tʃʰ] in "chief."

Table 7.7. **Percent Yes grouping for "tough"-probe (from Derwing, Nearey, and Dow 1986)**[15]:

Real words	% Yes	Nonsense words	% Yes
tub	100	$lutt_1$	100
retain	97	tupp	100
tune	97	toose	97
team	97	teef	97
$beat_1$	94	reteal	94
tree	92	twif	89
tweak	83	triz	89
streak	83	lutts	81
stream	83	stam	81
beast	83	struff	81
beats	78	hatten	67
beaten	69	$lutt_2$	53
butter	56	naitth	44
$beat_2$	44	vist	44
eighth	25	geater	39
seized	14	rediff	17
chief	11	pudd	17
buddy	11	guzzed	14
width	9	chuff[16]	14
bead	6	lidden	14
dwell	6	rudds	14
dream	6	medth	11
three	6	dupp	9
sudden	3	threff	6
redeem	3	zadey	6
seeds	3	doove	6
dune	3	dweck	6
dean	3	drabe	3
dumb	0	dobe	3
jig	0	jabe	0

---

[15]The words "$beat_1$" and "$lutt_1$" were pronounced with a final released stop. The words "$beat_2$" and "$lutt_2$" were pronounced with a final unreleased stop.

[16]"Chuff" is actually a real word with a few different meanings. I don't think that matters. Subjects were unlikely to know it.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

This latter example is particularly interesting, because it shows a parallel to the vowel categorization experiment. The affricate [tʃʰ] in "chief" is usually considered a distinct phoneme, not a cluster beginning with the phoneme /t/. However, it does contain a first element which is phonetically much like certain allophones of /t/. It is mostly not categorized by the subjects as containing a /t/, but its "Yes" response rate is higher than that of words which really have no /t/ at all, such as "dumb" or "jig." This same effect is found in the (supposedly) nonsense word "chuff" (presumably pronounced [tʃʰʌf]) and also in the test for /d/ with the nonsense word "jabe" (presumably [dʒejb]), which showed a 25% "Yes" response when asked if it contained the first sound of the word "duck." Interestingly, though, the real word "jig" only showed a 3% "Yes" response when tested with "duck." Derwing *et al.* consider that orthographic bias may be more of a factor with the real words than with the nonsense words (1986: 53).

The comparison of the affricates to the simple stops shows an effect directly parallel to the "diphthong effect" seen in the vowel-categorization test for the pairs comparing [Ar] and /aj/ to /ɑ/. The /Ar-ɑ/ and /aj-ɑ/ pairs were generally not categorized with /ɑ/, but their positive response percentages were still higher than that of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

clearly different vowel phoneme pairs in Set D. We could say that what we have here is not just a "diphthong effect" but a "complex phoneme effect" in which complex phonemes classifiable as monophonemic in a given language still show weak categorization with a single segment which resembles one of the parts of the complex phoneme (at least the first part). This categorization is weak, but higher than that of totally distinct segments.

The cognitive aspects of phonological categorization are still barely known. All the studies mentioned thus far have been done for a few segments and features of North American English. It is necessary to have cross-linguistic data concerning a variety of different phonological categories before anything can be said firmly. The relationship between response times and percentage of Yes/No responses is clear from the numbers in Table 7.1, and Figures 7.1 and 7.2, but the prototype explanation works better to explain this as a general trend than to account for the categorization of all of the "controversial" vowels of this study. For example, the /ang-e/ group shows both a middling Yes/No response percentage and a very quick response time.

Additionally, no phonological model that I am aware of can represent non-discreteness. I am not even sure how such a thing could be done. The data collected in the experiment in this study are

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

certainly interesting for the purpose of the greater understanding of phonological categories, but for the goal of this dissertation--the classification of vowels before /r/, /l/, and /ŋ/ in California English--the data will serve primarily to be used in conjunction with data gathered from other domains to help us choose between competing discrete solutions, as we shall see in Chapter 8.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 8: Analysis

The purpose of this chapter is to review the various accounts of the RGDs discussed in Chapter Three in order to see how well they are supported by the evidence discussed so far. For each account, it will be shown what kinds of evidence (historical, acoustic phonetic, phonological, psycholinguistic) support it and what kinds of evidence do not support it. The status of vowels before /l/ and /ŋ/ will also be discussed using the same types of evidence. The various accounts reviewed in this chapter are all supposed to apply to General American, which would include California English. Seldom is there a specific variety of General American mentioned by the author.[1] In this chapter, it will be discussed how these accounts could apply to California English (and, by extensions, any other dialect of GA that patterns like California English). The application of the various accounts to other dialects of GA will be discussed in Chapter Nine.

---

[1]An exception to this is Bloomfield, who specifies that he is describing "the type of standard English that prevails in Chicago" (1933: 91).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

8.1. The Status of Vowels before /r/.

8.1.1. The Tense Vowel Analysis.

This type of analysis is found in Bloomfield 1933, Teeter 1966, Hammond 1999, and perhaps Harris 1994 (see section 3.2.1 for discussion). In such an analysis, the nuclei of the RGDs [Ir Er Ar Or] would be underlyingly /i e ɑ o/, so that the words in "peer", "pair", "par", "pore" would be phonologically /pir per pɑr pOr]. Note that in such an analysis, it is necessary for the vowel /ɑ/ to be considered tense. It is not always considered so.

The following facts support the tense vowel analysis:

Historical:

1) The vowels in [Ir Er Or] are (either entirely or partially) historically cognate with the vowels /i e o/.

Phonetic:

2) The vowel in [Ar] was in the range of /ɑ/.

3) The vowel in [Or] was sometimes within the range of /o/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonological:

4) The vowels /i e a o/ would all behave reasonably similarly phonetically as a natural class before /r/. The vowels /i e o/ would all be lowered somewhat as manifested in their surface variants. The vowel /a/ would not lower, because it is already very low as it is.

Psycholinguistic:

5) The vowel in [Ir] was sometimes identified with /i/ on the psycholinguistic test.

6) The vowels in [Ar] and [Or] were sometimes identified with /a/ and /o/on the psycholinguistic test.

The following facts do not support the tense vowel analysis:

Historical:

1) The vowel in [Ar] is not historically cognate with /a/.

Phonetic:

2) The vowel in [Ir] is only sometimes in the range of /i/.

3) The vowel in [Er] is never in the range of /e/.

4) The vowel in [Or] is only sometimes in the range of /o/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonological:

5) Not all of the members of the category of tense vowels are found before /r/. We have to account for the absence of the tense vowel /u/ before /r/ in this dialect.

6) Characteristic of the tense vowels /i e u o/ is a homorganic post-vocalic glide: [j] for the front vowels, [w] for the back vowels. This is especially true for the mid vowels /e/ and /o/. This glide is a defining feature of these tense vowels. Sometimes it is considered to be inserted by an unconditioned glide insertion rule (Chomsky & Halle 1968: 183). Sometimes it is considered to be there always after the vowel (Bloomfield 1933: 91). However, these glides are not found before /r/. If we use the tense vowel analysis, we would have to complicate matters by putting in a specific exception to the presence of the glides, whose presence is otherwise non-distinctive.

Psycholinguistic:

7) The vowel in [Er] was never identified with /e/ on the psycholinguistic test.

8) The vowels in [Ar] and [Or] were only sometimes identified with /ɑ/ and /o/ on the psycholinguistic test.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Conclusion: The data do not support the tense vowel analysis very well. The strongest evidence against it is the complete non-identification of the vowel in [Er] with /e/ by any of the eighteen subjects in the psycholinguistic test.

8.1.2. The Lax Vowel Analysis.

This type of analysis is found in Kenyon & Knott (1953), Bronstein (1960), Lehiste (1967), and Akmajian *et al.* (1995). In such an analysis, the nuclei of the RGDs [Ir Er Ar Or] are underlyingly /ɪ ɛ ɑ ɔ/, so that "peer", "pair", "par", and "pore" would be /pɪr pɛr pɑr pɔr/. Note that in such an analysis, it is necessary to consider the vowels /ɑ/ and /ɔ/ to be lax. They are not always considered as such.

The following facts support the lax vowel analysis:

Phonetic:

1) The vowel in [Er] sometimes is in the range of /ɛ/.

Psycholinguistic:

2) The vowel in [Er] was sometimes identified with /ɛ/ on the psycholinguistic test.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following facts do not support the lax vowel analysis:

Historical:

1) The vowels in [Ir Er Ar Or] are not historically cognate with /ɪ ɛ ɑ ɔ/, but usually with /i e æ o-ɑ/.

Phonetic:

2) The vowel in [Ir] is not in the range of /ɪ/.

Phonological:

3) The vowel /ɔ/ does not exist as a separate phoneme in the dialect in question. By the phonemic principle, the vowel in [Or] would then have to be the tense vowel /o/, since [o] and [ɔ] would be in complementary distribution. The vowel [ɔ] would occur only before /r/, and the vowel [o] would occur everywhere but before /r/.

4) The vowel /ɑ/ and the vowel /ɔ/ in dialects in which it exists contrastively, are not usually considered lax, but tense, since they can occur in open syllables in words like "spa" and "paw."

5) Not all the members of the lax vowel category would be found before /r/. We still would not have /æ/, /ʌ/, and /ʊ/. It is difficult to eliminate these three vowels as a natural sub-class of the lax vowels.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Psycholinguistic:

6) The vowel in [Ir] was almost never identified with /ɪ/ on the psycholinguistic test.

7) The vowel in [Er] was only sometimes identified with /ɛ/ on the psycholinguistic test.

Conclusion: The data do not support the lax vowel analysis at all. The positive evidence is scant and not strong. The negative evidence is abundant and often strong. The lax vowel solution is the weakest, most problematic proposal to account for the vowels before /r/.

8.1.3. The Archiphonemic Analysis:

This type of analysis is found in Moulton (1960), Gramley and Patzold (1992), and Wardhaugh (1995). In such an analysis, the nuclei of the RGDs [Ir Er Ar Or] would all be "archiphonemes."

An archiphoneme can be here defined non-abstractly as a segment which:

a) Occurs in an environment of neutralization of contrast of two (or more) phonemes which otherwise contrast in the language

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

b) Shares phonetic characteristics which are otherwise distinct for the two (or more) phonemes in question

c) (In this case) is identified with those two (or more) phonemes at approximately the same rate (well or poorly) by subjects in a psycholinguistic study.

I am using a definition of archiphoneme similar to that used by Davidsen-Nielsen (1978) or Akamatsu (1981) in which an archiphoneme does not just represent defective distribution but a segment which is associated with and "subsumes" the member phonemes of the neutralizable opposition (Akamatsu 1981: 129). I am using this criterion (which thus requires the inclusion of criterion (b), above, sharing phonetic characteristics) in order to distinguish the archiphonemic analysis from the tense vowel or lax vowel analysis, above, or the "arbitrary list" analyses, below. The tense vowel, lax vowel, and arbitrary list analyses all involve a lack of contrast of vowels before /r/, but in these analyses the vowel which does occur before /r/ is always considered to be only one of the specific vowel phonemes which does contrast in other environments.

In the particular analysis used by Moulton, the nucleus in [Ir] is a neutralization of /i/ and /ɪ/, the nucleus in [Er] is a neutralization of /e/ and /ɛ/, and the nucleus in [Or] is a neutralization of /o/ and /ɔ/. However, Moulton considers the nucleus in [Ar] to be /ɑ/, a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vowel which does not participate in a tense/lax pair akin to /i-ɪ/, /e-ɛ/, etc.

The following facts support the archiphonemic analysis:

Historical:

1) The analysis is partially consistent with some of the historical facts. The vowels before /r/ are usually cognate with one of the vowels that make up their archiphoneme. The nucleus in [Ir] is cognate with /i/, the nucleus in [Er] is cognate with /e/, and the nucleus in [Or] is cognate with /o/.

Phonetic:

2) The fact that many of the vowels before /r/ share phonetic characteristics with more than one canonical vowel, or are "between" two of the canonical vowels in the vowel space. For example, the nucleus in [Er] begins like /e/, but moves into the range of /ɛ/, and lacks a [j] off-glide.

Phonological:

3) The reduced contrast in vowels before /r/ (tautologically).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following facts do not support the archiphonemic analysis:

Phonological:

1) There are still many vowels whose non-occurrence before /r/ is not accounted for by any archiphonemic account. For the high back vowels /u/ and /ʊ/, we have a potential for archiphonemic neutralization without a vowel in that area before /r/. Conversely, we have a mid-back vowel before /r/, but there is no potential archiphonemic neutralization in the mid-back area in the California dialect, since the vowel /ɔ/ does not occur as a separate phoneme. It is also unclear how the vowels /æ/ and /ʌ/ fit into such an analysis.

Psycholinguistic:

2) It is not born out by the psycholinguistic test. If the archiphonemic solution is correct, we would expect the nucleus in [Ir] to pattern equally (well or poorly) with both /i/ and /ɪ/, and the nucleus in [Er] to pattern equally with both /e/ or /ɛ/. However, [Ir] patterns somewhat with /i/, but not at all with /ɪ/, while [Er] patterns weakly with /ɛ/, and not at all with /e/.

Conclusions: The archiphonemic account doesn't really work, and is strongly undermined by the psycholinguistic evidence. A lot of the weaknesses of this approach do not come specifically from its

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

application to the vowels before /r/, but from its application to American English in general. While vowels like /i-ɪ/, /e-ɛ/, and /u-ʊ/ seem to fall neatly into tense/lax pairs, the rest of the vowel system of American English is not so symmetrical. Even in dialects which have a contrasting vowel /ɔ/, this vowel is not the lax counterpart to /o/, since it fails one of the usual litmus tests for the category of "lax vowels" in English by being able to occur in open syllables.

There are proposals for a system of tense/lax vowel contrast in American English which attempt to account for these assumptions. One such is found in Giegerich (1991: 58), where the vowels of GA pattern like this:

Table 8.1. The basic General American Vowel system (from Giegerich 1991)

tense	lax
i	ɪ
e	ɛ
ɑ	æ
u	ʊ
o	ʌ

non-patterning: ɔ, aj, aw, ɔj[2]

In such a system, the lax counterpart of /o/ is /ʌ/, and the lax counterpart of /ɑ/ is /æ/. The vowel /ɔ/ and the diphthongs /aj aw

[2]Giegerich does not include [ɚ] in this scheme.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

ɔj/ do not participate in the tense/lax pairs in such a system, though the fact that they can occur in open syllables makes them more like the vowels in the "tense" category. Since the vowel phoneme /ɔ/ does not occur independently in California English, its lack of a lax counterpart is not relevant here.

If we derive archiphonemes from such a system, and apply them to the vowels before /r/, we have partial success. The vowel in [Ir] can be an archiphoneme of /i/ and /ɪ/. The vowel in [Er] can be an archiphoneme of /e/ and /ɛ/. The vowel in [Or] can be an archiphoneme of /o/ and /ʌ/, and the vowel in [Ar] an archiphoneme of /ɑ/ and /æ/. In the latter two cases, however, the archiphonemicity is not supported by the phonetic facts. The vowel in [Or] is only phonetically similar to /o/, and very much unlike /ʌ/, while the vowel in [Ar] is only phonetically similar to /ɑ/, not very much like /æ/. This is relevant if we remember that I am using the definition that an archiphoneme must be be neutralized for some feature(s) of all the phonemes it subsumes. In both cases, the vowel found before /r/ is only reasonably phonetically similar to the "tense" vowel in the pair. That ends up making this variation of an archiphonemic solution like the tense vowel solution discussed in section 8.1.1, above. We still, of course, would have the lack of contrast in the /u-ʊ/ region unaccounted for.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

8.1.4. The "Arbitrary List" analysis.

In such an analysis, the distribution of vowels found before /r/ could not be derived by any reference to a natural class of sounds, but would simply have to be listed individually. Such an analysis would generally be ill favored in the domain of phonological theory, because it would not capture any generalizations. Nevertheless, it is a possible solution, which could be proposed if no other satisfactory ones are found. Some linguists have effectively used such a solution, as mentioned in section 3.1.4, but this usually comes from a lack of thorough consideration of the issue.

There are a theoretically enormous number of possible arbitrary lists of vowels to which one could assign the vowels found before /r/ in English. The only possibilities I am considering in this section are ones which have some motivation in an independent domain: specifically, history and synchronic phonetics.

8.1.4.1. The Historically Consistent Solution.

In such an analysis, the vowel in [Ir] would be /i/, since they both come from ME /ę̄/ and /ẹ̄/, the vowel in [Er] would be /e/, since

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

they both come from ME /ă/, and the vowel in [Ar] would be /æ/, since they both come from ME /ā/. The vowel in [Or] in California English has as its sources ME /ǭ/, /ŏ/, and /ọ̄/, so it could be considered any of the possible cognates: /u/, /ɑ/, or /o/. Such an analysis is similar to the one used in Chomsky & Halle 1968.

To consistently apply such an analysis, we should also consider the vowel [ɚ] to be underlyingly a /Vr/ sequence, since that is what it is historically. It could be either /ɪr/, /ɛr/, /ʌr/, or /ʊr/, since [ɚ] come historically from sequences of ME /ĭr/, /Er], and /ŭr/.

An analysis that is historically based has its advantages in that it is in one respect simpler than an analysis that is not consistent with the historical facts. It is a simpler explanation to assume that no changes has occurred than that a change has occurred.

The following facts support the historical/arbitrary analysis:

Historical:

1) It is consistent with the historical data (tautologically).

Phonetic:

2) There is reasonably phonetic similarity of /i e o/ to the vowels in [Ir Er Or], respectively.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Psycholinguistic:

3) The vowel in [Ir] was sometimes identified with /i/ on the psycholinguistic test.

4) The vowel in [Or] was sometimes identified with /o/ on the psycholinguistic test.

The following facts do not support the historical/arbitrary analysis.

Historical:

1) Prioritizing historical consistency in the determination of the underlying classifications of the vowels before /r/ does not help us in the case of [Or] and [ɚ], which have multiple historical sources.

Phonetic:

2) The vowel in [Ar] is not phonetically very similar to /æ/.

3) The vowel in [Ir] is sometimes outside the range of /i/.

4) The vowel in [Er] is always outside the range of /e/.

5) The vowel in [Or] is sometimes outside the range of /o/.

6) The off-glides usually found as distinctive cues of /i/, /e/, and /o/, (or /u/) are not present.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonological:

7) Not only would the vowels in question not be derivable from a natural class, they would also not behave together as a natural class in the rule which would explain their allophones before /r/. The vowels /i/ and /e/ would be lowered. The vowel /o/ would also be lowered (provided we say that the vowel in [Or] is /o/). The vowel /æ/ would be lowered and retracted significantly, which doesn't happen to the other front vowels. Whichever vowel we choose to be the source of [ɚ] would have to be deleted, leaving the /r/ to syllabify. If we consider the vowel in [Or] to be /ɑ/, then it would have to rise and be rounded. Thus, using the historical/arbitrary analysis would fail to capture generalizations in two areas. We would have to have an arbitrary list of vowels which can occur before /r/, and then an arbitrary list of allophonic rules which apply to these vowels.

Psycholinguistic:

8) The vowel in [Er] was never identified with /e/ on the psycholinguistic test.

9) The vowel in [Or] was only sometimes identified with /o/ on the psycholinguistic test. It was almost never identified with /ɑ/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

8.1.4.2 The Phonetically Consistent Solution.

In such an analysis, we would assign the vowels in [Ir Er Ar Or] to whatever canonical vowel phonemes they are phonetically most similar to. The vowel in [Ar] would be /ɑ/. The vowel in [Or] would have to be /o/. It could not be /ɔ/ because this vowel does not exist as an independent phoneme in California English. Application of the phonemic principle would tell us that this [ɔ], if it occurred before /r/, would have to be an allophone of /o/. The vowel in [Ir] could be /i/ or /ɪ/[3], and the vowel in [Er] could be /e/ or /ɛ/. I am going to propose that they are /i/ and /ɛ/, respectively in order to also be consistent with the psycholinguistic data, since the vowels in [Ir] and [Er] were strongly not identified with /ɪ/ and /e/ on test. Considering the vowels in [Ir] and [Er] to be /i/ and /ɛ/ also distinguishes this solution from the tense vowel solution (section 8.1.1, above).

---

[3]It is possible that the monosyllabic diphthongs [ɪə] exists in some rhotic dialects of American English in a few words like "idea", contrasting with the bisyllabic sequences [ijə] in words like "Medea" (Trager & Bloch 1941: 243, Bronstein 1960: 200). In such a case, this diphthong [ɪə] would likely be monophonemic (/ɪ/+/ə/ is not a possible phoneme sequences since the lax vowel /ɪ/ cannot end a stressed syllable before another vowel in English) and it would be possible that the nucleus in [Ir] could be this diphthong, which it resembles phonetically. Nevertheless, I am not considering this possibility, as the diphthong [ɪə] appears to be very rare (even in dialects in which it

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following facts support the phonetic/arbitrary solution:

Phonetic:

1) The vowels in [Ir Er Ar Or] are reasonably phonetically similar to /i ɛ ɑ o/ (tautologically).

2) The vowel in [Ar] is in the range of /ɑ/.

3) The vowel in [Er] is sometimes in the range of /ɛ/.

4) The vowel in [Or] is sometimes in the range of /o/.

Psycholinguistic:

5) The vowel in [Ir] was sometimes identified with /i/ on the psycholinguistic test.

6) Although the identifications of the vowels in [Er Ar Or] with /ɛ ɑ o/ were somewhat weaker than that of [Ir] with /i/, they were still more than complete non-identifications.

The following facts do not support the phonetic/arbitrary solution:

Historical:

1) It is not consistent with the historical data.

---

occurs) and of marginal phonemic status, only occurring in a few words like "idea" and "theater."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonetic:

2) The vowel in [Ir] is usually not in the range of /i/.

3) The vowel in [Er] is sometimes not in the range of /ɛ/.

4) The vowel in [Or] is sometimes not in the range of /o/.

Phonological:

5) The vowels also do not all behave together as a natural class with respect to their allophones before /r/. The vowels /i/ and /o/ would be lowered, while /ɛ/ would actually have to be raised a bit, and /ɑ/ would pretty much stay in place.

Psycholinguistic:

6) The vowels in [Er Ar Or] were only sometimes identified with /ɛ ɑ o/.

Conclusion: The nature of these two arbitrary solutions is such that they will be supported by some data. It would be a waste of time to consider an arbitrary solution that is not supported by any data.[4] The arbitrary solution that is based in synchronic phonetics appears to be a better one than the one that is derived from

---

[4]For example, saying that the vowels in [Ir Er Ar Or] are underlyingly /o u i aj/, respectively.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

historical patterns. This, of course, depends on the degree to which synchronic phonetics are considered stronger supporting evidence than historical consistency in a phonological framework. In an extremely abstract framework such as that found in Chomsky & Halle (1968), synchronic phonetic similarity is barely a factor, while historical consistency is extremely important. However, most phonological analyses begin with synchronic phonetic data. Historical consistency is usually considered of secondary importance, because most linguists are fully comfortable with the concept of sound change. A given segment in a synchronic set of data may be different from its historical source due to sound change.

Thus, the phonetic/arbitrary solution "works", and is consistent with the phonetic and psycholinguistic data, because it was derived from the phonetic and psycholinguistic data. Note that the phonetic and psycholinguistic data are to a certain extent consistent with each other as well. This should not surprise us, as subjects may be basing their responses on phonetic cues, or on mental categories they have formed from phonetic cues.

However, even though the phonetic/arbitrary solution "works" (and we would not be considering it if it didn't work), we still have to consider it with respect to other solutions. We will find that considering the vowels before /r/ as belonging to an arbitrary list of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vowels has no advantages on the monophonemic solution considered in section 8.1.5, below. Both of them require an arbitrary list to be stipulated somewhere in the phonology of the language, but the monophonemic solution is actually more consistent with other facts about the language, and can be derived from general principles about how glides are treated in English. Hence, though the phonetic/arbitrary solution has advantages over the tense vowel, lax vowel, and archiphonemic solutions, it gains nothing in comparison to the monophonemic solution, having all the same disadvantages but lacking many of the advantages.

8.1.5. The Monophonemic Analysis.

As stated before in section 3.2.2.1, I am counting as "monophonemic" any account which treats the RGDs in a parallel manner to the diphthongs ending in [j] or [w], for example Veatch's glide-slot analysis (1991).

In the monophonemic analysis, the diphthongs [Ir Er Ar Or] would simply be placed in the inventory of phonemes alongside /i ɪ e ɛ æ u ʊ o ɑ ʌ aj aw ɔj/. They would not be considered sequences of one of the canonical vowel phones followed by /r/. Indeed, in such

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

an analysis, there would be a general constraint against glides appearing in the coda. This constraint would apply to /r/ as well as to /j/ and /w/. The only glides which could occur post-vocalically are those which are specified in the inventory as the off-glides of specific diphthongs, such as /ɔj/, /aw/, or [Ar].

Since such an analysis has not been commonly used, we should first show that it is an acceptable analysis before it is evaluated, determining whether it is possible, and whether there is precedent for it.

1) Is it possible? Empirically speaking, the RGDs are diphthongs. Furthermore, we have established (section 3.1), based upon such criteria as those used by Trubetzkoy (1969) or Pike (1947b: 131), that it is possible for diphthongs to be monophonemic or biphonemic. Hence, the RGDs could be monophonemic.

2) Is there precedent for this sort of thing? The possibility of diphthongs being monophonemic is usually mentioned for diphthongs in [j] or [w]. Has it ever been claimed that a diphthong in [ɹ] is monophonemic for any language besides American English? I can find no such claims in the literature. This could be due to the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

rarity of [ɹ] as a sound. Maddieson (1984) finds such a sound[5] in only 25 of the 918 (2.8%) of the languages in his sample (English is not in his sample). Likewise, rhotacized vowels appear to be very rare cross-linguistically. Maddieson (1984) lists only two languages (Tarascan and Mandarin) that have rhotacized vowels of any sort, and lists no languages that have diphthongs with containing rhotic elements[6]. However, the inventory descriptions of some languages describe phenomena that could be parallel to the RGDs of American English.

A possible parallel situation is that of Danish as described by Basbøll (1975) (and also Grønnum 1998). Sequences of /Vr/ in Danish are similar to the /Vr/ sequences in English in the following ways:

1) Post-vocalic /r/ is non-consonantal. In Danish, /r/ in onsets is usually the uvular fricative [ʁ], but post-vocalically it is the low back off-glide [ɒ̯][7]. English post-vocalic /r/ also is non-consonantal (as it usually is in onsets as well).

2) There is a limited set of vowels contrasting before /r/. The standard set of Danish vowels is /i e ɛ y ø œ u o ɔ a/ with contrasting

---

[5]I am including in this category anything Maddieson labels as an alveolar, retroflex, or unspecified dental/alveolar approximant. Wiyot is the only language Maddieson lists with more than one such sound.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

long and short varieties. However, the only /Vr/ sequences allowed are [iɒ̯ æɒ̯ yɒ̯ œɒ̯ uɒ̯][8].

3) The vowels found before /r/ are sometimes different from their cognates in other environments, and may not occur independently. For example, the vowel in [æɒ̯] is cognate with the vowel [ɛ]. Short vowel [æ] does not normally occur (there is independent long [æ:], which is phonologically long /a:/). Likewise, the low front rounded vowel [œ] does not occur independently. It should be pointed out, though, that these lower vowels may be found after an onset /r/ as well.

This is not to say that Basbøll considers the /Vr/ sequences in Danish to be monophonemic. Basbøll initially proposes that all the Danish diphthongs are biphonemic (Grønnum 1998 concurs with this), but then concludes by saying that [i̯] diphthongs are phonological diphthongs (i.e., monophonemes) in all situations, while the [u̯] and [ɒ̯] diphthongs could be considered VC sequences if we look at all words, but monophonemic diphthongs if the data is restricted to the core set of abstract morphemes. In any situation,

---

[6]It must be mentioned that Maddieson's criteria for the inclusion of diphthongs in the inventory of sounds are very strict (1984: 161-162).
[7]Grønnum transcribes this off-glide as [ʌ̯].
[8]There are other /Vr/ sequences found, but they are in marginal words or multi-morphemic forms. If we restrict ourselves to the "core" diphthongs (Basbøll's term for diphthongs which occur in monophonemic standard

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

these diphthongs contrast with the [ð] diphthongs ([ð] represents a central approximant in Danish in the transcriptions of Basbøll and Grønnum), because the [ð] diphthongs do not have a restricted set of vowels in any circumstances.

What the Basbøll analysis of Danish shows is that the decision whether to classify a phonetic diphthong as monophonemic or biphonemic within a given language is not necessarily clear-cut. The case of diphthongs in Danish may be in case of flux, with formerly unrestricted sequences of vowel plus consonant ([i̯] comes from [j] or [g], [u̯] comes from [v] or [g], and [ɒ̯] comes from [r]) becoming more restricted, beginning to behave like single units (monophonemic diphthongs). In this case, the situation may be indeed parallel to English, with the exception that the [j] and [w] diphthongs in English have a longer monophonemic history, being derived historically from long vowels, and that the [r] diphthongs appear to be further on their road to monophonemicity as well.

One might claim that the RGDs should be regarded as biphonemic, with the /r/ in the coda, because it makes for a more consistent account of English syllable structure. For example, post-

---

vocabulary words), the count is fewer. This is true for the diphthongs in [j] and [w] as well.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

vocalic /r/ seems to participate in coda consonant clusters in much the same patterns as /l/ (see Kreidler 1989: 123-125, Giegerich 1992: 160). I do not believe that syllable structure is a good indicator of bi- vs. monophonemicity for the reason that the syllable structure of a language is often very conservative and can be accounted for historically. The phonology of the segments in the language may have changed dramatically while not changing the shapes of the words.

I will give an example of this. If we are to regard the syllable structure of English as primary in determining the bi- vs. monophonemic status of the RGDs, then we would have to regard [Ir Er Ar Or] as biphonemic, since they pattern in the syllable much like sequences of /ɛl æl ɑn/, etc. do. This is not surprising, since the RGDs are derived from /Vr/ sequences. In such an analysis, we would also have to regard the vowel [ɚ] as biphonemic, since it is also derived from historical /Vr/ sequences, and patterns like a sequence of a short vowel followed by /l/, etc.

However, if we are to regard the synchronic phonetics of English as primary in determining the bi- vs. monophonemic status of [ɚ], we would want to regard it as monophonemic, since it is a steady state vowel, not a phonetic sequence of another vowel followed by [r]. To this we may add the psycholinguistic evidence

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

discussed in Chapter 7. Subjects overwhelmingly did not categorize [ɚ] with the vowels [ʌ], [ʊ], or [ɛ]. If we regard [ɚ] as monophonemic, we can still account for the fact that it patterns in the syllable like a sequence of /vowel + sonorant/ by appealing to its historical sources. It used to be a /Vr/ sequence, and the syllabic patterns of English are conservative and date back to before the time when these /Vr/ sequences underwent the changes which turned it into [ɚ].

The arguments for the monophonemic or biphonemic status of [ɚ] are consistent with the available data in the following ways:

	Monophonemic	Biphonemic
Phonetic:	accounted for	contradicted
Psycholinguistic:	accounted for	contradicted
Syllable structure:	accounted for (historically)	accounted for; also accounted for (historically).

The monophonemic analysis is consistent with all the data. The biphonemic analysis contradicts the phonetic and psycholinguistic data. The only data it is consistent with is the syllabic structure. Note, however, that even if we use syllable structure as a determiner of synchronic phonological status, we still must acknowledge that there are historical factors that could explain the synchronic state of the language. Hence, the role of the syllable structure of the language in accounting for synchronic phonological status is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

redundant. Since syllable structure is the only data that supports a biphonemic analysis of [ɚ], removing it as redundant takes away any support for the biphonemic analysis at all.

I have used the example of [ɚ] to illustrate that syllable structure cannot be used as primary evidence in determining bi- vs. monophonemic status of complex segments, as it is usually redundant to a historical explanation and may remain conservative while the phonetics of the language change considerably.[9]

Now that we have established that the monophonemic analysis for the RGDs is viable, let us discuss how the facts we have thus far seen support or contradict the analysis.

The following facts support the monophonemic analysis:

Historical:

1) It accounts for certain recent historical changes. The contrast between the vowels /ɑ/ and /ɔ/ in words such as "don" and "dawn" has been lost over large portions of North America, including

[9]The use of syllable structure might be more convincing in a language which has a very limited syllable canon, but English has at least eighteen possible syllable shapes (Hammond 1999: 37). Treating [ɚ] and the RGDs as monophonemic doesn't significantly alter the syllable canon of English.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

California. However, the diphthongs /aj/ and /ɔj/ such as in "buy" and "boy" still remain distinct in dialects that have the merger of /ɑ/ and /ɔ/. In addition, the diphthongs [Ar] and [Or] such as in "bar" and "bore" still remain distinct as well. The first elements in the diphthongs /aj/ and [Ar] are close to [ɑ], while the first elements in the diphthongs /ɔj/ and [Or] are historically much like [ɔ] (but see below).

If we want to account for this, we could do it in two ways. One such way would be to specify exceptions to the /ɑ-ɔ/ merger, as below:

ɔ > ɔ / _j, _r

ɔ > ɑ / elsewhere

Such a rule works, and we could even put /j/ and /r/ together in a natural class, but there is a simple solution. If we consider the diphthongs /ɔj/ and [Or] to be monophonemic, which as we have seen, we have ample reason to do, then all we have to do is state the change as follows:

ɔ > ɑ

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In this case, the vowels which occur in the diphthongs /ɔj/ and [Or] are not really part of the phoneme /ɔ/, so they are not affected by its merger with /ɑ/. The second account is thus simpler than the first one. Judging the diphthongs /ɔj/ and [Or] to be monophonemic (which we have reason to do) renders the rule which accounts for the /ɑ-ɔ/ merger exceptionless. Judging the diphthongs /ɔj/ and [Or] to be biphonemic means that we have to specify exceptions to the rule, making it more complicated. Notice that the two exceptions in the first account are in the exact situations where monophonemicity is a possible analysis. This is coincidental. This coincidence could not be considered a by-product of the /ɑ-ɔ/ merger. The consideration of /ɔj/ and [Or] as distinct monophonemes pre-dates the /ɑ-ɔ/ merger, and is done by linguists who don't even show any awareness of the /ɑ-ɔ/ merger (for example, De Camp 1945). Also, even once we have accounted for the exceptions to the rule in the first account, we still have to answer the question of bi- vs. monophonemicity of the diphthongs in the language that is the end product of the rule.

Another set of recent historical changes is mentioned by Thomas (2001: 24, 30), wherein he states that the nuclei in /ɔj/ and [Or] are rising such that these two diphthongs are commonly becoming [oj] and [or-ur]. This change does not precede or necessarily even overlap the merger of /ɑ/ with /ɔ/. Most of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thomas's speakers are from areas which keep /ɑ/ and /ɔ/ distinct. Here is another situation in which [Vr] sequences behave like the diphthongs in [j] and [w], and not like standard [VC] sequences.

Phonetic:

2) The segment /r/ in American English is a central approximant like [j] or [w], not a true consonant like /n/. Such an analysis would be more consistent with the phonetic facts of /r/. It is more consistent to treat [Vr] sequences like [Vj] or [Vw] sequences, instead of [Vn] sequences.

3) The vowels which do occur before /r/ do not generally occur independently, specifically:

a) The vowel in [Ir] is not in the range of any other vowel.

b) The vowel in [Er] is only sometimes is the range of any other vowel.

c) The vowel in [Or] is only sometimes in the range of any other vowel.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonological:

4) There is a reduced set of vowels that can occur before [r], [j], and [w], while all vowels can occur before true consonants like [n][10]

5) If we use the monophonemic analysis, we don't have to worry about accounting for the odd selection of vowels that occur before [r]. We don't need to decide which of the categories "tense" or "lax" the vowels belong to, and attempt to match the vowels in these categories with the vowels that occur before [r]. Indeed, we cannot independently account for which vowels occur before [r]. The RGDs would simply be primitives listed in an inventory, not derivable by any principle.

6) We also would not have to (and cannot) account for the precise phonological rules that affect the vowels before [r]. They are not really "before" /r/ in any syntagmatic sense. Rather, the phonetic characteristics of the diphthongs are already pre-specified in the inventory.

7) Sequences of the diphthongs /aj aw/ followed by /r/ have been resyllabified to the bisyllabic /ajɚ/ and /awɚ/. This has not happened to /ajn/ and /awn/ sequences. We thus don't have to have any synchronic rule which accounts for the resyllabification of words like "hire." We do not expect tautosyllabic sequences of /ajr/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to occur. The glide /r/ cannot occur after the diphthong /aj/ because there would be a constraint that says all post-vocalic glides have to be specified in the inventory. Hence, tautosyllabic /ajr/ would no more be possible than /awj/ or /ɔjw/. A word like "hire" would simply contain a syntagmatic sequence of the diphthong /aj/ followed by the vowel [ɚ].

8) It accounts for the distribution of the intervocalic flap [ɾ] in American English. This flap derives from an underlying /t/ and /d/ in certain intervocalic environments in words like "butter" or "atom." However, it is noted by many (Kahn 1980: 93, Jensen 1993: 150, Harris 1994: 217-218) that we also find flaps in American English after [r] in words like "parting", "carder", and "forty." Putting the [Vr] sequences in the inventory with the other vowels would account for this rule. Note that the diphthongs /aj aw ɔj/ do not behave any differently from vowels like /ɪ ɛ ʌ/, etc. in this respect, since we have flaps in words like " spider", "shouter", and "loiter."

9) It accounts for the facts of deletion of final /t/ and /d/, as mentioned in Guy (1980). The consonants /t/ and /d/ frequently drop out word finally in clusters. This may happen after true consonants in words like "test" (/tɛst/ > [tɛs]), but does not happen after /r/ in words like "cart" (/kArt/ > [kArt], *[kAr]).

---

[10]Except [ʊ].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Psycholinguistic:

10) The vowels which occur before /r/ were not generally identified with any of the canonical vowels on the psycholinguistic test, specifically:

a) The vowel in [Er] was not identified most of the time with /ɛ/, and never with /e/.

b) The vowel in [Or] was not identified most of the time with /o/, and never with /ɑ/.

c) The vowel in [Ar] was not identified most of the time with /ɑ/.

11) In speech errors which involve exchange or substitution of different vowels in an utterance, such as saying "sedden duth" [sɛɾən dʌθ] for "sudden death" [sʌɾən dɛθ], [Vr] sequences behave like single units , and the vowel is seldom separated from the following [r] (Shattuck-Hufnagel 1986). For example, the target utterance "sharp teeth" [ʃArp tiθ] comes out to be "sheep tart" [ʃip tɑrt], not something like *[ʃirp tɑθ]. Other examples of this are "hair blower" [hEr blo.ɚ] becoming "ho blairer" [ho blEr.ɚ], not something like [hOr ble.ɚ], and "state the parsing" becoming "start the parsing." Shattuck-Hufnagel only has one counter-example to this, where

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"steered the ship" [stIrd ðə ʃɪp] becomes "stirred the sheep", presumably [stɚd ðə ʃip].[11]

It must be mentioned that Shattuck-Hufnagel gives examples where [Vl] sequences also behave like units, such as "basketbour callt" for "basketball court." However, there are also some clear examples where a vowel moves out of a [Vl] sequence alone, such as "fit the bull" [fɪt ðə bʊl] for "foot the bill" [fʊt ðə bɪl], and "aleeminum and stool" [əlimənəm ɛnd stul] for "aluminum and steel" [əlumənəm ɛnd stil].

Thus, in terms of speech errors [Vr] sequences usually behave like the diphthongs /aj aw ɔj/, which behave like single units in speech errors as well (Shattuck-Hufnagel 1986: 126-127).

The following facts do not support the monophonemic analysis:

Historically:

1) It is inconsistent historically. The RGDs were at one point clearly biphonemic sequences of canonical vowels followed by a coda /r/.

[11]Shattuck-Hufnagel actually transcribes this as /stɪrd ðə ʃip/, which contradicts the orthography of "stirred", which is definitely [stɚd]. The transcription /stɪrd/ may be an attempt at representing an underlying form.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonological:

2) We would have to add four new units to the inventory of phonemes.

Psycholinguistic:

3) In the psycholinguistic test, some of the vowels before [r] did not pattern exactly like the diphthongs /aj/ and /aw/. The vowel in [Ir] was actually identified most of the time with /i/. The positive identification rates of the /Er-ɛ/ and /Or-o/ pairs were each less than 50%, but still higher than those of the diphthong and /Ar-ɑ/ pairs.

The historical inconsistency is not a major barrier. It is true that, all else being equal, we would prefer an analysis which is historically consistent. It is true that at any given time, some elements of a language will be changing, but it is also true that most elements of a language at any given time will be staying the same. It is a simpler explanation to assume that no change has occurred than that a change has occurred. However, many factors concerning historical [Vr] sequences clearly have changed, specifically the phonetic change of /r/ from a true consonant to a central approximant, the existence of stressed [ɚ], the loss of contrast of (and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

deletion of) /ɪ/, /ɛ/, and /ʌ/, the resyllabification of /ajr/ and /awr/ sequences, the loss of other contrasts (for example, /o-ɔ/), and the sometimes very sharp phonetic differences between the vowels before /r/ and their non-rhotic cognates (for example, [Ar] and [æ], [Or] and [ɑ]), that an appeal to strict historical consistency is impractical. The situation of vowels before /r/ is one situation in which, clearly, the language has changed.

I believe that the data from the psycholinguistic test is ambiguous as to whether it supports a phonetic/arbitrary solution (as in section 8.1.4.2, above), in which the vowels in [Ir Er Ar Or] would be /i ɛ ɑ o/, (but non-prototypical examples thereof), and a monophonemic solution in which [Ir Er Ar Or] would be entries in the inventory parallel to /aj aw ɔj/.

However, of these two solutions (phonetic/arbitrary, and monophonemic), the latter is the simpler. Both require the items to be listed in the phonology of the language at some point, their existence being underivable from other factors. But in the monophonemic analysis, this fact can be derived from treating [r] parallel to the other central approximants [j] and [w], applying the general constraint that all sequences of /vowel + glide/ are monophonemic diphthongs in the inventory. In the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

phonetic/arbitrary solution, we still have to account for the /r/ separately, placing it in the coda.

Having to add new items to the inventory is perhaps the largest strike against the monophonemic analysis. But, four is a fairly low number, and it is consistent with the rule of thumb (discussed in Section 3.1.3, above) that monophonemic interpretations for diphthongs should be avoided when they add more than three or four vowels to the inventory of phonemes (Burquest 1998: 165). We are adding four, a number that appears to be within the reasonable amount one can add.

Crucial to the monophonemic analysis of the RGDs is the idea that American English /r/ is phonologically like /j/ and /w/ and not like other consonants, including sonorant consonants like /n/. Below is a checklist incorporating all the evidence gathered in this study to show how this is so:

Table 8.2. Comparison of /r/ to glides and true consonants.

	j/w	r	n
1.Phonetically a central approximant?	y	y	n
2.Reduced set of vowel contrasts before?	y	y	n
3.Stressed syllabic exists?	y	y	n
4.Not allowed after tautosyllabic diphthongs?	y	y	n
5.Vowels which occur before don't occur independently?	y	y	n
6.Vowels before behave independently in sound changes?	y	y	n
7.Flaps found afterwards?	y	y	n
8.Deletion of final /t, d/ afterward?	n	n	y
9.Vs before don't move out in speech errors?	y	y	n

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The evidence is, I think, pretty convincing. American English /r/ behaves like /j/ and /w/, not like a true consonant. This is all due to the unconditioned change which began around 600 years ago in which /r/ changed from a trill or tap to a central approximant. It was likely that the change was at first sub-phonemic, and didn't affect the phonology of the language. But later, phonetic factors gradually brought about a series of sound changes which resulted in a situation for Modern California English in which /r/ is phonologically like /j/ and /w/ in all respects, including the status of the vowels found before it, with which the /r/ combines to form a monophonemic diphthong. The only explanation which is consistent with the data shown on the checklist above is the monophonemic solution. All other accounts treat /r/ parallel to /n/ and not to /j/ and /w/, and would have to defend themselves against the evidence represented in the checklist above.

8.2. Incorporating the Findings into Phonological Descriptions.

What follows are suggestions as to how to incorporate the findings into phonological theory using a few recent general works on English phonology.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

HAMMOND (1999).

Hammond works within the framework of Optimality Theory (OT). Such a framework still requires there to be an inventory of vowels, which Hammond gives on page 106. Hammond lists the vowels [i ɪ e ɛ æ u ʊ o ʌ ɔ ɑ] and the diphthongs [aj aw ɔj ju]. To adjust this analysis to the dialect in question, we would have to remove [ɔ] from the inventory (since it doesn't contrast in California English), and add the diphthongs [Ar Er Ir Or].[12] I will transcribe these as [ɑr er ir or], reflecting the general starting points of the diphthongs. Hence, the modification of Hammond's inventory would look like this (from Hammond 1999: 106):

Table 8.3. Vowels and Diphthongs of English (modification of Hammond 1999)

Vowels of English

[i]	heed	[u]	who'd
[ɪ]	hid	[ʊ]	hood
[e]	heyed	[o]	hoed
[ɛ]	head	[ʌ]	hud
[æ]	had	[ɑ]	hod
		[ɚ]	herd

Diphthongs of English

[aj]	bye	[ir]	beer
[aw]	bow	[er]	bear
[ɔj]	boy	[ɑr]	bar
[ju]	pew	[or]	bore

[12]Many linguists, including the author, would not put [ju] in the inventory. Since that is not a matter at issue here, I will leave it in the inventories of linguists who include it.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Optimality Theory employs constraints to account for phonotactic patterns. For example, in English, [h] is not allowed in codas. Hammond formalizes this as a *CODA constraint: *CODA/h (p. 58). Hammond also mentions that [w,j] can only occur in codas as part of the diphthongs [aw aj ɔj] (p.34), but does not formalize this into a constraint. Applying the findings of this study to Hammond's analysis, we should amend the sentence on p.34 to read "The consonant [h] cannot occur word-finally, while the consonants [w,j,**r**] can occur word-finally as part of the diphthongs [aw,aj,ɔj,**ir,er,ɑr,or**]." (Bold face here indicating my additions) Subsequently, all Hammond's constraints which treat /r/ as a regular consonant in codas (pp. 146-147) are unnecessary.

JENSEN (1993)

Jensen (1993: 34-36) provides an inventory of vowels somewhat similar to Hammond's (see above), but different in that he considers the vowels in "bee", "bay", "gnu", and "doe" to be underlyingly diphthongs [ij ej uw ʌw]. Jensen lists the short (lax) vowels [ɪ ɨ ʊ ɛ ə ɔ æ ɑ ɒ] on one chart, and the tense vowels and diphthongs [ij jɨw uw ej ʌw oj ǽw ɑ̆j ɒ̆] on another. To adapt his charts to the data in question, we would have to remove the vowels

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[ɨ ɔ ɒ ɒ̃], which do not occur contrastively in California English, and add the diphthongs [ir er ɑr or].

English vowels à la Jensen 1993.

	-back	+back	
		-round	+round
+high, -low	bit [ɪ]		book [ʊ]
-high, -low	bet [ɛ]	but [ə]	
-high, +low	bat [æ]	balm [ɑ]	

Table 8.4. Short, lax vowels (modification of Jensen's Table 4, p. 34)

	-back	+back	
		-round	+round
+high, -low	bee [ij], beer [ir]	music [jɨw]	gnu [uw]
-high, -low	bay [ej], bare [er]	doe [ʌw]	boy [oj], boar [or]
-high, +low	cow [æ̀w]	buy [ɑ̆j], bar [ɑr]	

Table 8.5. Tense vowels and diphthongs (modification of Jensen's Table 5, p.36)

HARRIS (1994).

Harris gives no explicit inventory of vowels and diphthongs. Generally, long vowels and diphthongs are treated as "branching nuclei." Thus, the word "tie" [taj] is (Harris 1994: 260):

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

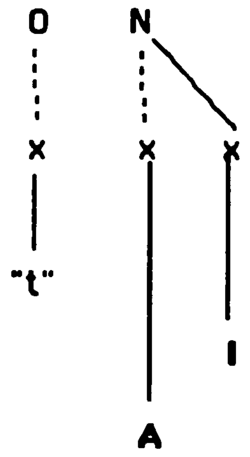


Figure 8.1. Representation of the word "tie" (from Harris 1994)

Harris also gives an example of a monosyllabic pronunciation of the word "tire" without the off-glide [j]. This he transcribes as [taər] and represents as the following: (p. 260)

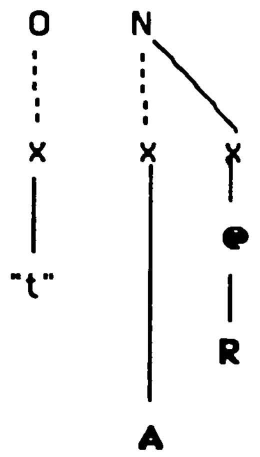


Figure 8.2. Representation of mono-syllabic pronunciation of the word "tire" (from Harris 1994)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

These two representations for [taj] and [taər] are reasonably parallel, with the exception of the fact that the off-glide in [taər] includes both a coronal element "R" and a centering element "@", while the off-glide in [taj] contains only a palatal element "I". The representation of [taər], however, would work fine for words containing [Ar] such as "tar", of California English as well. This contrasts with, for example, the syllable [kæm] in one pronunciation of the word "camera" (when it is pronounced [kæmrə]), in which the consonant [m] is in the rhyme, but not in the nucleus (p. 189. In this representation, the "U" is a labial element, the "?" is a stop element, and the "N" is a nasal element):

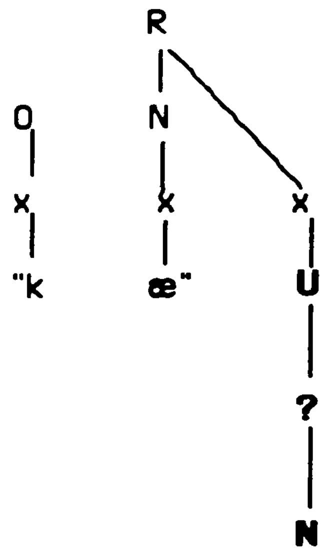


Figure 8.3. Representation of the syllable [kæm] in "camera" = [kæmrə] (from Harris 1994)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Harris's representation of the [Ir] in "fear" also followed the pattern above of putting the [r] in the nucleus (p. 259):

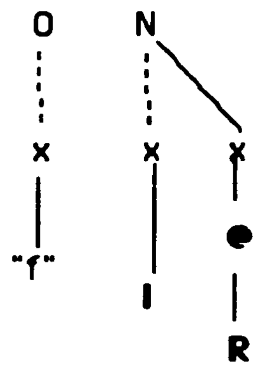


Figure 8.4. Representation of the word "fear" (from Harris 1994)

Hence, Harris's representations really do treat [Vr] sequences as parallel to [Vj] and [Vw] diphthongs, and his constraint barring non-branching stressed nuclei in domain-final position (or lax vowels word-finally) which is supposed to account for the reduction of vowel contrast before [r] is unnecessary, and doesn't even work (see discussion, section 3.2.1).

VEATCH (1991).

Veatch already does consider the RGDs to be phonologically parallel to the diphthongs in [j] and [w]. All that is necessary is to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

adapt his system for "Reference American" (an abstraction) to the California English dialect under study here. His system, with representative words, is as follows (p. 81):

	V		V:		Vr		Vj		Vw	
high	i	u	i:	u:	ir	ur	□	□	□	□
mid	e	ʌ	e:	o:	er	or	□	oj	□	□
low	æ	ɑ	a:	ɔ:	ær	ar	□	aj	□	ɑw

representative words:

	V		V:		Vr		Vj		Vw	
high	kit	foot	fleece	goose	near	cure	□	□	□	□
mid	dress	strut	face	goat	square	north	□	choice	□	□
low	trap	lot	palm	thought	marry	start	□	price	□	mouth

Table 8.6. Reference American Vowel structure with representative words (from Veatch 1991).

California English doesn't contrast the vowels in "lot", "palm", and "thought," represented by /ɑ/, /a:/, and /ɔ:/ here, so we can reduce these all to /ɑ/. Veatch considers the vowels in "fleece", "goose", "face", and "goat" to be underlying long vowels, not diphthongs. But, the removal of /a:/ and /ɔ:/ makes the whole /V:/ column superfluous, since we could consider Veatch's /i: e: u: o:/ to be /ij ej uw ow/, and put them in the appropriate /Vj/ and /Vw/

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

categories. Also, CE does not contrast the vowel in "marry" with the one in "square", so we can eliminate Veatch's /ær/. The subjects under study do not contrast Veatch's /ur/ with [Or][13] either. We can consider both of these to be [Or].

The subsequent table for the vowel structure of CE vowels would look like this:

	V		Vr		Vj		Vw	
high	i	u	ir	□	ij	□	□	uw
mid	e	ʌ	er	or	ej	oj	□	ow
low	æ	ɑ	□	ar	□	aj	□	ɑw

Table 8.7. California English vowel structure (modification of Veatch 1991).

This version of the chart has far fewer gaps than Veatch's Reference American chart above. The vowel [ɚ] does not appear in the chart. This is because Veatch analyzes this vowel as a stressed syllabic /r/, not a vowel (pp. 85-86).

[13]Though the example word "cure" is likely to be pronounced [kjɚ].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

8.3. Analysis of Vowels before /l/

As mentioned in Chapter 4, phonological analysis of the vowels before /l/ is not as difficult as for the vowels before /r/. We can simply say that California English has the following vowels:

/i ɪ e ɛ æ u ʊ o ɑ ʌ ɚ aj aw ɔj/

and that they all occur before /l/ in words like "eel", "ill", "ale", "L", "Al", "pool", "pull", "pole", "all", "hull", "earl", "aisle", "owl", and "oil."

Even here, however, we get into some problems. In section 6.3.5, we determined that for many speakers, words like "aisle" and "owl" are actually bisyllabic, rhyming with "denial" and "avowal." The same is likely true for "oil." We would either have to have:

A) A rule which resyllabifies /l/ after diphthongs

for example: /l/ -> [ɫ̩] / aj,aw,ɔj _

or B) a constraint which prohibits /aj aw ɔj/ before tautosyllabic /l/.

In the latter case, words like "aisle", "owl", and "oil" would not be underlyingly /ajl awl ɔjl/ respectively, because this would be blocked by the constraint. Rather, they would have to be underlyingly bi-syllabic /aj.əl, aw.əl, ɔj.əl/ (assuming an underlying representation of /əl/ for [ɫ̩]), the equivalent of the bimorphemic sequences in "denial" (/də naj + əl/) and "avowal" (/ə vaw + əl/).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The latter analysis is preferable. There is no need to posit a resyllabification rule when the sequences in "aisle", etc. can be just considered underlyingly bisyllabic, the equivalents of the rhyming sequences in "denial", etc.

We would also have to account for the distinct phonetics of the allophones of the vowels /i ɪ e ɛ æ/ and /u ʊ o ɑ ʌ/ before /l/. As determined in Section 6.3, the front vowels /i ɪ e ɛ æ/ all insert a post-vocalic [ə] before the /l/, while the back vowels /u ʊ o ɑ ʌ/ have rounder/backer allophones. We could account for this by the two following rules:

1) $\underset{[+\text{front}]}{V} \rightarrow \quad V\text{ə} \quad / \_\ l$

2) back vowels -> backer & rounder / _ l

The second rule is impossible to put into a feature notation which does not allow for non-discrete degrees of roundness, and backness, etc.

We also have to account for the fact that the post-vocalic glide [j] does not occur after /e/ before /l/. In a way, this is similar to the constraint disallowing /aj aw ɔj/ before tautosyllabic /l/. Tautosyllabic sequences of [jl] don't seem to be possible in California

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

English. Whether tautosyllabic sequences of [wl] are possible is difficult to tell. Note from section 6.3.5. that the word "owl" is not bisyllabic as often as "Nile" is.

This constraint is somewhat similar to that found in Kahn (1980: 122), where he states that tautosyllabic glide/glide sequences [wj, jw, rw, rj, wr, jr] are not allowed in English. Were /l/ considered a glide, it would fall out naturally that [ajl awl ɔjl] and [ejl] would not be possible. But /l/ does not behave exactly like the glides [j w r]. Characteristic of the glides [j w r] in American English is that they can only occur post-vocalically as part of monophonemic diphthongs which are pre-listed in the inventory (see section 8.1.5, above). They do not occur after canonical vowels. However, /l/ can still occur after canonical vowels, and is in this sense more like a typical consonant of English.

Let us assume here that we are dealing with a conservative variant of English in which /l/ is a standard consonant. Also, note that the glides in /aj aw ɔj/ do not behave the same way as the glide in /e/ before /l/. The glide after /e/ is non-existent, giving us [eəl] from underlying /el/. Were the same thing to happen to /aj aw ɔj/, we would get [al al ɔl] from underlying /ajl awl ɔjl/. This may be true for some dialects, but in CE we have [ajɫ awɫ ɔjɫ].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Likewise, if the glide in /e/ behaved the same way as those in /aj aw ɔj/ before /l/, we would have bisyllabic [ejɨ] for "ale." That may be true in some dialects, but in CE we have [eəl] (see Section 6.3.6). For the more conservative of the two variants of California English under consideration here, we should just say that the vowels before /l/ are members of the canonical set of vowel phonemes, and account for their status by the following rules and constraints:

1) Diphthongs /aj aw ɔj/ are not allowed before tautosyllabic /l/.

2) Front vowels /i ɪ e ɛ æ/ insert a post-vocalic [ə] before tautosyllabic /l/.

3) Back vowels /u ʊ o ɑ ʌ/ have backer/rounder allophones before tautosyllabic /l/.

4) Tense vowels do not insert post-vocalic glides before tautosyllabic /l/.

Recall that in Section 8.1.5, we claimed that the RGDs [Ir Er Ar Or] were monophonemic diphthongs in the inventory akin to /aj aw ɔj/. If this is true, then we should expect the constraint against diphthongs before tautosyllabic /l/, above, to apply. In such a situation, we would likely see the same sort of resyllabification we saw with historical /ajl awl ɔjl/ sequences in which "Nile" came to rhyme with "denial" and "owl" with "avowal." Thus, a word like

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"Carl" could have a bisyllabic pronunciation, and might rhyme with the bimorphemic "car'll" as in "The car'll start." If evidence of such a rhyme were found, it would support the view that both /r/ and /l/ have become or are in the process of becoming phonological glides in some dialects of American English.

Though it is possible to regard the /Vl/ sequences as equivalent to sequences like /Vn/, and the vowels before /l/ as belonging to the set of canonical vowel phonemes, there are many things we have observed which point to [Vl] sequences behaving more like [Vr] (and hence, [Vj] and [Vw]) sequences than true vowel + consonant sequences. A run-through of the same checklist we used to compare /r/ to the central approximants will help illustrate these tendencies:

Table 8.8. Comparison of /l/ to glides and true consonants.

	j/w/r	l	n
1. phonetically a central approximant?	y	sometimes	n
2. reduced set of vowel contrasts before?	y	often	n
3. stressed syllabic exists?	y	often	n
4. not allowed after tautosyllabic diphthongs?	y	y	n
5. vowels which occur before don't occur independently?	y	perhaps	n
6. vowels before behave independently in sound changes?	y	n	n
7. flaps found afterwards?	y	n	n
8. deletion of final /t, d,/ afterward?	n	y	y
9. Vs before don't move out in speech errors?	y	sometimes	n

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The items on the checklist require some explanations. The numbers for the explanations below correspond to the entries on Table 8.8.

1) We have determined that for some speakers (6 of the 14 in this study), post-vocalic /l/ is not a true lateral, but a central approximant like [ɰ]. This has also been found elsewhere (Ash 1982).

2) Many of our speakers showed a reduced contrast of the vowels /o/ and /ʌ/ before /l/. One had reduced contrast of /u/ and /ʊ/. Mergers of /i-ɪ/, /u-ʊ-o/, /e-ɛ/, /ʌ-ɔ/, /ɔ-ʊ/, and /æ-ɛ/ are also reported in various areas of North America. Speakers of California English have, of course, merged the contrast of /ɔ/ and /ɑ/ before /l/, as they have in other environments as well. If we begin with the full set of canonical vowel phonemes before /l/, we have:

/i ɪ e ɛ æ u ʊ o ɔ ɑ ʌ aj aw ɔj/.

The common /ɑ-ɔ/ merger gives us:

/i ɪ e ɛ æ u ʊ o ɑ ʌ aj aw ɔj/.

The resyllabification of /l/ after /aj aw ɔj/ gives us:

/i ɪ e ɛ æ u ʊ o ɑ ʌ/.

At this point in time, the number of vowels which can occur before /l/ is not restricted to anywhere near the degree as the number of vowels which can occur before /r/ is. However, the loss

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of contrast in vowels before /r/ did not occur overnight, but took place gradually over several hundred years (see Chapter 2). The current situation of vowels before /l/ does not resemble the current situation of vowels before /r/, but it may be parallel to certain historical stages in the development of vowels before /r/. Therefore, in the future, the situation of vowels before /l/ may indeed be like that of vowels before /l/.

If the following mergers (which are all attested for some dialects of GA) took place, we would end up with a situation in which the vowels before /l/ would be similar to that of vowels before /r/.

We have already seen evidence of the /ʌ-o/ and /u-ʊ/ mergers in California. Let us speculate that they spread to the general population. This gives us:

/i ɪ e ɛ æ u o ɑ/.

Now, suppose that some of the other mergers that have been attested in various areas of North America spread into California (or all spread to the same dialect, it doesn't matter where). The vowels /i/ and /ɪ/ could merger. Likewise, /e/ and /ɛ/ could merge. The three-way merger of /u-ʊ-o/ reported in Western Pennsylvania and Ohio (Dickey 1997, Thomas 1989) would not affect this hypothetical future dialect of California English the same way, since all three merge to /ʊ/, which has already merged to /u/ in our hypothetical

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

future dialect. But let us suppose that the remaining /u/ and /o/ merge, giving us one vowel (let us call it /o/) from previous /u/, /ʊ/, /o/, and /ʌ/. Let us also suppose that the /æ-ɛ/ merger described by Veatch (1992) interacts with the /e-ɛ/ merger to also reduce to one contrast, which I will call /ɛ/. This could give us:

/i ɛ o ɑ/.

The interaction of all the mergers of vowels before /l/ in American English could give us a four-way contrast, similar to the situation of vowels before /r/.

There is one distinction between the mergers of vowels before /r/ and those before /l/. In the case of vowels before /r/, the loss of contrasts does not necessarily come about due to merger of the vowels in question. That is to say, that the lack of contrast in /i/ and /ɪ/ before [r] does not come about because they merged before /r/. The same is true of /e/ and /ɛ/. Rather, /ɪ/ and /ɛ/ dropped out before /r/ (leaving a syllabic rhotic), and then /i/ and /e/ underwent sound changes. However, the loss of contrasts before /l/ all seem to result in a vowel which is clearly a member of the canonical set of vowel phonemes. For example, /ʊ/ has become /u/ before /l/, and /ʌ/ has become /o/. In the case of vowels before /r/, we have vowels whose phonological categorization is ambiguous, and which seem to share phonetic features with more than one of the set

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of canonical vowel phonemes, in addition to being in an environment of reduced phonological contrast.

However, I conjecture that the ambiguous phonetic characteristics of the vowels before /r/ is a direct result of the loss of phonological contrast. The loss of /ɪ/ and /ɛ/ before /r/ meant that the rhotic cognates of /i/ and /e/ "had room" to lower. Likewise, the fact that the cognate of /ɑ/ before /r/ did not lower and unround (as it did in most other environments) meant that the cognate of /æ/ could occupy the low, unrounded, non-front position in the vowel space. The loss of contrasts in vowels before /l/ is relatively recent, but I believe that in the future it may result in some phonologically ambiguous vowels.

3) We have determined that a stressed syllabic [ɫ] has developed from former /ʊl/ sequences. This is parallel to the stressed [ɚ] which developed from sequences of ME /ĭr ĕr ŭr/. Note that this sound change is mutually exclusive with the /u-ʊ/ merger, in which /ʊl/ becomes /ul/. Therefore, it is possible that our speculative future for /Vl/ sequences would actually look like:

/il ɛl ul ɑl ɫ/

There is one major difference between the developments of stressed [ɚ] and stressed [ɫ], however. Specifically, [ɚ] is very common, since /ĭr ĕr ŭr/ sequences were common in Middle English.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

However, /ʊl/ sequences are rare. Middle English /ū/ usually became CE /ʌ/. It remained /ʊ/ before /l/ only after labials in the words, "pull", "bull", "full", "wool", and few others. Stressed [ɨ] might not be common enough to stand as a distinct phoneme on its own.

4) /l/ may not have resyllabified after /aw/ in all words for all speakers, but its resyllabification after /aj/ and /ɔj/ is so widespread that I think this question can be answered in the affirmative.

5) To answer the question "do the vowels which occur before /r, l, ŋ/ also occur independently?", phonetic and psycholinguistic data was provided in Chapters 6 and 7. Often, the vowels before /l/ fell outside of the normal range of allophony for the canonical vowels. This was especially true for the back vowels, whose variants before /l/ had much lower F2s. In the psycholinguistic test, the vowels /i ɪ e o/ were generally identified with their canonical correspondents, the vowels /ɑ ʌ ɛ ʊ/ less often. This suggests that some subjects have difficulty identifying some of the vowels before /l/ with their correspondents in non-lateral environments. This could be due to extreme phonetic deviation, lack of contrast, or deletion (in the case of /ʊl/ being [ɨ]). It is highly likely then, in a situation of further reduced contrast, that there could be difficulty identifying the Vs in /Vl/ sequences with one of the canonical vowel phonemes the same way it is now for the Vs in /Vr/ sequences, and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

we could say that these Vs which occur before /l/ do not occur independently.

6) So far, the Vs before /l/ have not patterned independently from the canonical vowels in any sound changes, the way the vowels before /r/ and /w j/ have. For example, the loss of contrast of /ɔ/ and /ɑ/ in many dialects of GA has also resulted in their lack of contrast before /l/, such that "doll" (formerly /dɑl/) and "call" (formerly /kɔl/) rhyme. It should be mentioned that there are situations in which vowels before /l/ have behaved differently in sub-phonemic sound changes, for example in dialects where /u/ and /o/ have fronted and/or unrounded, they remain backed and rounded before /l/ (Thomas 2001: 32). And, of course, we have seen mergers in vowels before /l/ which don't usually occur before other consonants.[14] Were we to find examples where the vowels before /l/ truly remain distinct from their non-lateral cognates in terms of phonemic merger (for example, vowels merge in most environments, but remain distinct before /l/), that would be good indication that /Vl/ sequences are like diphthongs in /jwr/ and not /VC/ sequences.

7) Pronunciation of the word "boulder" by all 14 speakers reveals a true stop [d], not a flap [ɾ], as opposed to the word "border",

[14]The /i-ɪ/, /e-ɛ/, and /u-ʊ-o/ mergers reported in Western Pennsylvania also occur before /g/ (Dickey 1997).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

which has a flap. The /l/ is very much like a consonant in this respect. I have no clear evidence of any instances of flapping after /l/, even where it has vocalized to [ɰ][15].

8) Guy (1980) claims that /-t, -d/ drop out in clusters after /l/, just like they do after /n/, /s/, etc. Thus, /l/ is like a true consonant in this respect as well, so the deletion may happen in a word like "hold" (/hold/ > [hol]).

9) We have seen in the data from Shattuck-Hufnagel (1986) that vowels can sometimes move out of /Vl/ sequences in speech errors, for example "fit the bull" [fɪt ðə bʊl] for "foot the bill" [fʊt ðə bɪl]. The /Vl/ can move out as a single unit, however, for example "basketbour callt" for "basketball court."

The truth of the matter is that the /Vl/ sequences are in a state of flux. They generally behave like /VC/ sequences, but there are some ways in which they behave like monophonemic diphthongs. Their status is something which should definitely be kept track of, and De Camp's claim that treating /Vl/ sequences like monophonemic

[15]Though see Guenter 2001 for something which looks like flapping in some pronunciations of the word "boulder."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

diphthongs perhaps "will be justified a century hence" (made in 1945) may come true[16].

If such a thing does come to pass, a possible phonological analysis for it would be as follows:[17]

VEATCH (1991).

Veatch considers the mergers which have occurred before /l/, the resyllabifications that have taken place, the vocalization of /l/, and the loss of some post-vocalic glides, and speculates that /l/ may be moving into the "glide slot" alongside /r w j/. Assuming a future dialect as above, which contains only /i ɛ ɑ o/ before /l/, one can modify Veatch's analysis thus:

	V		Vr		Vj		Vw		Vl	
high	i	u	ir	□	ij	□	□	uw	il	□
mid	e	ʌ	er	or	ej	oj	□	ow	el	ol
low	æ	ɑ	□	ar	□	aj	□	ɑw	□	ɑl

Table 8.9. Future American Vowel Structure (modification of Veatch 1991)

[16]That "century hence" at the time of De Camp's writing is less than fifty years away from the time of this writing.

[17]Though, of course, any phonological frameworks used now might be completely out-of-date by that time, the direction of linguistic theory being a far more difficult thing to speculate on than the direction of sound change.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

This type of analysis is only possible if the contrasts between /i/ and /ɪ/, /e/ and /ɛ/, /u/ and /ʊ/, and /o/ and /ʌ/ have been lost before /l/, since the vowels in these pairs all have the same nuclei as each other, but are distinguished only by the presence or absence of a following glide slot, which would have to be occupied by /l/. [18] While all these mergers have been reported for somewhere in North America, they don't all occur in the same dialect. Veatch accounts for all the changes as being a result of /l/ shifting into the glide slot from its former coda position (p. 68). I believe the cause/effect relationship to actually be the opposite of this. The analysis of /l/ as a glide, and not a true consonant, is the result of many sound changes, not the cause. We have see in the situation of /r/ that the main motivating factor for the changes was the unconditioned change of /r/ from a consonant to a central approximant. This brought about a series of changes over the next five hundred years or so. It was not the case that the /r/ became a central approximant, and then instantly the other sound changes happened.

The same thing may be true of /l/. The change of /l/ from a lateral consonant to a central approximant may be the impetus behind all the other changes, but it does not instantly bring them

---

[18]That is to say, that in Veatch's analysis /i/ and /ɪ/ have the same nucleus, /e/ and /ɛ/ have the same nucleus, /u/ and /ʊ/ have the same nucleus, and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

about. Rather, we are witnessing a series of changes in process and spreading now in American English at the turn of the millennium. They may result in a future situation in which /l/ is best analyzed as a glide, not a consonant, but the "in between" states of the language still have to be accounted for.

8.4. Vowels before /ŋ/.

Since the velar nasal /ŋ/ is a true consonant, monophonemic analyses for /Vŋ/ sequences cannot be considered. The vowels that occur before /ŋ/ must belong to the set of canonical vowels /i ɪ e ɛ æ u ʊ o ɑ ʌ aj aw ɔj/. The question is to determine which vowels of this set they are, and to see if the limitations on the vowels which can occur before /ŋ/ can be accounted for phonologically.

The vowels in ‹ung› and ‹ong› are uncontroversial. Phonetic and psycholinguistic evidence from Chapters 6 and 7 classify them as /ʌ/ and /ɑ/ respectively. The vowels in ‹ing›, ‹eng›, and ‹ang› are more difficult to classify. We could be consistent with their historical sources and classify the vowels in ‹ing›, ‹eng›, and ‹ang› with /ɪ/, /ɛ/, and /æ/, respectively. This coincides with Swadesh 1935, Ladefoged

---

/o/ and /ʌ/ have the same nucleus.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1992, and Hammond 1999. To account for the limited contrast in vowels before /ŋ/, we would have to add the following constraint:

Only lax vowels are allowed before /ŋ/.

This would allow only /ɪ ɛ æ ʊ ʌ ɑ/ before /ŋ/.[19] We don't have any sequences of /ʊŋ/ in GA, but this is understandable, as /ʊ/ is a rare vowel.

Then we would have to account for allophony. The vowels are, of course, nasalized. This can be accounted for by a general rule that nasalizes vowels before the nasal consonants /n m ŋ/ in English. Other than nasalization, the back vowels /ʌ ɑ/ don't have very deviant allophones before /ŋ/. However, we have to account for the highly deviant allophones of the front vowels before /ŋ/. The vowels /ɪ ɛ æ/ would be realized phonetically as [ɪʲ ɛʲ ɛ̞ʲ] (see section 6.4). This can be accounted for by a rule:

1) $\underset{[+\text{front}]}{V} \rightarrow V^{j} \; / \_\, ŋ$

[19]Here, /ɑ/ would pattern as a lax vowel.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

This turns /ɪ ɛ æ/ into [ɪ^j ɛ^j æ^j]. We would then have to have a subsequent rule:

2) æ^j > ɛ̣^{j}

in order to account for the very raised nucleus in ‹ang›.

While this account works, and is consistent with the historical sources of the vowels, there are reasons to believe it may not be accurate.

First of all, the vowel in ‹ang› is phonetically [ɛ̣^{j}], and this is much more similar to /e/ than it is to /æ/. Likewise, the vowel in ‹ing› shares some phonetic characteristics with /i/.

Similarly, on the psycholinguistic test, subjects identified the vowel in ‹ang› more often with /e/ than they did with /æ/. Subjects also identified the vowel in ‹ing› with /i/ to some degree. These findings coincide largely with those found in Utah by Di Paolo (1988).

Thus, there is reason to identify the vowel in ‹ing› with /i/ as well as with /ɪ/, and reason to identify the vowel in ‹ang› with /e/ as well as with /æ/. This might by handled by the use of archiphonemes. Let us recall the previous definition of an archiphoneme as a segment which occurs in an environment of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

neutralization of contrast of two phonemes which otherwise contrast in the language, shares phonetic characteristics which are otherwise distinct for the two phonemes in question, and is identified with those two phonemes at approximately the same rate by subjects in a psycholinguistic study.

In this case, the vowel in <ing> would be an archiphoneme of /i/ and /ɪ/. It would be a high, front, unrounded vowel which is neutralized for the feature (usually assumed to be ±tense) which otherwise distinguishes /i/ from /ɪ/. The vowel in <ing> shares phonetic characteristics with both /i/ and /ɪ/ in that it begins much like /ɪ/, but has an off-glide like /i/.

The vowel in <ang> would be an archiphoneme of /e/ and /æ/. The trouble is that feature notations don't allow for a feature which exclusively distinguishes /e/ from /æ/. Usually, the feature (±tense) can serve to distinguish /e/ from /ɛ/, with the further feature (+low) needed to distinguish /æ/, which like /ɛ/ is (-tense) (Giegerich 1992: 106, 109). However, we have seen that there is a phonetic feature which /e/ and /æ/ share which /ɛ/ does not, that of duration. Both /e/ and /æ/ are fairly long vowels, while /ɛ/ is short (see Table 6.3 in section 6.4). Hence, /e/ and /æ/ would both share the feature [+long] (which would exclude /ɛ/), with the feature [+low] redundant. They would still contrast for [±tense]. The vowel in <ang> would be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[+long], but would neutralize for the feature [±tense] in the same way the vowel in <ing> does. Hence, the vowel in <ang> would be an archiphoneme of /e/ and /æ/. It shares some phonetic characteristics of both /e/ and /æ/. It has an off-glide like /e/, but is a somewhat more open vowel than /e/, in the direction of /æ/.

The vowel in <eng> is likely /ɛ/, though it does share some features with /e/. There is some historical evidence for the claim that the vowel in <eng> is /ɛ/, at least for some dialects of GA. Specifically, in dialects in which /ɛ/ becomes /ɪ/ before nasals, the vowel in "strength" becomes the same as the one in "string" (Wells 1982: 541). This is also evidence to support the claim that the vowels in <eng> and <ang> are distinct, since in the same dialects, the vowel in <ang> does not merge with the one in <ing>.

To account for the distribution limitations of the vowels before /ŋ/ in this manner, we would have to make the following constraints:

1) Only unrounded vowels are found before /ŋ/. This would exclude /u ʊ o/.

2) Diphthongs are not allowed before /ŋ/. This would exclude /aj aw ɔj/.

3) Front vowels neutralize for the feature [±tense] before /ŋ/. This would reduce the contrasts of /i-ɪ/ and /e-æ/. Since /ɛ/ has no

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

equivalent which is [+tense] but [-long], it would participate in this neutralization.

However, data in Chapters 6 and 7 and from Di Paolo (1988) tells us that there is in fact sound change occurring, in the following directions:

ɪ > i / _ ŋ

æ > e / _ ŋ

Increasingly, the vowels in <ing> and <ang> are being identified with the tense vowels /i/ and /e/, not with their lax ancestors /ɪ/ and /æ/. Furthermore, since the vowel in <eng> is extremely rare, we might expect it to lose its contrastive status, if it hasn't already for some speakers (note its absence in Hammond 1999: 113). This would leave us with four vowels before /ŋ/: /i/, /e/, /ɑ/, and /ʌ/. This limited distribution could be accounted for by the following constraints:

1) Only vowels which agree in tenseness and frontness are allowed before /ŋ/. This allows only front tense vowels and back lax vowels. The diphthongs /aj aw ɔj/ would be eliminated because they are all (+tense) and contain (-front) elements. Front lax vowels /ɪ ɛ

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

æ/ and back tense vowels /u ʊ o/ would also be eliminated. The vowel /ɑ/ would have to be (-tense) in this situation.

2) Only unrounded vowels are found before /ŋ/. This eliminates /ʊ/, and redundantly with the constraint above, /u/ and /o/, and perhaps the diphthongs /ɔj/ and /aw/, which contain rounded elements.

I believe this is the most likely analysis for the near future, and is probably true for many speakers now.

The analyses found in this chapter are meant to apply to CE and other varieties of GA which have similar phonetic and phonological patterns. Varieties which differ from CE in important respects will be discussed in the following chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 9: Vowels before /r/ in Other Dialects of English.

Dialects of English may vary from the dialect considered in the previous chapters in several ways, specifically:

A) They may contrast more RGDs, for example, having different vowels in the words "poor" and "pore."

B) They may contrast more canonical vowel phonemes, for example, having different vowels in the words "tot" and "taught."

C) They may lack any rhotic characteristics for the descendants of ME post-vocalic /r/, having for example a non-rhotic off-glide [ə]. An example of such a dialect would be RP British English.

D) They may have a truly consonantal reflex of ME /r/, for example a tap or a trill. An example of such a dialect would be Standard Scottish English (SSE).

The purpose of this chapter is to investigate a few dialects which differ from CE in some of the above characteristics to see what can be determined about the phonological status of the RGDs or their cognates in those dialects. Of course, we do not have the same mass of detailed phonetic and psycholinguistic data for these dialects that we have for CE. What follows, then, is extrapolation based upon what has been discovered for CE. In the absence of detailed phonetic and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

psycholinguistic evidence, the criteria used for these other dialects are largely structural.

We have seen from the previous chapters that there are ways in which the different domains of evidence coincide. Specifically, we have found that in CE the vowels before /r/ do not pattern with the canonical vowels in the structural domain (in that we don't have as many vowels contrasting before /r/ as we do before other consonants), in the acoustic phonetic domain (vowels before /r/ are frequently outside of the F1 and F2 range allowed for canonical vowels) and in the psycholinguistic domain (subjects do not identify the vowels before /r/ with canonical vowels).

It is thus hoped that what we have determined for CE may be of use in helping to understand the status of the vowels before /r/ in these other dialects, based upon the relationships between different domains of evidence we have seen.

9.1. LOT=THOUGHT, NORTH=FORCE≠POOR dialects

We shall first investigate other dialects of GA that may differ from CE in the number of RGDs and/or canonical vowel phonemes they contrast. It will help us if we use the lexical sets of Wells (1981: xviii-xix) to illustrate the potential contrasts and mergers.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.1 Background

In the dialect so far studied, Wells's lexical sets LOT and THOUGHT have the same vowel. The vowels in Wells's NORTH and FORCE lexical sets are also identical. In addition, there is no distinct vowel for Wells's CURE lexical set. This vowel has merged with the NORTH/FORCE lexical set in words such as "poor" and "boor", but has merged with the NURSE vowel [ɚ] after palatals in words like "sure" and "Ural." I will designate the "poor"/"boor" set of words as the POOR sub-set, since they behave differently than the vowel in the word "cure", which Wells uses to label this lexical set. Hence, we could designate the CE dialect studied so far as:

LOT=THOUGHT, NORTH=FORCE=POOR, NURSE=CURE

It was seen, however, that two of the fourteen subjects (Subject 11, a Male Northern Californian, and Subject 14, a Female Southern Californian) pronounced different vowels in the words "pore" and "poor." The vowel in the latter word is clearly higher than the one in the former word. Hence, such dialects could be designated as:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

LOT=THOUGHT, NORTH=FORCE≠POOR[1]

Data from Lehiste (1964) show the RGD in the word "poor" (or its equivalent in the variety of Midwestern English she has data from) to be between [u] and [ʊ], but closer to the latter. So, phonetically it is something like [ʊ̹]. This vowel will be transcribed as [U] according to the same conventions we have used for the other vowels in the RGDs. In such a dialect, the status of the vowel in [Ur] must be considered. If it does belong to one of the canonical vowel phonemes, it would likely be either /u/ or /ʊ/, so it is compared to both of them. However, the vowel in [Or] in such a case could only belong to /o/ of the canonical vowel phonemes, and hence the vowel in [Or] is only compared to /o/.

9.1.2. Formant dynamics (line graphs)

The line graphs in this chapter are designed the same way as the ones in Chapter 6. Each graph shows the F1 and F2 measurements in Hertz at three different points in time (beginning, middle, end) for the vowels in the RGDs compared with the average canonical vowel for that speaker.

[1]The CURE vowel may be merged with the NURSE vowel or not for such speakers. The important thing is that there is a distinctive higher back vowel

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Examination of Figure 9.1 shows that Subject 11's vowel in [Or] begins with an F1 much lower than that of /o/ at T1, nearing that of /o/ at T2, and being higher than that of /o/ at T3. F2 of the vowel in [Or] is much lower than that of /o/ at T1, nearing that of /o/ at T2, and is higher than it at T3.

Examination of Figure 9.2. shows that the F2 measurements of Subject 14's [Or] and /o/ pattern much like those of Subject 11. The F1 measurements are slightly different, however, in that F1 of /o/ and the vowel in [Or] are very close at T1 and T2, separating only at T3, where that of the vowel in [Or] is higher.

Examination of Figure 9.3 shows us that the F1 of Subject 11's vowel in [Ur] is much like that of /u/ at T1 and T2, raising to be like that of /ʊ/ at T3. The F2 of the vowel in [Ur] is lower than those of both /u/ and /ʊ/ at T1 and T2, but similar to that of /u/ at T3.

Examination of Figure 9.4 shows us that F1 of Subject 14's vowel in [Ur] is much like that of /u/ at T1, but raises to be like that of /ʊ/ at T2 and T3. The F2 of the vowel in [Ur] is lower than those of both /u/ and /ʊ/ at all three points in time. Conclusions regarding these data are found in Section 9.1.4, below.

---

before /r/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9.1 [O] compared to /o/ - Speaker 11 (mn)

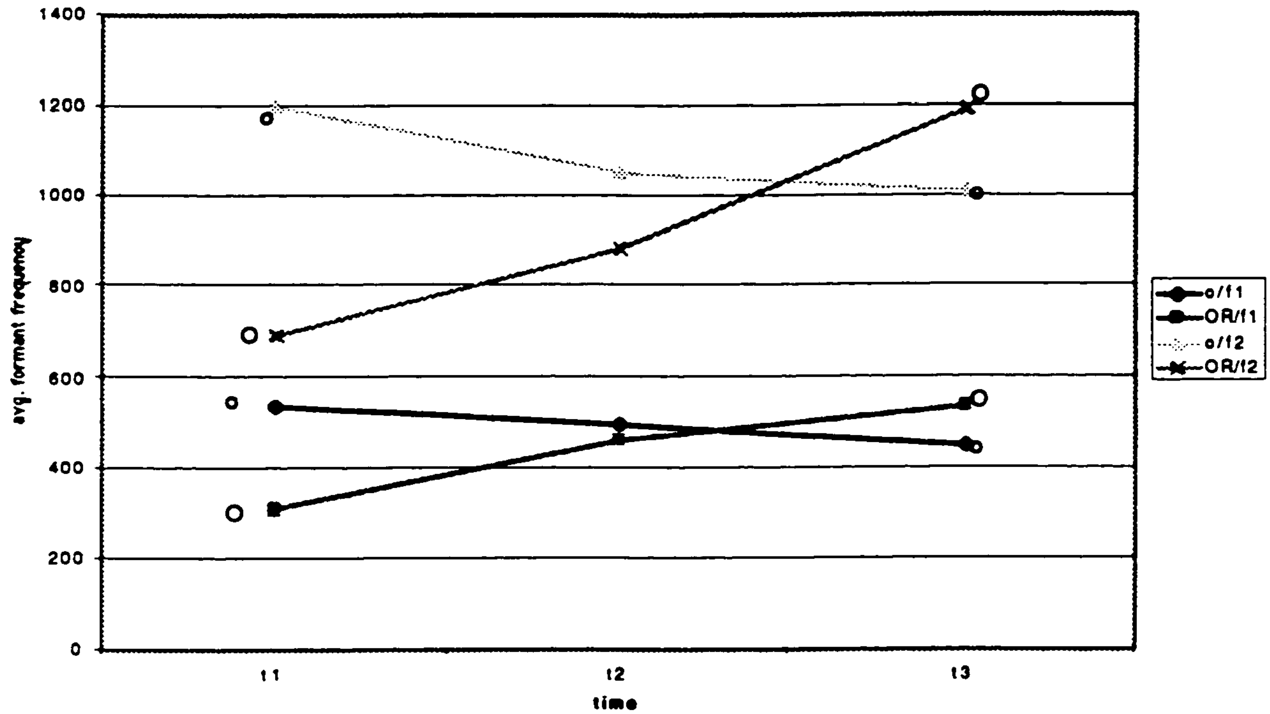
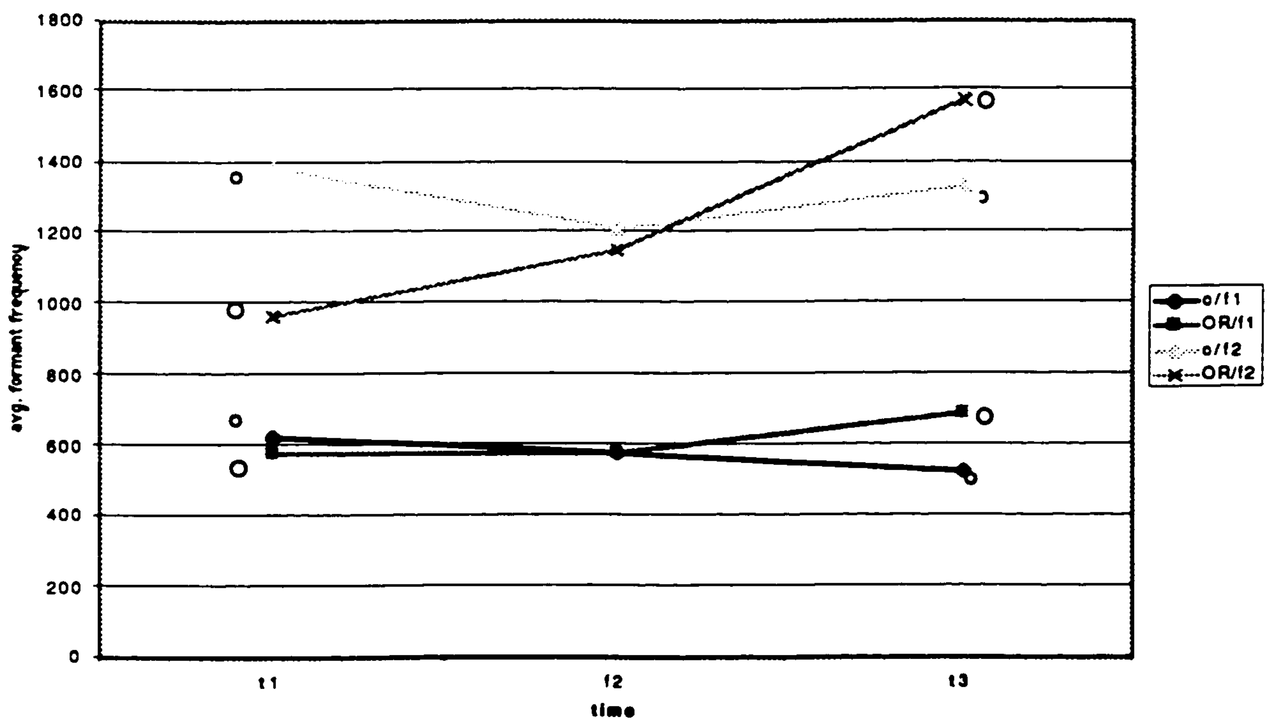


Figure 9.2 [O] compared to /o/ - Speaker 14 (fs)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9.3 [U] compared to /u ʊ/ - Speaker 11 (mn)

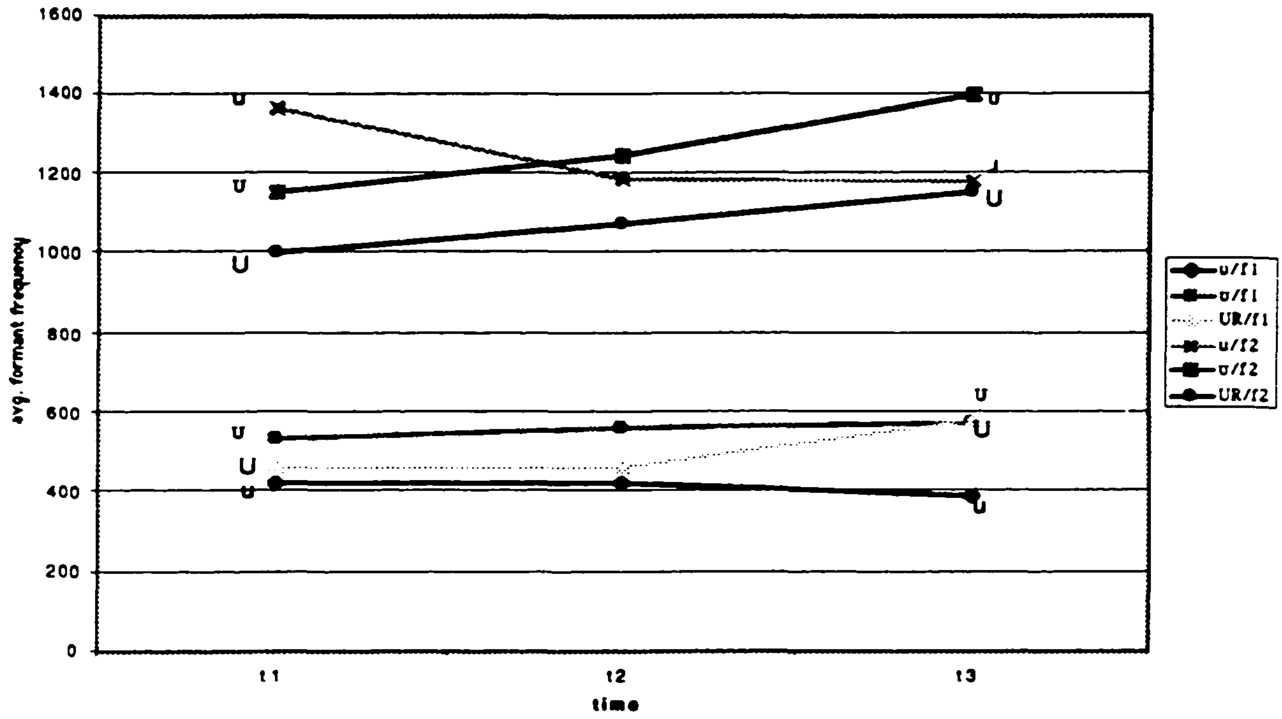
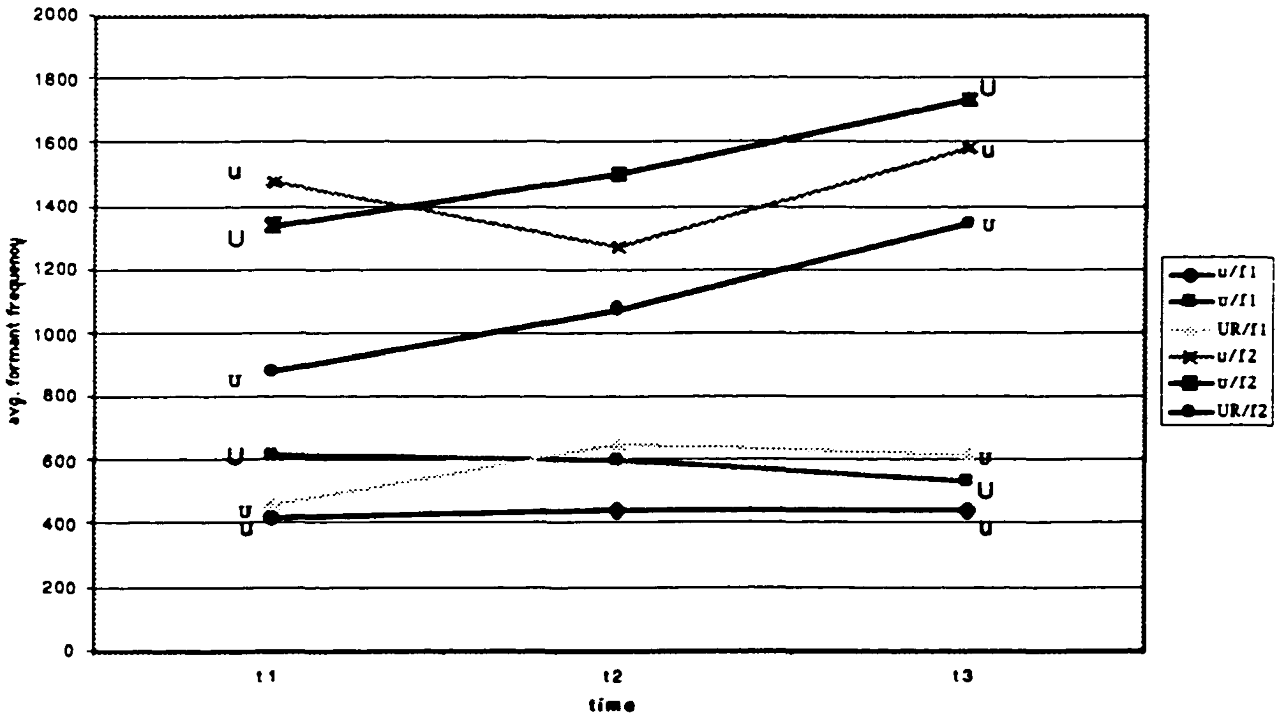


Figure 9.4 [U] compared to /u ʊ/ - Speaker 14 (fs)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.3. Range of Allophony (Scatter Graphs)

The scatter graphs in this chapter are designed the same way as the ones in Chapter 6. Each graph has an ellipse showing the confidence interval (2 Standard Deviations from the mean) for the range of canonical vowels.

Examination of the scatter charts in Figure 9.5 and 9.6 show us that the vowel in [Ur] is outside the ellipse of /u/ for Subject 11, but inside the ellipse for Subject 14. The inclusion of /l/ in the data does not change anything.

On Figures 9.7 and 9.8 we can see that the vowel in [Ur] is outside the ellipse of /u/ for both subjects 11 and 14, though only slightly so for Subject 11.. The inclusion of /l/ in the data does not change this.

On Figure 9.9 and 9.10 we can see that the vowel in [Or] is inside the ellipse of /o/ for Subject 11 and Subject 14. Conclusions regarding these data are found in Section 9.1.4, below.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9.5: /u/ - Speaker 11 (mn)

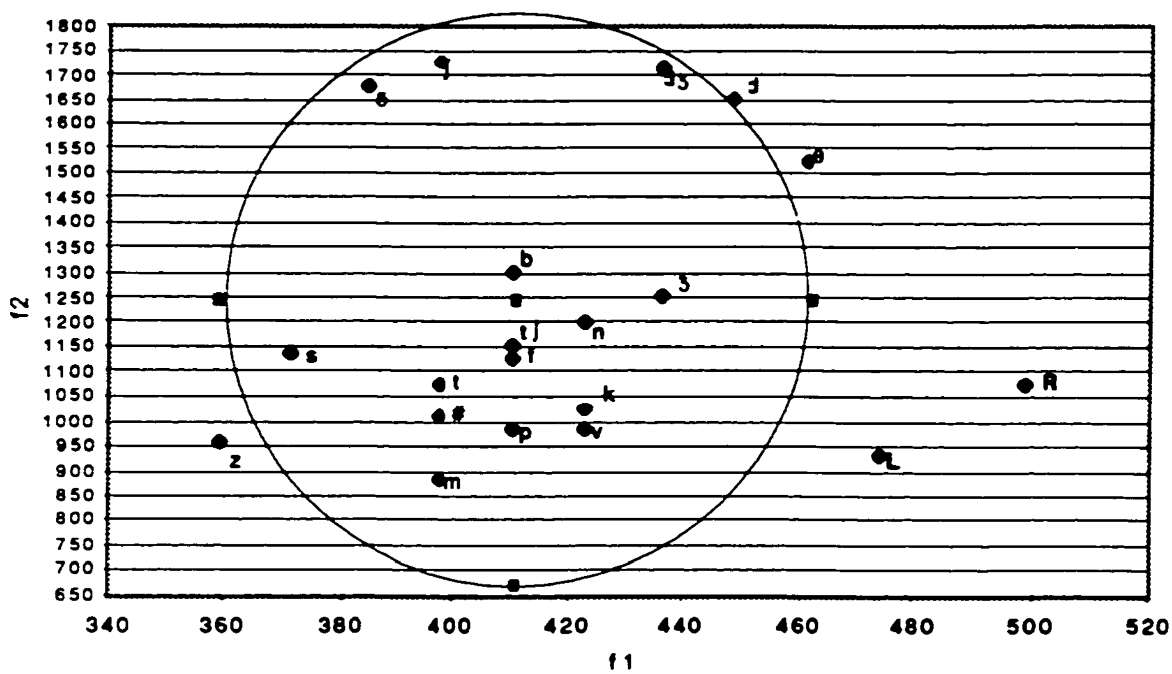
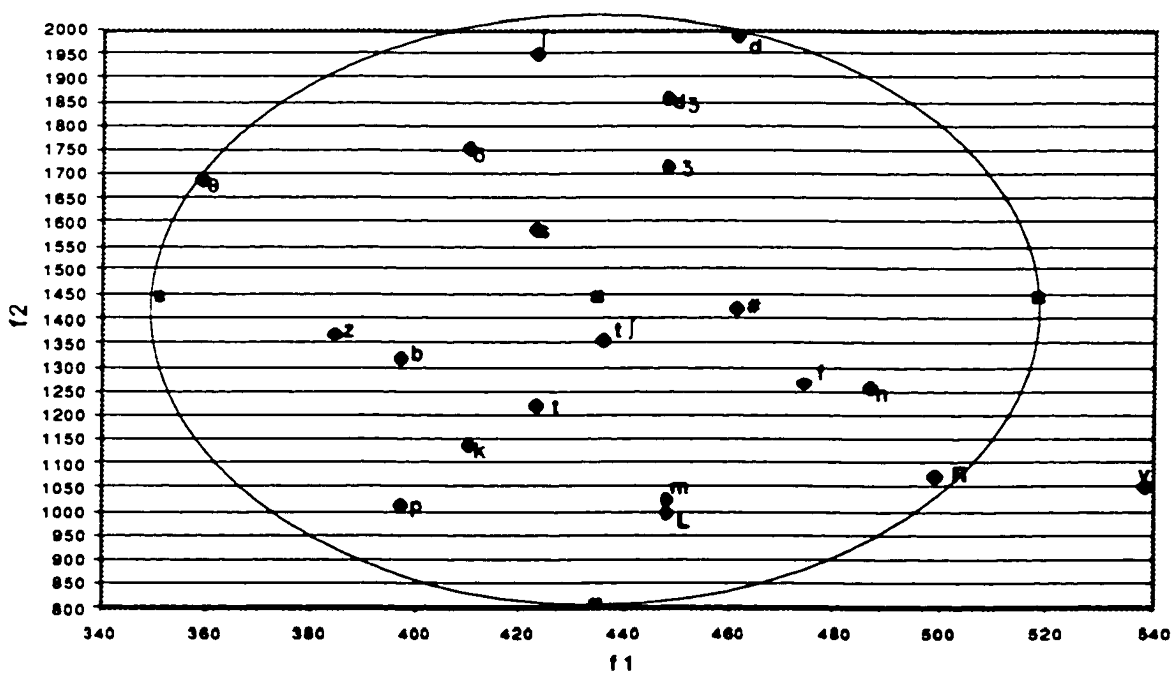


Figure 9.6: /u/ - Speaker 14 (fs)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9.7: /ʊ/ - Speaker 11 (mn)

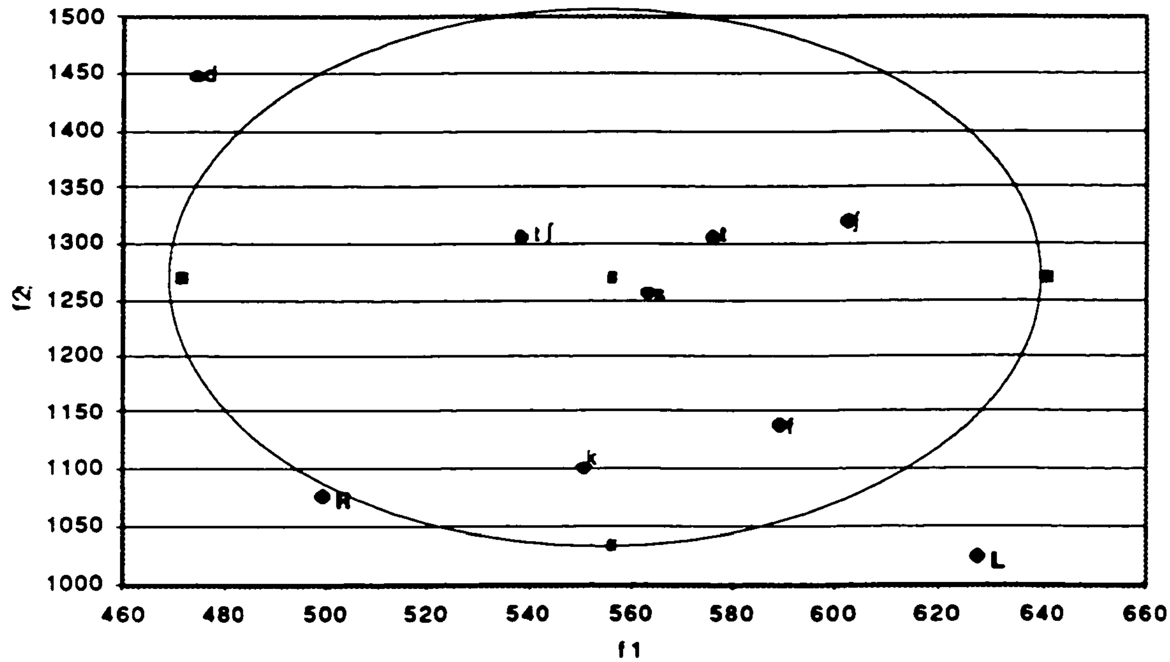
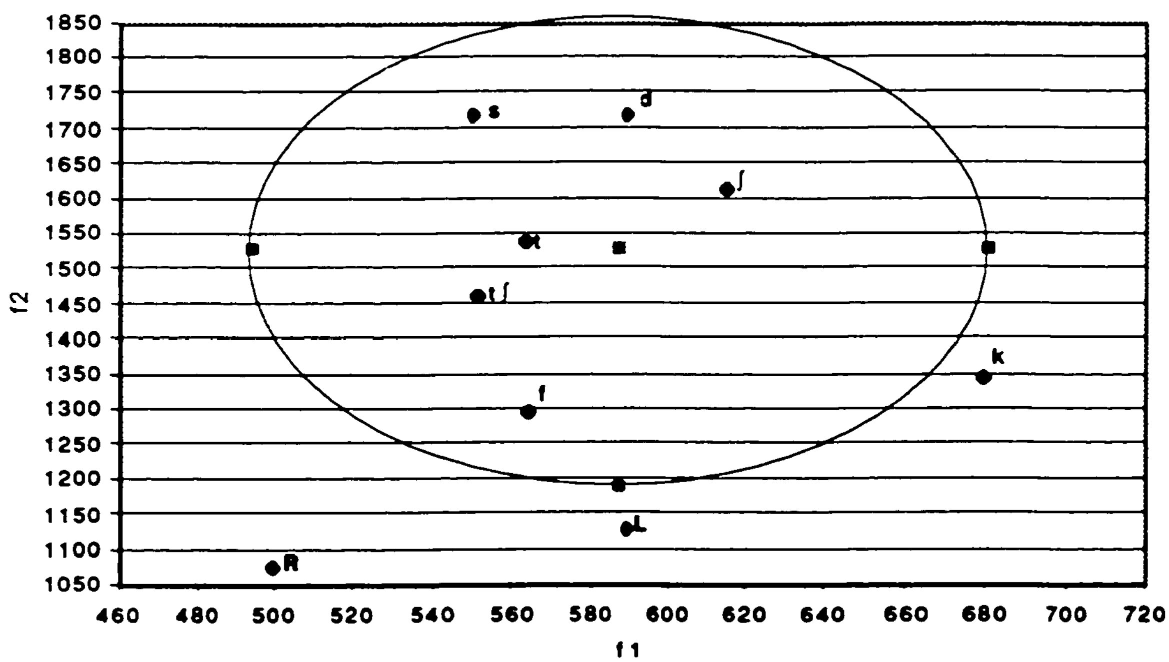


Figure 9.8: /ʊ/ - Speaker 14 (fs)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9.9: /o/ - Speaker 11 (mn)

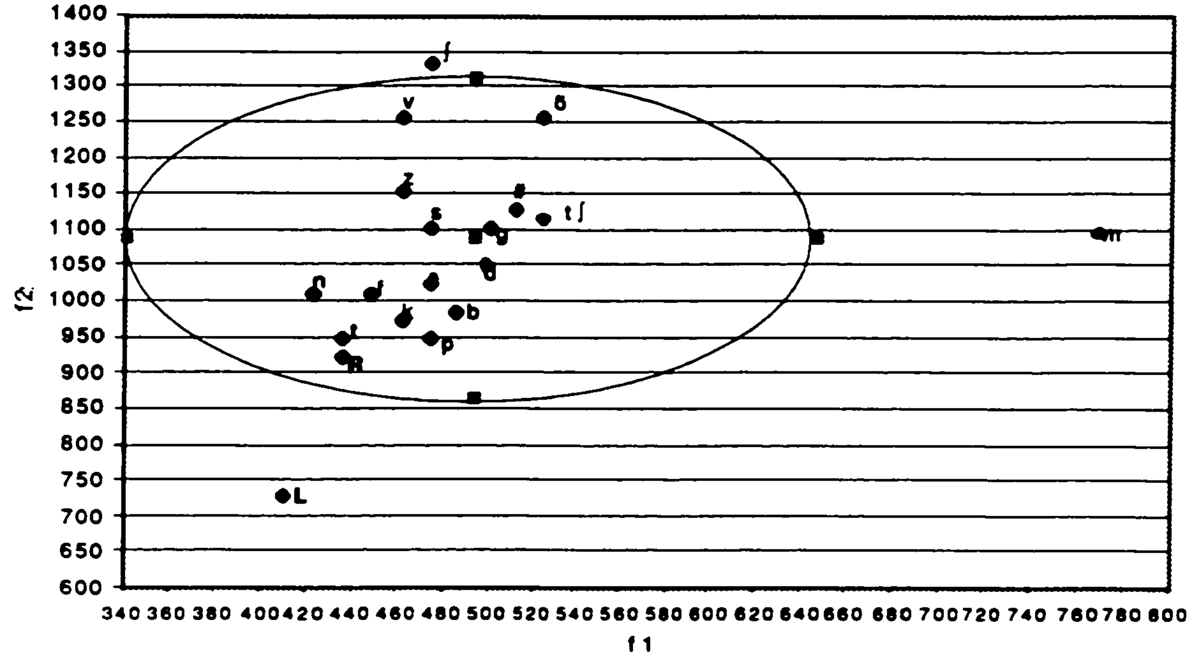
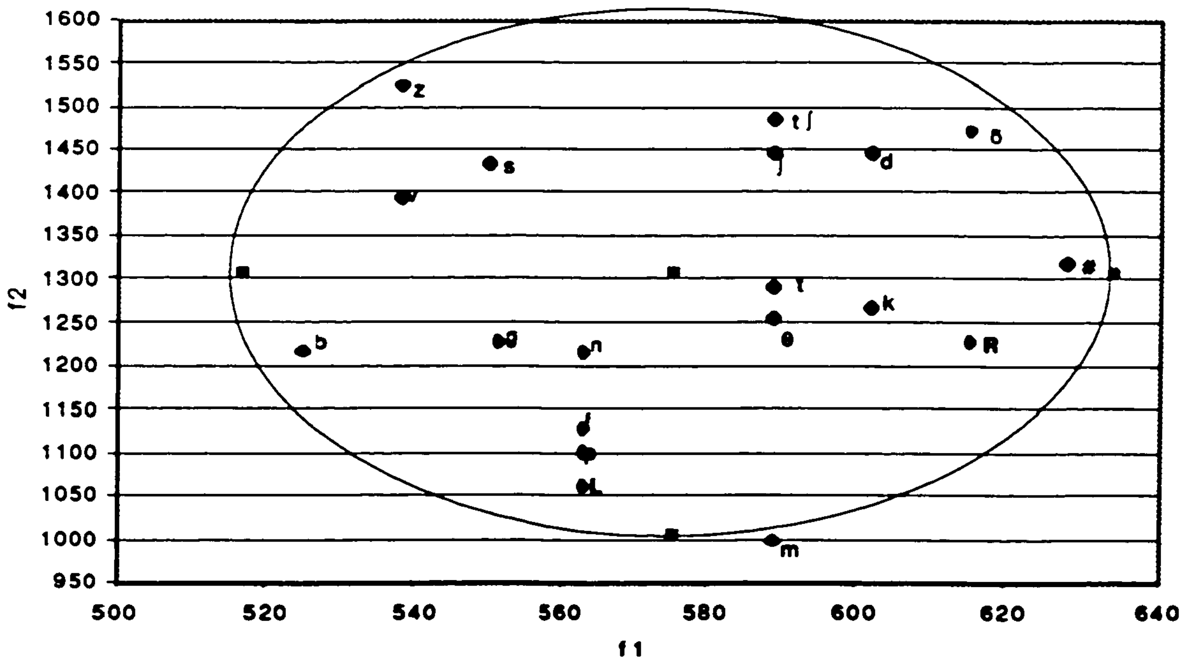


Figure 9.10: /o/ - Speaker 14 (fs)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.4. Conclusions (Acoustic Data)

Coupling the data from the scatter graphs with that from the line graphs, we can make the following conclusions for the vowels before /r/ of speakers of LOT=THOUGHT, NORTH=FORCE≠CURE dialects:

The vowel in [Ur] sometimes patterns like /u/ in terms of range but not like any canonical vowel in terms of formant dynamics.

The vowel in [Or] patterns like /o/ in terms of range but not like any canonical vowel in terms of formant dynamics.

It is interesting that the nuclei of the RGDs of speakers who have more contrastive vowels before /r/ in the round back area tend to fall into the range of the canonical vowels. This is perhaps not surprising, if we recall Burquest's rule of thumb that the more diphthongs one has, the more chance they have of being biphonemic (Burquest 1998: 165). These two speakers have more vowels contrasting before /r/, and are hence presented with more information that enables them to separate out the /r/ from the preceding vowel.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.5. Psycholinguistic Evidence

Unfortunately, the speaker of the stimuli on the psycholinguistic test makes no [Or]-[Ur] contrast. We cannot see how subjects would categorize the vowel in "poor" with respect to one of the canonical vowels. However, one of our NORTH=FORCE≠POOR speakers (Speaker 14) was a subject on the psycholinguistic test. One of the NORTH=FORCE=POOR speakers (Speaker 08) was also a subject on the psycholinguistic test. We can compare the two subjects Yes/No responses to various pairs in Set R (Table 9.1) to see if they differ:

We can see on Table 9.1 that Speaker 14/Subject 14 does have two more "yes" categorizations than Speaker 08/Subject 18, but it would be inaccurate to say that Subject 14 categorizes the vowels before /r/ with the canonical vowels on a regular basis. Both Subjects 14 and 18 categorize the vowel in [Ir] with /i/, but they do not categorize the vowel in [Er] with any canonical vowel. Subject 14 categorizes the vowel in [Or] with /o/ in the "bore/boat" pair but not in the "bore/load" pair. She categorizes the vowel in [Ar] with /ɑ/ in the "car/dock" pair but not in the "car/pod" pair. She shows the same inconsistencies here that many of the other subjects do (see Appendix C).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 9.1. Subject 14 and Subject 18's responses for Set R/Vowel Identification Test.

Set	group	pair	Spkr 14(Subj 14)[2]	Spkr 08(Subj 18)
R	Ir-i	beer/beet	y	y
	"	beer/bead	y	y
	Ir-ɪ	beer/bit	n	n
	"	beer/bid	n	n
	Er-e	bear/gate	n	n
	"	bear/spade	n	n
	Er-ɛ	bear/bet	n	n
	"	bear/bed	n	n
	Or-o	bore/boat	y	n
	"	bore/load	n	n
	Or-ɑ	bore/dock	n	n
	"	bore/pod	n	n
	Ar-ɑ	car/dock	n	n
	"	car/pod	y	n

It is difficult to make any conclusions based on the psycholinguistic evidence discussed in this section. Generally, conclusions based on the testing of one subject (or even two subjects) are not meaningful, as some chance variation is more likely to come into play. Only by examining the responses of a large body of subjects can any true patterns be revealed. That is why 18 subjects were tested for the experiment in Chapter Seven.

[2]This was just a coincidence. There was no intentional indexing between the speakers in the acoustic study and the subjects in the psycholinguistic study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.1.6. Analysis

If the vowel in [Ur] belongs to any of the canonical vowel phonemes it is most likely /u/, not /ʊ/, given that it patterns with /u/ in terms of range. Thus, a possible analysis for a LOT=THOUGHT, NORTH=FORCE≠POOR dialect would be the tense vowel solution, in which the vowels in [Ir Er Ar Or Ur] would be underlyingly /i e ɑ o u/ respectively. This natural class of vowels is predicted by the tense/lax pairs found in Giegerich (1992: p. 58), shown below. Since this dialect still lacks contrastive /ɔ/, the fact that /ɔ/ does not participate in a tense/lax pair is not an issue here:

<u>tense</u>	<u>lax</u>
i	ɪ
e	ɛ
ɑ	æ
u	ʊ
o	ʌ

non-patterning: aj, aw, ɔj

Thus, one of the objections to the tense vowel analysis found in section 8.1.1 is removed: if we say that "only tense vowels occur

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

before /r/ in a LOT=THOUGHT, NORTH=FORCE≠POOR dialect", then we have accounted for all the vowels that occur before /r/.

However, there are still problems with the tense vowel analysis for this dialect, most notably that the vowel in [Er] was very strongly not identified with /e/ by subjects in the psycholinguistic test, including Subject 14.

An archiphonemic analysis as discussed in section 8.1.3 would have the same problems. Although the presence of a vowel in the /u-ʊ/ area would make the archiphonemic neutralizations more complete, we still have to account for the fact that most of the subjects' categorizations are unequal: vowels in the /i-ɪ/ and /e-ɛ/ areas are definitely not identified with one of the members which make up the potential archiphoneme.

I would still recommend a monophonemic analysis for the RGDs of LOT=THOUGHT, NORTH=FORCE≠POOR dialects, with the caution that we are not dealing with as extreme a case as a LOT=THOUGHT, NORTH=FORCE=POOR dialect here. The presence of more vowels contrasting before /r/ may mean that a bi-phonemic analysis, such as a tense vowel or archiphonemic analysis, is more likely.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.2. LOT≠THOUGHT, NORTH=FORCE=POOR dialects

This would describe dialects such as those found in New York and Philadelphia (Labov 1994: 269). They merge the vowels in "pore" and "poor", but keep the vowels /ɑ/ and /ɔ/ in "tot" and "taught" distinct.

I have no psycholinguistic or detailed acoustic data for this dialect. We can still determine if any of the biphonemic analyses would predict the vowel contrasts well, using the tense/lax pairs as per Giegerich 1992, above.

Neither the tense, lax, nor archiphonemic analyses would account for the vowels which contrast before /r/ in such a dialect. Since we have a contrasting vowel /ɔ/ in this dialect, we have six potential contrasts to account for. The vowel in [Ir] would have to come from the /i-ɪ/ pair. The vowel in [Er] would have to come from the /e-ɛ/ pair. The vowel in [Ar] would most likely be /ɑ/ from the /ɑ-æ/ pair. The problem would be the assignment of the one remaining NORTH=FORCE=POOR vowel. We have the potential of assigning it to the /u-ʊ/, /o-ʌ/, or /ɔ/ categories. No matter what vowel we assign it to, the absence of the other vowels and vowel pairs contrasting before /r/ is unexplained. I recommend a monophonemic analysis for LOT≠THOUGHT, NORTH=FORCE=POOR

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

dialects as well. An arbitrary analysis is, of course, possible, but as explained in section 8.1.4.2, an arbitrary analysis has no advantages over a monophonemic analysis.

9.3. LOT≠THOUGHT, NORTH=FORCE≠POOR dialects

This would describe dialects which maintain a distinction between the vowels in "tot" and "taught" and between the vowels in the words "poor" and "pore." This is the dialect used by the speakers measured by Lehiste (1961). The broad spread of the /ɑ-ɔ/ merger throughout North America (Thomas 2001: 17) would limit such dialects mostly to the areas in the East which do not have the [Or-Ur] merger.

In such a dialect, the vowel in [Ir] would be in the /i-ɪ/ range, the vowel in [Er] in the /e-ɛ/ range, and the vowel in [Ar] would likely be /ɑ/ in the /ɑ-æ/ pair. The question would be what to do with the vowels in [Ur] and [Or]. An example of a speaker of such a dialect is Thomas's speaker 11, a 57-year old male Philadephian (Thomas 2001: 56). A chart of his F1 and F2 measurements (Figure 9.11) show his vowel in [Or] (labeled [ɔʳ=oʳ] on Figure 9.11) to be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

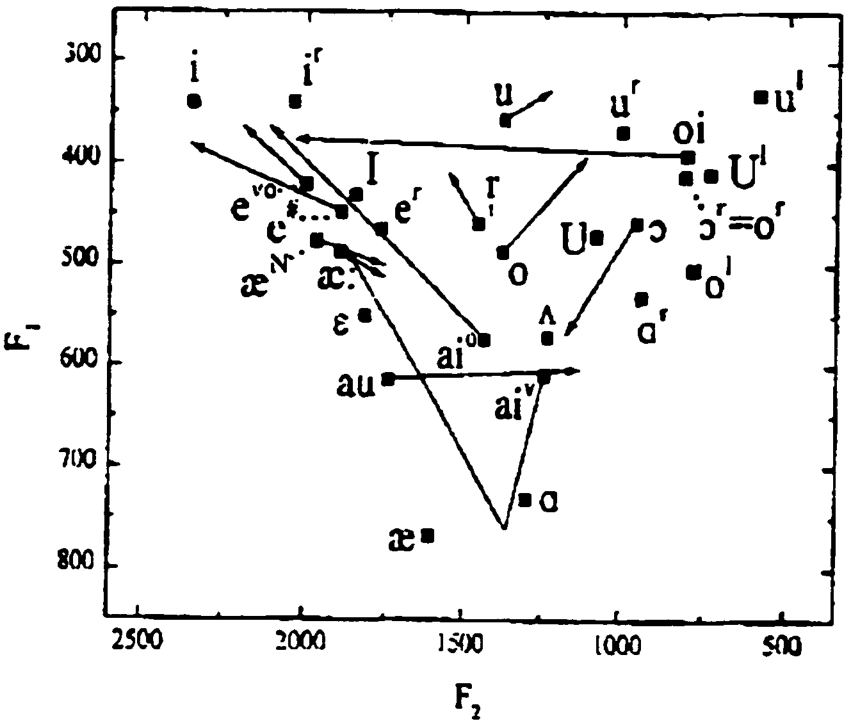


Figure 9.11. F1 and F2 measurements of Thomas's Speaker 11

very much like his /ɔ/, and his vowel in [Ur] (labelled [uʳ] on Figure 9.11) to be closest to /u/. He lacks a nucleus of an RGD in the /o-ʌ/ area. A tense vowel analysis is possible for such a dialect. The vowel /ɔ/ does not fit into a tense-lax pair, but that fact that it can occur in open syllables suggests it patterns more like the tense vowels. A tense vowel analysis for such a dialect, therefore, would predict that the vowels /i e ɑ u o ɔ/ are found before /r/. We would only have to have an additional constraint against /o/ occurring in order to make this analysis work. A monophonemic analysis for such

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

a dialect would still be possible, but the tense vowel analysis is, in the absence of any detailed phonetic and psycholinguistic evidence, less problematic that it is for other dialects discussed so far.

9.4. LOT≠THOUGHT, NORTH≠FORCE≠POOR dialects

In such a dialect, the vowels in the words "tot" and "taught" would be distinct, as would the vowels in the words "or", "ore", and "poor." Speakers who contrast the vowels in "or" and "ore" are increasingly rare. This variety is likely moribund, and does not predominate in any area (Thomas 2001: 30).

In such a dialect, the vowel in "north" and "or" is usually described as [ɔ], and the vowel in "force", "ore", and "pore" is described as [o] (Wells, 1982: 159-161). Hence, a tense vowel analysis for this dialect is initially unproblematic. If we say that only tense vowels are found before /r/ in such a dialect, this would predict that /i e ɑ u o ɔ/ are all found. Indeed, they all would be found contrasting in the words "ear", "air", "are", "poor", "ore", and "or", respectively.

This is the dialect of North American English which best lends itself to a biphonemic analysis in the absence of detailed phonetic and psycholinguistic data (which, given the moribund status of such

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

dialects, we are not likely to ever have). It is not coincidental that a more conservative dialect which has greater contrasts of vowels before /r/ should better lend itself to a biphonemic analysis. At one point in the history of English, /Vr/ sequences were unambiguously biphonemic. Now, I am claiming, they are monophonemic. The dialect under consideration here is at an intermediate stage, but is closer to the unambiguous biphonemic period than any of the other dialects under consideration here.

9.5. Some British Dialects: Rhotic and Non-rhotic

So far, all the dialects considered have been "rhotic." Wells (1982: 75-76) defines the difference between "rhotic" and "non-rhotic" dialects as such:

> "In the **rhotic** accents /r/ can occur, with an overt phonetic realization, in a wide variety of phonetic contexts, including preconsonantal and absolute-final environments, thus *farm* [fɑrm], *far* || [fɑr]. In the **non-rhotic** accents /r/ is excluded from preconsonantal and absolute-final environments, thus *farm* [fɑ:m], *far* || [fɑ:]. The rhotic accents include those typical of Scotland, Ireland, Canada, Barbados, certain western parts of England, and most of the United States, including GenAm. The non-rhotic accents include those typical of Australia, New Zealand, South Africa, Trinidad, certain eastern and southern parts of the United States, and most of England and Wales, including RP."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.5.1. GA and RP

Let us take RP British English as an example of a non-rhotic dialect. In RP, the cognate of GA [Ir] (< ME /ę̄r/ and /ẹ̄r/) is the diphthong [ɪə]. The cognate of GA [Er] (< ME /ār/) is the diphthong [ɛə]. The cognate of GA [Ar] (< ME /ar/) is the long vowel [ɑ:]. The cognate of GA [Or] (< ME /ōr/ and /ǭr/) is the diphthong [ɔə], which merges with the vowel [ɔ:] for most speakers (Cruttenden 1994: 110). The cognate of GA [Ur] (< ME /ọ̄r/) is the diphthong [ʊə], which may also merge with [ɔ:] for many speakers (Cruttenden 1994: 83, Giegerich 1992: 63). The cognate of GA [ɚ] (< ME /ĭr/, /ĕr/, /ŭr/) is the central non-rhotic vowel [ɜ]. The cognate of GA [ajɚ] (< ME /īr/) is [ajə]. The cognate of GA [awɚ] (< ME /ūr/) is [awə].

The diphthongs [ɪə], [ɛə], and [ʊə] are treated as monophonemic by many sources (ten Havre 1975, Wells 1982 Cruttenden 1994, Giegerich 1992, Coleman 1998), though others (Cohen 1952, Vachek 1963, Halle & Mohanan 1985, Gramley & Pätzold 1992) do not treat them as monophonemic. RP centering diphthongs are certainly treated as monophonemic far more often than their cognates in GA.

I am going to argue that the two dialects in question, GA and RP, are not significantly different with respect to how they treat the former /Vr/ sequences, and hence that to treat the descendants of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

these sequences as monophonemic in one dialect but biphonemic in the other is inconsistent.

Let us assume an RP dialect in which [ɔə] and [ʊə] have not merged with [ɔ:]. Let us contrast this with a GA dialect in which [Or] and [Ur] have not merged. Comparing the descendants of the former /Vr/ sequences in both the dialects we get:

Table 9.2 Reflexes of Middle English VR sequences in GA and RP.

ME	GA	GA Phonetic Approximation	RP
ār	Er	eɚ	ɛə
ăr	Ar	ɑɚ	ɑ:
ẹ̄r, ę̄r	Er, Ir	iɚ	ɪə
ĕr, ĭr, ŭr	ɚ	ɚ	ɜ
īr	ajɚ	ajɚ	ajə
ọ̄r	Ur	uɚ	ʊə
ǭr, ŏr	Or	oɚ	ɔə
ūr	awɚ	awɚ	awə

There is little difference between the two dialects. The inventories are nearly identical. In both dialects, the descendants of the ME /īr/ and /ūr/ are now triphthongs which are best analyzed as bisyllabic. The descendant of ME /ĭr ĕr ŭr/ is a central vowel which must be added to the inventory. The descendants of the remaining /Vr/ sequences are diphthongs. The only exception to this is the RP descendant of ME /ār/, which is a long vowel, and has merged with the vowel [ɑ:], which also has non-rhotic sources. Otherwise, the only

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

real difference between the two dialects is that the off-glide of the GA dialects has a lowered F3. Kahn (1980: 150) makes this point with regard to phonological features, saying that the only difference between "/r/-ful" and "/r/-less" pronunciations of a word like "course" is that in the latter case, the features [+high] and [+coronal] (features pertaining to retroflex articulation in Kahn's analysis), are absent from the off-glide.

9.5.2. GA and RP and SSE

These two cases (RP and GA) can be contrasted with a dialect such as Scottish Standard English (SSE). In such a dialect, /r/ is a true consonant, usually a tap. Furthermore, there are many more vowels contrasting before /r/. Let us take one variety of SSE (Giegerich 1992: 63) and compare it to our versions of GA and RP under consideration to see how they treat the descendants of the ME /Vr/ sequences[3].

---

[3]It must be mentioned that some varieties of SSE do have reduced vowel contrasts before /r/, collapsing /ʌr/ with /ɪr/ or both of these with /er/. This to a certain extent mirrors the merger which took place elsewhere in the 16th and 17th centuries (see Section 2.2.1).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

*Table 9.3. **Reflexes of ME /Vr/ sequences in GA, RP, and SSE***

ME	GA	RP	SSE
ār	eɚ	ɛə	eɾ
ăr	ɑɚ	ɑ:	aɾ
ę̄r, ę̄r	iɚ	ɪə	iɾ
ĕr	ɚ	ɜ	ɛɾ
ĭr	ɚ	ɜ	ɪɾ
īr	ajɚ	ajə	ʌjɾ
ǭr	uɚ	ʊə	ʉɾ
ǭr	oɚ	ɔə	oɾ
ŏr	oɚ	ɔə	ɔɾ
ūr	awɚ	awə	ʌwɾ
ŭr	ɚ	ɜ	ʌɾ

Although Wells's classification (see above) puts GA and SSE together as "rhotic" and separates RP as "non-rhotic", there is in fact much more similarity between GA and RP with respect to the phenomenon in question than there is between GA and SSE. In both GA and RP, /r/ has vocalized, vowel contrasts have been reduced before /r/, former sequences of /ajr/ and /awr/ have resyllabified, sequences of ME /ĭr ĕr ŭr/ have become monophthongs, and the remaining descendants of /Vr/ sequences are diphthongs which can be treated monophonemically. In SSE, however, /r/ is still phonetically a consonant, and can be treated phonologically as one as well. We still have a full contrast of vowels before /r/ which can "unhesitatingly" be assigned to each of the canonical vowel phonemes (Wells 1982: 213), including the diphthongs /aj/ and /aw/ (which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

have somewhat higher nuclei in SSE), since resyllabification has not occurred.

9.5.3. Rhotic vs. Non-rhotic?

The difference between GA and SSE, two dialects which are both supposedly "rhotic" can be illustrated by a revision of Table 8.2 in Table 9.4, below. This table is a checklist which compares /r/ in GA (California dialect) to the glides /j w/ on the one hand and to a true consonant (represented by /n/), on the other. To this checklist, let us add /r/ from the variety of SSE described above. The glides /j w/ and the consonant /n/ are not considered to behave differently in GA and SSE, so we don't need separate columns here:

Table 9.4. Comparison of GA and SSE /r/ to glides and true consonants.

	j/w	GA r	SSE r	n
1.Phonetically a central approximant?	y	y	n	n
2.Reduced set of vowel contrasts before?	y	y	n	n
3.Stressed syllabic exists?	y	y	n	n
4.Not allowed after tautosyllabic diphthongs?	y	y	n	n
5.Vowels which occur before don't occur independently?	y	y	n	n
6.Vowels before behave independently in sound changes?	y	y	n	n
7.Flaps found afterwards?	y	y	N/A[4]	(n)
8.Deletion of final /t, d/ afterward?	n	n	?[5]	(y)
9.Vs before don't move out in speech errors?	y	y	?[6]	(n)

---

[4]SSE does not exhibit the flapping of intervocalic /t d/ found in GA.
[5]I have no reports of this sort of deletion in SSE.
[6]The data on speech errors used in Shattuck-Hufnagel 1986 were collected in the United States. I don't know of a similar study done in Scotland. I would

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We can see from Table 9.4 that SSE /r/ behaves phonologically very differently from GA /r/, even though they have the same ancestor in ME /r/. SSE /r/ is phonetically a consonant, and phonologically one as well.

It is then put into question what the terms "rhotic" and "non-rhotic" as used by Wells and others really mean. Specifically, what it does mean to say that "/r/ can occur?" The use of slashes around the "r" would indicate that this means that in rhotic accents there are clear pre-consonantal/final instances of the phoneme /r/, while in non-rhotic accents, this phoneme does not occur in pre-consonantal and final environments.

However, there are some things which can make us question whether this definition really describes the dichotomy of English accents claimed above, specifically:

1) There are many analyses in which supposed "non-rhotic" dialects like RP are considered to actually have underlying /r/ in pre-consonantal/final position (for example, Coleman 1998: 280). One reason for this is that there may be no post-vocalic [r] in an isolated pronunciation of a word like "far" in RP, but there frequently

---

predict that it would be found that vowels in /Vr/ sequences move out independently in SSE.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is when such a word is followed by another word beginning with a vowel, as in "far and away." Hence, RP could be considered "rhotic" according to the definition given above.

2) The analysis favored in this dissertation, supported by evidence gathered from a variety of domains, holds that there actually is no distinct phoneme /r/ in pre-consonantal/final position in the supposed "rhotic" CE. Rather, the [Vr] sequences that exist are monophonemic diphthongs in the inventory of phonemes. Hence, CE could be considered "non-rhotic" according to the definition given above.

The definition of "rhotic" could be amended to say that it defines a dialect of English in which a phonetically rhotic sound can occur in pre-consonantal/final position. Then we would have to define what we mean by a "phonetically rhotic" sound. We could use the definition of a "rhotic" sound as one with a lowered F3. Thus, that would include the [ɚ] of GA and the [ɾ] of SSE, but not the [ə] of RP. However, Ladefoged & Maddieson (1996: 244) find that certain sounds conventionally termed "rhotic" do not have lowered F3's. This puts into question the significance of using F3 as a distinctive criterion to distinguish accents. We could just as likely put GA and RP together because their descendants of ME pre-consonantal/final /r/ are phonetically vocalic ([ɚ] and [ə], respectively), while SSE

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

would be in a separate class because its descendant of ME /r/ is phonetically a consonant with some type of occlusion in the oral cavity.

The term "rhotic", as conventionally used, only seems to mean that where there is a post-vocalic ‹r› in the spelling, we pronounce something which sounds "r-like", rather than the off-glide [ə] of RP, etc.

The terms "rhotic" and "non-rhotic" may still have some value in casual definitions, but they don't tell us anything about the phonetics or phonological system of the languages in question. I propose the following classifications:

1) Consonantal /r/: SSE

2) Vocalized /r/

   a) rhotic: GA

   b) non-rhotic: RP

However, even this more detailed taxonomy may not capture the true relationships between the various Modern English dialects with respect to how they treat the descendants of ME /Vr/ sequences. GA dialects, as we have seen, may have 4 or 5 or 6 such vowels. Though the RP variety used as an example in Tables 9.3 and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9.4 has 4 such vowels, this is unusual. Most RP varieties merge [ɔə] with [ɔ:] (the THOUGHT and NORTH sets), and many merge this remaining vowel with [ʊə] (the CURE vowel) as well, leaving only 3 or 2 distinct descendants of former /Vr/ sequences.

SSE varieties have fewer total contrasting vowels than RP dialects, having merged /æ-ɑ/, /u-ʊ/, and /ɔ-ɒ/ (the TRAP/BATH, GOOSE/FOOT, and THOUGHT/LOT lexical sets respectively), leaving an inventory of /i ɪ e ɛ u o ʌ ɑ ɔ aj aw ɔj/. Yet not all varieties of SSE contrast all these vowels before /r/. Some have merged /ʌ/ and /ɪ/, as in "word" and "bird" to /ʌ/, and some have merged this latter vowel further with /ɛ/, as in "heard", all to /ɜ/ before /r/ (Giegerich 1991: 63). Resyllabification of /ajr awr/ sequences is not reported for SSE.

There seems to be a scale of rhoticity. Variables in this scale are the following:

1) Degree of "consonantality" of the descendant of ME post-vocalic /r/. In SSE, post-vocalic /r/ is a true consonant, the tap [ɾ]. In GA, post-vocalic /r/ is an off-glide [ɚ], which is still phonetically very similar to the pre-vocalic /r/, [ɹ]. In RP, post-vocalic /r/, where there is a distinct descendant of it, is the off-glide [ə], which is very vocalic, being phonetically most similar to other vowels which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

are not derived from rhotic environments, such as in the unstressed syllable in words like "about."

2) Number of vowels contrasting before /r/. This correlates positively with the "degree of consonantality" above. Dialects where post-vocalic /r/ is [ɾ] have more contrasts than dialects where it is [ɚ], which generally have more contrasts than dialects where it is [ə].

3) Phonological identifiability of vowels before /r/ with canonical vowels. This also correlates positively with the first two variables. As we have seen, the vowels before /r/ in SSE are "unhesitatingly assignable" to the canonical vowel phonemes (Wells 1982: 213). The possible exception to this is the [ɜ] which results in SSE varieties which merge /ʌ/, /ɪ/, and /ɛ/ before /r/. Giegerich (1991: 64, 247) doesn't know which canonical vowel phoneme to assign this vowel to, and suggests an archiphonemic analysis. This validates the scale being used here. A loss of contrast of vowels before /r/ is related negatively to the identifiability of one of the vowels. As we have seen, there is great difficulty (and nothing resembling consensus by linguists) in assigning the vowels before /r/ is GA with any canonical vowel phonemes. We have seen acoustic, psycholinguistic, and phonological evidence of this difficulty in Chapters 6, 7, and 8.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We have seen in sections 9.3 and 9.4 above that it is easier to assign vowels before /r/ to canonical vowel phonemes in GA dialects where there are more contrasts before /r/. This also validates the use of this scale. Furthermore, for RP varieties, which generally have the fewest vowels contrasting before former /r/, monophonemic treatments are very commonly assumed; many linguists do not even attempt to assign the vowels in words like "near" and "square" to a canonical vowel phoneme (see list in section 9.5.1, above).

The dialects discussed thus far are put into a "scale of rhoticity" in Table 9.5. I have added to this scale a dialect of New Zealand English (NZ) which further merges the [ɪə] and [ɛə] vowels in NEAR and SQUARE, as per Wells (1982: 608-609).[7] I am assuming that all GA, RP, and NZ varieties have resyllabified /ajr/ and /awr/, and that the variety of NZ has the THOUGHT=NORTH=POOR merger.

I have also added to the scale some varieties of Irish English (IrE). In most IrE varieties, post-vocalic /r/ is the retroflex approximant [ɻ] (Wells 1982: 432). Most varieties of IrE allow all vowel phonemes (usually 14) to contrast before /r/ (Wells: 420). The only vowel lacking is /ʊ/ (IrE has /u:/ in words like "poor"), but

[7]This merger is also found in some other dialects of English, such as West Indian and East Anglian.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

this is due to an accidental gap, not a historical loss of contrast (Wells: 420).

However, some varieties of IrE show mergers of vowels before /r/. For example, "Typical Southern Irish provincial" contrasts the vowels /e:/, /ɛ/, and /ʌ/ before /r/ in the words "pair", "per", and "purr." but "Typical Dublin" IrE merges the vowels in "pair" and "per" to /e:/. Furthermore, "Smart Dublin" IrE merges all three of these vowels, such that "pair", "per", and "purr" are all [pʌr] (Wells: 421).

These varieties of IrE seem to represent intermediate stages between SSE and GA. On the one hand, /r/ is phonetically not a consonant, but a central approximant in these IrE varieties (like GA, unlike SSE). On the other hand, we find a large range of vowel contrasts before /r/, and the vowels that occur can be easily assigned to the canonical vowel phonemes (like SSE, unlike GA). I would say the IrE /r/ is phonetically a central approximant, but phonologically a consonant. Sequences of /Vr/ in IrE are best analyzed as biphonemic.

On the scale of rhoticity, the GA varieties are still much more similar to the RP varieties than they are to the varieties of IrE or SSE, for which a biphonemic analysis of /Vr/ sequences is uncontroversial.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 9.5 Scale of Rhoticity

	/r/ is:	Variety	Vs_/r/	total Vs	%
more rhotic	[r], [ɾ]?	ME	12	12	100%
	[ɾ]	SSE word≠bird≠heard	11	11	100
	"	SSE word=bird≠heard	10	11	91
	"	SSE word=bird=heard	9	11	82
	[ɻ]	IrE pair≠per≠purr	13	14	93
	"	IrE pair=per≠purr	12	14	86
	"	IrE pair=per=purr	11	14	79
	[ɚ]	GA NORTH≠FORCE≠POOR,THOUGHT≠LOT	6	14	43
	"	GA NORTH=FORCE≠POOR,THOUGHT=LOT[8]	5	13	38
	"	GA NORTH=FORCE=POOR,THOUGHT≠LOT	5	14	36
	"	GA NORTH=FORCE=POOR,THOUGHT=LOT[9]	4	13	31
	"	GA NORTH=FORCE=POOR,THOUGHT≠LOT	4	14	29
	[ə]	RP THOUGHT≠NORTH≠CURE	4	15	27
	"	RP THOUGHT=NORTH≠CURE	3	15	20
	"	RP THOUGHT=NORTH=CURE	2	15	13
less rhotic	"	NZ SQUARE=NEAR	1	15	7

In this table, the first column represents the degree of rhoticity, with "more rhotic" accents at the top and "less rhotic" accents at the bottom. The second column shows what the usual post-vocalic descendant of ME /r/ is in the respective dialect. The third column shows what the dialect/variety is and which mergers of vowels it has. The fourth column shows how many vowels the dialect in question has before tautosyllabic /r/. The fifth column shows how many total "canonical" vowels the dialect in question has contrasting in non-rhotic environments, and the sixth column shows what percentage of the "canonical" vowels could be considered to contrast before tautosyllabic /r/ (fourth column divided by fifth column).

Given that GA and RP are more similar to each other with respect to the phenomena in question than GA is to SSE, it would be much more consistent to treat the former /Vr/ sequences in GA and RP the same way. Treating the /Vr/ sequences in GA as biphonemic

[8]As represented by Speakers 11 and 14.

[9]As represented by most of the CE speakers in Chapter 6.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(as is frequently done) actually makes GA look a lot more like SSE, something not actually supported by the data.

Since monophonemic analyses are most common for RP varieties, this type of analysis should be extended to GA. It indeed, can be extended to GA with little modification. As an example of this, let us take the analysis for RP vowels found in Coleman (1998). He treats the RP descendants of former /Vr/ sequences as monophonemic. That is to say, that they are in the inventory alongside the vowels like /ɪ ɛ æ/ and the diphthongs like /aj ɔj/ etc. His complete inventory is as below:

	short		rising		centering		
	front	back	to front	to back	front	back	central
close	/ɪ/	/ʊ/	/ij/	/uw/, /iw/	/ir/	/ur/	
mid	/ɛ/	/o/	/ej/, /ɔj/	/əw/	/er/	/or/	/ər/
open	/æ/	/ʌ/	/aj/	/aw/		/ar/	

Table 9.6 Inventory of RP Vowels (from Coleman 1998: 280)

Note how similar the underlying forms in Coleman's RP inventory are to those used for North American dialects by Veatch 1991 and Jensen 1993 (see section 8.2, above). One could not use such an inventory for SSE. There would be too many vowels before

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/r/, and since they would all correspond to some vowel in the first two columns, there would be no reason to put them in the inventory.

To adapt these underlying forms to RP surface phonetic structure, we would need some sort of "r-deletion" rule which turns post-vocalic /r/ (when it's not before another vowel) into a [ə] in /ir er ur/, but a lengthening element in /ar or ər/.

To adapt this framework to GA, all we need to do is get rid of this "r-deletion" rule. That is the only difference between the two dialects.

Hence, I have shown that RP and GA are far more structurally and phonetically similar to each other than previously thought. Monophonemic analyses are usually assumed for RP, while biphonemic analyses are assumed for GA, but this is inconsistent and complicates matters. The monophonemic analysis used for RP can easily be adapted to account for the facts of GA. This is further support for the monophonemic analysis for GA /Vr/ sequences.

So far, though, only tautosyllabic /Vr/ sequences have been analyzed. Heterosyllabic /Vr/ sequences may pattern differently, and will be examined in the next chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 10: Vowels before intervocalic /r/.

Dialects of GA can also differ with respect to how many vowels they allow before intervocalic /r/. The differences here do not necessarily correspond to how many vowels they allow before tautosyllabic /r/. In the latter case, the maximum number of vowels that can contrast is six. In the case of intervocalic /r/, a variety of GA might contrast many more than six vowels, or it may contrast as few as four (five, if we include [ɚ]).

Let us contrast two dialects here. One (Dialect A) is a conservative dialect, similar to Joos's "Northern English", supposedly similar to an earlier American dialect (Joos 1934), and the dialect described in Trager & Bloch (1941), and Hammond (1999: 125-26).

The other dialect (Dialect B) is similar to Joos's "General American" and the Midwestern speech described by Trager & Bloch (1941: 241-242). I am taking things one step further by having the dialect correspond to the contrasts (or lack thereof) exhibited by the speakers of California English recorded in Chapter 6. All the speakers further collapsed one possible contrast found in Dialect A, having the vowel in "jury" the same as that in "curry", [ɚ]. In Dialect A, "jury" has [ʊ], but "curry" has [ɚ].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In the table below, the first column contains the vowels of Middle English; the second column gives their usual development in Modern GA. The third column gives their usual development before tautosyllabic /r/. The fourth column gives their development before intervocalic /r/ in the conservative Dialect A, and the fifth column gives their development in the California Dialect B as described above.

Table 10.1 Development of ME vowels before intervocalic /r/

ME	GA	_r[1]	Dialect A	Dialect B	example word
ā	e	Er	er	Er	Mary
ă	æ	Ar	ær	Er	marry
ē	i	Ir	ir	Ir	dreary
ĕ	ɛ	ɚ	ɛr	Er	merry
ī	aj	ajɚ	ajr	ajr	virus
ĭ	ɪ	ɚ	ɪr	Ir	spirit
ọ̄	u	Ur,Or	*[2]	*	*
ǭ	o	Or	or	Or	glory
ŏ	ɑ	Or	ɑr	Ar	sorry[3]
ū	aw	awɚ	awr	awr	dowry
ŭ	ʌ	ɚ	ʌr	ɚ	furrow

[1]Vowels before intervocalic /r/ pattern like vowels before tautosyllabic /r/ when the /r/ precedes a morpheme division. Thus, words like "starry" and "furry" which come from "star" and "fur" plus the suffix "-y" have the same vowels as "star" and "fur", respectively.

[2]I can find no clear examples of words derived from ME /ọ̄/ before intervocalic /r/ in monomorphemic words. Joos (1934) and Trager & Bloch (1941) use inflected forms of the adjective "poor" ("poorer" and "poorest") and Hammond (1999) uses the borrowed word "guru" to fill in this gap.

[3]Words derived from ME /ŏ/ before intervocalic /r/, such as "sorry", "borrow", "orange" typically have variants with both [ɑ] and [ɔ] in North America. As we can see from the table, [ɑ] would be the expected vowel, because vowels before intervocalic /r/ typically pattern like their counterparts in non-rhotic environments. The [ɔ] variant is likely a result of some conservative assimilatory effect of the following /r/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

What is interesting to notice from the table is that the vowels before intervocalic /r/ do not always behave the same way as their cognates before tautosyllabic /r/. This is particularly true in the case of the descendants of the ME short vowels. The ME long vowels give us the same vowels before tautosyllabic /r/ in GA as they do before intervocalic /r/. However, the short ME /ă/ becomes [A] before tautosyllabic /r/, but [æ] before intervocalic /r/. ME /ĕ/ becomes [ɚ] before tautosyllabic /r/, but [ɛ] before intervocalic /r/. ME [ĭ] becomes [ɚ] before tautosyllabic /r/, but [ɪ] before intervocalic /r/. ME /ŏ/ becomes /O/ before tautosyllabic /r/, but [ɑ] before intervocalic /r/. ME /ŭ/ becomes [ɚ] before tautosyllabic /r/, but [ʌ] before intervocalic /r/.

The descendants of the ME short vowels before intervocalic /r/ in Dialect A are the same as they are in non-rhotic environments. This indicates that ME (and conservative GA) intervocalic /r/ was/is not ambisyllabic. It belonged only to the onset of the following syllable (Miller 1993).

In Dialect B another story emerges. The descendants of the ME short vowels before /r/ are not the same as their cognates before tautosyllabic /r/ (like Dialect A), but they are also not the same as their cognates in non-rhotic environments (unlike Dialect A).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Specifically, ME /ă/ is [æ] in non-rhotic environments in CE, [A] before tautosyllabic /r/, but [E] before intervocalic /r/. ME /ĕ/ is [ɛ] in non-rhotic environments, [ɚ] before tautosyllabic /r/, but [E] before intervocalic /r/. ME /ĭ/ is [ɪ] in non-rhotic environments, [ɚ] before tautosyllabic /r/, but [I] before intervocalic /r/. ME /ŏ/ is [ɑ] in non-rhotic environments, [O] before tautosyllabic /r/, and [A] before intervocalic /r/[4]. ME /ŭ/ is [ʌ] in most non-rhotic environments, [ɚ] before tautosyllabic /r/, and [ɚ] before intervocalic /r/ (this is the only case where the two reflexes are identical in CE).

The changes in vowels before intervocalic /r/ going from Dialect A to Dialect B are not the same as those before tautosyllabic /r/. Nor can they be explained by the same reasons. If we recall from Chapter 2, there were four basic types of changes in vowels before /r/:

1) The short vowels /ĭ ĕ ŭ/ were deleted. This was explained by a failure to distinguish these short vowels from a transition to the /r/.

2) Other vowels became (or remained) rounder, backer, and lower.

[4]Though the vowels [ɑ] and [A] aren't very phonetically different, they have been shown to be perceptually different in Chapter 7.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3) Sequences of /ajr/ and /awr/ resyllabified to [ajɚ] and [awɚ]. This was not actually a change in the vowel, but in the following /r/.

4) Some vowels merged, such as the /o/ and /ɔ/ in "ore" and "or".

This second tendency is violated before intervocalic /r/ in numerous instances. ME /ē/ (both open and close varieties) became a lower vowel than its non-rhotic reflex before intervocalic /r/, but ME /ī/ became a higher vowel. ME /ā/ became a lower vowel than its non-rhotic reflex before intervocalic /r/, but ME /ē/ and /ă/ became higher vowels, significantly so in the latter case.

The changes in vowels before intervocalic /r/ cannot be explained by, and indeed are contrary to, many of the phonetic reasons given for the changes in vowels before tautosyllabic /r/.

The only type of change which is common the vowels before tautosyllabic and intervocalic /r/ is the total merger of contrast, the fourth type of change mentioned above. For example, /o/ and /ɔ/ (and /u/, in some dialects) merged before tautosyllabic /r/. This is explained by the fact that GA /r/ is phonetically a central approximant. Hence, this /r/ forms a diphthong with the previous vowel. It has been found (Gay 1968) that for diphthongs, the steady states of the vowels may not be the main cue, but rather the degree

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of transition of F2. Diphthongs like [or], [ɔr], and [ur] may have different steady state nuclei, but their rates of change of F2 are similar, hence listeners may not be able to distinguish them clearly. The same explanation could account for the mergers of pre-vocalic [ir-ɪr], [er-ɛr-ær].

What has happened in Dialect B in all situations is that the pre-vocalic /Vr/ sequences have been replaced by the same sequences that occur tautosyllabically: [Ir Er Ar Or ɚ]. The connection between the vowel and the following /r/ is a very tight one in all environments. We could say they do not form parts of a syntagmatic sequence, but together represent a paradigmatic unit (a monophonemic diphthong) which must be specified in the inventory.

Thus, the formerly heterosyllabic /V.r/ sequences become their most phonetically similar counterparts from the inventory. Specifically, [i.r] and [ɪ.r] become [Ir], [e.r], [ɛ.r] and [æ.r] become [Er], [ɑ.r] becomes [Ar], [o.r] becomes [Or] and [ʌ.r] becomes [ɚ].

This is another way in which /r/ changes from behaving like a consonant of English, to behaving like the glides /j/ and /w. A parallel to the change of vowels before intervocalic /r/ can be illustrated by the following example:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

For some speakers, the Modern English word "lawyer" rhymes with "foyer" and "annoyer" (Bronstein 1960: 196, Veatch 1991: 51)[5]. Yet, their vowels have different histories. The word "lawyer" is historically bimorphemic, consisting of the stem "law" (<OE *lagu*) plus the suffix "-yer" (a rarer variant of "-er"). Hence, the syllable division should be /lɔ.jɚ/. The word "annoyer" is also bimorphemic, consisting of the stem "annoy" plus the agentive suffix "-er", which is very productive in Modern English. Hence, the syllable division should be /ə.nɔj.ɚ/.

Two interesting things to note are:

1) For some speakers, the two words "lawyer" and "annoyer" rhyme.

2) For these speakers, the [ɔ] in "lawyer" did not merge with /ɑ/ in California English as it usually has, including in the root word "law."

This can be accounted for by the same principles explained for /Vr/ sequences above. The rate of change of F2 in [ɔj] and [ɔ.j][6] All /vowel + glide/ sequences in English must belong to the same

---

[5]Though for other speakers, it does not. Kenyon & Knott (1953) have "foyer" as [fɔɪɚ] and "lawyer" as [lɔjɚ]. This suggests a syllable (or even morpheme) division in "lawyer" between the "law" and the "-yer", because Kenyon & Knott's transcription for the diphthong in "noise" is [ɔɪ], not [ɔj].

[6]The vowel /ɔ/ in GA dialects that have it contrastively is not necessarily phonetically identical to the nucleus in /ɔj/. Thomas (2001: 24) cites evidence

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

monophonemic diphthongs which are in the inventory, whether they occur before a vowel or a consonant. These sequences are [aj aw ɔj ij ej uw ow]. We can get these in words like "bias", "dowager", "paranoia", "Mia", "La Brea", "skua", and "boa." We cannot have sequences like [ɛw], [ɔw], [æj], [uj] before other vowels, just like we cannot have them before consonants or word-finally.

Hence, in CE, the /Vr/ sequences [Ir Er Ar Or] now behave exactly like the /Vj/ and /Vw/ sequences in every way, even when they don't in more conservative varieties of GA like Dialect A. This is another prediction born out by treating the RGDs as monophonemic.

The reason for this reanalysis of pre-vocalic /Vr/ sequences can be seen as a matter of simplicity. Let us consider a conservative variety which contrasts the words "Mary", "merry", and "marry", as [mEri][7], [mɛri], and [mæri], respectively, as per Miller (1993). How do we represent the contrast in the two words "Mary" and "merry", for example?

One possible way would by contrastive syllable division. The two words would have the same underlying vowels, but "Mary" would be /mɛr.i/, while "merry" would be /mɛ.ri/. It is questionable

---

that the nucleus in /ɔj/ is actually more like [o] and that the vowel /ɔ/ can have many variations, including [ɒ], [uə], etc. (pp. 16-17).

[7]It appears that the sequences of /tense vowel + r/ such /e.r/ and /i.r/ are the first to become phonetically identical to the tautosyllabic RGDs in some dialects.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

whether this can be done. Veatch (1991: 249) says some dialects may have such a contrast, but says it is "a rather tenuous distinction." Malmberg (1955: 80) says that syllable division can contrast phonemically (in monomorphemic words) such that a language could contrast /a.pa/ with /ap.a/. Whether this is true or not, I can think of no other pairs of English words (not counting ones with vowels before /r/) for which it is true. Giegerich (1991: 205) claims that "no two words of English are distinct from one another in terms of syllable structure alone." To require such a distinction only for vowels before intervocalic /r/ would be complicating things indeed.

Another possible way to represent the "Mary/merry/marry" contrast in this conservative variety of American English (Dialect A) would be to assign the words different underlying vowels. "Merry" would have /ɛ/, and "marry" would have /æ/. That leaves /e/ for "Mary" (these underlying representations are used by Miller 1993). This brings up the question of syllable division. In words like "marry" (/mæri/) and "merry" (/mɛri/), what syllable does the /r/ belong to? If it belongs in the first syllable, or is ambisyllabic, then we have a problem, because we have licensed the rhymes /ær/ and /ɛr/, which cannot occur independently. Even the conservative GA dialect under consideration here has a limited number of vowel

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

contrasts before tautosyllabic /r/. The word "mare" exists with [Er], but this is the vowel in "Mary", not "merry" or "marry."

We could put the /r/ in the onset of the second syllable, giving us /mɛ.ri/ and /mæ.ri/. This solution is still problematic in that it allows the "lax" vowels /ɛ/ and /æ/ to end open syllables, something they cannot do elsewhere in English words (Miller 1993). Allowing a dialect of GA to have a three-way contrast of "Mary", "merry" and "marry", but only a one-way contrast in "mare" requires some very specific complex phonological rules no matter how we try to account for it. It should not surprise us that so many speakers of various GA dialects could not pick up on these contrasts, and chose to eliminate them.

What I have shown in this chapter is that

1) The changes in vowels before intervocalic /r/ cannot be accounted for by the same phonetic explanations given to account for the changes in vowels before tautosyllabic /r/ in Chapter 2. That is not to say that no phonetic factors are at work. The fact that /r/ is a central approximant in intervocalic position as well as syllable-finally means that it can form a diphthong with the previous vowel. We have seen that for diphthongs, the rate of formant transitions, not just the steady states of the nuclei, can be an important

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

perceptual cue. Thus, sequences of [iɹ] and [ɪɹ] might be more difficult to distinguish than sequences of, say [iz] and [ɪz]. This would account for the possibility of mergers before intervocalic /r/.

2) That the changes which have occurred in vowels before intervocalic /r/ result in a tendency for pre-vocalic /Vr/ sequences to be reduced to the same limited set of /Vr/ sequences that are found elsewhere. Thus, /Vr/ diphthongs come to follow the same patterns as /Vj/ and /Vw/ diphthongs in yet another way. Once again, we have further support for the monophonemic analysis of /Vr/ sequences.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 11: Conclusion.

The main point I wished to make in this dissertation is that the phonological status of the /Vr/ sequences in GA is something which requires close examination. There is a paucity of actual defended arguments for the status of these sequences, though there is a plethora of undefended representations.

It is quite obvious from reading a discussion of the issue that the status of these sequences is in doubt. There is complete consensus among linguists as to what phoneme all the stressed canonical vowels of GA belong to. Nobody has to (or ever does) defend a claim that the vowel in "if" belongs to the same phoneme as the vowel in "pig", even though they may have significant phonetic differences.

What I hoped to show in Chapter 1 was that a mere cursory examination of the issue of /Vr/ sequences will show why a defended argument must be made for their representations. The /r/ of GA is not a "true" consonant, but a central approximant. Hence, /Vr/ sequences in GA are diphthongs. Diphthongs can be monophonemic or biphonemic. Hence, we must determine whether the /Vr/ sequences of GA are monophonemic or biphonemic. I have further shows that the concept of "monophonemic" vs. "biphonemic"

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is not just limited to classical phonemic theory, but is a concept which has a part to play in any sort of phonological framework.

Even if we assume that the RGD's of GA are sequences of two phonemes, it is still very much in doubt which of the canonical vowel phonemes the nuclei of these diphthongs belong to. A cursory look at the data will tell us why this is so. There is a lack of contrast of vowels before /r/ in GA. This, in and of itself, does not put their phonological status into doubt. There is also a lack of contrast of vowels before /ʒ/ in GA as well, but there is no doubt that the vowel in "beige" belongs to the same phoneme as the vowel in "ape", etc. This lack of contrast does not in itself necessitate that the phonemic status of the vowels before /r/ is difficult to determine, but it does not make matters any easier. What is interesting is that this lack of contrast of vowels before /r/ coincides with the fact that /r/ is a central approximant in GA (and hence /Vr/ sequences are diphthongs), and with the fact that the vowels that do occur before /r/ are generally "between" the F1 and F2 ranges of two or more of the canonical vowel phonemes (Lehiste 1964).

So, we have two questions to answer here:

1) Are the RGD's of GA monophonemic or biphonemic?

2) If they are biphonemic, which of the canonical vowels (if any) do their nuclei belong to?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Though I advocate a monophonemic analysis of the RGD's as being the most consistent with the evidence, biphonemic analyses are still possible. However, there is no analysis which can be assumed. Any treatment of vowels before /r/ must be defended. A biphonemic solution is not any more of a default analysis than a monophonemic one. And, if a biphonemic solution is selected, the choice of which canonical vowel phonemes the vowels before /r/ belong to must be defended from among the various possibilities (tense vowel, lax vowel, archiphonemic, arbitrary). There is no default analysis in this situation either.

In Chapter 2, I make a brief historical digression in order to illustrate why the phonological status of the RGD's came to be in doubt. What I hoped to show in Chapter 2 is that sequences of /Vr/ were once just like any other /VC/ sequence of English and did not show any remarkable phonological behavior. They still are this way in some dialects of English like SSE. The change of /r/ from a true consonant to a central approximant was initially sub-phonemic and didn't change the phonology of the language. However, this initially sub-phonemic sound change caused assorted deletions, assimilations, and resyllabifications which greatly reduced the inventory of vowels before /r/ and made them phonetically distinct from their canonical non-rhotic counterparts.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 2 is important because the historical relations between the vowels before /r/ and the canonical vowels of English is not often recognized. A summary of all of the sound changes that have taken place involving /Vr/ sequences in English is enough to show that /r/ of Modern GA really is a unique consonant. The vowels before /r/ really do form a system of their own unlike those before the more conventional consonants. In ME, /r/ was just like any other consonant. If we assume that /r/ is just like any other consonant in GA, that is the equivalent of saying that nothing major has happened pertaining to /r/ and the vowels before it since ME. As I have shown in Chapter 2, quite a few sound changes have happened. To assume that /r/ is just another consonant of GA is not a safe assumption.

In Chapter 3 I hoped to show that there is a vast literature and some well agreed upon criteria for deciding whether a given diphthong in a given language is monophonemic or biphonemic. Despite this, such criteria are seldom used when considered the phonological status of the RGD's in GA. Very few of the analyses reviewed in Chapter 3 would I consider to be actual defended arguments. Even when the authors give some criteria for their representations, they do not consider other criteria which may be relevant. Even more rarely does any author truly consider all possibilities to see which one is best supported by the data.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Additionally, it was determined in Chapter 3 that there is data that still needs to be collected in order to inform a proper analysis.

In Chapters 4 and 5 I showed that there are some parallels between the vowels before /l/ and /ŋ/ in GA and the vowels before /r/. Hence, these vowels should be investigated as well.

In Chapters 6 and 7, I gathered data relevant to the issue. Chapter 6 contains acoustic data, building on the work of Lehiste (1964), but going into more detail, including the positional variants of all vowels of GA (CE dialect) before all consonants for a large body of speakers. Generally, it was found that the nuclei of the RGD's fell outside the ranges of any of the canonical vowels.

Chapter 7 verges into seldom-explored territory by using psycholinguistic testing in the service of phonological categorization. The psycholinguistic test was not intended to take precedence over any other criteria, but to serve as additional evidence in the support of one type of analysis versus another. Once conducted, the results of the psycholinguistic test are data which must be taken into account by anyone doing a thorough analysis of the matter.

From the results of the psycholinguistic test, another possibility of classification not previously considered was revealed. The results did show some similarity to prototype effects found for other types of categorization. There is so far only a small amount of literature on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the application of prototype effects to phonological categorization. These works were reviewed and compared to the data at hand. The application of prototype theory to phonological categorization certainly is intriguing, but at present so little is known about if that it was decided to continue with conventional phonological categorizations.

In Chapter Eight, all the evidence gathered so far (and some additional evidence) was used in order to weigh all the possible analyses of the RGD's and the vowels in them. It was concluded that the evidence supports the monophonemic analysis as the least problematic. This was best illustrated by the use of a checklist (Table 8.2) in which /Vr/ sequences were found to pattern like the diphthongs /aj aw ɔj/ in every respect, and not like the conventional /VC/ sequences. These findings were applied to a few types of phonological description. All that was truly necessary was to add the RGD's into inventories alongside the other vowels and diphthongs. That it took very little adjustment to previous phonological descriptions in order to make them fit the data should not surprise us. If the monophonemic analysis is correct, it should fit into a phonological description very easily. Rather, it is the treatment of /Vr/ sequences as conventional /VC/ sequences that requires significant tampering of a phonological description.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapters 9 and 10 raise matters which show support for the monophonemic analysis advocated in Chapter 8. In Chapter 9 it was shown that, with respect to the phenomena in question, GA is far more similar phonetically and structurally to RP, a dialect for which monophonemic analyses of erstwhile /Vr/ sequences are common, than to SSE, a dialect for which only biphonemic analyses of /Vr/ sequences are possible.

In Chapter 10, it was shown that sequences of /V/ followed by intervocalic /r/ have been much more conservative than tautosyllabic /Vr/ sequences, and have kept their full range of contrasts in some GA varieties into the twentieth (and probably twenty-first) century. The sequences of /V/ followed by intervocalic /r/ in such varieties are best analyzed as biphonemic. However, it was shown that there is a general tendency for vowel contrasts to be reduced before intervocalic /r/ as well. The resulting /Vr/ sequences are phonetically identical to the tautosyllabic /Vr/ sequences which are classified as monophonemic in Chapter 8. In this way, /r/ comes to pattern with /j/ and /w/ in another way. The vowels found before intervocalic /r/ are the same ones found before tautosyllabic /r/, parallel to the situation with /j/ and /w/.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Speakers of American English (and linguists) have difficulty in figuring out exactly which canonical vowel phonemes the vowels before /r/ belong to. That, coupled with the reduction in number of former /Vr/ sequences to as few as four in some American dialects has meant that speakers have found it easier to just learn these sequences individually rather than trying to parse them into separate components. The change to monophonemicity may not have gone all the way just yet (people still seem to identify the vowel in [Ir] with /i/, for example), and might still be in the process of spreading. But, at the turn of the millennium in California, /Vr/ sequences behave a lot more like monophonemic diphthongs than biphonemic /VC/ sequences. Non-tautosyllabic /Vr/ sequences have held on to their biphonemic character longer than tautosyllabic ones, but there is a general tendency to classify these sequences as monophonemic as well.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix A: Pedagogical Recommendations.

Based on my findings, I make the following recommendations:

1) The status of vowels before /r/ in American English must be incorporated into phonological theory. This is not frequently done. For example, Jensen (1993), in a modern general book on English Phonology, does not address the issue of /Vr/ sequences, though he does explicitly consider the biphonemic vs. monophonemic status of English affricates (pp. 29-30), and diphthongs in /j/ and /w/ (pp. 37-38), and considers /r/ to be [-consonantal] in feature notation (p. 30).

Though I advocate a monophonemic analysis of the RGD's as being the most consistent with the evidence, biphonemic analyses are still possible. However, there is no analysis which can be assumed. Any treatment of vowels before /r/ must be defended. A biphonemic solution is not any more of a default analysis than a monophonemic one. And, if a biphonemic solution is selected, the choice of which canonical vowel phonemes the vowels before /r/ belong to must be defended from among the various possibilities (tense vowel, lax vowel, archiphonemic, arbitrary). There is no default analysis in this situation either.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

So far, there is nothing resembling consensus on the matter of vowels before /r/. Most linguists just avoid the issue. I do recommend that some sort of consensus in representing the vowels before /r/ be reached.

2) The results of the findings in this dissertation should be incorporated into linguistic pedagogy. Students in introductory-level linguistics classes are often asked to write common English words in phonetic and phonemic transcription. They often have great difficulty choosing which vowel symbols to represent the vowels before /r/. Explicit instruction is required here. A survey of some common introductory-level linguistics textbooks show that only one (Akmajian *et al.*) even addresses the issue of vowels before /r/ in American English, while others (Fromkin & Rodman, Yule, Finegan, O'Grady *et al.*) give it no mention.

I recommend a monophonemic solution in this case, as it is simplest just to add a few RGD's to the list of vowel phonemes which is usually given in every introductory linguistics class. If this is not done in the textbook being used for the class, it can easily be added by the instructor.

For the specific representations of the RGD's, I recommend the transcriptions [ir er ar or ur] for [Ir Er Ar Or Ur], based on the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

phonetic and psychological data gathered in Chapters 6, 7, and 9. However, another possible solution would be to use symbols that are not used for any of the canonical vowel phonemes as much as possible. This has the advantage of emphasizing the paradigmatic nature of these diphthongs.

For example, the diphthongs in the words "how" and "high" are usually represented something like /aw/ and /aj/. The use of the symbol /a/ helps emphasize the unitary nature of these diphthongs, because /a/ is not used independently to represent a canonical vowel, the symbol /ɑ/ usually being used to represent the vowel in the word "hot." The diphthong in the word "boy" is usually represented something like /ɔj/. This may make the diphthong seem syntagmatic for those who have a contrastive vowel /ɔ/, but emphasizes the diphthong's unitary nature for those who do not have the vowel /ɔ/ independently.

Thus, representing [Ar] and [Or] as /ar/ and /ɔr/ respectively might be helpful, particularly to those speakers who lack an /ɑ-ɔ/ contrast. Such an aid, however, is not possible for the vowels in "ear", "air", and "poor", since the vowels /i ɪ e ɛ u ʊ/ are contrastive in most environments for all varieties of GA.

An easier solution might be to represent monophonemic diphthongs with a tie-bar. Thus, the diphthongs in the words "how",

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"high", and "boy" would be /aj/, /aw/, and /ɔj/ respectively, while the diphthongs in "ear", "air", "are", "ore", and "poor", would be /iɹ/, /ɛɹ/, /ɑɹ/, /oɹ/, and /uɹ/, respectively.

3) The study of vowels before /l/ does not at this point in time require the phonological analysis that is required for vowels before /r/. That is not to say that vowels before /l/ should be ignored. The allophony of vowels before /l/ and the resyllabification of /diphthong + l/ sequences should be given some attention. Linguists interested in the phonology of American English would be well advised to pay attention to the changes in the vowels before /l/ taking place. The situation of /Vl/ sequences may be like that of /Vr/ sequences in the not too distant future.

Instructors of linguistics should also be aware of the deviant allophony and mergers of vowels before /l/. Using the word "pull" as an exemplar for the vowel [ʊ], for example, is not a wise idea. Many native speakers of American English may not have such a vowel in that word.

4) The status of vowels before /ŋ/ requires explicit mention as well. A defended analysis is required here. Even if a traditional analysis (i.e., as lax vowels) is used, some statement of allophony

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

should be made. Linguistics instructors should also be aware here that their students' perception of these vowels may be different from what they assume. Increasingly, students see the vowels in words like "sing" and "sang" as tense vowels, not lax.

Vowels before /ŋ/ also make poor examples of canonical vowels. Kenyon & Knott (1953) use the word "sang" as an exemplar of the vowel [æ] throughout. This clearly cannot be done anymore.

5) The findings in this dissertation should be incorporated into the pronunciation guides of dictionaries. Despite the claims of O'Neil (1981: xxv-xxxvii), dictionary pronunciation guides do not represent the phonetic level but an underlying level. This can be illustrated by comparing the symbols used by the four major American dictionaries (*Merriam-Webster's Collegiate Dictionary, Tenth Edition* (MW), *Webster's New World Dictionary* (WNW), *Random House Webster's College Dictionary* (RHW) and *The American Heritage Dictionary of the English Language, Third Edition* (AHD)) to the inventory of American English vowel phonemes as found in Giegerich 1992.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Giegerich	MW	WNW	RHW	AHD
i	ē	ē	ē	ē
ɪ	i	i	i	ĭ
e	ā	ā	ā	ā
ɛ	e	e	e	ĕ
æ	a	a	a	ă
u	ü	o͞o	o͞o	o͞o
ʊ	u̇	o͝o	o͝o	o͝o
o	ō	ō	ō	ō
ɔ	ȯ	ô	ô	ô
ɑ	ä	ä	o, ä	ŏ, ä[1]
ʌ	ə	u	u	ŭ
aj	ī	ī	ī	ī
aw	au̇	ou	ou	ou
ɔj	ȯi	oi	oi	oi

Table A.1 Symbols for English vowel phonemes in four dictionaries

The symbols used in the dictionary pronunciation guides have a nearly one-to-one correspondence to the inventory of phonemes, not phones. They do not represent predictable phonetic details such as lengthening, nasalization, et cetera.[2] If findings show that the inventory of phonemes is different from what previously thought, this must be represented in a dictionary's pronunciation guide.

Many dictionary pronunciation guides do give special symbols for vowels before /r/. Let us examine the same four dictionaries to see how they represent the historical /Vr/ sequences:

[1]RHW and AHD allow for dialects that contrast the vowel in "bother" (the \o\ or \ŏ\) with the one in "father" (the \ä\).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

	MW	type	WNW	type	RHW	type	AHD	type
ɚ	ər	b	ʉr	a	ûr	a	ûr	a
Ir	ĭr	d	ir	d	ėr	b	îr	a
Er[3]	er,ar	d	er	d	âr	a	âr	a
Ar	är	c	är	c	är	c̈	ar	d
Or[4]	ȯr	d	ôr	c	ôr	c	ôr	c
Ur	u̇r	d	o͝or	c	o͝or	c	o͝or	d

Table A.2. Representations of /Vr/ sequences in four dictionaries

The representations fall into four categories, as described below:

a) Those which use a symbol for a vowel before /r/ which is distinct from any of the symbols used for the non-rhotic vowels. This is effectively a monophonemic representation for the RGD in question.

b) Those which do not use a distinct symbol for a vowel before /r/, but do give the sequence its own entry in the pronunciation guide. This could also be considered a monophonemic representation, with the introduction of a new symbol being avoided for practical purposes.

c) Those which do not use a distinct symbol for a vowel before /r/, but do include an exemplar word in the pronunciation guide so

---

[2]Though some dictionaries may indicate nasalization for borrowings from languages like French, where nasalization is phonemic.
[3]MW transcribes all [Er] words with both \er\ and \ar\, effectively claiming that they are either /ɛr/ or /ær/ in various dialects.
[4]MW, RH, and AHD allow for possible [ɔr]/[or] contrasts. All [ɔr] words are transcribed with the equivalent of [ɔ] thus \ȯr, ôr, ôr\, while all possible [or]

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that the reader has some idea of which symbol is being used. This is effectively a biphonemic representation which may acknowledge that the vowels before /r/ have distinct allophones.

d) Those which use no distinct symbol for a vowel before /r/. This is a biphonemic representation which does not treat the vowels before /r/ as unusual in any way.

We can see from the chart above that treating the former /Vr/ sequences as monophonemes is not uncommon in dictionary pronunciation guides. The vowel [ɚ] is universally recognized as monophonemic. Monophonemic treatments of [Ir] and [Er] are fairly common. Monophonemic treatments of the other RGD's aren't found, though the text explanations of dictionary pronunciation guides (for example, the one in WNW) may call attention to the unusual status of vowels before /r/.

Since the monophonemic strategy is partially recognized by some dictionary pronunciation guides, it may as well be fully implemented. I recommend distinct symbols for all vowels before /r/ in all dictionary pronunciation guides.

---

words have the equivalent of an [ɔr] transcription, plus the appropriate equivalent of an [or] one as well, which is \ōr\ in all cases.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6) There are a number of possibilities for future study in areas relating to the topic of this dissertation, namely:

a) The phonetic data gathered in Chapter 6 could be gathered for a different dialect area. Most specifically, it would be interesting to gather the phonetic data for speakers of a dialect which has contrastive /ɔ/, or which contrasts the vowels in "poor" and "pore." Likewise, it would be interesting to gather the data for a dialect in which the canonical vowel have different phonetic realizations than those of CE, such as the "Northern Cities Shift" area (Labov *et al*, 1972). It would also be interesting to gather the data for speakers of SSE, to confirm or contradict the claim that vowels before /r/ in SSE are not significantly different phonetically from their correspondents in non-rhotic environments.

b) The psycholinguistic test in Chapter 7 could be expanded. First of all, I think it should be done again on another body of subjects just to see if the results are reproducible. It could also be performed for speakers of a dialect which has other vowel contrast in rhotic and non-rhotic environments, or which has substantially different phonetic realizations of canonical vowels than CE. In such a situation, many vowel pairs would have to be added to the test.

Were I to perform the test again, there are many pairs I would add to it. First of all, I would add more pairs with vowels before /r/,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/l/, and /ŋ/, so that the numbers of responses in these test sets would be closer to the numbers in the control sets. This would help to determine if the differences in the responses of the test sets and control sets were real or largely due to random factors.

There are also possibilities for test pairs which were not considered. The vowels before /r/, /l/, and /ŋ/ were only compared to the canonical vowels. They could also be compared to each other. For example, the vowel in "air" could be compared to the vowel in "ale." Perhaps some of these non-prototypical vowels might join together to form categories of their own.

It would also be interesting to conduct such a test for speakers of SSE and RP. My prediction would be that speakers of SSE would classify the vowels before /r/ with the canonical vowels, while the RP speakers might classify the corresponding vowels of RP with the canonical vowels to an even lesser extent than the CE speakers.

c) So far, all the data which supports the idea of prototype effects in phonological categorization has been gathered for speakers of North American English. In order to truly be able to say that there are prototype effects in phonological categorization, experiments such as the ones done by Jaeger & Ohala (1984), Derwing *et al.* (1986), and Guenter, Lewis, & Urban (1999, and in this dissertation) should be performed using many different languages.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

d) The general idea of how diphthongs (not just RGD's) are categorized with respect to canonical vowels needs some cross-linguistic investigation as well. A test like the one in Chapter 7 could be done with speakers of a wide variety of languages which have diphthongs. For example, the diphthongs of some languages (Dutch, Frisian, German) are often considered to be monophonemic like those of English, but the diphthongs of some other languages (Finnish, for example), are usually considered biphonemic. A psycholinguistic test would determine if this distinction were reflected in native speakers' categorizations.

e) The effects of orthographic bias are also unknown. It might be useful to conduct such a test on a body of illiterate subjects, or on speakers of a language whose conventional orthography is not alphabetically based (Chinese or Japanese, for example) to see what the effects of orthographic bias are.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix B: Acoustic Data

B1: F1, F2, and F3 measurements (Hz) for all speakers at three points in time for all words measured. If formant value is missing, speaker did not pronounce the word.

Speaker 01: Male, age 22. From Ventura (Southern California)

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	307	2076	2846	307	2499	3115	346	1846	2653
"	E	269	2499	3576	307	2499	3499	269	2423	3269
"	each	269	2615	3576	269	2615	3576	307	2615	3769
"	ease	346	2692	3384	307	2499	3230	307	2269	2846
"	eat	269	2538	3461	307	2615	3346	384	2499	2884
"	eke	384	2615	3692	307	2615	3653	230	2961	3384
"	eve	307	2692	3461	307	2576	3499	346	2076	2999
"	fatigue	269	2499	3115	346	2423	3153	346	2538	3115
"	heap	384	2653	3461	384	2576	3153	346	2115	2615
"	heath	269	2615	3346	346	2576	3153	346	2269	2884
"	heed	346	2615	3461	384	2615	3538	461	2153	2999
"	keen	307	2653	2653	346	2769	2769	346	2269	2269
"	O'Keefe	307	2423	3384	384	2384	3230	192	2230	2846
"	piece	384	2461	3461	346	2423	3269	307	2230	2884
"	quiche	307	2384	3346	346	2384	3192	307	2576	3115
"	scheme	384	2307	3384	346	2499	3230	307	1692	2730
"	siege	269	2346	2769	307	2615	3153	346	2384	3461
"	teethe	307	2576	3423	384	2461	3269	384	2076	2730
/ɪ/	dish	346	2115	2961	499	2192	2923	538	1961	2846
"	give	384	2384	3384	538	2192	2999	499	1461	2384
"	hick	423	2230	2846	423	2230	2769	461	2307	2653
"	him	307	2346	3115	384	2230	2769	423	1730	2576
"	hip	538	2115	2884	461	1999	2807	499	1769	2615
"	his	423	2115	2961	499	1999	2884	423	1807	2846
"	hiss	346	2076	2884	423	2038	2884	423	1884	2692
"	id	384	2269	3038	461	2230	2923	499	1846	2884
"	if	423	2230	2999	499	2153	2769	615	1884	2576
"	in	346	2269	2769	346	2076	2730	346	1807	2730
"	it	423	2230	2923	538	2153	2923	576	1961	2923
"	itch	461	2230	2923	423	2115	2923	423	1999	2923
"	midge	538	1999	2846	499	1999	2923	384	1923	2961
"	Pibb	538	2153	2884	538	2076	2884	538	1692	2576
"	pig	576	2269	2846	538	2115	2923	384	2423	2846
"	pith	538	2038	2807	615	1961	2884	499	1769	2730
/e/	A	538	2153	2923	499	2269	2923	576	2269	2807
"	Abe	461	2384	2884	538	2384	2999	461	1576	2461
"	ace	538	2307	2961	461	2384	2999	384	2192	2923
"	ache	384	2269	3038	499	2346	2999	384	2653	3038
"	age	499	2192	2961	423	2538	2923	384	2192	3038
"	aid	576	2307	3038	538	2576	3076	499	1884	2730
"	aim	499	2423	2999	499	2499	2999	384	1730	2653
"	ape	538	2384	3076	461	2423	3115	461	1692	2846
"	ate	423	2384	2923	538	2461	3038	423	2423	2961
"	beige	576	2038	2846	499	2384	2999	423	2269	2999
"	faith	615	2076	2653	538	2307	2999	461	2192	2884
"	H	499	2461	2999	461	2461	3153	307	2499	3269
"	haze	461	2230	2961	538	2307	2923	461	1884	2846
"	pain	346	2461	3192	423	2499	3115	423	2269	3076
"	pave	499	2269	2923	538	2307	2961	538	1769	2615
"	safe	615	1807	2692	538	2192	2923	423	2384	2961
"	scathe	499	2269	2999	461	2346	2999	384	1730	2653
"	vague	576	1961	2769	653	2230	2923	423	2384	2807
/ɛ/	Beth	692	1807	2730	730	1846	2730	769	1538	2692
"	Bev	692	1807	2730	769	1807	2807	615	1423	2615
"	ebb	692	1961	2807	807	1923	2846	576	1499	2615
"	Ed	615	2038	2846	653	1961	2884	538	1769	2884

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	edge	576	1999	2961	692	2038	2884	576	2038	3038
"	etch	692	2076	2846	730	2038	2807	730	1961	2923
"	F	692	1961	2769	769	1807	2692	769	1653	2499
"	heck	807	1923	2692	730	1884	2576	576	2038	2615
"	M	769	2076	2692	884	1999	2692	846	1499	2576
"	N	653	1961	2730	615	1961	2730	499	1807	2653
"	peg	692	1961	2730	653	2038	2807	576	2346	2884
"	pep	807	1884	2653	730	1807	2692	615	1730	2576
"	pet	807	1884	2846	769	1846	2846	692	1846	2807
"	Pez	692	1846	2884	653	1730	2846	538	1538	2769
"	S	692	1923	2846	769	1923	2653	807	1846	2730
"	Tesh	730	1807	2615	807	1807	2576	692	1846	2615
/æ/	add	807	1923	2730	884	1807	2692	692	1576	2615
"	Anne	423	2384	3115	423	2499	3307	384	1730	2692
"	ash	807	2153	2692	999	1807	2692	961	1730	2538
"	ass	923	1999	2769	999	1769	2692	961	1538	2615
"	at	807	1999	2846	999	1884	2692	653	1615	2769
"	badge	615	1961	2769	807	1846	2692	576	1846	2884
"	hack	999	1846	2576	961	1846	2538	769	1999	2499
"	hag	999	1961	2576	884	1846	2730	576	2230	2807
"	half	884	1999	2615	884	1846	2461	961	1615	2423
"	ham	538	2499	2999	423	2346	2653	423	1461	2076
"	has	961	2038	2769	846	1846	2769	653	1499	2730
"	hatch	999	1769	2461	961	1730	2461	884	1769	2692
"	path	884	1923	2615	846	1653	2538	730	1576	2461
"	perhaps	923	1730	2461	923	1692	2461	692	1384	2576
"	scab	576	2230	2884	884	1846	2461	769	1461	2307
/u/	douche	423	2230	2923	384	2038	2653	307	1884	2461
"	dude	461	2115	2769	499	1999	2576	384	1846	2576
"	goose	346	1807	2384	384	1692	2576	346	1807	2615
"	hoop	384	1230	2653	423	1269	2769	346	1038	2653
"	hoot	384	1384	2807	423	1499	2615	346	1884	2615
"	kook	384	1576	2538	423	1615	2461	346	1499	2499
"	move	384	1346	2653	346	1346	2653	461	1269	2576
"	ooze	307	1576	2538	423	1423	2538	346	1730	2653
"	pooch	384	1384	2653	346	1230	2615	307	1230	2461
"	rouge	384	1576	2153	423	1692	2307	423	1846	2307
"	soothe	461	1846	2653	461	1730	2461	384	1615	2615
"	spoof	423	1653	2538	307	1692	2384	346	1461	2499
"	spoon	384	1538	2499	461	1423	2538	423	1576	2538
"	stooge	346	2076	2769	346	1807	2653	384	2115	2461
"	tooth	384	1961	2653	461	1730	2346	346	1769	2423
"	tube	384	2076	2692	423	1884	2576	346	1269	2653
"	who	423	1307	2499	346	1230	2576	423	1346	2499
"	whom	346	1076	2730	346	1076	2730	346	1692	2653
/ʊ/	butch	499	1115	2769	461	1230	2576	576	1807	2346
"	hood	538	1346	2884	576	1269	2769	538	1769	2807
"	hoof	576	1538	2807	576	1499	2884	538	1346	2730
"	hook	538	1499	2653	538	1499	2653	461	1423	2692
"	push	538	1384	2461	423	1538	2307	461	1653	2230
"	puss	423	1307	2538	499	1384	2653	576	1499	2730
"	put	538	1192	2615	538	1461	2615	499	1807	2846
/o/	gauche	461	1884	2499	538	1461	2499	423	1384	2576
"	globe	576	1269	2807	576	1269	2884	423	999	2884
"	home	307	1038	1730	307	1038	1692	384	999	1846
"	hope	615	1192	2807	499	1115	2769	499	999	2769
"	hose	692	1384	2692	423	1192	2653	384	1538	2807
"	host	576	1346	2730	576	1269	2807	461	1346	2730
"	loathe	615	1384	2807	538	1269	2769	499	1269	2769
"	oaf	653	1346	2499	615	1192	2692	423	961	2730
"	oak	615	1538	2461	576	1461	2615	461	1115	2692
"	oat	576	1307	2769	576	1153	2730	461	1192	2692
"	oath	576	1346	2538	615	1230	2692	499	1153	2730
"	ode	615	1307	2653	499	1192	2615	499	1461	2192
"	owe	615	1423	2461	576	1269	2499	461	1038	2576
"	own	423	1269	1807	499	961	1807	384	1115	1807
"	poach	615	1461	2692	499	1384	2615	499	1230	2461
"	stove	576	1730	2653	538	1538	2538	538	1269	2499

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	vogue	615	1384	2346	615	1346	2499	576	1076	2538
/ɑ/	Goth	576	1653	2499	730	1269	2423	730	1230	2692
"	hob	730	1307	2423	692	1230	2461	615	1076	2538
"	hock	692	1192	2384	692	1230	2538	769	1423	2384
"	hodge	846	1307	2538	769	1269	2499	615	1692	2653
"	hog	846	1230	2307	692	1230	2307	692	1384	2346
"	hop	769	1230	2692	692	1269	2692	769	1230	2576
"	odd	730	1153	2499	692	1192	2538	615	1538	2461
"	off	692	1115	2461	692	1192	2499	730	1230	2461
"	on	961	1269	2384	961	1192	2384	923	1461	2346
"	ought	769	1115	2269	730	1192	2269	653	1384	2423
"	Oz	846	1153	2499	769	1192	2576	653	1461	2461
"	posh	692	1153	2384	653	1307	2423	769	1423	2346
"	Scotch	615	1576	2192	846	1576	2307	769	1461	2384
"	spa	692	1192	2307	730	1346	2576	846	1346	2576
"	Tom	923	1384	2576	961	1346	2461	999	1346	2346
"	toss	730	1307	2461	653	1230	2653	730	1230	2615
/ʌ/	hub	769	1576	2846	807	1461	2846	615	1192	2576
"	Huck	807	1461	2692	692	1423	2653	615	1576	2653
"	huff	769	1499	2499	692	1461	2576	692	1307	2461
"	hug	807	1423	2653	769	1538	2692	576	1576	2653
"	hum	923	1461	2461	846	1346	2692	884	1230	2461
"	hun	884	1423	2730	961	1423	2730	730	1576	2615
"	hush	884	1461	2692	807	1499	2653	692	1461	2576
"	hut	807	1538	2730	769	1499	2653	576	1653	2653
"	hutch	730	1538	2769	769	1538	2730	576	1769	2884
"	of	769	1461	2538	769	1384	2692	653	1346	2538
"	pudge	846	1423	2846	692	1461	2807	538	1923	2692
"	pus	807	1499	2730	769	1423	2807	769	1499	2923
"	scuzz	692	1807	2499	692	1538	2499	538	1538	2730
"	spud	615	1499	2730	769	1499	2730	576	1692	2730
"	up	807	1461	2576	807	1461	2730	730	1269	2730
[Ir]	ear	307	2461	3076	346	2461	3076	423	1961	2499
[Er]	air	615	2269	2730	615	2115	2769	576	1692	2423
[Ar]	are	769	1153	2307	730	1269	2269	692	1346	1923
[Or]	ore	269	961	2346	307	807	2192	346	1038	1884
[ɚ]	her	615	1576	1769	576	1384	1846	692	1461	1846
/il/	eel	346	2576	3423	307	2538	3192	461	2307	2769
/ɪl/	ill	346	2038	2884	423	1769	2846	538	1461	2769
/el/	ale	461	2192	2923	499	2307	2923	653	1384	2730
/ɛl/	L	807	1807	2807	807	1692	2807	769	1423	2807
/æl/	Al	807	1923	2730	961	1653	2576	769	1346	2692
/ul/	pool	307	846	2653	307	961	2807	423	961	2999
/ʊl/	pull	615	1153	2769	576	1076	2884	538	1076	2923
/ol/	hole	269	692	2423	423	846	2653	346	769	2884
/ɑl/	hall	846	1230	2538	653	1076	2692	576	961	2615
/ʌl/	hull	653	1115	2769	538	1038	2884	538	961	2769
<ing>	ping-	461	2153	2807	346	2653	2961	269	2692	2999
<eng>	length	423	1461	2692	461	1730	2769	384	1769	2576
<ang>	hang	307	2346	3230	384	2423	3115	384	2615	3076
<ong>	-pong	1076	1346	2307	1038	1269	2499	1076	1384	2461
<ung>	hung	961	1423	2615	884	1346	2692	923	1307	2499

Speaker 02: **Male, age 19. From Palo Alto (Northern California)**

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	307	2269	2846	307	2423	2923	384	2076	2576
"	E	307	2499	3499	269	2461	3423	307	2384	3153
"	each	230	2423	3423	346	2423	3461	307	2384	3269
"	ease	230	2423	3384	269	2461	3384	346	2153	2961
"	eat	346	2461	3461	307	2499	3423	384	2423	3384
"	eke	230	2461	3423	307	2499	3384	269	2461	3269
"	eve	269	2499	3307	230	2499	3384	384	2115	2769
"	fatigue	423	2192	2923	346	2230	2923	307	2384	2999

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	heap	384	2384	3038	346	2384	3115	423	2115	2923
"	heath	423	2499	3307	384	2461	3269	461	2384	2999
"	heed	346	2499	3384	423	2499	3346	346	1999	2846
"	keen	385	2692	3269	307	2769	3269	384	1999	2961
"	O'Keefe	307	2461	3384	346	2423	3269	384	2307	2923
"	piece	384	2499	3346	423	2423	3076	461	2269	3038
"	quiche	461	2538	3269	384	2499	3115	346	2307	3038
"	scheme	346	2615	3192	307	2576	3230	269	1692	2846
"	siege	423	2307	2884	461	2307	2884	346	2307	2961
"	teethe	346	2423	3307	269	2461	3307	346	1999	2884
/I/	dish	346	2269	2884	423	2153	2846	499	2038	2769
"	give	384	2153	2923	423	1923	2653	384	1538	2615
"	hick	461	1999	2846	499	1923	2730	423	2115	2692
"	him	384	1999	2923	384	1807	2846	423	1538	2730
"	hip	423	1999	2923	461	1923	2846	461	1692	2692
"	his	461	2115	2884	499	1999	2961	384	1807	2846
"	hiss	499	2076	2884	499	1999	2884	461	1884	2923
"	id	576	2076	2846	576	2038	2807	538	1923	2807
"	if	499	1923	2884	499	1884	2692	499	1807	2653
"	in	423	2115	2846	346	2038	2923	384	1769	2961
"	it	499	1999	2846	538	2038	2884	423	1884	2923
"	itch	499	2115	2884	538	2115	2961	384	1999	3076
"	midge	461	2076	2807	499	2076	2923	423	1999	2999
"	Pibb	538	1807	2807	499	1846	2807	461	1615	2730
"	pig	538	2038	2884	499	2153	2807	461	2192	2653
"	pith	499	2038	2846	461	1961	2846	538	1769	2769
/e/	A	461	2192	2846	423	2269	2999	461	2153	2961
"	Abe	423	2192	2846	384	2269	2999	423	1653	2576
"	ace	423	2230	2961	461	2346	3153	423	2192	2961
"	ache	538	2115	2923	461	2230	3038	499	2307	2923
"	age	461	2269	2884	423	2346	2999	423	2153	2884
"	aid	576	2153	2884	423	2384	2961	384	1999	2807
"	aim	423	2076	2884	423	2230	2999	384	1653	2769
"	ape	499	2230	2884	423	2423	2961	423	1884	2692
"	ate	499	2307	2961	461	2423	2999	384	2384	2961
"	beige	538	2038	2730	499	2230	2884	461	2076	2692
"	faith	499	2076	2807	499	2269	2884	423	2038	2884
"	H	499	2384	2884	499	2269	2884	384	2269	2923
"	haze	576	2307	3076	499	2307	2999	384	1999	2884
"	pain	346	2307	2999	346	2423	2923	346	1961	2807
"	pave	615	2384	2961	499	2423	2999	499	1846	2769
"	safe	538	1999	2807	499	2230	2884	423	2230	2846
"	scathe	538	2346	2884	461	2346	2884	499	1884	2807
"	vague	615	1846	2615	538	1999	2884	423	2307	2846
/ε/	Beth	576	1692	2692	692	1807	2692	615	1769	2730
"	Bev	615	1807	2769	615	1807	2769	576	1538	2769
"	ebb	692	1769	2884	538	1692	2846	461	1538	2653
"	Ed	499	2038	2807	576	1884	2846	576	1769	2769
"	edge	576	1961	2769	538	1961	2807	461	1961	2807
"	etch	653	1961	2730	653	1961	2923	576	2038	2961
"	F	615	1923	2846	653	1923	2807	653	1730	2807
"	heck	692	1884	2730	692	1999	2807	615	2038	2769
"	M	692	1884	2923	538	1846	2923	538	1576	2769
"	N	538	1884	2846	576	1884	2807	538	1692	2846
"	peg	615	2038	2807	538	2115	2923	499	2269	2846
"	pep	653	1730	2846	576	1653	2846	576	1576	2653
"	pet	653	1923	2807	615	1807	2807	576	1846	2807
"	Pez	653	1923	2769	499	1807	2807	461	1615	2769
"	S	653	1846	2884	615	1807	2846	576	1692	2807
"	Tesh	615	1923	2846	615	1884	2807	576	1846	2769
/æ/	add	807	1692	2653	846	1730	2730	730	1730	2846
"	Anne	346	2384	2999	346	2115	2884	346	1615	2884
"	ash	807	1692	2769	923	1769	2769	769	1923	2846
"	ass	692	1769	1653	884	1615	1653	807	1576	1538
"	at	807	1807	2730	884	1769	2769	692	1730	2923
"	badge	653	1846	2653	846	1730	2769	615	1884	2923
"	hack	923	1769	2769	923	1692	2769	884	1884	2615
"	hag	846	1846	2730	692	1923	2769	538	2230	2730

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	half	961	1769	2692	961	1653	2807	846	1615	2769
"	ham	461	2230	2961	538	2038	2807	538	1423	2884
"	has	846	1653	2692	769	1692	2769	576	1730	2923
"	hatch	999	1884	2769	884	1807	2769	846	1961	2807
"	path	846	1807	2923	884	1653	2730	961	1769	2730
"	perhaps	884	1615	2730	884	1730	2769	846	1538	2692
"	scab	461	2192	2692	769	1884	2538	615	1499	2499
/u/	douche	461	2038	2653	423	1884	2576	384	1653	2461
"	dude	423	1923	2653	423	1884	2384	499	1730	2384
"	goose	461	1769	2384	423	1576	2423	384	1730	2499
"	hoop	499	1307	2269	423	1230	2423	423	1038	2269
"	hoot	423	1499	2384	423	1269	2346	384	1307	2346
"	kook	384	1346	3384	346	1384	3461	269	1230	3499
"	move	461	1461	2384	423	1269	2384	423	1230	2423
"	ooze	423	1346	2307	423	1461	2269	423	1730	2423
"	pooch	538	1307	2384	461	1346	2384	423	1576	2384
"	rouge	461	1653	2307	384	1653	2384	461	1653	2307
"	soothe	499	1769	2576	384	1769	2576	346	1692	2692
"	spoof	499	1384	2423	384	1384	2307	461	1384	2461
"	spoon	423	1423	2384	307	1307	2576	384	1615	2576
"	stooge	423	1923	2653	461	1769	2461	461	1807	2346
"	tooth	423	1769	2346	423	1576	2384	384	1730	2423
"	tube	461	1961	2461	461	1807	2384	423	1346	2346
"	who	346	1153	2346	346	1076	2499	423	1153	2615
"	whom	423	1076	2461	346	999	2576	384	961	2615
/ʊ/	butch	615	1192	2653	499	1307	2615	461	1807	2423
"	hood	538	1461	2692	499	1499	2730	538	1807	2807
"	hoof	538	1346	2538	538	1269	2576	499	1307	2653
"	hook	653	1461	2576	576	1384	2615	499	1307	2384
"	push	615	1192	2538	538	1346	2499	576	1807	2461
"	puss	615	1307	2730	538	1461	2692	538	1807	2923
"	put	615	1269	2730	499	1538	2615	576	1730	2499
/o/	gauche	576	1576	2384	461	1269	2499	499	1730	2384
"	globe	615	1384	2846	538	1346	2769	576	1153	2730
"	home	346	961	2999	423	999	3076	423	923	3230
"	hope	576	1230	2615	576	1153	2615	576	1038	2653
"	hose	576	1499	3384	538	1346	3461	384	1576	3615
"	host	499	1423	2576	499	1192	2538	423	1499	2538
"	loathe	499	1230	2846	538	1423	2653	576	1538	2692
"	oaf	653	1538	2692	499	1269	2692	499	961	2615
"	oak	615	1346	2499	538	1192	2576	423	999	2576
"	oat	576	1423	2615	538	1230	2615	538	1538	2461
"	oath	653	1461	2692	576	1384	2692	538	1461	2576
"	ode	538	1384	2576	538	1230	2576	499	1615	2461
"	owe	653	1384	2615	499	1153	2576	499	999	2653
"	own	730	1307	2884	423	961	2730	384	1384	2692
"	poach	499	1307	2423	499	1230	2538	461	1615	2346
"	stove	538	1615	2730	576	1538	2730	499	1307	2653
"	vogue	538	1346	2615	576	1346	2538	461	1230	2423
/ɑ/	Goth	653	1769	2538	884	1307	2846	961	1615	2807
"	hob	769	1346	2769	807	1269	2807	653	1307	2730
"	hock	846	1346	2615	807	1346	2615	884	1461	2499
"	hodge	807	1269	2692	807	1384	2730	653	1807	2692
"	hog	961	1423	2692	884	1346	2769	615	1538	2576
"	hop	884	1423	2769	807	1423	2769	846	1384	2692
"	odd	730	1307	2769	846	1307	2807	692	1576	2769
"	off	884	1230	2923	884	1269	2961	923	1307	2923
"	on	807	1115	3269	769	1269	3269	730	1499	2961
"	ought	846	1230	2846	846	1307	2884	846	1615	2923
"	Oz	884	1346	2923	846	1269	2884	538	1538	2923
"	posh	884	1423	2730	923	1346	2653	923	1653	2692
"	Scotch	576	1730	2576	884	1576	2615	769	1999	2884
"	spa	692	1269	2538	769	1230	2576	807	1384	2576
"	Tom	807	1307	2961	884	1307	3192	923	1307	3038
"	toss	807	1423	2692	807	1230	2730	884	1423	2692
/ʌ/	hub	692	1499	2846	653	1423	2807	538	1423	2730
"	Huck	653	1576	2769	653	1576	2846	538	1615	2769

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	huff	846	1423	2884	769	1423	2961	730	1346	2884
"	hug	692	1538	2653	615	1615	2615	499	1692	2384
"	hum	846	1346	2999	730	1384	2961	730	1230	2923
"	hun	730	1499	3076	769	1576	3076	769	1615	2923
"	hush	807	1499	2807	692	1653	2730	692	1846	2807
"	hut	807	1538	2923	730	1730	2846	692	1692	2961
"	hutch	807	1653	2769	730	1692	2730	692	1961	2730
"	of	692	1615	2576	576	1499	2807	538	1384	2538
"	pudge	692	1461	2692	538	1692	2730	499	1961	2730
"	pus	769	1423	2692	692	1576	2692	653	1692	2846
"	scuzz	576	2038	2538	692	1653	2692	538	1576	2884
"	spud	653	1461	2653	576	1615	2769	461	1692	2923
"	up	769	1499	2692	692	1499	2769	538	1384	2692
[Ir]	ear	269	2269	2846	384	2269	2769	499	1730	2346
[Er]	air	538	2153	2769	576	1961	2653	576	1653	2307
[Ar]	are	769	1307	2461	807	1115	2653	730	1346	2346
[Or]	ore	423	807	2923	423	923	2807	538	1192	2307
[ɚ]	her	576	1423	1769	461	1384	1730	576	1384	1769
/il/	eel	269	2461	3423	384	2461	3346	384	2384	3115
/ɪl/	ill	538	2038	2769	538	1846	2961	576	1423	2999
/el/	ale	538	2192	2923	499	2230	2923	615	1884	2923
/ɛl/	L	615	1653	2807	576	1576	2884	653	1269	3038
/æl/	Al	923	1576	2769	999	1499	2769	730	1269	2769
/ul/	pool	384	769	2884	384	729	2769	346	769	2846
/ʊl/	pull	538	1038	2884	538	1038	2884	538	1038	2846
/ol/	hole	461	769	2999	346	769	3192	384	807	3076
/ɑl/	hall	807	1115	2999	730	1038	2961	653	1153	3269
/ʌl/	hull	692	1192	3115	730	1038	3076	615	961	3076
<ing>	ping-	346	2153	2807	346	2192	2653	269	2230	2615
<eng>	length	423	1384	2846	423	1884	2769	346	2384	2730
<ang>	hang	346	2153	2884	423	2192	2884	346	2423	2807
<ong>	-pong	807	1269	2807	884	1346	2923	730	1346	2884
<ung>	hung	884	1576	2884	846	1423	2961	692	1384	2730

Speaker 03: Male, age 23. From El Monte (Southern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	384	2807	3653	384	2769	3653	384	2423	3499
"	E	346	2846	3461	461	2884	3269	269	2846	3230
"	each	307	2961	3192	384	2961	3230	346	2846	3384
"	ease	384	2846	3307	461	2884	3307	307	2115	3038
"	eat	423	2884	3807	346	2884	3692	384	2807	3461
"	eke	461	2807	3499	384	2807	3499	346	2999	3499
"	eve	346	2807	3692	346	2807	3807	461	2499	3307
"	fatigue	384	2538	2999	423	2653	3115	384	2615	3115
"	heap	384	2846	3653	346	2807	3615	384	2846	3538
"	heath	461	2961	3076	423	2961	3576	384	2692	3115
"	heed	423	2846	3499	346	2807	3615	384	2615	3499
"	keen	461	2923	3615	346	2923	3730	461	2961	3653
"	O'Keefe	346	2730	3384	307	2807	3346	423	2692	3384
"	piece	384	2846	3538	269	2730	3538	423	2576	3153
"	quiche	307	2884	3499	346	2769	3538	384	2923	3230
"	scheme	499	3153	3423	423	2923	3346	423	2807	3499
"	siege	384	2461	2999	346	2807	3230	423	2307	3038
"	teethe	423	2653	3269	384	2807	3230	461	2346	2999
/ɪ/	dish	461	2230	3038	576	2192	2923	538	2230	2923
"	give	384	2423	3038	538	2192	2961	538	1769	2807
"	hick	461	2384	3192	615	2230	3192	576	2192	3038
"	him	461	2346	3192	499	2115	3115	653	1461	3038
"	hip	423	2307	3192	538	2192	2999	615	1961	2807
"	his	461	2230	3038	538	2153	3038	461	1846	3076
"	hiss	499	2230	3076	538	2115	3038	461	1961	3153
"	id	461	2346	3076	499	2307	3192	499	2115	3038
"	if	499	2307	3076	653	2115	2999	615	1807	2807
"	in	461	2499	3269	461	2307	3346	423	1884	3230

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	it	461	2423	3192	499	2269	3153	538	2115	3076
"	itch	384	2384	3153	423	2461	3230	499	2076	3076
"	midge	615	2153	2961	499	2346	3153	461	2230	3192
"	Pibb	499	2230	2999	423	2192	3038	538	2038	2807
"	pig	615	2269	2961	499	2230	3076	461	2307	2884
"	pith	653	2115	3153	615	2076	3076	576	1923	3038
/e/	A	499	2423	3230	499	2576	3269	423	2538	3269
"	Abe	576	2615	3153	461	2653	3192	461	2076	2884
"	ace	461	2692	3076	461	2884	3230	423	2423	3076
"	ache	653	2653	3153	538	2730	3115	499	2846	3115
"	age	499	2615	3076	461	2692	2961	384	2576	2999
"	aid	499	2653	3115	461	2692	3076	384	2192	2961
"	aim	615	2730	3115	538	2846	3192	538	2653	3115
"	ape	538	2653	3192	499	2769	3230	423	2923	3038
"	ate	499	2576	2999	423	2807	3192	307	2846	3230
"	beige	653	2423	2846	576	2576	3153	423	2307	2923
"	faith	615	2076	2769	653	2499	3076	615	2346	3115
"	H	499	2884	3192	384	2884	3192	423	2692	3153
"	haze	461	2615	3115	423	2730	3230	307	2192	2961
"	pain	499	2538	3230	461	2692	3269	384	2884	3269
"	pave	576	2423	3115	461	2423	3153	461	1730	2884
"	safe	653	2038	2961	538	2499	3038	576	1961	2769
"	scathe	384	2653	2999	423	2499	3192	423	2153	2923
"	vague	615	2307	2884	576	2346	3076	615	2423	2961
/ɛ/	Beth	653	1923	2884	769	1923	2846	730	1653	2807
"	Bev	653	2038	2961	692	1961	2884	653	1538	2846
"	ebb	769	2153	3038	730	2038	3115	653	1692	2807
"	Ed	499	2346	3153	615	2192	3038	615	2076	3115
"	edge	653	2307	3115	692	2269	2999	538	2038	3153
"	etch	461	2115	3076	653	2115	2961	538	2076	2961
"	F	692	2076	2807	692	1846	2884	615	1653	2884
"	heck	846	2153	2999	769	2038	2923	769	1999	2769
"	M	615	2192	3192	615	2115	3269	615	1499	3115
"	N	576	2384	3076	538	2192	3115	538	1846	2999
"	peg	653	2461	3038	576	2346	3076	538	2423	3038
"	pep	615	1961	2961	692	1999	2846	692	1923	2807
"	pet	807	2076	2999	807	2115	2961	769	2038	3038
"	Pez	692	2076	2961	615	1923	2999	499	1769	2999
"	S	653	2153	2961	884	1923	3038	730	1807	2884
"	Tesh	846	2153	3115	769	2038	2999	730	1999	3076
/æ/	add	807	2153	2923	884	1999	2884	653	1884	2923
"	Anne	615	2384	3115	538	2038	2999	461	1653	2999
"	ash	923	1999	2884	923	1923	2807	961	1807	2846
"	ass	961	2038	2999	1038	1884	2846	1038	1730	2923
"	at	961	2153	2999	884	1999	2923	961	1807	2884
"	badge	615	2115	2884	884	2038	2884	653	1961	2999
"	hack	923	2076	2961	961	1961	2730	1076	1999	2846
"	hag	923	2115	2961	923	1961	2999	769	2038	2730
"	half	1076	1961	2846	999	1846	2807	1076	1807	2807
"	ham	846	2192	3038	961	1807	2999	653	1230	2961
"	has	999	1999	2884	884	1961	2884	692	1769	2923
"	hatch	999	1961	2730	884	1846	2769	884	1923	2884
"	path	1038	1884	2807	961	1692	2884	923	1653	2884
"	perhaps	923	1999	2769	961	1884	2807	807	1615	2769
"	scab	576	2461	2807	807	1999	2807	846	1692	2730
/u/	douche	346	1923	2576	269	1423	2653	423	1730	2692
"	dude	499	2346	2692	461	1961	2730	461	1884	2499
"	goose	461	1730	2653	461	1576	2769	346	1692	2807
"	hoop	423	1153	2923	423	1115	2807	384	1076	2730
"	hoot	461	1307	2615	384	1230	2692	346	1192	2692
"	kook	384	1384	2807	423	1230	2692	384	1269	2807
"	move	423	1076	2653	461	1230	2846	538	1076	2653
"	ooze	461	1269	2692	423	1269	2615	423	1653	2653
"	pooch	538	1115	2653	423	1115	2692	346	1269	2730
"	rouge	461	1269	2346	461	1153	2499	423	1653	2384
"	soothe	461	1730	2807	461	1576	2692	423	1538	2846
"	spoof	461	1423	2615	499	1346	2807	423	1269	2730
"	spoon	538	1423	2730	538	1269	2846	538	1423	2692

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	stooge	461	1923	2846	461	1807	2653	384	2076	2692
"	tooth	384	1846	2730	384	1615	2807	384	1499	2807
"	tube	499	1846	2730	461	1730	2769	499	1307	2769
"	who	538	1153	2615	461	1153	2615	423	1115	2576
"	whom	576	1076	2307	423	999	2423	499	999	2346
/ʊ/	butch	538	1269	2884	576	1384	2846	615	1961	2884
"	hood	653	1538	2884	576	1538	2846	615	1846	2961
"	hoof	576	1499	2807	615	1423	2807	576	1461	2961
"	hook	538	1384	2846	615	1384	2730	576	1384	2730
"	push	576	1423	2730	653	1499	2730	576	1846	2730
"	puss	692	1269	2961	615	1461	2961	653	1730	2999
"	put	576	1346	2769	576	1499	2884	499	1807	2884
/o/	gauche	499	1230	2538	461	1153	2576	499	1230	2653
"	globe	499	961	2923	615	1230	2807	461	1076	2692
"	home	461	1076	3038	499	923	3038	499	961	3115
"	hope	576	1192	2692	576	1115	2653	538	999	2730
"	hose	653	1346	2846	538	1192	2769	461	1538	2807
"	host	653	1269	2769	499	1192	2807	499	1384	2923
"	loathe	653	1384	3153	653	1461	2923	538	1384	2807
"	oaf	538	1307	2653	576	1076	2692	538	1076	2769
"	oak	576	1153	2730	499	1115	2730	576	1038	2730
"	oat	653	1423	2615	653	1269	2769	423	1230	2807
"	oath	576	1384	2653	499	1153	2846	461	1269	2807
"	ode	576	1269	2769	576	1153	2730	499	1423	2653
"	owe	615	1346	2653	615	1076	2807	384	1076	2692
"	own	538	1192	2846	461	999	2884	499	1076	2884
"	poach	615	1346	2653	538	1153	2653	499	1192	2730
"	stove	653	1730	2692	576	1269	2653	538	1115	2692
"	vogue	692	1307	2576	615	1230	2692	538	999	2884
/ɑ/	Goth	653	1461	2615	884	1269	2807	846	1384	2846
"	hob	884	1461	2769	923	1461	2807	692	1346	2769
"	hock	884	1269	2923	884	1269	2923	884	1307	2769
"	hodge	884	1384	2884	846	1423	2807	576	1923	2999
"	hog	807	1307	2653	923	1346	2615	653	1576	2615
"	hop	1076	1461	2807	999	1499	2769	961	1423	2730
"	odd	884	1423	2846	999	1499	2846	615	1884	2999
"	off	961	1461	2807	884	1384	2807	846	1384	2730
"	on	884	1346	2961	923	1384	2961	730	1730	2999
"	ought	923	1346	2807	846	1269	2807	807	1499	2807
"	Oz	846	1384	2884	846	1461	2769	653	1653	2961
"	posh	961	1461	2923	884	1423	2769	884	1769	2615
"	scotch	730	1615	2461	884	1346	2884	999	1538	2807
"	spa	730	1499	2730	846	1499	2884	807	1730	2769
"	Tom	961	1423	2923	1153	1384	2923	1230	1346	2884
"	toss	1038	1615	2769	961	1538	2769	730	1576	2730
/ʌ/	hub	769	1538	2846	692	1423	2884	615	1346	2769
"	huck	923	1615	2769	807	1499	2884	769	1461	2807
"	huff	807	1653	2807	692	1461	2730	730	1499	2807
"	hug	961	1730	2769	692	1653	2846	576	1615	2884
"	hum	730	1423	2384	692	1346	2230	692	1269	2307
"	hun	730	1576	2461	730	1538	2423	653	1846	2384
"	hush	807	1653	2923	730	1653	2730	615	1923	2961
"	hut	807	1653	2846	807	1653	2999	692	1923	2923
"	hutch	692	1615	2807	769	1653	2884	692	1923	2846
"	of	769	1499	2884	807	1499	2846	576	1423	2807
"	pudge	846	1615	2884	730	1653	2999	576	1999	3115
"	pus	884	1461	2961	846	1653	2807	730	1615	3076
"	scuzz	538	1961	2730	653	1769	2884	615	1692	2999
"	spud	615	1576	2730	692	1846	2961	615	1961	3038
"	up	730	1538	2884	730	1576	2846	653	1499	2961
[Ir]	ear	307	2807	3423	423	2653	3230	461	2038	2576
[Er]	air	615	2461	2961	615	2423	2884	576	2192	2461
[Ar]	are	807	1307	2615	807	1307	2615	807	1423	2115
[Or]	ore	384	999	2692	499	846	2615	615	1115	2153
[ɚ]	her	730	1461	1961	576	1423	1961	538	1769	1884
/il/	eel	307	2769	3615	346	2769	3461	499	2038	3153

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/ɪl/	ill	423	2192	3192	499	2038	3076	538	1538	3038
/el/	ale	576	2576	2999	538	2461	2961	499	2192	2961
/ɛl/	L	692	2076	2999	807	1846	3076	653	1346	2999
/æl/	Al	999	1961	2769	961	1807	2846	999	1576	2961
/ul/	pool	538	923	2692	423	999	2576	538	999	2846
/ʊl/	pull	461	1076	3615	423	961	3461	384	1076	3692
/ol/	hole	615	1038	2807	461	961	2807	346	846	2884
/ɑl/	hall	807	1230	2846	884	1115	2961	807	1153	3153
/ʌl/	hull	653	1153	2999	615	1076	3115	576	999	3153
<ing>	ping	538	2730	3192	461	2730	3192	423	2807	3115
<eng>	length	730	1538	3346	692	2115	3346	615	2653	3269
<ang>	hang	653	2499	3076	653	2461	3269	653	2653	3153
<ong>	pong	884	1307	2692	961	1307	2807	884	1346	2884
<ung>	hung	769	1423	2461	730	1423	2384	730	1423	2346

Speaker 04: Female, age 29. From Modesto (Northern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	461	1923	2461	346	2461	3038	499	2076	2692
"	E	461	2423	3192	384	2307	3038	384	2346	2923
"	each	423	2499	3076	423	2538	3076	307	2384	3038
"	ease	423	2538	3192	346	2461	2999	307	2115	2692
"	eat	384	2499	3269	461	2576	3115	384	2423	3153
"	eke	307	2384	2999	346	2384	3038	346	2384	3038
"	eve	423	2384	2999	384	2423	3076	307	2076	2807
"	fatigue	384	2384	2884	423	2346	2923	346	2307	2692
"	heap	384	2499	2961	384	2499	3307	307	2461	3076
"	heath	384	2538	3038	384	2576	2961	346	2346	2999
"	heed	384	2692	3038	346	2653	3076	346	2269	2961
"	keen	423	2615	3115	499	2538	2884	384	2576	2923
"	O'Keefe	346	2461	2961	384	2346	2999	384	2423	2884
"	piece	461	2423	2923	384	2423	2923	346	2346	2807
"	quiche	384	2423	2999	346	2346	2923	346	2423	2846
"	scheme	423	2307	2884	384	2461	2884	384	2423	2769
"	siege	384	2115	2692	423	2423	2884	461	2307	2730
"	teethe	423	2384	2884	423	2423	2846	423	1999	2653
/ɪ/	dish	499	1999	2769	499	1884	2692	538	1961	2653
"	give	423	2307	2730	423	1884	2615	423	1499	2384
"	hick	499	2076	2576	461	1999	2576	538	2038	2384
"	him	384	1999	2423	346	1999	2538	538	1807	2461
"	hip	538	2115	2692	576	1961	2615	499	1807	2538
"	his	461	2038	2538	423	1846	2499	346	1692	2307
"	hiss	653	1961	2499	615	1884	2499	499	1846	2538
"	id	538	2192	2769	499	2076	2807	576	1961	2692
"	if	538	1999	2730	576	1884	2692	499	1807	2499
"	in	423	2153	2884	346	2038	2807	384	1923	2692
"	it	499	2192	2769	384	2115	2692	423	1923	2692
"	itch	423	2153	2846	461	2192	2884	423	1999	2730
"	midge	576	1769	2538	499	1923	2730	499	1846	2653
"	Pibb	576	2038	2769	423	1846	2576	576	1615	2423
"	pig	538	2269	2615	461	2076	2692	384	2230	2807
"	pith	615	2076	2730	538	2076	2807	499	2076	2615
/e/	A	692	2192	2692	499	2153	2846	499	2307	2807
"	Abe	499	2269	2846	576	2346	2846	423	1692	2384
"	ace	461	2192	2730	461	2192	2730	423	2269	2769
"	ache	538	2076	2923	499	2192	2807	423	2346	2730
"	age	499	2269	3038	423	2461	3115	384	2346	2961
"	aid	576	2115	2730	423	2384	2999	384	2384	2923
"	aim	461	2307	2923	499	2538	3076	423	2230	2846
"	ape	538	2269	3038	423	2423	2999	384	2461	2961
"	ate	461	2346	2923	423	2461	3038	384	2384	2961
"	beige	461	1961	2730	384	2423	2923	423	2269	2769
"	faith	538	1846	2499	499	2153	2769	307	2192	2884
"	H	615	2192	2769	499	2346	2961	384	2307	2923
"	haze	538	2230	2769	461	2346	2923	499	1923	2461
"	pain	461	2384	2807	538	2384	2730	461	2192	2846

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	pave	576	2269	2769	499	2384	2846	461	1653	2499
"	safe	461	1923	2538	538	2076	2653	423	2076	2538
"	scathe	538	2038	2692	461	2153	2730	423	1884	2499
"	vague	576	1884	2423	423	2153	2730	499	2230	2538
/ɛ/	Beth	692	1692	2461	692	1730	2538	692	1615	2461
"	Bev	692	1692	2538	653	1615	2499	538	1384	2384
"	ebb	692	1846	2730	615	1846	2769	576	1692	2692
"	Ed	692	1961	2807	615	1961	2807	423	1884	2807
"	edge	615	1961	2653	653	1884	2730	461	1884	2730
"	etch	692	1884	2692	615	1846	2692	615	1807	2692
"	F	730	1807	2499	730	1769	2384	730	1807	2461
"	heck	769	1846	2423	692	1846	2423	692	1846	2384
"	M	615	2115	2653	615	1923	2499	615	1615	2384
"	N	538	2153	2769	499	2076	2846	423	1807	2730
"	peg	615	2076	2807	499	1923	2692	461	2038	2576
"	pep	884	1884	2423	807	1730	2461	692	1615	2384
"	pet	884	1884	2730	769	1884	2807	692	1846	2730
"	Pez	730	1923	2769	576	1769	2576	423	1653	2423
"	S	730	1923	2461	692	1807	2461	692	1730	2461
"	Tesh	884	1961	2615	807	1884	2615	846	1846	2538
/æ/	add	884	1884	2692	923	1692	2576	769	1769	2615
"	Anne	769	2192	2730	769	1884	2576	653	1653	2423
"	ash	807	1923	2615	884	1730	2538	807	1769	2384
"	ass	807	1846	2653	999	1730	2423	923	1653	2499
"	at	807	1846	2615	961	1807	2692	884	1692	2538
"	badge	653	1923	2615	769	1884	2653	615	1769	2653
"	hack	961	1807	2769	1038	1807	2807	961	1769	2884
"	hag	846	1884	2653	769	1769	2615	653	1923	2461
"	half	884	1615	2692	999	1615	2769	999	1538	2615
"	ham	730	2230	2769	769	1923	2730	769	1499	2307
"	has	807	1730	2576	807	1692	2499	461	1538	2461
"	hatch	884	1884	2423	884	1807	2423	884	1730	2692
"	path	923	1807	2615	923	1653	2615	846	1576	2538
"	perhaps	846	1692	2461	846	1615	2461	769	1499	2269
"	scab	615	1923	2576	653	1846	2461	615	1576	2307
/u/	douche	423	1923	2615	384	1461	2423	499	1499	2384
"	dude	423	1923	2307	384	1499	2269	384	1615	2269
"	goose	499	1769	2346	423	1384	2346	384	1538	2307
"	hoop	346	1307	2384	461	1192	2384	461	999	2423
"	hoot	384	1076	2423	461	1115	2384	423	999	2423
"	kook	461	1307	2346	423	1230	2346	499	1038	2346
"	move	499	1307	2423	461	1115	2269	499	1038	2269
"	ooze	461	1153	2384	384	1153	2307	461	1653	2307
"	pooch	499	1115	2461	499	999	2461	384	1230	2423
"	rouge	461	1307	1807	461	1346	1961	461	1653	2038
"	soothe	346	1923	2538	384	1499	2423	346	1576	2384
"	spoof	384	1192	2346	307	1115	2384	384	1076	2461
"	spoon	423	1192	2230	423	999	2269	346	1461	2384
"	stooge	499	1769	2384	461	1307	2307	384	1730	2307
"	tooth	384	1884	2461	346	1653	2423	384	1615	2538
"	tube	423	1730	2384	423	1499	2423	307	961	2346
"	who	499	1307	2269	461	1115	2269	423	1038	2269
"	whom	307	884	2576	423	961	2461	346	807	2307
/ʊ/	butch	538	1115	2346	499	1307	2346	461	1576	2307
"	hood	692	1461	2538	576	1461	2653	576	1692	2615
"	hoof	499	1192	2346	499	1230	2423	499	1307	2384
"	hook	499	1461	2269	576	1307	2307	615	1346	2192
"	push	769	1384	2384	692	1461	2384	653	1653	2153
"	puss	653	1269	2153	692	1423	2346	576	1384	2461
"	put	576	1384	2307	615	1346	2230	576	1384	2153
/o/	gauche	461	1692	2192	499	1499	2115	461	1230	2192
"	globe	576	1346	2423	576	1153	2346	499	999	2423
"	home	423	1038	2346	461	884	2423	384	807	2461
"	hope	499	1076	2192	538	999	2230	423	923	2192
"	hose	730	1538	2384	461	1076	2384	423	1538	2423
"	host	730	1423	2384	653	1307	2461	538	1115	2423
"	loathe	615	1423	2499	538	1230	2307	576	1269	2384

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	oaf	499	1269	2230	384	1038	2384	346	923	2307
"	oak	615	1307	2346	461	1269	2269	499	1076	2230
"	oat	576	1307	2307	461	1230	2384	461	1076	2307
"	oath	576	1423	2230	499	1269	2307	499	1346	2346
"	ode	499	1423	2269	423	1192	2307	461	1499	2153
"	owe	653	1384	2153	538	1038	2423	461	961	2230
"	own	653	1384	2230	499	999	2346	576	923	2307
"	poach	538	1307	2346	461	1153	2346	461	1192	2346
"	stove	461	1615	2346	576	1307	2153	499	1153	2153
"	vogue	653	1307	2230	615	1269	2230	538	1115	2346
/ɑ/	Goth	807	1499	2307	692	1346	2346	769	1346	2384
"	hob	769	1230	2346	846	1346	2230	615	1307	2230
"	hock	884	1307	2346	884	1192	2423	923	1192	2423
"	hodge	846	1461	1692	884	1576	1615	846	1423	1615
"	hog	807	1230	2230	807	1230	2384	576	1384	2269
"	hop	961	1384	2346	923	1384	2423	846	1307	2307
"	odd	769	1230	2461	846	1307	2307	692	1615	2538
"	off	884	1346	2230	884	1423	2269	884	1307	2423
"	on	769	1192	2192	807	1115	2153	923	1461	2153
"	ought	807	1346	2307	846	1307	2269	730	1423	2307
"	Oz	692	1384	2384	730	1269	2423	538	1576	2384
"	posh	884	1307	2153	923	1269	2307	923	1538	2307
"	Scotch	884	1653	2230	846	1423	2269	769	1461	2192
"	spa	846	1192	2269	846	1230	2307	846	1269	2307
"	Tom	1076	1346	2115	1038	1269	2153	923	1153	1961
"	toss	846	1307	2192	846	1269	2269	769	1384	2269
/ʌ/	hub	769	1461	2346	653	1461	2384	576	1346	2307
"	Huck	807	1384	2538	730	1384	2384	653	1461	2346
"	huff	730	1384	2192	653	1384	2269	730	1499	2192
"	hug	730	1538	2384	730	1538	2384	653	1499	2384
"	hum	846	1346	2423	730	1384	2307	846	1307	2192
"	hun	807	1499	2307	807	1499	2384	730	1461	2461
"	hush	884	1576	2346	846	1615	2423	692	1576	2423
"	hut	923	1576	2346	730	1615	2384	653	1653	2423
"	hutch	807	1692	2384	653	1576	2384	538	1615	2615
"	of	807	1423	2423	846	1461	2423	615	1423	2384
"	pudge	884	1615	2307	730	1576	2461	769	1769	2653
"	pus	923	1499	2192	846	1499	2269	692	1576	2230
"	scuzz	538	1769	2307	538	1576	2384	423	1576	2346
"	spud	692	1499	2307	576	1499	2307	576	1615	2423
"	up	846	1538	2384	807	1423	2423	730	1461	2384
[Ir]	ear	384	2461	2923	423	2307	2615	384	1730	2153
[Er]	air	499	2115	2615	499	1961	2423	499	1653	2038
[Ar]	are	692	1384	1999	730	1346	1884	730	1461	1807
[Or]	ore	538	999	1961	423	961	1961	538	1346	1846
[ɚ]	her	615	1538	1884	538	1423	1846	461	1461	1884
/il/	eel	423	2461	3076	384	2346	3038	384	1692	2576
/ɪl/	ill	499	2038	2615	499	1961	2538	461	1615	2499
/el/	ale	499	2192	2653	499	2076	2730	384	1923	2115
/ɛl/	L	807	1576	2461	692	1384	2384	615	1230	2269
/æl/	Al	923	1576	2538	1038	1576	2384	923	1538	2499
/ul/	pool	423	961	2653	423	961	2538	307	807	2653
/ʊl/	pull	423	1038	2499	499	999	2499	461	884	2384
/ol/	hole	615	1115	2038	346	846	2192	346	769	2076
/ɑl/	hall	846	1269	2307	730	1076	2230	653	1115	2192
/ʌl/	hull	730	1269	2230	499	1038	2230	615	961	2269
<ing>	ping-	461	2307	2730	384	2346	2769	423	2307	2769
<eng>	length	692	1384	2423	692	1846	2423	576	2076	2615
<ang>	hang	769	2038	2576	653	2192	2692	653	2346	2615
<ong>	-pong	807	1346	1923	807	1192	1884	692	1230	1846
<ung>	hung	846	1346	2153	769	1384	2153	769	1461	2269

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Speaker 05: Female, Age 21. **From El Monte (Southern California)**

vowel	word		T1			T2			T3	
		E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	461	1961	2807	423	2461	2961	423	1961	2653
"	E	423	2846	3269	461	2884	3192	423	2499	3076
"	each	384	2884	3192	423	2923	3269	307	2769	3307
"	ease	307	2999	3192	384	2846	3269	423	2307	2999
"	eat	384	2884	3153	384	2846	3192	346	2846	3153
"	eke	423	2846	3192	423	2807	3230	269	2769	3230
"	eve	384	2884	3230	423	2730	3307	384	2153	2730
"	fatigue	384	2730	3192	384	2576	3115	384	2538	3038
"	heap	461	2846	3153	384	2884	3230	346	2038	2846
"	heath	461	2692	3153	384	2653	3115	461	2346	2961
"	heed	423	2769	3269	423	2923	3230	346	2692	3076
"	keen	461	2961	3461	384	2923	3307	461	2730	3192
"	O'Keefe	384	2692	3192	423	2538	2999	384	2461	2807
"	piece	423	2730	3230	423	2692	3192	384	2538	3038
"	quiche	423	2884	3307	423	2846	3153	346	2653	3038
"	scheme	307	2730	3384	423	2730	3346	423	2269	2884
"	siege	423	2384	3153	461	2538	3076	384	2384	2923
"	teethe									
/ɪ/	dish	461	2038	2961	461	1999	2884	461	2076	2923
"	give	499	2423	3307	538	2115	3038	499	1884	2846
"	hick	538	2269	2884	499	2192	2923	499	2269	2769
"	him	423	2153	3076	384	2115	3038	384	1730	2923
"	hip	538	2153	3038	499	1999	3076	461	1884	2884
"	his	461	2115	2961	423	2076	2846	423	1884	2923
"	hiss	461	2153	3038	538	2038	3038	499	1961	2884
"	id	499	2230	2999	461	2115	2999	538	1961	2999
"	if	538	2115	2923	499	1999	2923	461	1807	2846
"	in	576	2307	3038	499	2230	3076	576	2038	2961
"	it	461	2384	2961	538	2307	3115	499	2076	2999
"	itch	423	2346	3115	461	2269	3076	461	2076	3153
"	midge	576	1999	2923	499	2192	3076	499	2153	3038
"	Pibb	615	2038	2999	576	1999	3038	653	1692	2807
"	pig	615	2115	3076	576	2115	3076	461	2307	2769
"	pith	576	2038	3076	576	1999	2961	499	1961	2999
/e/	A	576	2346	3038	461	2615	3192	499	2423	2923
"	Abe	499	2269	2961	423	2499	2999	461	1846	2769
"	ace	499	2423	2884	423	2423	2923	423	2423	2884
"	ache	499	2461	2999	461	2423	2999	384	2692	2923
"	age	576	2307	2961	423	2461	2999	423	2230	2961
"	aid	538	2576	3038	346	2499	3076	461	2346	2961
"	aim	615	2384	2923	499	2499	2999	423	2115	2846
"	ape	538	2615	3076	423	2692	3192	423	2230	3038
"	ate	576	2653	3153	461	2576	2999	499	2576	2961
"	beige	461	2192	2923	499	2461	2961	499	2346	2923
"	faith	499	2230	2923	538	2423	3038	499	2346	3038
"	H	499	2461	2999	499	2538	2923	384	2423	2999
"	haze	538	2499	2999	461	2576	3076	499	2076	2923
"	pain	499	2576	2999	576	2653	3038	576	2730	2923
"	pave	576	2423	3038	423	2346	2999	461	1730	2692
"	safe	615	2076	3076	538	2346	3038	538	2038	2846
"	scathe									
"	vague	538	1961	2846	538	2192	2999	461	2538	2923
/ɛ/	Beth	730	1961	2846	769	1846	2961	846	1846	2999
"	Bev	692	1961	2923	730	1999	3076	691	1769	2807
"	ebb	807	1961	2961	769	2038	3153	730	1653	2730
"	Ed	730	2115	2999	692	2076	2999	538	1923	3038
"	edge	730	2038	3076	807	2038	3038	615	1923	3076
"	etch	807	2038	2961	769	2153	3076	615	2038	3153
"	F	807	1884	2961	846	1923	3153	961	1730	3076
"	heck	923	1961	2846	923	1961	2807	884	1961	2653
"	M	730	2153	2999	807	2076	3115	730	1730	2999
"	N	730	2076	3038	692	1961	3115	730	1884	3230
"	peg	499	2384	2999	423	2423	2961	499	2499	2923
"	pep	730	1961	3038	807	1807	2999	846	1730	2999
"	pet	923	1961	2923	807	1961	2923	884	1961	2884
"	Pez	884	2076	2961	923	1961	2961	576	1846	3038

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	S	846	1961	2884	730	2038	2923	807	1923	2961
"	Tesh	884	2038	2999	846	1923	2999	807	1923	2923
/æ/	add	846	1961	2884	961	1884	2846	692	1923	3038
"	Anne	923	2115	3038	846	1961	2961	846	1807	3038
"	ash	961	1923	2730	884	1769	2730	884	1730	2807
"	ass	884	1923	2807	923	1807	2846	846	1769	2846
"	at	923	1999	2884	846	1846	2846	884	1884	2846
"	badge	846	1923	2999	923	1846	2961	730	1884	3230
"	hack	961	1846	2923	1038	1769	2730	999	1884	2653
"	hag	961	1999	3038	1038	1884	3038	846	2076	2769
"	half	961	1807	2769	961	1692	2730	884	1730	2615
"	ham	923	2115	2923	769	1884	2999	692	1653	2999
"	has	999	1846	2961	961	1846	2961	692	1769	3076
"	hatch	961	1923	2538	923	1807	2576	884	1884	2769
"	path	961	1923	2961	1076	1846	2999	1038	1730	2923
"	perhaps	961	1846	2769	923	1769	2730	884	1692	2807
"	scab	884	2115	2807	807	1846	2884	884	1653	2884
/u/	douche	423	2230	2807	423	2076	2653	346	2153	2692
"	dude	499	2153	2807	423	1999	2769	499	1846	2692
"	goose	423	1807	2692	499	1653	2730	461	1769	2730
"	hoop	499	1538	2730	499	1423	2807	423	1269	2807
"	hoot	423	1423	2538	461	1307	2576	461	1346	2576
"	kook	423	1538	2730	423	1499	2769	346	1423	2653
"	move	499	1653	2576	499	1615	2653	384	1269	2730
"	ooze	499	1884	2807	423	1499	2730	423	1999	2769
"	pooch	538	1538	2615	499	1576	2499	538	1961	2461
"	rouge	423	1461	2346	346	1576	2461	423	1730	2423
"	soothe	461	2038	2923	538	2076	2769	423	1807	2653
"	spoof	423	1807	2576	423	1769	2653	461	1538	2653
"	spoon	499	1615	2653	423	1576	2423	423	1384	2307
"	stooge	423	2269	2769	423	2076	2653	423	2038	2615
"	tooth	499	2230	2692	423	2153	2730	423	2038	2769
"	tube	423	2076	2807	384	1923	2653	423	1538	2576
"	who	461	1461	2846	499	1461	2653	461	1923	2423
"	whom	538	1461	2499	538	1576	2538	499	1307	2384
/ʊ/	butch	538	1538	2807	576	1730	2807	576	1846	2884
"	hood	576	1692	2999	423	1769	2884	384	1923	2846
"	hoof	499	1615	2999	576	1653	2923	538	1576	2846
"	hook	576	1730	2923	653	1576	2884	615	1653	2884
"	push	576	1576	2961	615	1499	2884	615	1692	2884
"	puss	538	1384	2999	499	1538	3076	461	1961	2999
"	put	615	1538	2961	499	1576	2999	615	1807	2961
/o/	gauche									
"	globe	615	1384	3192	653	1538	2999	461	1192	2846
"	home	846	1461	2307	769	1384	2384	769	1269	2576
"	hope	769	1423	2807	653	1230	2884	538	1115	2846
"	hose	807	1653	2923	461	1461	2730	461	1807	2807
"	host	730	1576	2653	499	1499	2807	499	1807	2730
"	loathe	692	1615	3038	653	1499	3038	615	1538	2884
"	oaf	576	1384	2692	461	1346	2846	461	1192	2769
"	oak	615	1538	2846	461	1423	2807	384	1153	2692
"	oat	692	1461	3730	538	1307	3615	461	1230	3730
"	oath	692	1538	2846	499	1499	2923	538	1499	3076
"	ode	576	1538	2846	499	1499	2769	499	1653	2653
"	owe	615	1499	2807	461	1346	2769	461	1692	2384
"	own	769	1576	2346	576	1423	2538	499	1346	2499
"	poach	615	1499	2730	499	1423	2807	384	1538	2461
"	stove	576	1769	2846	576	1499	2807	423	1230	2846
"	vogue	538	1499	2846	615	1538	2961	538	1307	2884
/ɑ/	Goth	692	1461	2884	807	1384	2884	961	1499	2923
"	hob	923	1423	3115	923	1423	2923	846	1346	3115
"	hock	884	1538	2999	884	1461	2999	846	1423	2692
"	hodge	884	1461	2999	884	1461	2961	884	1769	2884
"	hog	884	1423	2961	846	1499	2961	538	1576	2807
"	hop	923	1423	2846	923	1384	2923	884	1346	2923
"	odd	884	1461	2807	884	1499	2999	730	1653	2923
"	off	807	1423	2653	884	1307	2884	846	1346	2884

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	on	884	1499	3230	807	1346	3307	846	1653	3038
"	ought	807	1307	2999	846	1423	2961	846	1499	2961
"	Oz	730	1307	2923	923	1423	2999	615	1846	2923
"	posh	884	1499	2807	846	1576	2884	884	1692	2923
"	Scotch	846	1461	2769	807	1576	2807	884	1615	2769
"	spa	769	1384	2961	846	1423	2999	769	1615	2961
"	Tom	846	1538	2961	884	1384	3192	846	1384	3269
"	toss	923	1346	2884	961	1423	2999	884	1576	3038
/ʌ/	hub	923	1692	2923	769	1576	2923	730	1538	2807
"	Huck	807	1615	2884	846	1653	2884	846	1692	2769
"	huff	846	1615	3076	846	1576	3038	884	1615	2999
"	hug	807	1653	2884	769	1538	2961	538	1769	2730
"	hum	807	1538	3346	769	1499	3230	769	1423	3346
"	hun	769	1692	3384	769	1692	3230	807	1730	3269
"	hush	769	1653	2999	730	1769	2961	692	1884	2999
"	hut	807	1730	2999	807	1730	2923	730	1846	3038
"	hutch	730	1615	3038	807	1653	2961	730	1807	3076
"	of	769	1653	3038	769	1615	3115	576	1499	2961
"	pudge	884	1576	3038	769	1769	3038	576	1961	2999
"	pus	884	1576	2961	807	1576	2999	769	1692	2999
"	scuzz	615	1769	2807	692	1807	2923	499	1769	2884
"	spud	692	1423	3038	807	1692	3076	807	1884	3038
"	up	846	1807	3038	807	1692	3076	769	1653	2961
[Ir]	ear	423	2807	3076	461	2499	2923	384	2153	2499
[Er]	air	653	2076	2923	653	2076	2807	615	1923	2576
[Ar]	are	769	1461	2769	692	1423	2846	769	1615	2615
[Or]	ore	576	1038	3038	499	999	2999	576	1538	2653
[ɚ]	her	692	1769	2269	538	1846	2423	576	1961	2384
/il/	eel	384	2807	3115	499	2653	2999	499	1846	2961
/ɪl/	ill	461	2269	2999	538	2076	2884	499	1615	3115
/el/	ale	499	2423	2961	499	2346	2923	576	1846	3076
/ɛl/	L	692	2038	3038	730	1923	2999	730	1884	3115
/æl/	Al	807	2038	2769	961	1884	2653	1115	1653	2692
/ul/	pool	423	1038	3115	384	923	3230	384	1038	3153
/ʊl/	pull	538	1076	3346	499	1038	3269	499	1038	3307
/ol/	hole	499	1038	3269	499	961	3230	576	999	3192
/ɑl/	hall	884	1269	3038	730	1115	2923	769	1192	3038
/ʌl/	hull	538	1115	3038	423	1076	2999	384	1038	2923
<ing>	ping-	499	2653	3192	461	2423	3038	423	2307	2923
<eng>	length	730	1615	3153	769	2038	3115	576	2538	2923
<ang>	hang	769	2384	3076	730	2307	3076	538	2538	3076
<ong>	-pong	846	1346	2884	884	1384	2961	807	1499	3192
<ung>	hung	769	1499	3192	769	1538	3230	769	1538	3269

Speaker 06: Male, age 21. From Redwood City (Northern California)

		T1			T2			T3		
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	384	1999	2346	461	1961	2538	461	1769	2230
"	E	346	2192	3307	423	2269	3230	423	2269	2884
"	each	384	2192	3307	346	2192	3230	307	2115	2999
"	ease	384	2192	3115	384	2192	2999	384	1999	2692
"	eat	384	2269	3307	423	2230	3153	384	2230	3038
"	eke	384	2038	3230	384	2115	3269	346	2153	3038
"	eve	346	2153	3307	307	2192	3192	384	2115	2846
"	fatigue	384	2115	2692	384	2038	2615	423	2115	2423
"	heap	461	1999	3153	346	2076	3115	384	2076	2730
"	heath	307	2076	2999	423	2038	2769	384	1884	2307
"	heed	346	2038	2961	461	2076	2961	423	2115	2653
"	keen	384	2461	3115	384	2538	3192	384	2461	2923
"	O'Keefe	461	2192	3038	461	2153	2884	461	2115	2538
"	piece	346	2076	3076	423	2192	2961	384	2115	2769
"	quiche	461	2192	3115	384	2192	2961	423	2230	2769
"	scheme	461	2230	2884	461	2269	2961	346	2269	2846
"	siege	384	2115	2807	346	2153	3076	346	2076	2730
"	teethe	346	2115	3038	384	2153	2999	384	2115	2730
/ɪ/	dish	499	1884	2615	538	1807	2461	423	1807	2461

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	give	423	2076	2846	615	1923	2461	538	1576	2307
"	hick	538	1961	2615	615	1884	2499	499	1884	2384
"	him	692	2076	2730	576	1961	2653	576	1538	2461
"	hip	576	1923	2499	538	1884	2461	576	1576	2230
"	his	499	1923	2384	461	1692	2384	423	1615	2384
"	hiss	499	1884	2538	576	1846	2384	538	1653	2461
"	id	538	2038	2615	615	1961	2499	538	1692	2538
"	if	538	1884	2423	653	1846	2461	615	1730	2461
"	in	653	1923	2730	576	1846	2692	538	1653	2769
"	it	423	1846	2576	576	1846	2538	538	1730	2461
"	itch	499	1923	2576	576	1846	2576	538	1846	2615
"	midge	653	1999	2615	615	1923	2653	538	1884	2653
"	Pibb	499	1961	2538	615	1923	2538	538	1576	2230
"	pig	615	1999	2499	538	2038	2499	461	2076	2423
"	pith	576	1923	2615	615	1846	2538	576	1653	2499
/e/	A	653	1961	2499	615	2076	2615	538	2076	2461
"	Abe	499	1961	2730	499	2038	2730	499	1807	2384
"	ace	499	1923	2692	538	1999	2576	461	1999	2576
"	ache	461	1884	2653	499	2115	2807	423	2384	2807
"	age	499	1999	2615	499	2038	2730	461	2076	2769
"	aid	423	2115	2769	499	2115	2807	461	2076	2846
"	aim	538	2115	2692	576	2115	2730	499	2192	2692
"	ape	576	1999	2653	499	2153	2692	423	1961	2769
"	ate	499	1999	2692	461	2115	2769	423	2307	2846
"	beige	576	1999	2461	615	1999	2576	499	1923	2538
"	faith	538	1884	2423	538	2038	2499	461	1961	2307
"	H	615	1961	2576	538	1961	2653	461	1999	2730
"	haze	576	2115	2615	499	2038	2653	499	1884	2576
"	pain	538	1961	2576	461	2269	2769	576	2269	2846
"	pave	576	2038	2730	576	2153	2730	538	1769	2269
"	safe	576	1730	2423	576	1923	2538	538	1961	2538
"	scathe	576	2115	2576	499	1961	2538	538	1615	2384
"	vague	538	1923	2423	653	2038	2576	461	2076	2461
/ɛ/	Beth	614	1692	2346	769	1692	2499	730	1576	2653
"	Bev	615	1846	2461	692	1692	2538	615	1461	2423
"	ebb	730	1769	2499	730	1769	2461	692	1538	2269
"	Ed	576	1846	2653	576	1730	2576	615	1653	2615
"	edge	615	1884	2538	615	1807	2576	461	1769	2499
"	etch	615	1730	2499	538	1730	2615	538	1692	2576
"	F	653	1692	2461	538	1692	2423	653	1576	2499
"	heck	692	1807	2615	653	1769	2423	692	1846	2384
"	M	653	1846	2461	692	1769	2653	615	1384	2730
"	N	730	1923	2730	730	1807	2653	730	1576	2730
"	peg	615	1884	2653	615	1769	2499	576	1923	2346
"	pep	653	1730	2423	730	1538	2423	692	1576	2269
"	pet	769	1846	2576	653	1730	2653	692	1653	2538
"	Pez	692	1730	2615	615	1730	2653	538	1576	2499
"	S	653	1692	2499	730	1730	2499	730	1615	2499
"	Tesh	692	1730	2499	653	1653	2538	692	1653	2499
/æ/	add	846	1769	2576	807	1769	2538	769	1730	2576
"	Anne	653	2038	2653	653	1961	2653	692	1653	2846
"	ash	730	1846	2538	769	1769	2499	769	1538	2423
"	ass	692	1653	2461	846	1730	2499	653	1576	2499
"	at	923	1846	2692	884	1730	2576	884	1576	2692
"	badge	692	1769	2423	807	1769	2499	730	1576	2461
"	hack	923	1807	2538	846	1692	2576	923	1730	2538
"	hag	769	1846	2461	730	1653	2423	692	1846	2307
"	half	884	1730	2461	923	1576	2499	923	1461	2423
"	ham	692	2038	2653	653	2076	2653	653	1499	2730
"	has	730	1846	2653	692	1692	2538	615	1538	2615
"	hatch	807	1769	2538	807	1692	2576	769	1576	2538
"	path	807	1730	2538	923	1692	2461	884	1576	2615
"	perhaps	730	1769	2576	769	1692	2538	730	1461	2269
"	scab	538	1923	2423	692	1653	2423	730	1384	2346
/u/	douche	499	1730	2192	384	1576	2115	423	1576	2269
"	dude	461	1923	2461	423	1884	2346	423	1653	2269
"	goose	423	1999	2307	384	1730	2153	423	1692	2384
"	hoop	461	1423	2230	423	1384	2153	384	1153	2230

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	hoot	576	1461	2076	499	1461	2153	499	1307	2115
"	kook	461	1423	2153	423	1384	2192	423	1153	2192
"	move	576	1499	2307	538	1653	2346	499	1384	2307
"	ooze	423	1538	2192	423	1461	2153	423	1615	2384
"	pooch	461	1653	2230	461	1576	2153	384	1615	2115
"	rouge									
"	soothe	461	1923	2346	423	1615	2307	384	1615	2307
"	spoof	423	1615	2307	499	1576	2269	423	1346	2384
"	spoon	499	1692	2192	576	1499	2307	384	1499	2269
"	stooge	384	1961	2538	423	1961	2307	423	1884	2461
"	tooth	384	1961	2384	499	1769	2269	423	1576	2307
"	tube	384	1999	2307	461	1884	2307	423	1346	2153
"	who	423	1307	2346	461	1115	2192	384	1115	2115
"	whom	423	1384	2230	461	1269	2153	461	1230	2307
/ʊ/	butch	576	1423	2346	653	1461	2230	576	1576	2384
"	hood	615	1576	2307	576	1576	2423	538	1692	2461
"	hoof	538	1346	2269	538	1346	2230	499	1384	2346
"	hook	615	1499	2384	653	1461	2307	499	1423	2115
"	push	615	1384	2230	653	1499	2307	538	1653	2346
"	puss	615	1384	2384	576	1346	2346	615	1538	2461
"	put	499	1423	2307	615	1461	2269	538	1576	2423
/o/	gauche									
"	globe	576	961	2153	576	1115	2230	538	1038	2269
"	home	615	1115	2384	576	1115	2653	615	1115	2692
"	hope	538	1192	2192	538	1038	2115	461	961	2153
"	hose	615	1269	2269	461	1076	2230	538	1615	2499
"	host	615	1384	2192	538	1230	2115	461	1615	2423
"	loathe	653	1346	2576	615	1346	2346	461	1307	2615
"	oaf	615	1461	2307	576	1269	2230	499	999	2269
"	oak	615	1269	2384	615	1153	2269	461	1038	2192
"	oat	538	1461	2269	576	1192	2307	461	961	2230
"	oath	653	1384	2307	576	1307	2230	615	1269	2307
"	ode	576	1461	2346	653	1307	2307	576	1346	2115
"	owe	576	1307	2230	576	1115	2269	576	1076	2038
"	own	615	1346	2269	653	1115	2461	692	1230	2346
"	poach	461	1307	2153	538	1115	2115	499	1230	2076
"	stove	499	1576	2307	615	1230	2269	499	1038	2230
"	vogue	538	1230	2269	615	1192	2269	423	1038	2269
/ɑ/	Goth	615	1615	2346	846	1307	2384	807	1346	2346
"	hob	730	1230	2615	692	1307	2538	692	1346	2461
"	hock	923	1384	2615	846	1192	2423	807	1384	2230
"	hodge	884	1346	2576	846	1346	2499	692	1499	2269
"	hog	730	1269	2576	769	1269	2499	692	1269	2153
"	hop	730	1346	2538	846	1307	2538	884	1307	2499
"	odd	769	1269	2653	730	1307	2423	692	1461	2499
"	off	730	1192	2461	769	1192	2499	692	1269	2461
"	on	730	1230	2230	730	1269	2153	615	1307	2192
"	ought	807	1230	2461	846	1384	2346	769	1346	2384
"	Oz	769	1307	2461	884	1192	2538	730	1346	2499
"	posh	730	1115	2346	692	1269	2346	769	1499	2269
"	scotch	692	1538	2307	692	1384	2423	692	1499	2423
"	spa	692	1230	2384	692	1269	2461	769	1269	2538
"	Tom	730	1384	2692	769	1192	2884	692	1153	2807
"	toss	846	1384	2307	846	1423	2384	807	1346	2423
/ʌ/	hub	653	1538	2423	692	1499	2346	576	1423	2499
"	huck	692	1423	2384	692	1423	2384	576	1499	2423
"	huff	653	1384	2423	692	1346	2384	653	1384	2538
"	hug	730	1423	2461	730	1384	2423	576	1423	2115
"	hum	730	1423	2423	807	1230	2153	769	1230	2230
"	hun	769	1423	2307	692	1346	2153	769	1346	2269
"	hush	576	1538	2307	653	1499	2423	653	1615	2346
"	hut	692	1576	2461	692	1461	2499	653	1499	2499
"	hutch	692	1576	2499	653	1576	2461	653	1461	2576
"	of	692	1423	2384	653	1307	2461	692	1230	2153
"	pudge	692	1423	2461	692	1499	2384	576	1576	2538
"	pus	769	1461	2346	692	1499	2461	769	1499	2653
"	scuzz	576	1653	2384	692	1576	2423	576	1461	2615
"	spud	615	1461	2576	615	1538	2576	615	1653	2538

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	up	653	1423	2423	730	1346	2461	576	1307	2538
[Ir]	ear	384	2153	2846	461	1999	2538	576	1576	2153
[Er]	air	538	1999	2538	576	1923	2499	653	1730	2230
[Ar]	are	769	1269	2269	769	1307	2115	730	1384	1961
[Or]	ore	499	884	2115	538	884	2076	538	1076	1730
[ɚ]	her	576	1461	1730	538	1346	1653	538	1307	1653
/il/	eel	346	2115	3269	384	2115	3153	423	2115	3038
/ɪl/	ill	538	1846	2499	653	1653	2538	576	1423	2615
/el/	ale	538	1999	2538	538	1923	2423	653	1769	2346
/ɛl/	L	615	1692	2576	769	1576	2615	730	1346	2653
/æl/	Al	615	1576	2499	846	1538	2538	923	1576	2615
/ul/	pool	499	1038	2230	499	1038	2499	538	999	2769
/ʊl/	pull	576	999	2576	576	884	2538	461	923	2730
/ol/	hole	538	923	2461	576	884	2576	576	961	2730
/ɑl/	hall	692	1115	2499	730	1038	2499	653	1076	2653
/ʌl/	hull	576	999	2538	576	961	2692	461	846	2884
<ing>	ping	423	2192	2807	461	2307	2615	499	2307	2499
<eng>	length	692	1461	2576	653	1923	2730	615	2038	2692
<ang>	hang	692	2115	2653	692	2115	2653	499	2384	2846
<ong>	pong	692	1230	2615	730	1230	2692	807	1192	2346
<ung>	hung	730	1269	2307	692	1307	2153	692	1192	2153

Speaker 07: Female, Age 20. From Hayward (Northern California)

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	499	2269	2999	461	2576	2961	423	2307	3076
"	E	384	2730	3461	423	2961	3269	384	2807	3346
"	each	269	2769	3307	461	2846	3269	423	2846	3346
"	ease	346	2807	3384	461	2807	3115	461	2269	3230
"	eat	384	2884	3346	346	2769	3307	346	2499	3423
"	eke	346	2769	3384	423	2807	3192	423	2769	3384
"	eve	423	2846	3346	423	2769	2999	461	2499	3307
"	fatigue	461	2730	3230	499	2615	3115	423	2461	3307
"	heap	384	2730	3269	384	2692	2961	346	2461	3307
"	heath	384	2961	3269	423	2807	3076	423	2038	3192
"	heed	346	2846	3153	461	2730	3038	423	2499	3230
"	keen	384	2807	3153	499	2769	3230	423	2961	3153
"	O'Keefe	346	2730	3115	461	2730	2923	423	2307	3153
"	piece	461	2807	3076	423	2538	2999	346	2269	3076
"	quiche	461	2769	3192	346	2730	3192	423	2576	3307
"	scheme	461	2692	3192	461	2692	3153	461	2076	3269
"	siege	499	2461	3192	461	2615	3038	461	2538	3076
"	teethe	423	2807	3230	499	2615	2884	423	2076	3192
/ɪ/	dish	499	2307	2961	499	2153	2884	423	2192	3038
"	give	461	2461	2807	538	2192	2923	499	1730	2923
"	hick	499	2384	2923	423	2346	2923	461	2307	2999
"	him	538	2192	2884	538	2076	2769	538	1923	2961
"	hip	538	1961	2884	538	1961	2807	538	1769	2846
"	his	538	2230	2884	461	2115	2807	461	2076	2884
"	hiss	499	2230	2999	423	2153	2923	538	2038	2923
"	id	538	2269	3038	423	2307	3153	461	2076	3076
"	if	461	2384	3115	576	2346	2923	538	2115	3192
"	in	499	2230	2884	576	2192	2769	499	2115	2923
"	it	538	2423	3038	538	2307	2999	461	2230	3038
"	itch	538	2384	3192	499	2423	3230	576	2307	3192
"	midge	576	2230	2923	576	2346	3115	499	2346	2884
"	Pibb	461	2230	2846	499	2076	2807	538	1923	2884
"	pig	499	2346	2961	423	2384	2884	461	2423	3153
"	pith	576	2192	2923	615	2115	2923	499	1884	2999
/e/	A	538	2499	3153	576	2653	3230	461	2538	3269
"	Abe	538	2423	3115	538	2615	2807	538	1999	3115
"	ace	499	2499	3346	499	2615	3384	461	2230	3230
"	ache	499	2653	3307	499	2692	3115	346	2730	3423
"	age	461	2692	3307	461	2769	3269	461	2423	3307

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	aid	423	2499	3269	461	2653	3076	461	2576	3192
"	aim	538	2461	3038	538	2615	2692	346	2076	3115
"	ape	461	2846	3192	499	2769	2999	461	2230	3153
"	ate	576	2307	3192	499	2692	3115	384	2730	3115
"	beige	461	2076	3192	461	2615	3115	461	2615	2884
"	faith	499	2192	2884	538	2615	2846	423	1961	2807
"	H	499	2692	3307	538	2730	3230	461	2653	3269
"	haze	461	2538	3076	499	2615	2999	499	2153	3153
"	pain	576	2499	3076	538	2576	3307	499	2653	3076
"	pave	423	2538	2961	461	2576	2961	538	1961	2961
"	safe	615	2269	2999	576	2538	2884	576	1961	3038
"	scathe	538	2538	2923	538	2461	2923	461	2192	2923
"	vague	615	2115	3038	653	2499	2923	461	2499	2884
/ɛ/	Beth	576	1884	2769	730	1923	2846	615	1807	2692
"	Bev	615	1923	2807	769	1923	2769	576	1769	2846
"	ebb	615	2115	2999	615	2038	2846	538	1730	3115
"	Ed	730	2153	3115	653	2230	3076	499	2115	2923
"	edge	615	2269	3153	653	2346	3153	615	2230	3076
"	etch	576	2307	3153	730	2307	3192	692	2307	3076
"	F	692	2038	2923	769	1999	2961	730	1846	2999
"	heck	538	2153	2653	538	2153	2769	499	2192	2769
"	M	576	2269	2807	692	1961	2692	538	1807	2884
"	N	461	2192	3115	615	2230	3076	576	2153	2923
"	peg	692	2307	2923	653	2269	2846	499	2230	2846
"	pep	884	1923	2730	884	1846	2769	692	1692	2807
"	pet	807	2038	2923	730	2115	2923	615	1999	2846
"	Pez	807	1999	2923	846	1961	3076	538	1999	2961
"	S	846	2153	3115	769	1999	3192	653	1999	2999
"	Tesh	846	2115	2923	730	1961	2999	730	2038	2961
/æ/	add	807	2230	2692	884	1961	2846	615	2038	2846
"	Anne	576	2576	2961	692	2346	2692	653	1923	3269
"	ash	923	1999	2807	961	1807	2730	884	1999	2769
"	ass	769	1923	2692	923	1884	2769	884	1692	2846
"	at	769	2038	2769	961	1999	2807	807	1923	2884
"	badge	576	1846	2807	923	1846	2961	730	1923	2769
"	hack	923	2038	2692	923	1923	2730	884	1807	2769
"	hag	769	2269	2884	653	2153	2769	499	2423	2923
"	half	961	1923	2884	923	1730	2769	923	1384	2769
"	ham	769	2538	2884	653	2076	2653	730	1538	2999
"	has	961	1807	2769	884	1846	2923	576	1730	2769
"	hatch	999	1961	2769	999	1846	2884	846	1884	2807
"	path	961	1769	2730	999	1692	2615	961	1499	2615
"	perhaps	999	1769	2653	961	1653	2615	846	1538	2692
"	scab	538	2384	2846	807	1769	2653	653	1346	2923
/u/	douche	384	2192	2807	461	1884	2769	461	1999	2807
"	dude	538	2307	2653	499	1846	2499	538	2153	2884
"	goose	461	1961	2692	538	1692	2653	461	1846	2692
"	hoop	499	1423	2769	423	1230	2769	461	1076	2692
"	hoot	538	1538	2692	384	1423	2730	423	1615	2653
"	kook	499	1615	2846	384	1461	2807	423	1384	2807
"	move	576	1384	2999	538	1499	2961	538	1346	2846
"	ooze	461	1730	2999	538	1461	2807	538	1846	2769
"	pooch	423	1576	2807	423	1538	2499	346	1653	2769
"	rouge	499	1576	2538	538	1769	2499	461	1884	2423
"	soothe	461	2038	2846	538	1653	2769	384	1538	2769
"	spoof	499	1307	2884	461	1423	2923	346	1230	2846
"	spoon	538	1538	2769	576	1538	2807	538	1538	2730
"	stooge	461	2269	2730	499	1961	2653	423	2230	2923
"	tooth	423	2153	2769	384	1961	2884	346	1692	2807
"	tube	499	2153	2807	423	2115	2769	423	1807	2807
"	who	499	1807	2999	538	1461	2884	499	1884	2884
"	whom	576	1769	2769	538	1422	2730	423	1115	2692
/ʊ/	butch	538	1192	2999	615	1499	2769	499	2076	3038
"	hood	499	1807	2769	461	1846	2961	499	2192	2923
"	hoof	576	1499	2923	499	1499	2769	384	1423	2769
"	hook	461	1538	2884	576	1461	2769	461	1423	2961
"	push	615	1538	2807	538	1769	2846	538	1961	2807
"	puss	576	1499	2730	576	1769	2730	461	1846	2692

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	put	538	1615	2807	576	1692	2961	538	1923	2807
/o/	gauche	615	1692	2923	576	1269	2884	461	1192	2653
"	globe	653	1230	3192	653	1269	3038	576	1153	3230
"	home	653	1192	2846	615	1230	2884	499	1038	2769
"	hope	615	1384	2923	576	1153	3153	461	1038	2807
"	hose	653	1423	3192	499	1307	3038	499	1384	2961
"	host	576	1307	2999	576	1115	2999	576	1076	2923
"	loathe	653	1461	2999	653	1346	2884	499	1269	3076
"	oaf	576	1499	2884	653	1307	3038	576	1153	2884
"	oak	653	1461	2923	615	1346	3115	461	1038	3038
"	oat	615	1269	3038	538	1153	2999	499	1153	2884
"	oath	576	1423	3269	499	1230	3307	461	1115	2961
"	ode	653	1423	3192	576	1346	2807	499	1346	2961
"	owe	576	1346	2846	576	1346	2730	461	1499	2961
"	own	538	1307	2807	576	1307	2692	499	1307	2846
"	poach	653	1384	2961	538	1346	2615	576	1884	2884
"	stove	499	1884	2807	615	1384	2730	615	1269	2884
"	vogue	615	1307	3038	653	1192	3115	499	1115	3038
/ɑ/	Goth	576	1538	2769	884	1269	2807	846	1384	2923
"	hob	769	1346	2769	807	1307	2769	615	1269	2730
"	hock	846	1307	2807	923	1423	2576	846	1423	2999
"	hodge	807	1230	2615	884	1346	2730	615	1884	2576
"	hog	884	1307	3038	923	1307	2999	653	1384	3038
"	hop	923	1346	2846	961	1346	2769	807	1461	2923
"	odd	807	1384	2769	923	1461	3115	576	1846	2730
"	off	807	1346	2884	807	1307	2730	846	1423	2846
"	on	923	1230	2653	923	1346	2653	961	1538	2692
"	ought	846	1307	2923	884	1230	2961	846	1576	2923
"	Oz	923	1346	2846	961	1461	3038	576	1769	2961
"	posh	846	1346	2846	961	1423	2769	769	1384	2846
"	Scotch	846	1384	2653	807	1423	2653	653	1923	2692
"	spa	807	1269	2615	884	1307	2923	538	1807	2769
"	Tom	923	1269	2692	923	1269	2730	846	1230	2538
"	toss	923	1307	2769	807	1346	2807	846	1615	2923
/ʌ/	hub	807	1615	2961	769	1576	2846	538	1615	2923
"	Huck	846	1769	2884	730	1692	2846	538	1576	2807
"	huff	923	1692	2961	884	1576	2807	884	1576	2884
"	hug	846	1653	2923	692	1615	2846	538	1615	2999
"	hum	961	1538	2615	807	1538	2615	576	1423	2653
"	hun	653	1499	2692	653	1615	2653	692	1884	2576
"	hush	846	1692	2846	730	1769	3076	653	1961	2730
"	hut	884	1730	2846	846	1846	2923	576	2038	2653
"	hutch	884	1923	2692	846	1846	2884	615	1999	2807
"	of	730	1692	2730	923	1615	2846	692	1730	2807
"	pudge	807	1692	2807	653	1807	2961	538	2038	2846
"	pus	846	1653	2807	846	1730	3153	692	1884	2730
"	scuzz	692	1846	2846	730	1846	2999	499	1884	2846
"	spud	730	1384	2846	692	1846	3038	538	2115	2884
"	up	846	1730	2846	730	1692	2807	653	1538	2923
[Ir]	ear	423	2692	2999	499	2307	2346	576	1846	3230
[Er]	air	461	2499	2961	576	2461	2461	653	1999	3038
[Ar]	are	846	1230	2307	846	1423	2115	538	1615	2576
[Or]	ore	461	923	2999	615	961	2269	538	1307	3153
[ɚ]	her	615	1346	1769	576	1461	2192	576	1923	1769
/il/	eel	384	2846	3461	423	2807	3230	538	1846	3423
/ɪl/	ill	499	2038	3038	576	1807	3153	576	1576	2846
/el/	ale	538	2346	2999	538	2423	3115	576	2269	3076
/ɛl/	L	730	1769	3115	730	1769	3192	807	1346	2999
/æl/	Al	846	1730	2730	884	1730	2769	846	1499	2730
/ul/	pool	576	923	2730	499	999	2653	461	961	2615
/ʊl/	pull	423	1038	3307	499	923	3384	538	999	3230
/ol/	hole	538	961	3307	538	884	3384	499	923	3307
/ɑl/	hall	807	1269	3307	846	1230	3461	653	1076	3307
/ʌl/	hull	576	1076	3423	615	923	3461	499	961	3346
<ing>	ping-	461	2576	2999	576	2730	2923	576	2769	2923
<eng>	length	576	1846	3192	615	2538	3269	461	2653	3346

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

<ang>	hang	653	2499	3230	538	2461	3115	538	2653	2961
<ong>	-pong	884	1230	2576	884	1192	2576	807	1192	2615
<ung>	hung	923	1461	2692	923	1461	2730	730	1423	2692

Speaker 08: Male, age 19. From Los Angeles (Southern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	346	2499	2615	346	2384	2923	384	1846	2384
"	E	307	2461	3038	384	2576	3153	346	2153	2923
"	each	346	2538	3115	307	2461	2999	346	2384	3115
"	ease	269	2423	2999	346	2499	2923	269	1923	2576
"	eat	423	2538	2999	384	2538	2999	384	2153	2846
"	eke	384	2615	3038	346	2576	2961	346	2576	3038
"	eve	384	2692	3038	384	2461	2961	423	1538	2307
"	fatigue	307	2384	2884	384	2423	2807	269	2346	2692
"	heap	346	2384	2769	384	2461	2692	269	1923	2461
"	heath	346	2538	2999	346	2461	2999	346	2115	2769
"	heed	423	2461	3153	384	2461	3038	423	2038	2730
"	keen	423	2499	2807	346	2576	2923	346	2230	2923
"	O'Keefe	346	2423	2961	346	2423	2999	269	2153	2653
"	piece	346	2346	2884	307	2538	2999	461	2269	2807
"	quiche	423	2384	2846	384	2269	2807	423	2230	2730
"	scheme	423	2499	3076	346	2538	2961	384	2499	2923
"	siege	384	2192	2692	346	2230	2769	384	2384	2692
"	teethe	346	2423	2884	423	2423	2999	423	1884	2538
/ɪ/	dish	499	1923	2653	461	1923	2576	538	1923	2576
"	give	423	2076	2615	538	1923	2538	538	1499	2307
"	hick	499	1999	2499	538	1999	2384	423	2038	2307
"	him	538	2038	2807	499	1999	2615	576	1692	2461
"	hip	423	2038	2807	538	1999	2769	499	1692	2576
"	his	461	1999	2653	423	1961	2692	346	1692	2576
"	hiss	538	1961	2846	538	1884	2769	461	1846	2730
"	id	423	2115	2923	499	2153	2884	461	1923	2846
"	if	461	1961	2730	499	1923	2653	461	1846	2653
"	in	423	2038	2807	461	2076	2846	461	1961	2807
"	it	461	2192	2884	499	2076	2846	461	2076	2769
"	itch	461	2307	2615	423	2153	2769	423	2038	2692
"	midge	538	1846	2692	538	1961	2769	384	1923	2807
"	Pibb	423	1999	2615	461	1846	2499	423	1692	2384
"	pig	499	1961	2653	346	2038	2576	384	2192	2499
"	pith	423	1923	2499	499	1769	2461	461	1730	2499
/e/	A	461	2038	2884	423	2230	2769	384	2038	2538
"	Abe	461	2076	2769	346	2269	2730	384	2076	2461
"	ace	461	2115	2769	384	2384	2846	307	2153	2769
"	ache	499	2192	2730	499	2115	2730	384	2346	2653
"	age	423	2230	2769	423	2384	2846	423	2192	2769
"	aid	499	2115	2807	499	2192	2769	461	2346	2692
"	aim	423	2192	2846	423	2115	2884	423	1615	2692
"	ape	499	2192	2730	499	2192	2846	423	2384	2692
"	ate	538	2384	2884	384	2499	2999	346	2423	2846
"	beige	576	1884	2538	423	1999	2769	269	1999	2615
"	faith	538	1769	2538	499	2076	2615	384	1999	2461
"	H	538	2192	2846	423	2269	2884	346	2192	2769
"	haze	499	2115	2730	423	2076	2653	384	1615	2423
"	pain	653	2115	2499	499	2307	2653	538	2192	2653
"	pave	461	2076	2653	461	2115	2769	384	1576	2538
"	safe	499	1769	2576	499	2115	2692	461	2153	2730
"	scathe	461	1999	2653	499	2038	2615	423	1653	2346
"	vague	499	1807	2538	461	1999	2769	346	2269	2692
/ɛ/	Beth	653	1653	2461	653	1653	2499	692	1615	2499
"	Bev	538	1615	2538	653	1730	2653	653	1384	2384
"	ebb	615	2115	2884	576	1884	2769	499	1538	2423
"	Ed	538	1923	2653	576	1846	2730	499	1807	2615
"	edge	499	1999	2615	538	1961	2692	461	1884	2730
"	etch	538	1961	2769	576	1923	2653	423	1923	2692
"	F	692	1846	2692	576	1692	2538	692	1653	2461

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	heck	653	1884	2384	615	1730	2269	576	1807	2269
"	M	653	1884	2499	615	1846	2615	576	1538	2307
"	N	576	1923	2846	576	1923	2730	576	1807	2692
"	peg	653	1961	2576	499	1999	2538	423	2192	2423
"	pep	692	1692	2538	730	1692	2461	615	1576	2384
"	pet	692	1807	2615	692	1730	2499	538	1769	2538
"	Pez	615	1769	2653	653	1692	2807	384	1653	2692
"	S	615	1807	2692	615	1884	2730	615	1769	2653
"	Tesh	730	1692	2653	615	1846	2576	653	1769	2538
/æ/	add	807	1769	2423	730	1692	2499	653	1615	2499
"	Anne	692	1999	2538	692	1923	2615	653	1461	2423
"	ash	692	1730	2499	807	1615	2499	615	1576	2230
"	ass	884	1576	2307	846	1461	2307	692	1499	2346
"	at	807	1692	2461	884	1576	2615	769	1576	2576
"	badge	653	1730	2653	846	1730	2423	653	1576	2461
"	hack	807	1538	2384	807	1538	2384	807	1538	2153
"	hag	846	1653	2346	653	1769	2423	499	2076	2307
"	half	807	1461	2499	807	1499	2461	730	1538	2384
"	ham	769	1846	2499	730	1576	2461	692	1384	2230
"	has	807	1730	2423	769	1692	2461	461	1499	2461
"	hatch	769	1538	2499	730	1499	2346	653	1538	2346
"	path	730	1653	2499	807	1576	2423	730	1499	2346
"	perhaps	807	1538	2307	769	1384	2269	692	1423	2192
"	scab	615	1884	2307	807	1576	2384	653	1384	2307
/u/	douche	346	1884	2384	384	1499	2192	346	1423	2192
"	dude	384	1923	2423	423	1730	2346	346	1615	2269
"	goose	384	1576	2115	423	1269	2192	384	1307	2192
"	hoop	461	1153	2153	461	1038	2192	423	1076	2038
"	hoot	423	1269	2153	461	1153	2115	346	1076	2076
"	kook	461	1230	2269	423	1038	2269	423	884	2192
"	move	499	1192	2115	461	999	2153	423	923	2192
"	ooze	384	1384	2192	423	1153	2115	384	1653	2230
"	pooch	423	1076	2346	384	999	2269	384	1192	2269
"	rouge	461	1384	2076	423	1346	1961	346	1653	1999
"	soothe	499	1692	2615	423	1538	2384	346	1499	2461
"	spoof	384	1230	2153	461	1153	2230	346	1076	2230
"	spoon	346	1269	2230	384	1307	2269	384	1230	2230
"	stooge	346	1576	2192	384	1307	2230	307	1423	2115
"	tooth	384	1538	2307	461	1307	2346	307	1423	2307
"	tube	461	1615	2269	384	1461	2307	384	1115	2269
"	who	461	1192	2192	384	961	2230	346	1076	2153
"	whom	384	961	2346	384	961	2269	346	846	2346
/ʊ/	butch	461	1115	2192	461	1192	2192	461	1423	2076
"	hood	499	1153	2153	384	1307	2269	499	1423	2038
"	hoof	461	1038	2269	499	1038	2269	461	1038	2192
"	hook	538	1115	2307	499	1076	2307	499	1038	2230
"	push	499	1192	2307	538	1230	2153	423	1423	2153
"	puss	576	1076	2230	576	1153	2192	461	1346	2230
"	put	538	1153	2192	499	1192	2269	499	1423	2192
/o/	gauche	461	1499	2192	538	1269	2269	423	1115	2192
"	globe	499	1269	2461	461	1307	2384	461	923	2307
"	home	576	999	2346	423	1038	2384	346	884	2307
"	hope	499	1076	2230	423	999	2346	423	884	2192
"	hose	499	1115	2307	461	999	2230	461	1461	2153
"	host	576	1461	2269	461	1192	2230	346	1192	2115
"	loathe	538	1115	2730	576	1230	2423	538	1192	2576
"	oaf	576	1269	2192	499	999	2192	423	923	2192
"	oak	538	1230	2269	499	1076	2269	346	999	2230
"	oat	576	1384	2307	499	1115	2269	461	1038	2346
"	oath	538	1346	2384	538	1153	2423	423	961	2346
"	ode	615	1499	2346	538	1076	2230	346	1230	2076
"	owe	653	1461	2269	538	1038	2192	423	999	2038
"	own	576	1269	2230	461	999	2346	384	961	2153
"	poach	576	1192	2307	423	1076	2346	384	1192	2269
"	stove	576	1576	2346	499	1230	2307	499	923	2230
"	vogue	499	1269	2269	499	1307	2230	499	999	2269
/ɑ/	Goth	692	1423	2192	769	1230	2230	769	1192	2499

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	hob	730	1269	2423	730	1230	2384	730	1153	2346
"	hock	769	1230	2423	730	1153	2423	769	1307	2115
"	hodge	769	1307	2423	807	1230	2307	653	1384	2423
"	hog	653	999	2307	692	1038	2192	576	1076	1961
"	hop	846	1384	2384	730	1192	2576	769	1076	2423
"	odd	846	1230	2423	769	1076	2576	653	1230	2461
"	off	653	1076	2423	653	999	2615	615	1038	2461
"	on	769	1230	2499	769	1230	2576	615	1192	2576
"	ought	576	1076	2461	653	999	2423	615	1038	2384
"	Oz	846	1230	2423	807	1192	2423	461	1307	2538
"	posh	769	1230	2384	730	1192	2384	807	1230	2307
"	Scotch	576	1461	2076	769	1307	2153	769	1423	2153
"	spa	692	1153	2384	692	1230	2384	692	1307	2423
"	Tom	769	1230	2576	692	1230	2499	615	1230	2499
"	toss	769	1192	2423	730	1153	2384	692	1153	2423
/ʌ/	hub	730	1423	2615	692	1307	2576	615	1153	2423
"	Huck	653	1192	2384	692	1153	2230	615	1269	2115
"	huff	653	1307	2346	769	1269	2307	692	1307	2384
"	hug	576	1230	2230	615	1192	2307	461	1192	2230
"	hum	615	1230	2230	615	1115	2230	576	1038	2115
"	hun	653	1307	2384	615	1307	2499	653	1423	2461
"	hush	769	1307	2384	692	1269	2269	576	1423	2269
"	hut	692	1307	2499	692	1307	2384	730	1423	2346
"	hutch	653	1307	2192	730	1307	2153	615	1461	2153
"	of	615	1346	2384	538	1230	2538	499	1192	2423
"	pudge	692	1192	2653	615	1307	2576	615	1269	2730
"	pus	807	1192	2461	769	1153	2423	692	1192	2499
"	scuzz	653	1538	2346	576	1384	2461	384	1346	2576
"	spud	615	1192	2499	653	1384	2653	576	1461	2576
"	up	769	1230	2576	730	1192	2615	653	1076	2461
[Ir]	ear	384	2192	2846	384	2461	2653	384	1692	2269
[Er]	air	576	1999	2807	538	1884	2615	499	1730	2230
[Ar]	are	692	1230	2153	615	1192	2076	692	1230	1653
[Or]	ore	423	884	2384	423	807	2192	538	1038	1730
[ɚ]	her	576	1269	2307	576	1384	1730	499	1307	1499
/il/	eel	346	2461	2923	384	2461	3038	346	2461	2846
/ɪl/	ill	538	1923	2884	538	1807	2615	538	1923	2461
/el/	ale	615	1999	2499	538	2038	2576	615	1999	2576
/ɛl/	L	615	1884	2615	653	1692	2615	615	1884	2576
/æl/	Al	730	1615	2499	807	1538	2346	730	1615	2192
/ul/	pool	384	769	2538	384	807	2346	384	769	2653
/ʊl/	pull	538	769	2923	461	807	2923	538	769	2961
/ol/	hole	499	923	2461	461	884	2653	499	923	2923
/ɑl/	hall	615	961	2576	576	961	2499	615	961	2692
/ʌl/	hull	615	1076	2423	576	961	2653	615	1076	2846
<ing>	ping-	423	2269	2692	461	2269	2653	423	2269	2499
<eng>	length	653	1307	2807	692	1576	2807	653	1307	2769
<ang>	hang	730	1807	2692	615	1923	2499	730	1807	2499
<ong>	-pong	769	1153	2115	692	1076	2038	769	1153	2038
<ung>	hung	730	1192	2384	692	1230	2384	730	1192	2230

Speaker 09: Female, age 21. From Los Angeles (Southern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	384	2307	2923	423	2499	3038	384	1884	2730
"	E	461	2923	3307	423	2846	3384	461	2307	3038
"	each	423	2769	3269	461	2730	3307	384	2499	3038
"	ease	346	2730	3346	423	2692	3230	461	2192	2999
"	eat	384	2807	3346	461	2807	3269	423	2615	3076
"	eke	384	2769	3307	423	2730	3307	307	2884	3153
"	eve	461	2923	3269	384	2769	3269	423	2423	2884
"	fatigue	423	2961	2999	384	2499	3076	307	2499	2961
"	heap	423	2846	3192	384	2846	3076	384	2230	2923
"	heath	461	2846	3192	423	2653	3153	423	2307	2923
"	heed	461	2846	3192	423	2846	3269	461	2269	3038

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	keen	346	2846	3153	384	2769	3307	384	2461	3230
"	O'Keefe	346	2923	3230	307	2807	3192	307	2192	2923
"	piece	346	2923	3307	269	2730	3153	307	2307	2961
"	quiche	346	2923	3076	423	2730	3192	423	2615	3192
"	scheme	269	2923	3423	346	2807	3461	384	2461	3038
"	siege	423	2538	3038	346	2730	2999	423	2423	2961
"	teethe	499	2692	3307	461	2692	3076	499	2307	2884
/ɪ/	dish	461	2115	2961	423	2115	3192	461	2192	3076
"	give	499	2423	2999	423	2192	2999	461	1807	2807
"	hick	576	2423	3115	461	2307	3076	499	2384	3038
"	him	692	2269	3269	730	2230	3269	769	1961	3115
"	hip	461	2346	2999	538	2076	2961	423	1961	2846
"	his	615	2269	2999	538	2076	2999	538	2115	2923
"	hiss	423	2269	2999	499	2307	3076	461	2038	2999
"	id	461	2384	3153	461	2461	3192	461	2076	3038
"	if	538	2230	3076	538	2269	3076	576	1884	2999
"	in	499	2423	3307	499	2230	3384	461	2038	3346
"	it	538	2269	3076	499	2230	2999	576	2153	3076
"	itch	538	2499	3115	423	2384	2999	538	2230	3153
"	midge	692	1961	2961	653	2307	3115	499	2153	3115
"	Pibb	461	2230	2923	499	2192	2961	423	1730	2807
"	pig	538	2499	3038	461	2499	2961	346	2461	2999
"	pith	576	2269	3038	423	2076	2999	499	2038	2961
/e/	A	538	2538	2999	499	2576	3269	538	2423	2999
"	Abe	576	2538	3153	461	2653	3230	538	1999	2923
"	ace	576	2576	3115	461	2576	3230	384	2230	2999
"	ache	538	2615	3230	423	2615	3384	461	2807	3076
"	age	538	2615	3230	423	2653	3307	346	2461	3115
"	aid	538	2538	3153	461	2538	3192	499	2230	2923
"	aim	499	2461	3192	423	2730	3269	346	1846	2923
"	ape	423	2730	3192	538	2615	3269	538	2115	2961
"	ate	499	2730	3192	423	2730	3269	461	2461	3076
"	beige	499	2346	3038	423	2538	3076	384	2307	2999
"	faith	538	2269	2923	538	2461	3115	499	2269	3076
"	H	423	2538	3115	346	2653	3115	423	2423	2999
"	haze	538	2423	2999	499	2538	3076	461	2038	3076
"	pain	499	2653	2999	423	2730	3115	576	2038	3038
"	pave	423	2615	3076	461	2499	3076	499	1999	2846
"	safe	653	2076	3076	615	2384	3076	499	2038	2961
"	scathe	461	2538	3038	538	2538	2999	499	2192	2884
"	vague	499	2115	2999	499	2384	3038	423	2615	3153
/ɛ/	Beth	884	1961	3038	846	1923	2769	884	1807	2346
"	Bev	769	1999	2923	769	1923	3038	807	1692	2923
"	ebb	730	1999	3038	769	2076	3192	769	1692	2961
"	Ed	692	2153	2999	807	2115	2961	576	2038	3076
"	edge	846	2153	3076	692	2038	3038	692	2038	3038
"	etch	846	2115	3115	730	2153	3230	769	2115	3269
"	F	884	1923	2961	961	1999	3038	923	1769	2923
"	heck	846	1999	2999	923	1923	3038	884	1884	2961
"	M	884	2038	3115	807	2115	3269	923	1884	2999
"	N	923	2115	3192	884	2230	3230	807	2038	3307
"	peg	807	2038	2961	692	2192	3076	576	2269	2884
"	pep	846	1961	2999	807	1807	2961	807	1961	2846
"	pet	884	1923	3038	923	2076	3038	730	1923	3038
"	Pez	807	1999	2923	807	1999	2961	730	1884	2923
"	S	846	1961	2923	923	2038	2846	923	1961	2730
"	Tesh	846	1923	2961	846	2038	3076	884	1999	3038
/æ/	add	961	2115	2999	999	1807	2846	730	1884	3076
"	Anne	884	2346	2923	923	1961	2961	884	1576	2884
"	ash	807	1884	2923	961	1769	2884	923	1807	2769
"	ass	1038	1884	2846	999	1884	2846	1038	1730	2884
"	at	961	2076	2884	1115	1884	2923	961	1884	2923
"	badge	961	1884	2961	961	1807	2846	846	2076	2961
"	hack	1076	1884	2692	923	1884	2884	999	1846	2692
"	hag	999	1961	2769	923	1884	2807	923	1807	2769
"	half	1038	1961	2807	1115	1730	2807	999	1692	2807
"	ham	884	2384	3038	769	2153	3038	807	1653	2846
"	has	1192	1807	2769	1153	1692	2692	846	1653	2769

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	hatch	999	1884	2884	961	1807	2923	923	1884	2884
"	path	1038	1807	2807	999	1692	2807	999	1692	2807
"	perhaps	999	1846	2692	999	1769	2846	999	1576	2653
"	scab	884	2384	2923	923	1961	2769	961	1615	2692
/u/	douche	538	2307	2923	423	2269	2961	423	2115	2923
"	dude	499	2307	2961	461	2307	2846	423	1999	2846
"	goose	423	2192	2807	499	2038	2884	461	2038	2923
"	hoop	499	1692	2846	499	1576	2884	423	1115	2961
"	hoot	499	2192	2807	499	2076	2730	461	1923	2807
"	kook	461	1730	2692	423	1576	2807	384	1576	2769
"	move	499	1730	2923	423	2038	2884	423	1653	2884
"	ooze	423	1807	2884	423	1653	2884	461	1692	2884
"	pooch	461	1653	2730	346	1807	2846	499	1999	2769
"	rouge	499	1692	2384	423	1730	2461	461	1846	2499
"	soothe	384	2076	2884	384	1999	2846	423	1807	2923
"	spoof	499	1692	2923	423	1615	2846	423	1538	2846
"	spoon	499	1769	2807	499	1846	2884	538	1884	2846
"	stooge	384	2307	2846	423	2115	2846	307	2076	2846
"	tooth	384	2269	2999	423	2153	2769	384	2115	2807
"	tube	423	2269	2884	423	2038	2769	461	1499	2730
"	who	384	1769	2692	461	1884	2769	423	1999	2653
"	whom	423	1923	2807	346	1730	2846	384	1230	2692
/ʊ/	butch	461	1615	2884	615	1653	2999	538	1923	3038
"	hood	499	1846	2923	423	1961	2923	538	1923	3038
"	hoof	499	1692	2961	423	1653	2884	384	1538	2884
"	hook	461	1538	2846	461	1499	2961	461	1423	2884
"	push	423	1615	2807	538	1884	2846	499	1923	2846
"	puss	538	1538	2999	499	1576	3076	461	1653	3115
"	put	538	1807	3076	653	1653	3115	576	1807	3153
/o/	gauche									
"	globe	653	1499	2846	615	1538	2961	653	1192	2961
"	home	769	1230	2884	769	1307	2884	807	1153	2923
"	hope	499	1384	2846	499	1115	2846	499	1115	2846
"	hose	576	1461	2807	538	1346	2846	461	1576	2923
"	host	538	1423	2884	423	1269	2846	461	1499	2846
"	loathe	692	1730	2923	576	1538	3038	615	1538	3115
"	oaf	769	1538	2807	692	1461	2884	730	1423	2923
"	oak	692	1730	2923	653	1538	2846	615	1384	2923
"	oat	538	1615	2884	423	1384	2730	499	1423	2730
"	oath	576	1576	2769	499	1384	2884	423	1576	2923
"	ode	653	1653	2499	615	1346	2807	499	1615	2730
"	owe	653	1692	2884	653	1538	2846	615	1615	2423
"	own	730	1692	2807	653	1423	3038	692	1499	2807
"	poach	499	1576	2923	538	1499	2884	461	1615	2846
"	stove	461	1846	2730	499	1461	2653	538	1115	2769
"	vogue	615	1653	2884	653	1538	2884	538	1307	2846
/ɑ/	Goth	884	1461	2884	923	1538	2846	1038	1576	2807
"	hob	1038	1499	2769	961	1423	2769	807	1307	2807
"	hock	1038	1307	2961	923	1269	2846	923	1307	2807
"	hodge	961	1538	2846	961	1499	2884	807	1730	2884
"	hog	961	1269	2769	884	1153	2846	807	1423	2769
"	hop	961	1384	2807	1076	1461	2999	884	1307	2769
"	odd	846	1307	2846	961	1461	2846	884	1807	2499
"	off	846	1269	2692	884	1307	2807	846	1192	2884
"	on	730	1230	2692	807	1269	2961	692	1653	3153
"	ought	961	1346	2884	846	1307	2884	807	1538	2769
"	Oz	884	1346	2807	884	1423	2807	807	1653	2730
"	posh	923	1423	2923	961	1499	2846	923	1730	2692
"	Scotch	846	1499	2538	846	1538	2769	769	1730	2807
"	spa	730	1499	2846	923	1461	2923	884	1730	2730
"	Tom	807	1153	2730	884	1269	2846	807	1153	2653
"	toss	961	1230	2884	923	1423	2846	807	1615	2923
/ʌ/	hub	923	1769	2999	807	1692	2961	884	1538	2923
"	Huck	961	1692	2884	846	1615	2923	807	1538	2846
"	huff	884	1576	2807	923	1615	2807	999	1576	2884
"	hug	961	1769	2884	923	1730	2961	653	1846	2846
"	hum	884	1423	2999	884	1423	3076	846	1384	2999

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	hun	923	1576	2807	807	1653	2692	884	1807	2538
"	hush	923	1846	2923	884	1846	3076	807	1807	2884
"	hut	923	1769	2769	846	1807	2923	884	1807	3153
"	hutch	769	1730	2730	730	1846	2807	692	1884	3038
"	of	807	1730	2884	769	1769	2923	653	1653	2846
"	pudge	923	1615	2923	807	1846	2999	692	1884	3269
"	pus	1076	1846	3038	923	1730	3153	846	1846	3192
"	scuzz	769	1884	2846	730	1846	2999	807	1769	2999
"	spud	807	1730	2884	769	1769	2846	576	1923	3153
"	up	884	1692	2769	846	1692	2846	807	1538	2807
[Ir]	ear	384	2769	3423	423	2576	3230	538	1884	2807
[Er]	air	615	2307	3423	538	2269	3230	615	2076	2807
[Ar]	are	769	1346	2538	846	1230	2384	807	1269	2423
[Or]	ore	461	961	2615	538	1076	2538	769	1499	2346
[ɚ]	her	807	1692	2269	692	1653	2269	615	1769	2230
/il/	eel	499	2653	3192	538	2346	3038	653	1846	2999
/ɪl/	ill	615	2115	3230	615	1730	3269	615	1538	3230
/el/	ale	461	2538	3115	423	2499	3230	499	2384	3076
/ɛl/	L	769	1923	3038	846	1923	3115	884	1653	2961
/æl/	Al	999	1961	2846	999	1692	2807	999	1576	2846
/ul/	pool	538	1038	3038	576	1038	2999	538	1076	2999
/ʊl/	pull	423	961	3192	461	1038	3269	346	1192	3346
/ol/	hole	692	1115	3038	769	1038	3153	730	1192	3269
/ɑl/	hall	846	1346	3115	846	1307	3384	769	1346	3269
/ʌl/	hull	499	1230	3307	653	1230	3499	576	1230	3423
<ing>	ping-	346	2846	2923	346	2884	3076	346	2884	2923
<eng>	length	615	1730	3230	653	2192	3230	653	2499	3192
<ang>	hang	615	2538	3076	499	2499	3115	346	2769	3038
<ong>	-pong	846	1384	2653	923	1423	2730	846	1384	2807
<ung>	hung	846	1615	2807	807	1615	2884	846	1499	2961

Speaker 10: Female, age 21. From Lake Tahoe, CA (Northern California)

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	423	2461	2884	423	2461	2999	461	1923	2730
"	E	307	2653	3423	423	2653	3461	346	2423	3076
"	each	384	2307	3230	384	2499	3192	346	2538	3115
"	ease	346	2499	3269	384	2615	3230	423	2153	2961
"	eat	346	2307	3192	423	2615	3115	307	2269	3076
"	eke	384	2499	3307	423	2653	3346	384	2576	3192
"	eve	384	2692	3269	346	2692	3346	384	2076	2769
"	fatigue	423	2423	3076	384	2423	2846	384	2461	2730
"	heap	384	2538	3115	346	2576	2999	384	1730	2692
"	heath	384	2461	3192	461	2615	3192	461	2269	2923
"	heed	384	2576	3115	346	2576	3153	384	2153	2961
"	keen	461	2692	3153	423	2615	3115	461	2461	3076
"	O'Keefe	461	2461	3076	384	2538	2999	384	2192	2807
"	piece	499	2461	2999	384	2499	2961	461	2307	2961
"	quiche	461	2384	2923	423	2499	2999	346	2384	2923
"	scheme	461	2461	3153	499	2499	3192	461	2038	2923
"	siege	461	2423	2923	384	2423	2884	423	2076	2923
"	teethe	461	2499	2999	461	2576	3269	423	2423	2961
/ɪ/	dish	461	2192	3038	499	2192	2999	461	2038	2999
"	give	423	2076	2807	499	2153	2807	461	1692	2538
"	hick	576	2269	2807	499	2192	2807	461	2115	2615
"	him	499	2076	2884	461	2038	2884	461	1615	2769
"	hip	461	2038	2884	499	1961	2846	461	1653	2538
"	his	384	2230	2999	461	1999	2961	461	1846	2923
"	hiss	499	2038	2923	384	2038	2961	384	1884	2961
"	id	384	2153	3076	499	2192	3038	461	2038	2999
"	if	576	2076	2884	499	2192	2923	461	1923	2730
"	in	423	2384	2961	499	2384	2999	499	2038	2961
"	it	538	2115	2923	576	2192	2999	499	2076	2999
"	itch	538	2115	2923	499	2153	2961	384	2153	2884
"	midge	461	1923	2846	499	2115	2999	461	1961	3038

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	Pibb	499	1923	2884	538	1999	2730	423	1615	2461
"	pig	499	2230	2807	499	2153	2769	384	2423	2576
"	pith	461	2076	2884	576	2038	2999	461	1923	2884
/e/	A	538	2192	2961	461	2576	2999	307	2384	2999
"	Abe	499	2346	2884	499	2307	2884	461	1576	2461
"	ace	499	2230	2961	461	2384	2923	461	2307	2961
"	ache	538	2307	2961	461	2384	2884	346	2384	2807
"	age	499	2192	3076	499	2384	2999	423	2230	3076
"	aid	576	2115	2999	461	2384	2999	461	1999	2961
"	aim	576	1999	2884	576	2269	3076	384	1769	2769
"	ape	499	2269	2884	499	2499	2999	499	1807	2730
"	ate	538	2307	3038	423	2423	3076	346	2384	3038
"	beige	499	2115	2807	538	2230	2846	423	1999	2846
"	faith	538	1961	2730	538	2153	2923	461	2115	2884
"	H	576	2153	2923	461	2423	2961	384	2269	2923
"	haze	615	2269	2961	499	2384	2961	461	1961	2961
"	pain	615	2384	2999	499	2461	2999	461	2192	2884
"	pave	538	2230	2884	423	2346	2884	461	1999	2653
"	safe	538	2038	2961	461	2230	2923	461	2115	2807
"	scathe	499	2269	2961	499	2307	2961	423	1884	2615
"	vague	615	1961	2961	499	2115	2846	461	2230	2769
/ɛ/	Beth	653	1692	2730	692	1730	2923	653	1615	3038
"	Bev	576	1884	2615	615	1769	2846	538	1576	2769
"	ebb	576	1999	2923	653	1884	2884	576	1538	2615
"	Ed	653	1923	2807	653	1961	2769	576	1923	2961
"	edge	576	1961	2923	692	1999	2846	538	1961	3076
"	etch	653	1999	2923	692	1999	2807	653	1999	2923
"	F	730	1807	2807	692	1923	2884	769	1807	2807
"	heck	730	1999	2730	692	1999	2807	576	1961	2615
"	M	692	1923	2961	730	1999	2961	653	1538	2846
"	N	653	1923	2961	653	2038	2961	576	1999	2923
"	peg	499	2153	2846	423	2076	2807	384	2115	2615
"	pep	615	1846	2807	615	1769	2692	538	1615	2730
"	pet	730	1884	2807	653	1923	2846	576	1884	2884
"	Pez	692	1923	2807	615	1961	2923	384	1730	2999
"	S	499	1923	2961	692	1884	2923	653	1807	2923
"	Tesh	692	1923	2769	692	1884	2846	730	1884	2846
/æ/	add	730	1769	2807	884	1769	2807	615	1846	3115
"	Anne	499	2346	2999	538	2384	2999	423	1884	2961
"	ash	730	1923	2769	884	1769	2730	730	1846	2692
"	ass	692	1884	2923	846	1846	2846	807	1730	2846
"	at	884	1769	2730	884	1846	2807	653	1807	2730
"	badge	692	1846	2653	807	1846	2576	615	1923	2923
"	hack	999	1846	2769	884	1769	2499	961	1769	2499
"	hag	999	1807	2692	923	1807	2653	692	1961	2499
"	half	923	1923	2730	884	1692	2807	961	1692	2653
"	ham	846	2153	2807	653	1999	2807	807	1538	2884
"	has	846	1884	2769	846	1884	2961	499	1730	3115
"	hatch	923	1923	2807	884	1884	2769	846	1923	2846
"	path	961	1692	2692	884	1653	2692	884	1692	2730
"	perhaps	807	1730	2461	769	1692	2576	730	1615	2576
"	scab	653	2076	2769	730	1846	2846	692	1538	2692
/u/	douche	461	2076	2807	538	1884	2461	423	1923	2576
"	dude	499	2038	2730	499	2038	2423	423	1961	2653
"	goose	461	1769	2499	538	1576	2461	461	1576	2653
"	hoop	538	1576	2538	461	1346	2576	423	1038	2653
"	hoot	461	1499	2615	423	1499	2461	499	1538	2461
"	kook	461	1538	2499	423	1499	2538	346	1384	2576
"	move	538	1576	2499	423	1461	2423	461	1384	2538
"	ooze	423	1538	2538	461	1538	2423	423	1692	2769
"	pooch	423	1576	2538	461	1576	2499	423	1692	2384
"	rouge	499	1615	2192	461	1615	2269	461	1692	2423
"	soothe	461	1961	2615	538	1923	2615	499	1615	2653
"	spoof	461	1538	2423	423	1423	2499	499	1423	2461
"	spoon	423	1499	2499	423	1576	2499	461	1730	2692
"	stooge	384	2153	2653	461	1923	2499	423	1846	2461
"	tooth	423	1730	2653	423	1846	2615	423	1923	2807
"	tube	461	1999	2538	461	1730	2499	423	1423	2499

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	who	384	1576	2576	461	1384	2538	384	1807	2538
"	whom	461	999	2653	461	999	2692	307	1038	2769
/ʊ/	butch	461	1384	2499	576	1499	2615	423	1730	2576
"	hood	615	1653	2692	538	1769	2730	538	1961	2807
"	hoof	615	1461	2692	538	1461	2576	615	1461	2538
"	hook	576	1538	2653	615	1538	2461	538	1499	2423
"	push	499	1499	2576	576	1576	2538	384	1692	2576
"	puss	499	1653	2769	499	1576	2769	461	1538	2923
"	put	576	1499	2615	538	1499	2653	499	1769	2846
/o/	gauche	538	1730	2461	499	1576	2423	538	1576	2499
"	globe	653	1230	2884	653	1384	2807	423	1115	2576
"	home	692	1115	2999	461	961	3038	423	961	3076
"	hope	499	1269	2653	461	1115	2692	461	1038	2499
"	hose	692	1538	2538	576	1307	2538	499	1576	2884
"	host	538	1384	2538	499	1346	2615	499	1499	2769
"	loathe	692	1461	2923	615	1384	2807	615	1384	2884
"	oaf	538	1499	2538	538	1307	2576	423	1153	2461
"	oak	615	1461	2538	538	1269	2461	499	1192	2538
"	oat	615	1384	2499	538	1307	2538	461	1423	2423
"	oath	653	1499	2615	499	1384	2499	499	1499	2653
"	ode	615	1576	2538	499	1346	2576	499	1653	2346
"	owe	615	1615	2730	615	1307	2538	461	1730	2423
"	own	615	1384	2769	615	1076	2769	538	1346	2615
"	poach	576	1461	2692	461	1269	2615	384	1576	2423
"	stove	576	1730	2692	576	1423	2499	538	1230	2499
"	vogue	576	1346	2538	538	1346	2499	423	1076	2461
/ɑ/	Goth	615	1576	2692	807	1423	2538	807	1576	2807
"	hob	769	1346	2615	730	1346	2692	576	1269	2538
"	hock	846	1346	2769	769	1346	2730	692	1384	2461
"	hodge	807	1346	2615	807	1461	2576	692	1576	2423
"	hog	692	1346	2653	615	1269	2576	653	1538	2384
"	hop	846	1346	2846	769	1461	2846	692	1423	2653
"	odd	692	1461	2769	846	1423	2692	653	1615	2807
"	off	769	1423	2692	846	1269	2653	769	1269	2692
"	on	730	1230	2884	769	1192	2846	730	1576	2884
"	ought	730	1423	2769	769	1307	2807	692	1499	2807
"	Oz	730	1269	2846	807	1307	2692	538	1653	2730
"	posh	807	1423	2653	846	1346	2538	884	1499	2499
"	scotch	692	1576	2423	807	1423	2538	692	1692	2576
"	spa	730	1346	2576	769	1461	2692	730	1538	2807
"	Tom	653	1269	2961	730	1307	3115	730	1269	2999
"	toss	807	1423	2730	846	1576	2692	846	1576	2807
/ʌ/	hub	807	1576	2730	692	1576	2769	538	1384	2653
"	huck	769	1576	2538	769	1576	2461	576	1576	2499
"	huff	807	1461	2692	769	1499	2692	730	1461	2576
"	hug	846	1692	2615	769	1653	2461	615	1692	2461
"	hum	653	1346	2923	692	1346	2884	769	1269	2961
"	hun	846	1730	2923	807	1615	2961	846	1653	2999
"	hush	769	1576	2730	653	1576	2730	730	1653	2884
"	hut	769	1615	2769	730	1807	2807	538	1769	2807
"	hutch	769	1653	2769	692	1653	2807	499	1807	2961
"	of	692	1730	2807	769	1538	2807	653	1384	2653
"	pudge	653	1576	2653	615	1730	2692	538	1769	2769
"	pus	807	1653	2884	692	1538	2769	692	1692	2769
"	scuzz	653	1846	2692	576	1692	2884	461	1615	2923
"	spud	653	1653	2730	615	1653	2884	576	1846	2999
"	up	692	1846	2769	730	1653	2846	538	1499	2653
[Ir]	ear	346	2499	2999	384	2307	2961	461	1923	2576
[Er]	air	538	2038	2961	576	2038	2807	576	1807	2346
[Ar]	are	730	1346	2576	769	1346	2461	692	1499	2269
[Or]	ore	538	1192	2499	576	1038	2307	615	1461	2038
[ɚ]	her	730	1576	1961	499	1538	1961	461	1615	1999
/il/	eel	384	2576	3076	423	2384	2961	499	1923	2923
/ɪl/	ill	576	1999	2961	538	1846	2884	615	1499	3076
/el/	ale	576	2115	2999	615	2230	2807	615	1923	2961
/ɛl/	L	653	1846	2807	730	1692	2807	692	1499	3115

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/æl/	Al	538	1846	2769	692	1807	2807	884	1692	2730
/ul/	pool	499	999	2884	461	999	2923	538	1038	2846
/ʊl/	pull	576	1153	3192	576	1038	3230	576	999	3192
/ol/	hole	576	961	2769	499	923	2884	461	1038	2961
/ɑl/	hall	692	1076	2923	653	1076	3038	576	1038	3038
/ʌl/	hull	653	1076	2961	576	961	3038	615	1038	3115
<ing>	ping	423	2307	2961	538	2307	2846	499	2230	2769
<eng>	length	730	1384	3115	730	1769	2923	769	2192	2846
<ang>	hang	653	2192	2807	653	2115	2846	499	2499	2807
<ong>	pong	769	1461	2730	653	1269	2615	769	1384	2807
<ung>	hung	884	1538	2846	807	1461	2884	653	1423	2807

Speaker 11: Male, age 22. From Mountain View (Northern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	346	1615	2461	423	2384	2999	346	1884	2692
"	E	307	2346	3230	346	2423	3307	307	2307	3038
"	each	307	2499	3115	384	2384	3192	307	2307	2884
"	ease	307	2423	3384	423	2384	3346	384	1807	2692
"	eat	346	2538	3230	346	2384	3230	346	2346	2999
"	eke	269	2384	3269	384	2423	3230	269	2461	2884
"	eve	346	2384	3230	346	2423	3307	307	1961	2576
"	fatigue	423	2346	2999	384	2307	2884	423	2076	2615
"	heap	346	2384	2999	423	2307	2961	384	2269	2884
"	heath	346	2269	3230	423	2269	2999	346	2153	2769
"	heed	384	2346	2923	423	2346	2923	423	2115	2769
"	keen	384	2384	3076	423	2615	3192	307	2423	2923
"	O'Keefe	346	2423	3038	384	2307	2884	461	2038	2499
"	piece	307	2346	3076	384	2346	3038	307	2423	2961
"	quiche	423	2384	2999	307	2423	2923	346	2384	2730
"	scheme	307	2269	3192	346	2384	3192	307	1999	2423
"	siege	384	2192	2807	346	2307	3038	346	2038	2653
"	teethe	384	2461	3230	384	2423	3153	384	2076	2499
/ɪ/	dish	384	2038	2769	461	2115	2807	461	2038	2846
"	give	461	2384	2884	576	2038	2807	423	1307	2807
"	hick	538	2192	2846	538	2192	2807	461	2230	2807
"	him	499	2269	2807	538	2115	2769	538	1461	2807
"	hip	538	2269	2846	653	2153	2730	538	1576	2615
"	his	423	2307	2884	423	1846	2730	346	1807	2769
"	hiss	576	2115	2807	576	2192	2846	461	1884	2807
"	id	423	2307	2961	423	2230	2923	461	1923	2807
"	if	423	2346	2807	499	2153	2769	576	1807	2615
"	in	423	2499	2961	461	2346	2999	461	1999	2846
"	it	384	2346	2846	538	2307	2884	499	2038	2807
"	itch	423	2307	2846	499	2192	2807	499	1961	2846
"	midge	423	2038	2653	461	2153	2807	423	2038	2807
"	Pibb	499	2115	2653	538	2038	2653	576	1499	2423
"	pig	461	2230	2769	423	2153	2615	461	2192	2538
"	pith	576	2038	2807	576	2076	2769	615	2076	2807
/e/	A	538	2384	2961	576	2461	3038	307	2384	2961
"	Abe	346	2384	2692	461	2461	2730	346	1846	2538
"	ace	461	2346	2961	384	2499	2923	307	2538	2961
"	ache	423	2346	2807	346	2307	2807	346	2269	2846
"	age	461	2230	2615	423	2423	2769	461	2115	2692
"	aid	423	2269	2730	384	2423	2999	307	2115	2807
"	aim	307	2307	2846	499	2384	2730	307	2269	2730
"	ape	499	2423	2692	346	2461	2730	384	2384	2538
"	ate	423	2461	2576	384	2538	2692	307	2346	2807
"	beige	499	1961	2615	461	2461	2730	307	2076	2653
"	faith	499	1961	2615	499	2230	2769	346	2384	2769
"	H	384	2423	2730	384	2538	2769	384	2461	2807
"	haze	499	2423	2884	384	2499	2846	346	1999	2692
"	pain	346	2423	2692	461	2692	2769	499	2499	2846
"	pave	538	2307	2538	346	2423	2615	346	1961	2538
"	safe	538	1961	2730	461	2230	2884	423	2423	2769
"	scathe	461	2346	2692	461	2192	2615	538	1807	2615

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	vague	499	1923	2269	461	2307	2807	346	2269	2692
/ɛ/	Beth	692	1692	2461	730	1769	2692	692	1730	2769
"	Bev	615	1769	2423	692	1769	2538	576	1499	2461
"	ebb	576	1923	2692	576	1807	2692	615	1307	2461
"	Ed	653	2076	2769	615	2038	2730	461	1961	2692
"	edge	653	2038	2730	653	2076	2730	538	1999	2730
"	etch	653	1961	2846	653	1961	2846	615	1961	2807
"	F	653	1769	2653	730	1807	2615	653	1576	2653
"	heck	769	1884	2653	730	1846	2499	692	1846	2384
"	M	615	2038	2807	615	2076	2807	653	1269	2807
"	N	653	2038	2807	730	1999	2884	653	1807	2961
"	peg	692	2076	2884	538	2115	2692	423	2192	2461
"	pep	730	1923	2692	769	1846	2616	769	1653	2538
"	pet	653	1846	2692	653	1807	2692	538	1692	2730
"	Pez	653	1961	2769	615	1884	2807	499	1692	2692
"	S	653	1769	2769	807	1846	2807	653	1730	2807
"	Tesh	692	1923	2692	692	1923	2692	692	1961	2807
/æ/	add	807	1884	2538	884	1730	2538	615	1730	2769
"	Anne	653	1923	2807	730	2115	2769	769	1461	2884
"	ash	846	1807	2499	923	1769	2538	884	1730	2461
"	ass	923	1653	2499	961	1730	2692	884	1615	2576
"	at	846	1884	2615	884	1769	2653	769	1653	2730
"	badge	615	1884	2615	884	1769	2576	692	1692	2769
"	hack	923	1692	2576	961	1692	2499	884	1653	2423
"	hag	923	2038	2769	846	2038	2769	461	2038	2692
"	half	999	1615	2615	923	1653	2576	961	1653	2615
"	ham	730	2269	2884	692	2153	2884	807	1269	2769
"	has	923	1769	2653	923	1769	2653	653	1576	2884
"	hatch	961	1923	2730	999	1807	2730	807	1730	2769
"	path	1038	1653	2615	999	1692	2730	999	1538	2769
"	perhaps	884	1576	2499	846	1653	2423	769	1423	2423
"	scab	615	2153	2653	884	1923	2653	769	1461	2538
/u/	douche	346	2038	2499	423	1692	2423	423	1461	2384
"	dude	461	1961	2499	423	1461	2461	461	1538	2346
"	goose	346	1307	2307	384	1076	2423	384	1038	2499
"	hoop	423	1038	2346	499	999	2423	307	923	2307
"	hoot	423	1076	2307	423	1115	2307	346	1038	2346
"	kook	499	1192	2423	423	999	2423	346	884	2346
"	move	461	1076	2461	423	999	2538	384	884	2576
"	ooze	346	961	2423	384	884	2499	346	1038	2384
"	pooch	423	1153	2384	423	1115	2384	384	1192	2423
"	rouge	423	1230	2153	461	1115	2423	423	1423	2307
"	soothe	423	1923	2346	346	1576	2307	384	1538	2346
"	spoof	461	1192	2346	346	1038	2423	423	1153	2461
"	spoon	423	1192	2346	423	1153	2346	423	1269	2307
"	stooge	423	1961	2461	461	1692	2384	423	1499	2230
"	tooth	461	1653	2346	499	1499	2346	423	1423	2346
"	tube	384	1730	2384	461	1307	2346	384	884	2384
"	who	384	961	2538	423	846	2423	384	1230	2499
"	whom	499	923	2499	384	884	2269	307	846	2269
/ʊ/	butch	499	1115	2730	538	1269	2692	576	1538	2461
"	hood	461	1269	2499	499	1384	2423	461	1692	2576
"	hoof	538	1115	2615	576	1153	2576	653	1153	2653
"	hook	499	1192	2615	576	1076	2538	576	1038	2576
"	push	653	1192	2615	576	1269	2653	576	1499	2423
"	puss	576	1153	2538	538	1230	2576	576	1384	2538
"	put	538	1076	2615	615	1346	2461	576	1499	2461
/o/	gauche	423	1538	2384	538	1307	2461	461	1153	2538
"	globe	576	1115	2769	499	999	2730	384	846	2692
"	home	576	1037	2192	423	998	2230	422	764	2192
"	hope	538	1076	2423	423	999	2461	461	769	2423
"	hose	499	1076	2384	461	999	2384	423	1384	2538
"	host	499	1076	2461	499	1076	2423	423	1153	2653
"	loathe	576	1384	2730	461	1038	2730	538	1346	2615
"	oaf	423	1115	2461	461	1076	2461	461	846	2499
"	oak	461	1076	2538	576	1038	2461	346	807	2499
"	oat	499	1038	2499	423	884	2576	384	923	2384

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	oath	461	1115	2499	499	1038	2576	461	923	2423
"	ode	576	1115	2576	499	1038	2653	423	999	2269
"	owe	653	1269	2576	461	999	2538	423	1115	2730
"	own	538	1115	2653	346	923	2884	384	999	2692
"	poach	538	1153	2423	538	1038	2423	499	1153	2153
"	stove	461	1730	2538	499	1192	2461	423	846	2576
"	vogue	538	1230	2499	538	1115	2615	423	961	2538
/ɑ/	Goth	615	1384	2538	769	1230	2884	769	1269	2846
"	hob	730	1153	2615	807	1115	2730	576	1115	2692
"	hock	846	1269	2692	884	1230	2730	846	1192	2769
"	hodge	692	1230	2538	769	1423	2576	692	1653	2346
"	hog	846	1153	2769	807	1230	2769	615	1307	2692
"	hop	884	1307	2653	807	1307	2576	769	1230	2615
"	odd	769	1153	2692	807	1153	2730	692	1576	2653
"	off	653	1038	2615	807	1192	2769	769	1153	2653
"	on	730	1153	2884	769	1192	3230	769	1423	2999
"	ought	846	1153	2923	846	1269	2769	730	1538	2653
"	Oz	769	1230	2846	769	1192	2730	576	1423	2769
"	posh	846	1192	2653	807	1269	2653	769	1461	2538
"	Scotch	730	1538	2499	807	1346	2653	769	1461	2615
"	spa	730	1230	2499	807	1307	2807	769	1423	2692
"	Tom	884	1192	3038	923	1192	3076	846	1153	2999
"	toss	884	1153	2692	923	1269	2769	769	1269	2653
/ʌ/	hub	769	1346	2653	730	1307	2653	576	1153	2538
"	Huck	730	1346	2653	769	1346	2615	769	1269	2692
"	huff	730	1307	2730	730	1269	2846	653	1269	2807
"	hug	692	1269	2807	653	1307	2769	499	1269	2692
"	hum	615	1115	3038	692	1076	2999	730	961	3038
"	hun	730	1307	2884	769	1499	2961	807	1576	2923
"	hush	730	1538	2615	692	1423	2499	615	1692	2499
"	hut	769	1461	2692	769	1461	2576	576	1692	2423
"	hutch	692	1499	2576	692	1538	2423	538	1615	2461
"	of	730	1269	2615	653	1230	2653	615	1115	2653
"	pudge	615	1384	2576	653	1499	2538	538	1653	2384
"	pus	846	1384	2576	730	1499	2692	769	1538	2653
"	scuzz	576	1615	2461	538	1499	2769	423	1461	2769
"	spud	615	1384	2461	653	1499	2576	615	1576	2653
"	up	653	1346	2884	692	1384	2769	576	1269	2538
[Ir]	ear	269	2346	3192	384	2346	2884	461	1576	2538
[Er]	air	461	2269	2730	423	2076	2576	538	1730	2499
[Ar]	are	692	1115	2692	730	1076	2692	615	1230	2538
[Or]	ore	307	692	2884	461	884	2807	538	1192	2346
[ɚ]	her	576	1269	1653	538	1346	1807	461	1423	1846
[Ur]	poor	461	999	2423	461	1076	2384	576	1153	2038
/il/	eel	384	2461	3461	384	2384	3384	461	2115	3192
/ɪl/	ill	346	2230	2884	461	2230	2730	538	1576	2692
/el/	ale	499	2307	2615	538	2269	2769	423	1999	2538
/ɛl/	L	807	1884	2461	807	1615	2615	615	1153	2730
/æl/	Al	846	1615	2384	923	1576	2461	923	1461	2576
/ul/	pool	461	923	2461	461	961	2499	499	923	2615
/ʊl/	pull	576	1076	2807	653	1038	2769	653	961	2846
/ol/	hole	423	769	2653	384	653	2769	423	769	2846
/ɑl/	hall	653	961	2923	653	1038	2884	615	846	2884
/ʌl/	hull	653	1076	2846	615	961	2999	692	999	2961
<ing>	ping-	423	2269	2769	384	2230	2769	346	2307	2576
<eng>	length	615	1269	2884	653	1692	2807	538	2076	2807
<ang>	hang	807	2192	2692	692	2269	2769	730	2384	2692
<ong>	-pong	730	1115	2423	884	1076	2769	884	1153	3038
<ung>	hung	730	1307	2576	653	1192	2653	692	1192	2692

Speaker 12: Female, age 27. From Downey (Southern California)

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	461	2307	3230	499	2884	3423	423	2230	3153

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	E	346	2884	3461	384	2884	3615	307	2807	3192
"	each	384	3038	3461	346	2961	3538	346	2884	3346
"	ease	346	2884	3346	423	2923	3307	346	2346	3115
"	eat	384	2999	3423	423	2961	3269	269	2499	3038
"	eke	423	2999	3499	423	2923	3499	346	2999	3384
"	eve	384	2923	3346	384	2961	3538	423	2538	2923
"	fatigue	461	2884	3423	384	2846	3346	384	2730	3115
"	heap	423	2615	3307	384	2615	3230	384	2346	2730
"	heath	461	2807	3346	423	2730	3269	346	2384	2961
"	heed	461	2807	3307	384	2846	3499	461	2807	3153
"	keen	346	2807	3423	423	2884	3307	269	2846	3423
"	O'Keefe	346	2807	3499	423	2730	3423	307	2807	3230
"	piece	384	2846	3269	423	2807	3346	423	2807	3230
"	quiche	384	2846	3307	384	2769	3307	384	2730	3346
"	scheme	384	2884	3423	461	2846	3538	499	2499	3076
"	siege	423	2653	3038	423	2730	3269	423	2730	3076
"	teethe	346	2846	3423	461	2884	3461	461	2384	2961
/ɪ/	dish	461	2346	2961	576	2307	2999	576	2192	2999
"	give	461	2653	3307	576	2346	3038	692	1615	2730
"	hick	538	2461	3076	615	2499	3076	615	2230	2961
"	him	692	2576	3192	615	2384	3076	692	1615	2884
"	hip	576	2499	3230	576	2307	3076	653	1961	2923
"	his	538	2499	3153	576	2346	3115	384	1999	2961
"	hiss	538	2384	3076	615	2153	3038	576	2115	2999
"	id	499	2692	3192	615	2461	3230	576	2115	2999
"	if	538	2461	3076	576	2230	3192	538	1923	2961
"	in	499	2615	3230	576	2499	3269	461	2115	3153
"	it	461	2769	3307	538	2461	3346	576	2269	3269
"	itch	423	2538	3230	576	2461	3192	499	2269	3115
"	midge	692	2192	2884	653	2423	3230	576	2346	3076
"	Pibb	499	2384	3038	576	2307	3038	538	1769	2846
"	pig	499	2384	3076	538	2423	2923	384	2615	2961
"	pith	576	2346	3076	615	2192	2999	615	2038	2999
/e/	A	538	2423	2999	576	2730	3269	384	2576	3115
"	Abe	461	2653	3153	499	2846	3307	423	2615	3153
"	ace	538	2846	3384	538	2884	3307	499	2538	3269
"	ache	499	2576	3115	423	2846	3384	423	2884	3192
"	age	538	2538	3153	461	2807	3346	384	2499	3076
"	aid	615	2384	3076	576	2923	3346	423	2807	3153
"	aim	615	2615	3269	423	2846	3307	423	2499	3076
"	ape	499	2730	3115	423	2769	3269	384	2423	3038
"	ate	461	2730	3192	461	2961	3384	269	2538	3076
"	beige	653	2038	2769	499	2653	3153	499	2423	2923
"	faith	615	2230	2846	576	2461	2999	346	2346	2884
"	H	576	2576	3153	538	2807	3192	384	2615	3192
"	haze	692	2538	3038	499	2576	3192	423	2153	3038
"	pain	692	2461	3153	615	2846	3269	499	2499	3153
"	pave	692	2423	2999	538	2692	3153	499	2192	2923
"	safe	576	2346	3038	576	2499	2999	461	1999	2884
"	scathe	538	2692	3269	538	2538	3230	461	2153	2999
"	vague	576	2153	2807	576	2461	3115	461	2692	3038
/ɛ/	Beth	730	2115	2884	846	2153	2923	807	2038	2999
"	Bev	653	1961	2923	769	2038	3038	615	1615	2769
"	ebb	730	2192	3038	846	2038	2999	653	1615	2769
"	Ed	730	2230	3076	769	2346	3192	576	2230	3038
"	edge	769	2307	2999	769	2384	2999	615	2153	2999
"	etch	615	2307	2961	769	2192	2961	653	2153	2961
"	F	692	2307	2923	884	2115	3038	846	1769	2846
"	heck	769	2076	2807	807	2076	2807	692	2076	2769
"	M	615	2153	2999	846	2230	3038	769	1576	2884
"	N	769	2346	3230	769	2307	3384	692	2230	3192
"	peg	769	2269	3076	730	2307	2999	576	2576	2884
"	pep	923	2038	2923	807	2038	2923	730	1846	2846
"	pet	769	2269	3038	769	2153	3038	576	2153	3076
"	Pez	730	2192	3076	692	2153	3076	538	2038	2884
"	S	730	2230	3038	769	2153	3153	769	1961	3153
"	Tesh	807	2192	2923	846	2115	2807	846	1999	2884
/æ/	add	653	2192	3230	923	1961	2961	692	1961	3115

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	Anne	615	2499	3115	769	2615	3230	807	1961	3115
"	ash	923	1999	2846	923	1961	2807	807	1807	2769
"	ass	884	2153	2807	961	1999	2846	961	1692	2653
"	at	884	2153	2923	961	1961	2961	769	1923	2846
"	badge	576	1961	2961	923	1961	2807	653	1923	2923
"	hack	961	2115	2807	999	1999	2846	1038	1884	2846
"	hag	884	2115	2884	961	2076	2884	653	2230	2923
"	half	999	2038	3038	1076	1999	2961	961	1769	2961
"	ham	846	2576	3038	730	2615	2999	769	1576	3153
"	has	884	1999	2999	961	1961	3038	692	1923	2999
"	hatch	961	1999	2884	999	1923	2884	846	1846	2807
"	path	884	2038	2846	961	1961	2769	999	1653	2884
"	perhaps	846	2076	2884	961	1807	2807	807	1499	2846
"	scab	576	2461	2884	846	2115	2923	884	1615	2769
/u/	douche	423	2346	2807	384	1961	2692	346	1961	2692
"	dude	346	2384	2923	461	2076	2846	423	1923	2653
"	goose	423	1884	2807	538	1653	2846	384	1999	2807
"	hoop	461	1192	2730	461	1115	2807	461	999	2730
"	hoot	461	1307	2769	423	1192	2730	423	1499	2730
"	kook	461	1538	2846	461	1499	2807	384	1269	2730
"	move	538	1192	2730	538	1230	2807	499	1115	2807
"	ooze	384	1461	2884	499	1192	2846	461	1999	2807
"	pooch	461	1192	2730	423	1153	2730	384	1538	2730
"	rouge	423	1692	2230	499	1846	2653	423	1961	2576
"	soothe	461	2153	2846	423	1884	2653	423	1615	2692
"	spoof	461	1346	2576	461	1346	2769	461	1192	2653
"	spoon	499	1653	2692	499	1576	2769	461	1653	2730
"	stooge	499	2269	2807	461	1884	2692	461	2230	2884
"	tooth	269	2230	2846	423	1999	2692	346	1923	2615
"	tube	499	2076	2653	384	1769	2576	384	1269	2576
"	who	538	1423	2769	461	1269	2769	423	1576	2653
"	whom	461	1269	2846	538	1038	2923	461	1076	2884
/ʊ/	butch	576	1192	2884	615	1269	2846	538	1846	2884
"	hood	576	1461	2730	576	1499	2769	615	2038	2846
"	hoof	615	1423	2730	653	1461	2730	653	1615	2807
"	hook	653	1307	2730	615	1423	2807	615	1461	2730
"	push	615	1230	2692	615	1499	2653	615	1961	2730
"	puss	653	1230	2769	692	1538	2730	615	1961	2923
"	put	576	1230	2846	653	1384	2846	692	1884	2807
/o/	gauche	538	1499	2692	615	1423	2692	499	1307	2692
"	globe	653	1461	2999	615	1423	2884	538	999	2846
"	home	769	1230	2730	692	1076	2807	538	1076	2769
"	hope	576	1192	2769	576	1115	2692	538	961	2730
"	hose	692	1423	2769	538	1076	2769	499	1423	2884
"	host	615	1153	2846	538	999	2730	499	1846	3038
"	loathe	576	1230	3192	576	1153	2884	538	1307	2884
"	oaf	615	1538	2730	576	1115	2730	499	923	2769
"	oak	576	1115	2846	615	1076	2999	384	923	2923
"	oat	576	1423	2846	576	1115	2923	423	1307	2692
"	oath	576	1192	2730	576	1076	2961	538	1307	2999
"	ode	576	1461	2769	576	1269	2807	499	1192	2807
"	owe	730	1499	2769	576	1307	2961	423	1346	2807
"	own	807	1461	2653	730	1230	2807	653	1192	2692
"	poach	653	1346	2730	576	1230	2807	423	1384	2576
"	stove	615	1999	2807	615	1423	2769	499	1153	2692
"	vogue	499	1269	2730	615	1230	2846	499	961	2807
/ɑ/	Goth	576	1846	2769	884	1307	2846	846	1499	2923
"	hob	923	1461	2807	846	1307	2884	730	1499	2807
"	hock	961	1346	2884	846	1346	2923	807	1346	2769
"	hodge	923	1346	2846	884	1538	2846	653	1884	2807
"	hog	884	1384	2769	884	1346	2846	769	1423	2807
"	hop	884	1423	2807	846	1346	2884	846	1384	2807
"	odd	769	1576	2730	884	1307	2884	615	1884	2923
"	off	807	1307	2730	884	1307	2730	807	1346	2807
"	on	730	1307	3423	769	1269	3307	846	1807	3153
"	ought	692	1269	2807	769	1269	2769	884	1576	2884
"	Oz	769	1538	2730	769	1423	2884	653	1884	2807
"	posh	846	1346	2730	846	1346	2769	807	1538	2692

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	Scotch	769	1692	2653	769	1499	2653	884	1692	2576
"	spa	730	1461	2576	807	1461	2692	884	1615	2730
"	Tom	769	1230	2307	807	1269	2461	769	1346	2423
"	toss	807	1461	2807	846	1384	2730	961	1615	2807
/ʌ/	hub	884	1576	2769	769	1499	2730	576	1269	2807
"	Huck	846	1461	2769	807	1461	2730	807	1423	2769
"	huff	923	1538	2807	846	1538	2884	846	1461	2846
"	hug	923	1615	2807	884	1576	2884	615	1576	2769
"	hum	884	1461	2653	769	1461	2653	769	1307	2692
"	hun	846	1538	2692	769	1615	2576	807	1923	2538
"	hush	884	1461	2692	769	1615	2846	807	1884	2846
"	hut	884	1615	2923	846	1615	2961	692	1923	2923
"	hutch	884	1615	2769	884	1692	2846	730	1999	2807
"	of	730	1653	2807	884	1576	2923	692	1307	3076
"	pudge	846	1653	2846	807	1769	2807	576	2038	2961
"	pus	846	1461	2807	923	1538	2923	807	1730	2961
"	scuzz	576	1923	2615	730	1884	2923	730	1923	3038
"	spud	692	1499	2807	846	1615	2769	615	1961	2999
"	up	846	1576	2653	846	1576	2846	769	1384	2653
[Ir]	ear	423	2846	3461	461	2692	3038	538	2153	2615
[Er]	air	499	2423	2999	538	2499	2999	653	2230	2538
[Ar]	are	884	1269	2538	730	1269	2461	730	1499	2346
[Or]	ore	538	999	2730	576	961	2576	653	1307	2192
[ɚ]	her	692	1576	1846	692	1538	1884	615	1499	2192
/il/	eel	346	2846	3307	461	2846	3346	730	1576	3192
/ɪl/	ill	423	2499	3076	615	2384	3230	653	1923	3192
/el/	ale	653	2499	2961	653	2499	2999	692	2423	3115
/ɛl/	L	653	2230	3076	807	2038	2999	884	1807	3346
/æl/	Al	923	1999	2884	961	1999	2923	1038	1730	3038
/ul/	pool	461	807	2769	499	846	2807	423	807	2807
/ʊl/	pull	576	1115	3115	653	923	3307	499	999	3384
/ol/	hole	615	1038	2807	538	961	2999	538	1038	3307
/ɑl/	hall	884	1269	2846	846	1307	2961	807	1230	3076
/ʌl/	hull	807	1230	2961	653	1192	3192	615	1038	3153
<ing>	ping-	499	2653	3192	499	2730	3230	461	2884	3115
<eng>	length	730	1538	3346	807	2192	3269	653	2615	2999
<ang>	hang	769	2346	3038	769	2499	2999	730	2615	2999
<ong>	-pong	769	1153	2807	769	1307	2884	769	1307	2692
<ung>	hung	730	1461	2807	807	1423	2807	807	1423	2807

Speaker 13: Female, age 23. From San Diego (Southern California)

			T1			T2			T3	
vowel	word	F1	F2	F3	F1	F2	F3	F1	F2	F3
/i/	dweeb	499	2192	2807	538	2538	3230	499	2076	2653
"	E	384	2538	3230	423	2692	3461	423	2461	3230
"	each	461	2538	3115	384	2653	3230	423	2384	3269
"	ease	423	2615	3192	423	2653	3192	384	2115	2846
"	eat	461	2730	3307	384	2692	3269	461	2461	3192
"	eke	384	2730	3269	346	2807	3461	346	2769	3269
"	eve	307	2730	3269	461	2615	3269	499	2076	2769
"	fatigue	538	2423	3038	499	2384	3076	499	2499	2884
"	heap	423	2769	3153	538	2615	3230	461	2230	2923
"	heath	461	2461	3153	499	2538	3269	384	2461	3076
"	heed	384	2576	3192	499	2615	3384	461	2269	2884
"	keen	346	2730	3115	384	2923	3153	384	2846	3038
"	O'Keefe	423	2692	3307	423	2730	3269	499	2730	3115
"	piece	307	2615	3269	346	2653	3384	346	2384	3307
"	quiche	384	2653	3076	423	2576	3269	461	2538	2999
"	scheme	499	2615	3384	615	2615	3423	769	1961	3076
"	siege	423	2423	2999	499	2461	3153	461	2307	2923
"	teethe	384	2538	3115	461	2538	2999	384	2230	2807
/ɪ/	dish	461	2230	2961	576	2115	2961	461	2038	2961
"	give	499	2423	3038	615	2192	2884	499	1961	2615
"	hick	692	2192	2846	692	2192	2884	615	2192	2730

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	him	499	2076	2461	461	1923	2461	461	1615	2461
"	hip	653	2153	2884	730	2038	2923	615	1653	2538
"	his	499	2269	2999	499	2153	2961	461	1923	2884
"	hiss	692	2115	2999	499	1961	2999	461	1961	2884
"	id	538	2346	2999	423	2307	2999	499	2192	2923
"	if	576	2192	2923	576	2115	2923	499	1961	2615
"	in	461	2423	3076	538	2423	3115	538	2230	3115
"	it	538	2269	3038	615	2153	2961	538	2115	2923
"	itch	538	2192	2961	538	2192	2999	499	2076	2846
"	midge	692	2038	2884	692	2115	3153	499	2038	3076
"	Pibb	499	2115	2807	461	2038	2769	499	1615	2692
"	pig	576	2269	2884	461	2384	2961	538	2269	2807
"	pith	538	2115	2807	615	1999	2846	653	1999	2730
/e/	A	653	2346	2923	653	2461	2884	461	2307	2884
"	Abe	692	2384	2923	615	2423	2999	423	1961	2730
"	ace	576	2423	3038	461	2653	3153	499	2423	3038
"	ache	576	2307	2961	653	2499	3076	423	2730	2999
"	age	423	2499	2999	423	2538	3076	499	2384	2923
"	aid	538	2461	2961	461	2615	2999	461	2115	2923
"	aim	576	2423	3038	615	2499	3076	499	1884	2538
"	ape	653	2346	2884	538	2538	2923	499	1999	2769
"	ate	538	2499	3038	461	2538	2999	384	2538	2999
"	beige	576	2192	2807	538	2423	3076	461	2269	2884
"	faith	615	2115	2730	499	2307	2769	384	2307	2615
"	H	538	2307	2923	538	2538	2884	423	2307	2923
"	haze	615	2269	3076	499	2423	2923	423	1923	2769
"	pain	423	2384	2961	423	2615	3115	346	2230	3038
"	pave	653	2461	2884	499	2423	2999	461	1846	2615
"	safe	653	2038	2884	615	2192	2961	538	2153	2730
"	scathe	538	2384	2923	538	2384	2884	576	2038	2769
"	vague	692	1923	2846	769	2153	2961	538	2346	2730
/ɛ/	Beth	653	1653	2615	807	1692	2923	807	1884	2961
"	Bev	692	1769	2653	846	1846	2846	692	1653	2615
"	ebb	730	1923	2884	769	1961	2884	615	1653	2499
"	Ed	769	2076	2846	846	2038	2846	615	1961	2961
"	edge	730	2038	2884	769	2115	2923	615	2038	3038
"	etch	807	1923	2884	807	1846	2923	692	1923	2807
"	F	846	1769	2769	846	1807	2769	961	1730	2615
"	heck	961	1923	2615	961	1923	2730	846	1923	2615
"	M	923	2038	2884	961	1961	2999	846	1538	2846
"	N	884	2076	2923	923	2038	3269	999	2076	3115
"	peg	846	1999	2807	730	2192	2807	615	2346	2807
"	pep	884	1653	2923	961	1615	2769	807	1499	2579
"	pet	884	1884	2846	923	1846	2923	730	1807	2884
"	Pez	884	1884	2807	846	1923	2923	692	1884	2807
"	S	884	1807	2884	884	1807	2884	807	1730	2807
"	Tesh	884	1846	2769	846	1846	2769	769	1923	2730
/æ/	add	884	1961	2884	1038	1846	2846	730	1769	2961
"	Anne	807	2192	2999	807	2038	2999	769	1692	2923
"	ash	1038	1769	2769	1038	1846	2730	923	1653	2769
"	ass	884	1807	2730	923	1730	2769	846	1615	2807
"	at	1038	1884	2807	1115	1846	2692	846	1769	2846
"	badge	769	1846	2615	1038	1692	2769	730	1769	3076
"	hack	999	1807	2615	1038	1846	2730	999	1769	2538
"	hag	961	1692	2692	999	1807	2846	615	2192	2730
"	half	1076	1846	2884	1153	1653	2846	1076	1653	2807
"	ham	923	2307	3076	884	1999	2999	807	1538	2884
"	has	961	1730	2807	961	1769	2961	692	1615	2807
"	hatch	1038	1692	2769	961	1730	2807	884	1730	2923
"	path	1038	1692	2730	1076	1769	2846	1038	1807	2807
"	perhaps	999	1730	2499	999	1692	2730	884	1576	2730
"	scab	692	2192	2769	961	1730	2615	769	1615	2653
/u/	douche	384	2192	2807	499	2038	2576	346	1961	2538
"	dude	461	2230	2807	461	1999	2653	423	2076	2692
"	goose	423	1999	2653	538	1846	2499	307	1884	2692
"	hoop	538	1384	2576	499	1307	2538	461	961	2423
"	hoot	538	1499	2538	499	1461	2576	461	1730	2576
"	kook	576	1423	2307	538	1307	2423	461	1192	2423

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	move	576	1384	2461	615	1576	2461	576	1269	2576
"	ooze	461	1884	2538	461	1923	2461	423	1807	2423
"	pooch	423	1423	2461	423	1423	2538	384	1615	2499
"	rouge	576	1576	2346	576	1730	2384	423	1730	2384
"	soothe	576	2038	2769	423	1653	2615	423	1769	2615
"	spoof	461	1615	2461	499	1499	2576	423	1153	2499
"	spoon	499	1576	2461	423	1461	2576	499	1538	2576
"	stooge	384	2192	2730	461	1999	2692	423	1999	2615
"	tooth	461	1923	2423	461	1961	2576	499	1923	2499
"	tube	461	2153	2807	461	1846	2576	499	1384	2423
"	who	461	1461	2499	423	1346	2615	499	1307	2576
"	whom	576	1153	2576	499	1076	2615	576	1115	2499
/ʊ/	butch	615	1423	2576	730	1653	2769	615	1846	2769
"	hood	576	1461	2653	653	1692	2653	576	1807	2846
"	hoof	884	1576	2769	730	1538	2730	615	1615	2730
"	hook	692	1461	2730	653	1499	2653	576	1461	2538
"	push	576	1538	2384	615	1730	2499	576	1846	2423
"	puss	653	1499	2538	653	1653	2692	576	1653	2769
"	put	653	1576	2692	692	1692	2769	499	1807	2730
/o/	gauche	499	1769	2499	538	1499	2499	499	1423	2423
"	globe	615	1384	2807	615	1423	2692	538	1115	2730
"	home	346	961	2423	346	884	2499	307	884	2423
"	hope	538	1307	2576	538	1115	2538	499	923	2615
"	hose	615	1384	2499	538	1346	2461	653	1230	2423
"	host	538	1269	2461	499	1153	2538	423	1384	2538
"	loathe	730	1346	2923	692	1423	2999	538	1230	2769
"	oaf	615	1461	2615	576	1346	2576	384	999	2538
"	oak	615	1499	2499	653	1307	2653	384	961	2576
"	oat	615	1884	2269	615	1307	2499	461	1307	2499
"	oath	692	1461	2576	576	1269	2692	461	1269	2846
"	ode	653	1461	2615	615	1230	2615	653	1576	2576
"	owe	807	1615	2730	692	1461	2846	499	1538	2461
"	own	769	1230	2461	769	1076	2615	730	1192	2423
"	poach	615	1307	2576	653	1269	2576	423	1192	2423
"	stove	576	1923	2692	692	1615	2576	653	1423	2461
"	vogue	692	1538	2576	730	1499	2653	576	1076	2538
/ɑ/	Goth	692	1769	2499	961	1499	2846	961	1384	2846
"	hob	923	1384	2884	884	1346	2884	769	1384	2730
"	hock	961	1384	2846	999	1384	2692	1115	1423	2307
"	hodge	961	1423	2846	961	1499	2769	769	1730	2846
"	hog	884	1307	2846	884	1384	2769	807	1499	2653
"	hop	961	1538	2769	999	1538	2846	846	1346	2769
"	odd	846	1346	2769	884	1307	2923	653	1653	2884
"	off	961	1461	2730	884	1423	2692	923	1384	2884
"	on	846	1230	2884	923	1423	3076	884	1576	2961
"	ought	846	1346	2769	999	1384	2769	846	1538	2807
"	Oz	846	1346	2653	961	1461	2730	615	1576	2923
"	posh	923	1346	2653	884	1269	2730	884	1384	2769
"	Scotch	730	1807	2653	923	1538	2653	923	1576	2692
"	spa	846	1269	2653	884	1461	2884	769	1653	2807
"	Tom	961	1346	2769	807	1307	3038	807	1307	3076
"	toss	884	1538	2923	923	1423	2846	884	1423	2846
/ʌ/	hub	807	1461	2846	846	1461	2884	730	1461	2576
"	Huck	846	1538	2615	884	1538	2615	884	1538	2346
"	huff	923	1538	2846	846	1461	2846	846	1346	2846
"	hug	884	1653	2692	846	1692	2692	730	1730	2423
"	hum	923	1307	2307	807	1307	2384	884	1269	2346
"	hun	923	1538	2346	923	1576	2461	846	1730	2499
"	hush	884	1538	2730	846	1615	2730	846	1538	2769
"	hut	961	1576	2769	961	1653	2961	653	1653	2923
"	hutch	884	1769	2846	846	1730	2807	807	1692	2961
"	of	846	1730	2846	884	1615	2846	615	1461	2807
"	pudge	961	1692	2884	884	1807	2884	692	1923	2961
"	pus	961	1499	2807	884	1499	2884	807	1576	2846
"	scuzz	653	1999	2807	769	1730	2807	576	1692	2846
"	spud	653	1423	2653	846	1653	2923	653	1807	2961
"	up	846	1615	2576	884	1423	2653	846	1423	2615

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

[Ir]	ear	384	2499	3153	499	2346	2923	653	1769	2538
[Er]	air	615	2423	2692	730	2153	2499	807	1884	2269
[Ar]	are	807	1384	2423	923	1307	2269	846	1692	2115
[Or]	ore	538	961	2538	576	999	2461	692	1461	2230
[ɚ]	her	653	1538	1923	615	1499	2076	576	1730	2115
/il/	eel	423	2615	3346	423	2576	3423	538	2307	2999
/ɪl/	ill	615	2230	2961	730	1692	2961	653	1269	2961
/el/	ale	692	2384	2999	730	2423	3038	730	1961	2923
/ɛl/	L	807	1846	2846	923	1846	2884	923	1576	2961
/æl/	Al	961	1807	2730	1038	1730	2769	961	1615	2999
/ul/	pool	461	1038	2615	423	923	2653	423	846	2730
/ʊl/	pull	653	1192	3269	692	1115	3192	653	1076	3192
/ol/	hole	653	1115	2769	653	999	2807	692	1076	2923
/ɑl/	hall	884	1269	2961	846	1192	2999	807	1153	3038
/ʌl/	hull	730	1153	2884	692	1153	2846	692	1230	2730
<ing>	ping-	576	2230	2807	730	2307	2846	576	2423	2769
<eng>	length	846	1423	3115	884	1846	3230	961	2346	2961
<ang>	hang	923	2192	2884	807	2153	2923	846	2384	2884
<ong>	-pong	923	1346	2461	884	1346	2576	846	1384	2423
<ung>	hung	846	1423	2269	884	1384	2346	807	1461	2346

Speaker 14: Female, age 20. From Los Angeles (Southern California)

			T1			T2			T3	
vowel	word	E1	E2	E3	E1	E2	E3	E1	E2	E3
/i/	dweeb	461	2538	3423	461	2923	3615	461	2192	3307
"	E	307	3230	3692	346	3038	3653	346	2730	3499
"	each	307	3269	3692	346	3115	3846	384	2846	3538
"	ease	307	3076	3769	384	2923	3538	346	2307	3307
"	eat	307	3192	3653	384	3307	3692	423	2961	3653
"	eke	307	3153	3846	423	3269	3884	307	3038	3653
"	eve	384	2884	3730	423	3076	3615	499	1884	3499
"	fatigue	384	2961	3538	384	2923	3538	384	2769	3192
"	heap	307	3038	3730	307	2961	3807	307	2346	3230
"	heath	461	3153	3576	346	3038	3576	346	2615	3230
"	heed	423	3230	3615	384	3038	3692	461	2538	3307
"	keen	499	3192	3653	461	3192	3884	346	2807	3384
"	O'Keefe	307	3038	3461	384	2961	3423	384	2769	3153
"	piece	423	3038	3499	346	2961	3499	423	2692	3384
"	quiche	346	2999	3538	346	2999	3576	346	2769	3346
"	scheme	461	3038	3423	576	2730	3307	499	2807	3192
"	siege	461	2846	3653	461	2884	3499	346	2307	3115
"	teethe	307	2999	3307	384	2923	3230	384	2115	2999
/ɪ/	dish	461	2615	3423	499	2576	3384	461	2499	3307
"	give	346	2846	3346	576	2499	3192	307	1538	2884
"	hick	576	2730	3230	576	2461	3076	538	2307	2769
"	him	576	2807	3307	615	2499	3269	538	1769	2961
"	hip	615	2576	3230	576	2346	2999	576	1730	2807
"	his	576	2807	3461	576	2346	3269	461	1961	3192
"	hiss	538	2499	3423	576	2499	3499	499	2192	3269
"	id	461	2999	3461	576	2846	3346	538	2538	3153
"	if	423	2807	3346	576	2499	3230	576	2192	2999
"	in	538	2884	3423	538	2769	3423	538	2384	3307
"	it	423	2884	3269	576	2576	3153	538	2307	2923
"	itch	499	2999	3615	499	2692	3461	423	2499	3538
"	midge	615	2076	3192	615	2576	3384	538	2384	3115
"	Pibb	538	2461	3346	576	2423	3192	538	1692	2846
"	pig	423	2769	3384	538	2769	3423	461	2730	3153
"	pith	576	2576	3269	576	2384	3307	653	2307	3192
/e/	A	538	2769	3115	538	2884	3346	423	2499	3192
"	Abe	461	2884	3269	461	2999	3461	461	1923	3038
"	ace	499	2884	3384	307	2923	3423	461	2769	3269
"	ache	461	2961	3346	538	3038	3423	499	2923	3192
"	age	423	2846	3461	538	2961	3461	384	2461	3269
"	aid	499	2961	3269	461	2999	3499	423	2653	3307
"	aim	423	2999	3269	499	2999	3384	461	2538	3346

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"	ape	499	2807	3384	423	3038	3461	423	2615	3384
"	ate	461	2884	3230	423	3038	3499	307	2807	3269
"	beige	576	2461	3153	538	2923	3192	499	2307	3192
"	faith	538	2346	2961	538	2807	3384	423	2576	3038
"	H	384	3115	3346	384	3076	3346	346	2846	3384
"	haze	499	2884	3153	461	2923	3307	384	2269	3115
"	pain	538	2807	3461	499	2923	3538	499	2730	3346
"	pave	499	2884	3307	499	2730	3307	499	1999	2807
"	safe	615	2538	3115	615	2730	3269	461	2499	3192
"	scathe	499	2923	3269	538	2807	3307	461	2230	3115
"	vague	538	2384	3076	576	2807	3269	576	2807	3153
/ɛ/	Beth	653	2230	2961	884	2230	3076	923	1999	2961
"	Bev	615	2269	3115	846	2076	3115	576	1692	2884
"	ebb	615	2384	2999	769	2307	2923	807	1576	2807
"	Ed	807	2384	2961	807	2384	2961	576	2269	3192
"	edge	615	2538	2884	692	2461	2884	576	2384	3153
"	etch	769	2346	2884	769	2307	2846	769	2307	2846
"	F	807	2230	2730	807	2076	2807	769	1846	2615
"	heck	999	2346	2730	884	2230	2846	846	2038	2615
"	M	730	2423	2961	653	2269	3153	653	1653	3192
"	N	730	2461	3153	807	2384	3115	615	2384	3346
"	peg	576	2384	2961	576	2499	2961	538	2499	2884
"	pep	884	2230	2961	846	1999	2846	769	1692	2692
"	pet	807	2192	3038	846	2269	2999	769	2230	2961
"	Pez	961	2384	3307	846	2269	3230	653	2038	3230
"	S	846	2461	2961	846	2230	2999	730	2115	2923
"	Tesh	884	2346	2923	807	2307	2961	730	2153	2807
/æ/	add	884	2192	2692	961	2076	2730	730	2153	3038
"	Anne	499	2692	3115	538	2499	3038	576	1961	3038
"	ash	999	2076	2692	999	1923	2576	961	1999	2576
"	ass	999	1961	2653	999	1999	2576	999	1730	2538
"	at	961	1999	2846	961	1999	2769	884	1999	2884
"	badge	615	2230	2923	1038	1961	2576	615	2307	3038
"	hack	999	1961	2653	1038	1923	2615	1038	1884	2230
"	hag	923	2115	2692	923	2153	2692	538	2346	2884
"	half	1038	1961	2653	1038	1769	2499	999	1615	2538
"	ham	884	2807	3076	807	2423	2884	730	1538	2461
"	has	999	2076	2807	999	1961	2692	576	2076	2923
"	hatch	999	2038	2807	961	1999	2576	769	1999	2923
"	path	999	1999	2807	999	1807	2730	961	1692	2538
"	perhaps	961	1923	2769	999	1846	2692	730	1653	2538
"	scab	692	2576	2807	961	1961	2692	692	1576	2384
/u/	douche	346	2192	3038	461	1653	2961	461	1999	2923
"	dude	423	2269	2961	499	1423	2961	461	2269	2923
"	goose	423	1538	2769	423	1384	2923	423	1846	2923
"	hoop	423	1076	3192	423	1076	3153	346	884	3038
"	hoot	346	1115	3038	538	1115	2961	384	1423	2923
"	kook	461	1192	3230	384	1153	3269	384	1076	3192
"	move	615	1153	2692	538	1038	3076	461	961	2884
"	ooze	384	1038	3153	423	1076	3153	346	1999	3153
"	pooch	423	1076	3038	461	1307	2961	423	1692	2846
"	rouge	461	1384	2730	423	1499	2846	461	2269	2769
"	soothe	384	1999	3269	346	1461	3153	499	1807	2999
"	spoof	461	1423	2961	461	1230	3115	499	1153	2961
"	spoon	499	1230	2923	423	1115	3192	538	1423	2730
"	stooge	423	2038	2999	461	1384	2999	461	2153	3038
"	tooth	346	1846	3115	384	1499	3307	346	1730	3115
"	tube	384	1653	3115	423	1346	3115	384	961	2999
"	who	423	1269	3115	423	1076	2999	538	1923	2884
"	whom	423	1076	2423	461	1038	2499	461	961	2461
/ʊ/	butch	538	1230	2961	576	1269	2923	538	1884	2653
"	hood	653	1346	3115	615	1653	3076	499	2153	3153
"	hoof	615	1269	2961	538	1269	2923	538	1346	2846
"	hook	692	1384	3038	730	1423	2999	615	1230	2846
"	push	692	1269	2999	576	1615	2961	576	1961	2999
"	puss	576	1499	2999	576	1730	2961	499	1923	3038
"	put	576	1384	2961	615	1576	2923	499	1653	2807

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

/o/	gauche	576	1499	2769	615	1346	2807	576	1499	2884
"	globe	576	1423	2923	538	1269	2961	461	961	2884
"	home	615	1038	2538	538	999	2576	615	961	2499
"	hope	576	1153	2884	499	1153	3038	615	999	2961
"	hose	615	1346	2961	499	1269	2961	499	1961	2999
"	host	576	1307	3269	576	1269	3230	499	1730	3153
"	loathe	692	1499	3153	615	1269	3038	538	1653	2999
"	oaf	538	1230	2923	576	1192	3115	576	961	2961
"	oak	730	1461	2923	576	1269	2961	499	1076	2923
"	oat	576	1461	2999	692	1115	2999	499	1307	2999
"	oath	653	1423	2961	576	1153	3115	538	1192	3192
"	ode	730	1423	2884	576	1115	3115	499	1807	2999
"	owe	807	1384	2961	538	1269	2961	538	1307	2923
"	own	538	1269	2499	576	1153	2576	576	1230	2461
"	poach	576	1307	3115	653	1307	3153	538	1846	3038
"	stove	615	1884	2884	538	1192	2884	461	1115	2923
"	vogue	615	1423	3038	615	1230	3076	423	1038	3076
/ɑ/	Goth	615	1499	2730	884	1307	2346	807	1653	2307
"	hob	846	1307	2384	923	1269	2384	615	1307	2461
"	hock	923	1230	2499	923	1346	2461	884	1423	2346
"	hodge	923	1384	2538	846	1461	2576	692	2038	2499
"	hog	923	1346	2423	884	1384	2653	615	1499	2807
"	hop	961	1499	2961	961	1423	2807	769	1346	2346
"	odd	846	1384	2346	884	1346	2307	730	2115	2961
"	off	846	1461	2461	846	1307	2461	884	1269	2615
"	on	884	1346	2461	884	1230	2615	615	1923	2307
"	ought	846	1192	2269	846	1269	2461	807	1692	2538
"	Oz	884	1384	2384	923	1461	2653	576	2076	3076
"	posh	846	1461	2499	884	1384	2384	846	1615	2384
"	Scotch	653	1653	2499	846	1346	2307	846	1846	2346
"	spa	884	1423	2499	884	1461	2346	884	1769	2499
"	Tom	846	1230	2269	807	1307	2384	884	1269	2346
"	toss	846	1461	2423	807	1423	2461	884	1692	2692
/ʌ/	hub	923	1653	2961	807	1538	3038	653	1307	2961
"	Huck	923	1615	2730	923	1538	2807	807	1538	2692
"	huff	884	1307	2846	769	1499	2923	769	1384	2846
"	hug	846	1576	2846	769	1538	2923	538	1499	2769
"	hum	961	1538	2576	846	1307	2461	846	1384	2576
"	hun	999	1692	2461	999	1807	2461	1038	2076	2461
"	hush	961	1807	2846	923	1884	2923	653	1846	2884
"	hut	961	1730	2961	884	1769	2961	653	1999	2923
"	hutch	961	1730	2807	846	1807	2807	692	2153	2961
"	of	923	1461	2884	846	1538	3038	538	1423	3038
"	pudge	884	1653	3038	807	1730	2999	615	2076	3153
"	pus	884	1692	2961	884	1769	2999	807	1923	3115
"	scuzz	576	1769	2807	807	1807	2999	615	1999	3230
"	spud	807	1538	2999	730	1730	3153	653	2153	3038
"	up	961	1538	2923	961	1576	2961	846	1538	2961
[Ir]	ear	307	3115	3846	461	2846	3615	615	1807	2884
[Er]	air	576	2846	3115	499	2653	2961	653	2384	2499
[Ar]	are	884	1346	2307	884	1538	2269	730	1653	2076
[Or]	ore	576	961	2923	576	1153	2846	692	1576	2384
[ɚ]	her	615	1461	2153	538	1384	1961	576	1999	2576
[Ur]	poor	461	884	2961	653	1076	2846	615	1346	2423
/il/	eel	384	3038	3461	499	2884	3269	576	2461	3076
/ɪl/	ill	499	2692	3153	615	2384	3230	653	1807	3269
/el/	ale	615	2653	2961	538	2538	3115	576	2230	2999
/ɛl/	L	923	1961	2923	884	1653	3076	769	1384	3307
/æl/	Al	999	1807	2423	999	1653	2653	999	1538	2730
/ul/	pool	423	961	3192	346	961	3307	576	1076	3461
/ʊl/	pull	653	1153	3423	615	1153	3423	499	1076	3499
/ol/	hole	576	1038	3115	576	1115	3115	538	1038	3153
/ɑl/	hall	807	1423	2807	807	1230	2961	730	1153	3076
/ʌl/	hull	884	1384	3307	730	1269	3384	692	1192	3499
<ing>	ping-	538	2961	3346	461	2999	3461	615	2999	3384
<eng>	length	692	1615	3038	884	2423	3115	807	2576	3038
<ang>	hang	884	2538	2961	807	2499	2999	692	2499	2961

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

<ong>	-pong	769	1384	2461	653	1346	2346	769	1346	2461
<ung>	hung	923	1499	2538	923	1499	2615	884	1499	2538

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

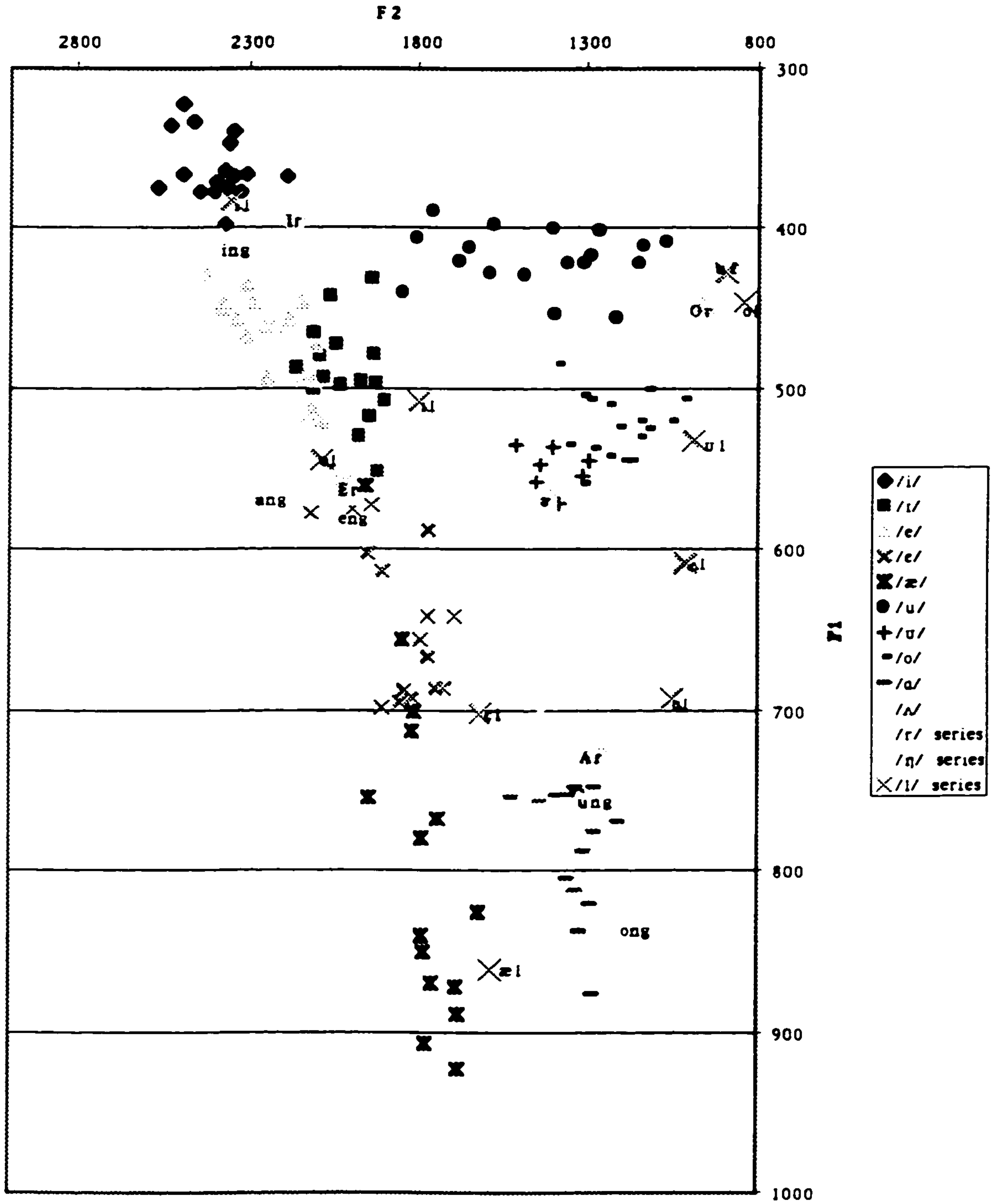
Appendix B.2 Durations and Rhyme Percentages of [Vn] sequences used as metrics to determine T1/T2/T3 of Rhotic Diphthongs. In the table, "vowel" indicates the duration of the vowel, "rhyme" indicates the total duration of the rhyme, including the vowel and the coda consonant, and "%" indicates the percentage of the duration of the total rhyme which is taken up by the vowel (=vowel/rhyme). The figures in bold indicate the figures used as metrics for the corresponding Rhotic Diphthong: "keen" or "in" for "ear", "pain" or "N" for "air", "spoon" or "own" for "ore", "on" for "are", and "hun" for "her." For Speakers 11 and 14, only the figures for "own" were used as a metric for "ore" because they have a contrastive vowel in "poor" (for which "spoon"'s figures were used).

	s01			s02			s03			s04			s05			s06			s07		
word	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*
keen	132	187	0.71	164	225	0.73	168	322	0.52	231	382	0.6	138	241	0.57	150	274	0.55	140	275	0.51
ear		222			168			359			393			270			257			248	
in	141	202	0.7	110	169	0.65	132	345	0.38	140	275	0.51	108	223	0.48	114	223	0.51	168	293	0.57
pain	180	263	0.68	148	212	0.7	248	372	0.67	264	446	0.59	162	265	0.61	136	206	0.66	175	250	0.7
air		255			181			334			339			215			256			275	
N	138	252	0.55	111	160	0.69	190	363	0.52	127	280	0.45	134	250	0.54	115	268	0.43	156	271	0.58
Anne	190	241	0.79	187	253	0.74	287	445	0.64	263	343	0.77	186	278	0.67	285	355	0.8	233	345	0.68
spoon	182	260	0.7	140	169	0.83	180	397	0.45	234	364	0.64	116	193	0.6	123	238	0.52	159	233	0.68
ore		265			218			378			426			245			270			295	
own	167	220	0.76	161	215	0.75	254	396	0.64	276	400	0.69	220	313	0.7	194	317	0.61	245	314	0.78
on	191	255	0.75	152	207	0.73	265	428	0.62	249	355	0.7	231	309	0.75	170	296	0.57	193	316	0.61
are		234			211			347			355			211			234			254	
hun	119	223	0.53	120	180	0.67	149	216	0.69	94	262	0.36	94	213	0.44	88	215	0.41	125	240	0.52
her		182			182			300			256			148			211			209	

	s08			s09			s10			s11			s12			s13			s14		
word	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*	*vowel*	*rhyme*	*%*
keen	123	251	0.49	104	216	0.48	109	220	0.5	141	269	0.52	166	297	0.56	114	212	0.54	159	277	0.57
ear		251			192			276			255			198			197			195	
in	87	219	0.4	83	196	0.42	74	172	0.43	103	242	0.43	124	248	0.5	98	202	0.49	140	310	0.45
pain	91	201	0.45	131	226	0.58	180	285	0.63	142	272	0.52	177	269	0.66	132	205	0.64	194	300	0.65
air		224			218			247			175			264			178			271	
N	61	181	0.34	91	233	0.39	83	193	0.43	111	238	0.47	144	268	0.54	115	218	0.53	143	273	0.52
Anne	149	250	0.6	188	293	0.64	225	394	0.57	239	345	0.69	241	340	0.71	198	289	0.69	260	404	0.64
spoon	120	227	0.53	83	169	0.49	119	211	0.56	127	235	0.54	150	223	0.67	142	253	0.56	176	333	0.53
ore		202			223			220			265			267			189			272	
own	140	248	0.56	141	249	0.57	177	278	0.64	199	344	0.58	175	284	0.62	165	254	0.65	219	355	0.62
on	108	218	0.5	196	311	0.63	132	207	0.64	214	335	0.64	216	330	0.65	152	242	0.63	221	349	0.63
are		188			180			200			218			253			197			237	
hun	50	161	0.31	76	215	0.35	84	207	0.41	71	197	0.36	135	269	0.5	80	167	0.48	89	210	0.42
her		143			125			175			144			180			131			185	
poor											100									235	

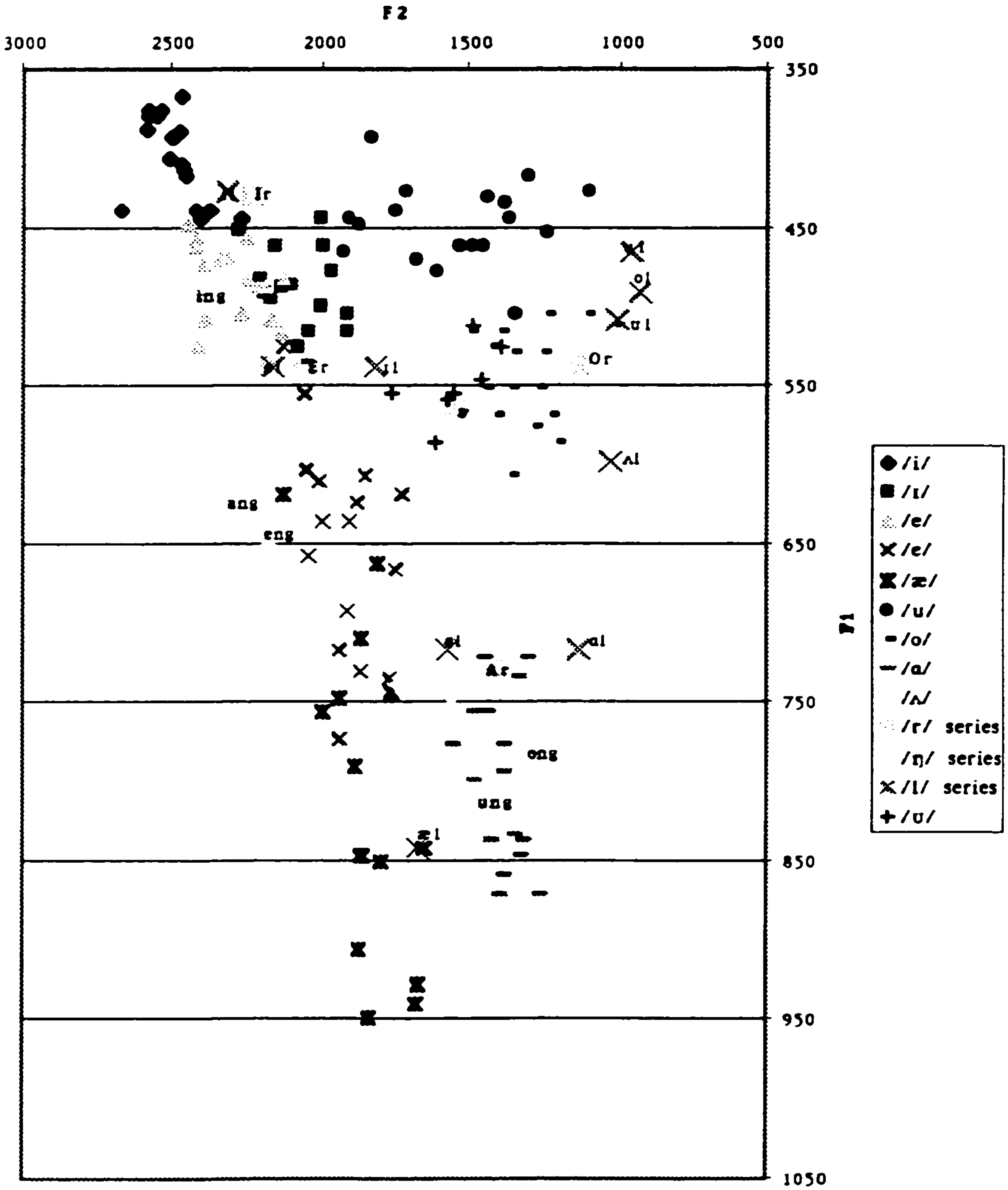
B.3 Scatter Charts (All Vowels)

Figure B.3.1. All Vowels (Males)



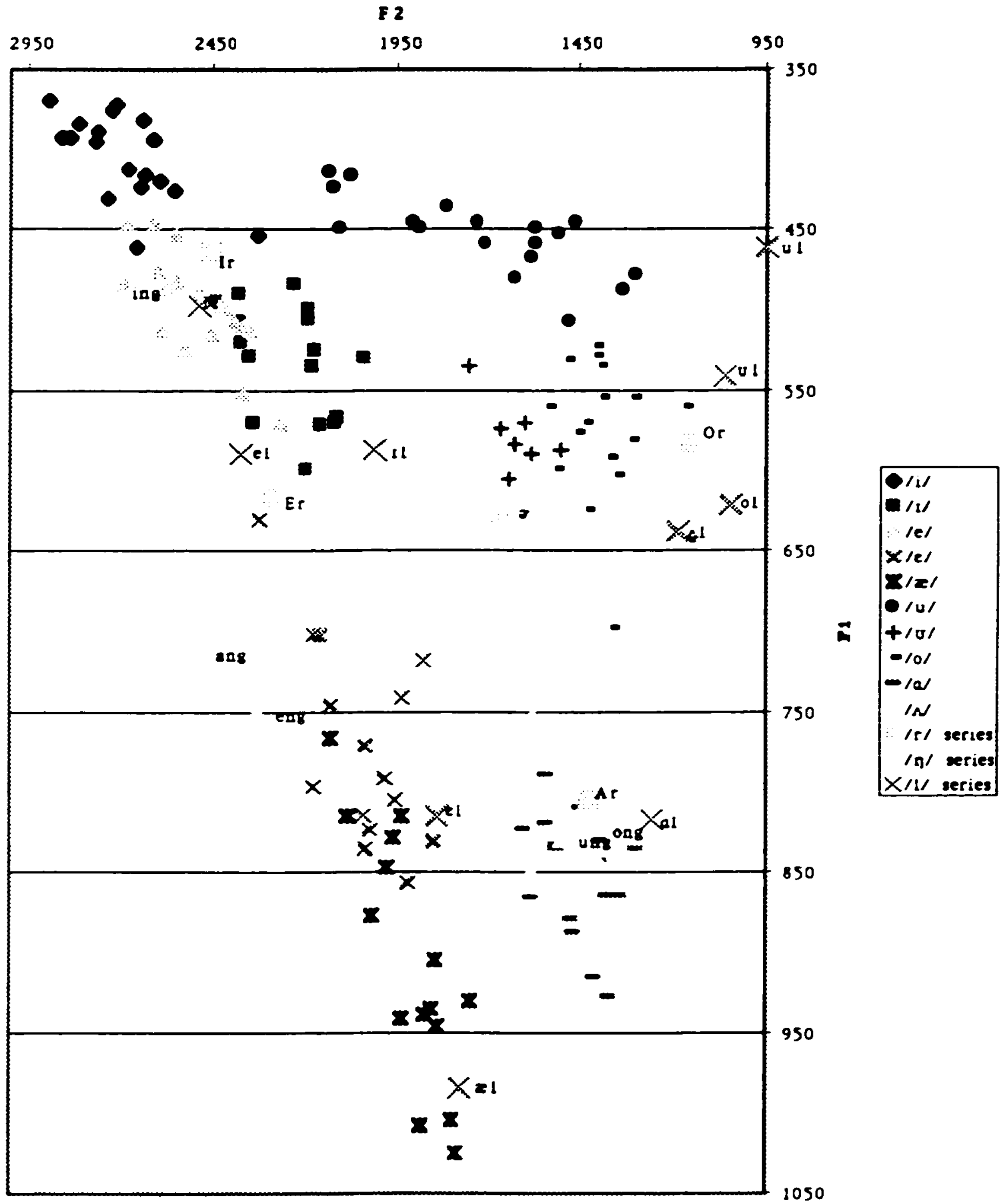
Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure B.3.2. All Vowels (Northern Females)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure B.3.3. All Vowels (Southern Females)



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

C.1 Response Times. Pairs are listed by First Word and Second Word in the Leftmost two columns. Response times are in seconds. Note on the numbering of subjects: Subjects 1 throught 10 were part of a pilot study. Other gaps in the series (20, 22, 24, 28, 29, 33) are subjects whose data had to be eliminated for various reasons.

Subjects→ Words↓		S11	S12	S13	S14	S15	S16	S17	S18	S19	S21	S23	S25	S26	S27	S30	S31	S32	S34
Word1	Word2																		
peel	beet	1.55	1.71	1.92	1.43	1.93	2.42	3.9	2.04	2.42	3.13	1.59	3.96	0.83	3.74	3.63	0.88	0.99	2.53
peel	bead	1.41	3.11	1.85	3.54	1.46	3.55	2.01	1.29	1.74	3.82	2.06	2.94	3.82	3.28	3.66	1.68	1.46	2.83
will	bit	2.31	2.64	1.65	2.15	1.76	1.5	2.7	6.38	1.93	4.67	1.27	3.52	1.55	1.93	2.48	3.63	2.32	2.54
will	bid	1.6	1.54	1.92	2.91	1.65	1.65	2.59	2.97	2.64	3.35	1.54	3.08	1.71	4.45	1.26	1.27	1.54	2.97
pail	gate	1.78	1.84	1.45	3.1	3.32	1.39	1.89	1.39	1.89	2.17	1.17	1.12	0.96	3.59	2.83	2	1.23	2.44
pail	spade	1.62	1.89	1.73	2.01	1.12	1.45	2.06	0.97	2.5	2.23	1.07	4.04	1.73	3.27	1.18	2.06	0.74	1.9
well	bet	1.86	2.24	1.69	2.34	1.91	1.2	1.24	1.41	2.29	4.38	2.18	1.9	0.86	3.06	1.63	0.98	1.2	1.74
well	bed	1.45	1.34	2.05	1.77	4.14	1.45	1.17	1.94	1.77	1.94	2.05	2.16	0.9	2	1.67	1.61	1.23	2.43
bell	deck	1.94	2.1	1.39	2.55	3.48	1.39	3.2	1.5	2.66	2.05	2.55	1.88	1.94	3.43	1.88	1.28	1.45	2.27
bowl	boat	1.71	2.59	1.88	2.15	1.44	3.46	2.27	2.42	1.17	2.87	1.6	1.61	1.33	2.48	3.14	1.44	3.14	2.26
hall	dock	1.49	1.71	1.32	2.2	2.97	1.54	3.29	3.3	1.92	1.49	1.6	2.14	0.61	2.8	1.21	1.76	1.32	1.27
dull	luck	2.23	2.34	2.18	2.29	4.1	2.84	3.71	5.86	2.01	1.46	1.14	2.45	1.47	2.51	2.45	3.27	1.41	2.56
pull	look	1.57	1.45	1.72	2.71	1.45	1.4	3.05	2	2.71	2.44	1.89	2.11	1.4	2.11	1.12	1.13	1.23	2.72
dull	bud	1.47	2.19	1.75	1.43	2.41	2.63	2.3	1.91	2.8	3.67	1.7	4.89	1.86	3.56	1.91	1.86	1.26	3.35
pull	hood	1.25	2.4	1.8	2.08	4.1	1.24	2.12	2.07	2.68	3.5	2.18	3.39	2.12	5.04	1.3	1.08	1.36	2.62
sing	bead	1.12	1.07	1.29	2.67	1.35	1.62	2.11	1.62	1.57	1.73	1.12	3	0.69	3.49	1.56	1.18	1.73	2.17
sing	bid	1.94	2.49	1.83	2.11	2.54	1.83	2.38	2.54	1.95	1.28	1.67	5.68	0.84	4.14	1.23	1.89	1.77	2.71
length	gate	1.1	1.76	2.31	3.14	1.21	1.65	5.06	1.1	1.15	3.68	1.11	3.08	2.03	2.2	1.49	0.72	0.61	3.18
length	spade	1.14	0.93	1.48	1.26	2.03	0.99	1.43	3.9	1.21	3.24	1.53	1.43	0.44	1.98	0.82	0.6	0.44	2.47
hang	spade	1.08	1.35	1.3	1.57	1.52	1.03	1.13	1.02	1.96	2.45	1.35	2.45	0.97	2.18	1.51	0.52	0.69	1.79
length	bet	1.28	1.22	1.34	3.04	1.22	1.44	1.33	3.96	2.54	4.02	0.89	2.48	2.87	3.97	2.81	1.88	1.17	2.26
length	bed	1.81	1.54	1.37	1.54	3.18	3.12	3.68	1.64	1.7	4.27	1.09	3.89	3.18	3.39	2.02	0.81	1.48	2.08
hang	bed	1.23	1.34	1.78	1.56	1.34	1.34	2.45	2.12	2.34	1.4	1.4	1.84	1.51	2.17	1.18	0.97	1.18	2.01
hang	sad	1.52	1.68	1.62	2.12	6.02	1.24	1.07	1.9	1.85	4.37	1.13	2.34	1.14	2.34	1.84	0.8	1.62	2.34
song	pod	1.18	1.35	1.07	1.45	1.62	1.9	1.85	1.84	1.08	2.67	1.56	1.56	0.69	2.83	1.13	1.67	0.96	1.84
lung	bud	1.84	1.47	1.24	3.06	3.43	3.16	2.01	1.3	2.56	4.27	1.51	1.57	1.19	2.73	2.45	0.96	0.97	2.62
beer	beet	2.09	1.93	1.93	2.48	1.99	1.98	1.49	5.56	1.77	2.37	2.04	2.04	2.2	3.42	1.6	2.43	1.49	2.97
beer	bit	1.61	1.38	1.44	2.26	2.93	1.27	3.42	1.55	2.27	1.44	1.38	3.81	2.21	2.26	1.61	1.11	1.71	1.88
beer	bead	1.8	2.18	2.07	2.4	3.06	2.68	3.28	1.8	1.68	4.26	2.29	1.85	1.64	1.52	2.01	1.24	1.41	2.18
beer	bid	1.83	1.72	1.94	2.43	1.56	1.56	2.87	1.72	1.73	2.27	1.33	4.02	1.12	2.27	1.39	1.17	1.45	2.49

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

bear	gate	1.38	1.33	1.05	1.43	1.38	1.1	1.06	1.65	1.28	3.36	0.94	1.33	0.67	0.88	0.94	0.78	1.06	1.76
bear	bet	1.5	2.71	1.5	2.66	3.21	2.1	3.21	2.05	4.03	2.99	1.45	1.89	2.99	3.15	2	1.12	2.44	2.76
bear	spade	1.1	1.38	0.82	2.09	1.43	0.94	0.94	1.92	0.94	1.11	1.38	3.35	0.39	1.87	2.09	2.14	0.88	3.08
bear	bed	2.14	1.76	2.2	5.06	5.38	2.85	4.45	2.03	2.69	1.65	1.27	1.64	1.21	1.26	3.78	1.71	1.53	2.09
bore	boat	2.25	2.31	1.76	4.45	4.12	4.51	3.02	2.53	1.82	2.42	2.03	4.67	0.71	5.44	1.87	1.1	1.32	4.23
bore	load	1.26	2.69	2.03	3.12	1.26	3.13	3.72	1.37	2.63	3.84	1.2	3.02	0.98	3.23	2.36	2.13	1.31	2.3
bore	dock	1.75	1.57	1.47	1.74	1.74	1.08	1.69	3.72	1.25	2.68	1.02	3.67	1.08	3.39	3.22	1.13	0.86	2.35
bore	pod	1.47	1.69	2.46	1.53	1.09	0.97	1.52	1.08	0.98	4.49	1.58	4	1.25	1.58	1.58	0.65	0.87	2.96
car	dock	1.22	1.22	1.71	2.7	4.79	2.1	2.53	1.33	2.04	2.87	2.05	3.14	0.61	2.09	1.44	0.72	1.16	2.48
car	pod	1.27	1.49	2.43	2.65	2.32	1.12	3.2	1.67	1.39	2.05	1.28	1.82	1.77	3.04	1.22	1.99	1.27	2.27
lurk	luck	3.56	2.35	1.57	1.25	3.11	1.02	2.23	2.34	1.85	5.47	1.3	1.9	0.64	3.66	1.85	1.19	1.8	2.68
lurk	look	1.89	1.4	1.61	1.68	1.29	1.28	1.56	1.34	2	1.45	1.23	1.23	0.9	2.16	0.9	1.12	1.18	2.6
lurk	deck	2.02	1.26	1.48	1.32	1.97	1.65	2.03	1.38	1.64	2.14	1.21	1.92	0.82	1.04	1.81	0.77	2.41	2.96
bird	bud	2.23	1.52	1.46	1.52	4.32	2.46	3.66	1.41	1.57	1.57	1.3	3.5	1.03	3.6	2.07	1.03	1.68	2.01
bird	hood	1.49	1.93	1.44	1.44	2.43	1.33	1.61	2.1	1.5	1.77	1.27	2.86	1.22	3.74	1.11	1.22	1.17	2.16
bird	bed	1.39	1.44	1.99	1.83	1.34	1.17	2.71	1.77	2.54	2.55	1.12	2.99	0.89	2.33	1.22	1.06	1.83	2.66
freight	gate	1.1	1.43	0.98	1.2	0.94	0.82	0.83	2.69	1.15	2.42	0.71	3.34	0.55	0.88	0.88	0.66	0.99	1.43
debt	bet	1.57	1.46	1.51	1.73	2.17	1.3	1.79	1.41	1.57	3.33	1.24	1.84	0.85	1.29	1.24	1.12	1.51	2.01
braid	spade	1.02	1.13	1.08	1.3	0.97	1.08	1.85	1.14	1.52	1.74	0.76	1.85	0.37	2.02	0.76	0.43	1.09	1.36
head	bed	1.28	1.39	1.4	1.51	2.44	1.23	2.27	1.45	1.56	3.15	1.12	1.34	1.01	1.51	1.12	0.85	1.51	1.45
blood	bud	2.15	1.49	1.76	1.71	1.82	1.32	4.01	1.38	1.77	2.31	1.43	3.96	1.04	1.98	1.6	1.48	2.64	1.92
could	hood	1.94	1.4	1.44	1.66	1.55	1.28	2	1.77	1.39	1.39	1.34	1.61	0.89	1.72	1.56	0.84	1.34	1.78
said	bed	1.35	1.29	1.23	1.73	1.51	1.12	1.45	1.45	1.62	1.4	1.28	0.96	0.74	1.73	0.91	0.79	1.23	1.45
coat	boat	1.88	1.49	1.21	1.22	1.43	0.99	2.53	1.66	1.76	1.71	1.05	0.88	0.88	1	1.05	0.67	1.22	1.71
clock	dock	1.23	1.23	1.23	1.34	1.12	1.12	1.39	1.18	1.83	1.67	1.18	2.28	0.63	1.34	1.12	0.8	0.9	2.05
node	load	2.09	1.1	1.04	1.43	1.98	1.26	1.59	1.38	1.48	1.26	1.26	0.87	0.6	1.21	0.77	0.88	1.1	1.48
prod	pod	1.22	1.11	0.95	1.55	1.27	1.33	1.22	1.77	1.22	1.38	1	2.1	0.83	1.17	0.78	1.16	1	1.82
grief	beet	1.51	1.35	1.23	1.79	1.51	1.29	2.28	1.46	2.72	1.62	1.13	0.74	1.3	1.89	1.51	1.78	1.41	2.06
weep	beet	1.73	1.24	1.19	1.57	1.35	1.07	2.12	1.19	1.78	2.34	1.57	1.51	1.07	2.33	1.07	0.91	2.11	2.28
myth	bit	1.52	1.74	1.46	1.84	1.74	1.3	1.57	1.57	1.9	3.38	1.57	2.17	1.41	2.5	1.24	1.13	1.74	2.4
grieve	bead	1.37	1.26	1.87	1.64	1.7	1.26	2.47	1.43	1.7	1.48	1.38	0.94	0.83	1.26	1.1	0.77	1.37	2.08
weep	bead	1.37	1.48	1.43	1.98	2.59	1.65	1.49	2.04	1.49	1.87	1.27	1.81	1.1	2.25	1.1	1.26	1.54	1.54
fizz	bid	1.63	1.36	1.36	1.69	2.4	1.41	1.85	1.58	1.41	1.91	1.08	1.3	0.86	1.74	0.97	1.03	1.41	1.96
rough	luck	1.38	1.37	2.36	1.15	1.26	1.7	1.48	1.15	1.59	3.78	1.21	2.74	1.21	1.97	1.76	1.15	0.82	1.92
pup	luck	1.38	1.16	0.99	2.91	1.32	1.27	1.21	1.49	1.16	2.42	1.82	1.82	1	2.42	1.21	0.99	0.94	1.38
put	look	2.42	1.71	1.76	1.82	1.65	1.43	2.42	1.93	2.48	3.24	2.53	1.21	1.71	1.43	2.43	1.76	1.26	2.31
breath	deck	1.5	1.28	1.22	1.67	2.6	1.06	1.72	1.39	1.62	3.64	1.28	1.5	0.79	1.44	1.06	0.89	1.22	1.83
pup	bud	2.19	1.8	1.47	1.75	2.63	1.54	3.4	2.02	1.91	2.35	1.64	2.46	1.15	2.57	1.64	1.42	1.42	2.24
smoke	boat	1.15	1.1	0.94	1.38	1.49	1.65	1.48	1.71	1.43	4.4	0.94	1.7	0.61	1.82	0.82	0.66	0.99	1.76
dot	dock	2.16	1.39	1.01	1.56	1.78	1.23	1.72	1.34	1.77	2.98	1.5	3.53	1.01	2.44	1.5	0.95	1.39	1.56
robe	load	1.43	1.43	1.38	1.98	1.21	1.7	3.08	1.43	2.14	2.15	1.44	1.71	0.72	1.92	0.99	0.71	1.26	2.59

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

dog	pod	1.7	1.53	1.75	2.19	2.19	2.08	3.45	1.26	2.08	3.13	1.31	4.17	1.31	2.47	0.93	3.01	1.2	2.79
beam	beet	1.68	1.24	1.14	1.63	1.52	3	1.3	1.25	1.69	4.54	1.25	2.34	0.7	1.57	1.03	1.19	1.2	2.18
beam	bead	1.37	2.09	1.37	1.65	1.43	2.42	1.99	2.09	1.76	2.42	1.66	2.42	0.83	2.04	1.1	0.82	1.1	1.26
dim	bit	1.57	2.45	1.63	2.29	2.23	2.95	3.61	1.97	2.29	2.07	1.91	2.9	1.3	1.42	2.84	1.35	1.41	2.67
dim	bid	1.95	1.68	1.3	2.23	1.85	2.06	2.12	1.85	3.28	3.71	1.85	2.67	1.68	2.78	2.12	2.01	1.46	2.18
game	gate	2.06	1.57	1.35	1.46	1.41	1.79	1.35	1.35	1.46	2.06	1.46	1.18	0.69	1.9	1.79	1.13	1.58	2.13
game	spade	1.31	1.68	0.97	1.69	1.24	0.92	1.41	1.08	1.42	2.4	1.24	2.18	1.3	2.46	1.64	1.8	0.76	1.31
stem	bet	1.48	2.47	1.21	2.75	1.76	2.09	1.76	1.59	3.24	3.46	1.43	2.52	1.04	2.36	3.02	1.7	1.48	3.4
stem	bed	1.35	1.79	1.57	1.62	2.56	2.29	1.35	1.35	1.25	4.26	1.24	2.95	1.41	2.78	1.84	1.08	1.14	1.62
comb	boat	1.33	1.56	1.61	3.32	2.27	2.11	2.05	1.72	2.05	3.65	1.17	2.16	1.51	2.82	1.77	1.39	1.23	1.78
comb	load	1.6	1.27	1.97	2.8	1.92	1.64	2.3	1.81	4.83	1.59	2.69	2.14	1.7	1.65	1.32	1.32	1.15	3.24
mom	dock	1.32	1.21	1.81	2.15	1.27	2.25	2.75	1.54	2.31	1.27	1.87	3.08	2.31	2.86	1.59	0.99	0.99	2.03
some	luck	1.35	1.96	1.57	1.96	2.67	1.14	1.51	1.79	2.39	4.54	1.3	3.16	1.3	2.78	1.18	0.8	0.96	1.9
some	bud	1.51	1.73	1.78	2.17	2.77	1.23	2.44	1.4	4.75	4.64	1.67	3.15	2.6	1.84	1.06	1.23	1.06	2.39
bee	bead	1.38	1.93	1.7	1.65	2.04	1.54	2.91	2.15	1.87	1.71	1.49	1.37	1.43	1.48	1.21	0.82	1.16	1.32
buy	pod	1.59	1.53	1.21	2.52	1.53	0.93	1.98	1.75	1.86	1.36	1.7	3.78	3.73	3.4	1.75	1.09	1.58	1.86
cow	pod	1.06	1.06	1.23	1.55	2.32	1.22	3.92	1.34	1.67	3.42	1.23	2.38	0.63	3.25	1.01	0.73	1.17	3.26
bit	beet	1.39	1.33	1.55	1.72	1.45	1.23	2.87	1.45	1.39	2.77	1.23	2.1	0.95	3.2	1.23	0.9	1.34	1.5
beet	bit	1.45	1.56	1.55	1.56	1.39	1.23	1.39	1.61	1.45	1.34	1.12	1.72	0.79	2.87	1.55	1.5	1.06	1.17
bide	bead	1.4	1.51	1.67	1.56	1.39	1.39	1.12	1.95	1.78	1.78	1.18	1.29	0.96	2.06	1.07	0.73	1.45	2.06
bid	bead	1.59	1.74	1.37	1.91	1.41	2.84	1.75	1.52	1.91	2.3	1.75	2.79	1.31	2.18	1.09	1.15	1.36	2.41
bad	bid	1.63	2.45	1.52	2.13	1.46	1.35	1.84	1.62	1.95	1.95	1.4	1.46	1.08	1.41	1.19	1.13	1.35	1.62
bead	bid	2.79	1.85	1.97	1.75	1.75	1.91	1.75	1.53	1.8	2.24	1.36	4.54	1.03	3.12	1.14	1.15	1.42	1.75
bite	gate	1.04	1.92	1.37	1.37	1.87	1.04	3.13	1.86	1.43	3.02	0.99	3.24	1.21	3.46	1.54	0.71	1.26	1.2
boot	gate	1.2	1.16	1.48	2.03	1.26	0.93	2.14	1.43	1.87	1.21	0.88	1.76	0.49	2.42	1.48	0.77	1.1	1.59
hit	bet	1.39	1.28	1.88	1.38	1.49	1.99	1.39	1.44	1.94	4.68	1.39	3.47	0.79	1.77	2.15	0.84	1.39	1.99
foot	bet	1.39	1.44	1.61	1.66	1.23	1.5	2.27	1.82	1.55	3.86	1.27	4.02	0.84	3.69	1.22	1.11	1.11	2.27
bread	spade	1.08	1.13	0.91	1.19	3.6	1.52	1.4	1.24	0.8	1.13	0.92	4.38	0.58	1.14	0.91	0.64	0.69	2.12
food	spade	0.81	0.92	0.97	1.03	1.46	0.75	1.19	0.92	0.97	0.86	0.59	1.69	0.42	1.8	1.52	0.31	0.59	1.63
lid	bed	1.41	1.84	2.23	1.68	1.57	1.57	4.15	1.41	2.73	5.53	1.18	3.21	0.91	3.17	2.01	1.51	2.88	2.4
hood	bed	1.36	1.57	1.58	1.62	1.46	1.29	2.56	2.17	1.84	1.79	1.13	3.33	0.69	3.06	1.95	1.24	1.13	2.61
look	luck	1.44	2.33	1.94	1.39	1.12	1.77	1.39	1.55	1.23	1.61	1.01	2.16	0.73	1.34	1.28	0.89	1.45	1.62
deck	luck	1.3	1.41	1.69	1.31	1.8	1.74	1.79	1.41	1.58	2.18	1.13	1.85	0.81	3.5	1.47	0.92	1.3	1.91
duck	look	1.4	1.45	1.78	1.56	1.4	1.34	2.27	1.56	1.51	2.82	1.18	2.66	0.91	2.5	1.18	0.96	1.5	2.38
deck	look	1.34	2.17	1.34	1.61	2.22	1.18	2.88	1.78	2.05	3.32	1.5	2.5	2.06	3.26	1.5	1.23	1.29	2.55
luck	deck	1.63	1.19	2.07	2.24	1.96	1.85	1.25	1.58	1.36	2.23	1.31	2.9	1.14	2.89	1.02	1.2	1.9	2.73
look	deck	1.61	1.4	1.56	2.06	1.28	1.18	1.78	1.45	1.4	1.51	1.29	1.34	1.12	1.4	0.96	0.9	0.96	2.44
hood	bud	1.59	2.3	2.58	1.64	1.43	1.65	4.06	1.48	2.85	2.69	1.32	1.65	2.97	2.63	3.08	0.93	1.54	1.97
bed	bud	1.65	1.54	1.93	1.44	1.43	1.32	1.82	1.59	1.6	1.49	1.38	2.31	0.88	2.42	1.05	1.05	1.26	2.59
bud	hood	1.86	2.8	2.36	1.75	4.34	1.43	2.96	1.59	1.59	2.08	1.38	3.35	2.14	2.36	1.49	1.53	1.59	2.53
bed	hood	1.41	1.52	1.52	1.46	1.24	1.18	1.3	1.51	2.61	2.56	1.3	1.35	0.74	2.34	1.08	0.86	0.97	2.39

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

bide	bed	1.35	1.41	1.35	2.01	1.74	1.68	2.56	1.57	1.9	2.95	1.29	1.79	0.97	3.11	1.18	0.97	0.91	3.11
bud	bed	1.54	1.37	2.48	1.49	1.87	1.92	3.41	2.53	1.54	2.42	1.38	2.7	1	2.86	1.16	1.05	1.48	2.42
bit	boat	1.48	1.37	1.86	2.25	1.49	1.26	3.13	1.21	1.48	3.24	1.21	2.19	1.04	1.32	1.48	1.21	1.87	2.19
deck	dock	1.25	1.42	1.15	1.8	1.15	1.59	1.7	1.36	2.3	1.36	1.31	1.75	1.09	2.08	1.09	0.76	1.25	1.8
bed	load	1.34	1.39	2.11	2.6	1.67	1.18	2.11	2.05	1.4	1.29	1.07	2.22	0.96	1.84	1.17	1.34	1.13	2.99
bed	pod	1.28	1.72	2.98	1.34	1.17	1.06	1.56	1.39	2.27	1.39	1.4	2.43	1.94	1.94	1.72	0.73	0.95	2.27
bike	beet	1.55	1.55	1.44	1.88	1.66	1.11	1.77	1.39	1.55	4.73	1.71	1.45	0.95	3.25	1.22	0.84	2.7	1.77
bath	bit	1.62	1.24	1.07	1.45	1.23	1.18	1.24	1.29	1.07	1.34	0.9	0.85	1.07	1.07	0.85	0.74	0.96	1.18
lit	luck	1.33	1.17	1	1.71	1.17	1.06	1	1.11	1.33	2.21	0.9	1.71	0.62	1.66	0.78	0.79	0.84	2.1
lap	look	1.28	1.61	1.61	1.5	1.29	1.06	1.34	1.4	1.28	1.94	1.28	1.61	0.84	1.67	0.84	0.79	1.66	3.04
dot	deck	1.4	1.56	1.23	1.5	1.84	1.78	1.4	1.29	1.4	2.94	1.12	2.99	1.17	2.66	1.56	0.96	1.39	2.5
big	bud	1.85	2.62	1.96	2.13	1.95	1.24	1.57	2.01	2.01	1.73	1.68	1.9	1.84	2.72	1.13	1.74	1.35	2.18
bike	boat	1.12	1.78	1.44	1.94	1.89	1.44	1.78	1.23	1.55	1.34	1.28	1.61	0.85	2.71	1.22	1.07	1.72	2.1
bed	dock	1.26	1.37	1.81	1.86	1.09	1.15	1.42	1.47	1.59	1.15	1.15	1.86	0.71	2.69	1.15	0.81	1.21	2.08
have	load	1.55	1.55	1.5	1.45	1.99	1.17	1.5	1.66	2.32	2.04	1.99	1.77	0.84	2.59	1.88	0.94	1	2.21
bed	load	1.64	1.2	1.7	1.43	1.21	0.98	2.58	1.48	1.32	2.74	0.82	1.65	0.77	2.03	1.2	0.66	0.93	2.09
bug	pod	1.3	1.41	1.41	2.29	1.24	1.03	1.14	1.25	2.29	3.01	1.09	2.12	0.7	1.41	1.14	0.86	0.87	3.49

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

C.2 Yes/No Responses.

Subjects→ Words↓ Word1	Word2	S11	S12	S13	S14	S15	S16	S17	S18	S19	S21	S23	S25	S26	S27	S30	S31	S32	S34
peel	beet	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y
peel	bead	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	N	N
will	bit	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y
will	bid	Y	N	N	Y	Y	N	N	N	Y	Y	Y	Y	N	Y	N	N	N	Y
pail	gate	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	Y
pail	spade	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y
well	bet	N	Y	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N
well	bed	N	N	N	N	Y	N	N	Y	N	N	Y	Y	N	Y	N	N	N	Y
bell	deck	Y	N	N	Y	Y	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N
bowl	boat	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y
hall	dock	N	Y	Y	Y	N	Y	N	N	N	N	Y	N	Y	Y	Y	N	N	N
dull	luck	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y
pull	look	N	N	Y	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	Y
dull	bud	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
pull	hood	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N
sing	bead	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N	Y	N	N	N
sing	bid	N	Y	N	N	Y	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N
length	gate	N	N	N	Y	N	N	N	Y	N	N	N	N	Y	N	N	Y	N	Y
length	spade	N	Y	Y	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	Y
hang	spade	N	Y	N	N	N	N	N	Y	Y	N	N	Y	N	Y	N	Y	N	Y
length	bet	N	N	N	N	N	N	N	N	N	Y	N	Y	Y	Y	N	N	N	N
length	bed	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	Y	N	Y	N
hang	bed	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
hang	sad	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	Y
song	pod	N	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y
lung	bud	N	Y	N	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y
beer	beet	N	Y	N	Y	Y	N	Y	Y	N	Y	N	Y	Y	Y	N	N	Y	N
beer	bit	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
beer	bead	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	N
beer	bid	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
bear	gate	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bear	bet	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	Y	Y
bear	spade	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bear	bed	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	Y	Y
bore	boat	Y	Y	N	Y	N	N	N	N	Y	Y	N	Y	N	Y	Y	Y	N	Y
bore	load	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	Y	Y	N	N

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

bore	dock	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
bore	pod	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
car	dock	N	N	Y	N	Y	N	N	N	N	N	Y	N	N	Y	N	N	N	Y
car	pod	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
lurk	luck	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N
lurk	look	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
lurk	deck	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bird	bud	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bird	hood	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
bird	bed	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
freight	gate	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
debt	bet	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
braid	spade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
head	bed	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
blood	bud	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
could	hood	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y
said	bed	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
coat	boat	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
clock	dock	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
node	load	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
prod	pod	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
grief	beet	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y
weep	beet	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
myth	bit	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
grieve	bead	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
weep	bead	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
fizz	bid	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
rough	luck	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
pup	luck	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y
put	look	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	N	Y	N	Y	N	N	N
breath	deck	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
pup	bud	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
smoke	boat	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
dot	dock	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
robe	load	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
dog	pod	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
beam	beet	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
beam	bead	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
dim	bit	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
dim	bid	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
game	gate	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

game	spade	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
stem	bet	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
stem	bed	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
comb	boat	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
comb	load	N	Y	N	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y
mom	dock	N	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N
some	luck	N	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	Y
some	bud	Y	Y	N	N	Y	N	N	Y	N	Y	N	Y	Y	Y	N	N	N	N
bee	bead	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
buy	pod	N	N	Y	N	N	Y	N	N	N	N	N	N	Y	N	N	N	N	Y
cow	pod	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N
bit	beet	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
beet	bit	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bide	bead	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bid	bead	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bad	bid	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bead	bid	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bite	gate	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
boot	gate	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
hit	bet	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
foot	bet	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bread	spade	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
food	spade	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
lid	bed	N	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
hood	bed	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
look	luck	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
deck	luck	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
duck	look	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
deck	look	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
luck	deck	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
look	deck	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
hood	bud	N	N	N	N	N	N	Y	N	N	Y	N	Y	Y	N	N	N	N	N
bed	bud	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
bud	hood	N	N	Y	N	N	N	N	N	N	N	N	N	Y	N	Y	N	Y	Y
bed	hood	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bide	bed	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bud	bed	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
bit	boat	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
deck	dock	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bed	load	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bed	pod	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

bike	beet	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bath	bit	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
lit	luck	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
lap	look	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
dot	deck	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
big	bud	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bike	boat	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bed	dock	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
have	load	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bed	load	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
bug	pod	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Bibliography

Akamatsu, Tsutomu. 1981. "About Neutralization and Archiphoneme." *La Linguistique* 17, 1: 127-130.

Akmajian, Adrian, Richard A. Demers, Ann K. Farmer, and Robert M. Harnish. 1995. *Linguistics.* Fourth Edition. Cambridge, MA. MIT Press.

Allen, Harold B. 1976. *The Linguistic Atlas of the Upper Midwest.* Volume 3. University of Minnesota Press.

American Heritage Dictionary of the English Language. Third Edition. 1996. Boston: Houghton Mifflin Company. [Rima Elkin McKinzey, Contributing Editor, Pronunciation]

Ash, Sharon. 1982. *The Vocalization of /l/ in Philadelphia.* Diss. University of Pennsylvania

Bagemihl, Bruce. 1995. "Language games and related areas," M. Goldsmith, ed. *The Handbook of Phonological Theory*, 697-712. Cambridge, MA: Blackwell.

Bailey, Charles-James N. 1985. *English Phonetic Transcription.* Dallas: Summer Institute of Linguistics.

Bailey, Guy, Tom Wikle and Lori Sand, 1991. "The Focus of Linguistic Innovation in Texas." *English World-Wide.* 12: 195-214.

Bailey, Guy, Tom Wikle, Jan Tillery, and Lori Sand. 1993. "Some Patterns of Linguistic Diffusion." *Language Variation and Change* 5:359-90.

Barber, Charles. 1976. *Early Modern English.* Edinburgh: Edinburgh University Press.

Barry, William J. 1997. "Another R-tickle." *Journal of International Phonetic Association.* Vol. 27, nos. 1 & 2.

Basbøll, H. 1975. *On the Phonological Interpretation of the Falling Diphthongs in Danish.* Annual Reports of the Institute of Phonetics. U. Copenhagen. 9: 49-108.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Beddor, Patrice Speeter and Sarah Hawkins. 1990. "The Influence of Spectral Prominence on Perceived Vowel Quality." *JASA* 87 (6) Suppl. 2: 2684-2704.

Benware, Wilbur A. 1986. *Phonetics and Phonology of Modern German.* Washington D.C.: Georgetown University Press.

Berg, Thomas. 1986. "The Monophonematic Status of Diphthongs Revisited," *Phonetica.* 43: 198-205.

Bernstein, Cynthia. 1993. "Measuring Social Causes of Phonological Variables." *American Speech* 68:227-40.

Bladon, R. A. W. and Björn Lindblom. 1981. "Modeling the Judgment of Vowel Quality Differences." In *JASA* 69 (5): 1414-22.

Bloomfield, Leonard. 1933. *Language.* Chicago: University of Chicago Press.

Booij, Geert. 1989. "On the Representation of Diphthongs in Frisian." *Journal of Linguistics.* 25: 319-332.

Bowden, John, and John Hajek. 1999. "Taba", *Handbook of the International Phonetic Alphabet*, 143-146. Cambridge. Cambridge University Press.

Bowie, David. 1998. "Does Perception Really Lead Production? Evidence from a Series of Related Mergers in Southern Maryland." Paper given at 27th meeting of New Ways of Analyzing Variation, Athens, GA, 2 Oct.

Boyd-Bowman, Peter. 1954. *From Latin to Romance in Sound Charts.* Washington D. C.: Georgetown University Press.

Bronstein, Arthur. 1960. *The Pronunciation of American English.* New York: Appleton-Century-Crofts.

Burquest, Donald A. 1993 (1998). *Phonological Analysis: a Functional Approach.* Second Edition. Summer Institute of Linguistics.

Carr, Philip. 1999. *English Phonetics* and *Phonology.* Oxford: Blackwell.

Catford, J. C. 1977. *Fundamental Problems in Phonetics.* Bloomington, IN: Indiana University Press.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chomsky, Noam and Morris Halle. 1991. *The Sound Pattern of English.* Cambridge, The MIT Press.

Clynes, Adrian. 1997. "On the Proto-Austronesian 'Diphthongs'" *Oceanic Linguistics.* Vol. 36, no. 2: 347-361.

Cohen, A. 1952. *The Phonemes of English.* The Hague: Drukkerij M. Uleman.

Coleman, John. 1998. *Phonological Representations.* Cambridge: Cambridge University Press.

Collier, R., Bell-Berti, F., and Raphael, L. J. 1982. "Some Acoustic and Physiological Observations on Diphthongs" *Language and Speech* 25: 305-323.

Cruttenden, Alan. 1994. *Gimson's Pronunciation of English.* London: Edward Arnold.

Dankovičová, Jana. 1999. "Czech" *Handbook of the International Phonetic Alphabet*, 70-73. Cambridge: Cambridge University Press.

Davidsen-Nielsen, Niels. 1978. *Neutralization and Archiphoneme: Two Phonological Concepts and their History.* Publications of the Department of English, University of Copenhagen, Vol. 7. Copenhagen: Akademisk Forlag.

De Camp, L Sprague, 1945. "hwɛn ɪz ə dɪfθɔŋ?" [When is a diphthong?] *Le Maître Phonétique.* 83: 2-5.

Dekeyser, X. 1983. *Aspects of the History of English Phonology and Morphology.* Antwerp: Inka.

Delattre, Pierre, 1965. *Comparing the Phonetic Features of English, French, German and Spanish: An Interim Report.* London: George G. Harrap and Co.

Derwing, Bruce L., Terrance M. Nearey, and Maureen L. Dow. 1986. "On the Phoneme as the Unit of the 'Second Articulation'," *Phonology Yearbook.* 3: 45-69.

Di Paolo, Marianna. 1988. "Pronunciation and Categorization in Sound Change." Ferrara, Brown, Walters, and Baugh, eds. *Linguistic Change and Contact: Proceedings of the Sixteenth Annual Conference on New*

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Ways of Analyzing Variation, 84-92. Austin, Texas: University of Texas.

Dickey, Laura W. 1997. *The Phonology of Liquids.* Diss. University of Massachusetts, Amherst.

Dobson, E. J. 1968. *English Pronunciation 1500-1700* (2 vols.) Second Edition. Oxford: Clarendon Press.

Donegan, Patricia. 1978. *On the Natural Phonology of Vowels.* Ohio State University Working Papers in Linguistics, No. 23. Columbus, Ohio: Ohio State University

Finegan, E. 1994. *Language: its Structure and Use.* Second Edition. Fort Worth, TX: Harcourt Brace College Publishers.

Fromkin, V. and Rodman, R. 1998. *An Introduction to Language.* Sixth Edition. Fort Worth, TX: Harcourt Brace College Publishers.

Gay, Thomas 1968. "Effect of Speaking Rate on Diphthong Formant Movements" *JASA* 44 (6): 1570-1573.

Gay, Thomas, 1970. "A Perceptual Study of American English Diphthongs" *Language and Speech*, Vol. 13, Part 2, 65-88.

Gerber, S. E. 1975. "Categorical Perception of Segmented Diphthongs" Gunnar Fant, Ed. *Speech Communication*, 131-136. Stockholm: Almqvist and Wiksell.

Giegerich, Heinz J. 1992. *English Phonology.* Cambridge: Cambridge University Press.

Givón, T. 1984. *Syntax: A Functional-Typological Introduction.* Philadelphia. John Benjamins Publishing Company.

Grønnum, Nina. 1998. "Danish" in *Journal of the International Phonetic Association.* Vol. 28, Nos. 1 & 2.

Guenter, Joshua. 2001. "What is American English /r/ *Really?*" in *Proceedings of the 26th Annual Meeting of the Berkeley Linguistics Society.* (to appear).

Guenter, Joshua, Julie L. Lewis, and Margaret Urban, 1999. "A Perceptual Study of Vowels before /r/." Ohala, Hasegawa, Ohala, Granville, and Bailey, (eds.) *Proceedings of the 14th International Congress of*

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Phonetic Sciences, 2461-2464. Regents of the University of California, Berkeley, CA.

Guy, Gregory. 1980. "Variation in the Group and the Individual: the Case of Final Stop Deletion." Labov, W., ed. *Locating Language in time and space.* pp. 1-36. Orlando: Academic Press.

Hagiwara, Robert. 1995. *Acoustic Realizations of American /r/ as Produced by Women and Men.* UCLA Working papers in Phonetics no. 90.

Halle, M. and Mohanan, K. P. 1985. Segmental Phonology of Modern English. *Linguistic Inquiry* 16: 57-116.

Hammond, Michael. 1999. *The Phonology of English.* Oxford: Oxford University Press.

Hankey, Clyde T. 1972. "Notes on West Penn-Ohio Phonology" Lawrence M. Davis, ed. *Studies in Linguistics in Honor of Raven I. McDavid, Jr.,* 49-61. University, AL: University of Alabama Press,

Harris, J. 1994. *English Sound Structure.* Oxford, Blackwell Publishers.

Heffner, R. M. S. 1964. *General Phonetics.* Madison, WI: The University of Wisconsin Press.

House, Arthur S. and Grant Fairbanks. 1953. "The Influence of Consonant Environment upon the Secondary Acoustical Characteristics of Vowels." *JASA* 25: 105-113. Also in *Readings in Acoustic Phonetics,* pp. 228-237. M. I. T. Press, Cambridge.

Jaeger, Jeri, and John J. Ohala. 1984. "On the Structure of Phonetic Categories," *Proceedings of the 10th Annual Meeting of the Berkeley Linguistics Society,* 15-26.

Jensen, John T. 1993. *English Phonology.* Philadelphia. John Benjamins.

Johnson, Bruce L. 1971. "The Western Pennsylvania Dialect of American English." *Journal of the International Phonetic Association* 1: 69-73.

Jones, Daniel. 1950 *The Phoneme: Its Nature and Use.* Cambridge: W. Heffer and Sons Ltd.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Joos, Martin. 1934. "stɹɛst vaölz plʌs r ɪn dʒɛnrəl əmɛrëkən" [Stressed Vowels plus /r/ in General American] *Le Maître Phonétique*. 48: 93-97.

Kahn, Daniel. 1980. *Syllable-Based Generalizations in English Phonology*. New York, Garland Publishing.

Kantner, Claude E. and Robert West. 1933. *Phonetics*. Madison, Wisconsin: College Typing Company.

Kenyon, John S. and Thomas A. Knott. 1953. *A Pronouncing Dictionary of American English*. Springfield, MA: G. & C. Merriam.

Knowles, Gerald. 1987. *Patterns of Spoken English*. New York: Longman.

Kreidler, C. W. 1989. *The Pronunciation of English*. Oxford: Blackwell Publishers.

Kuipers, Aert H. 1960. *Phoneme and Morpheme in Kabardian*. The Hague: Mouton and Company.

Kurath, Hans. 1964. *A Phonology and Prosody of Modern English*. Ann Arbor, MI: The University of Michigan Press.

Labov, W. 1994. *Principles of Linguistic Change*. Vol. 1. Oxford: Blackwell.

Labov, W., Yaeger, M., and Steiner, R. 1972. *A Quantitative Study of Sound Change in Progress*. Philadelphia: U. S. Regional Survey.

Ladefoged, P. 1993. *A Course in Phonetics*. Third edition. Fort Worth, TX: Harcourt Brace Jovanovich.

Ladefoged, Peter and Ian Maddieson. 1996. *The Sounds of the World's Languages*. Oxford: Blackwell.

Ladefoged, Peter. 1999. "American English" *Handbook of the International Phonetic Alphabet*, 41-44. Cambridge: Cambridge University Press.

Landau, Ernestina, M. Lončarič, D. Horga, and I. Skarič. 1999. "Croatian", *Handbook of the International Phonetic Alphabet*, 66-68 Cambridge: Cambridge University Press.

Lass, Roger. 1984. *Phonology*. Cambridge: Cambridge University Press.

Lavoie, Lisa M. and Abigail C. Cohn, 1999. "Sesquisyllables of English: The Structure of Vowel-Liquid Syllables." Ohala, Hasegawa, Ohala,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Granville, and Bailey, (eds.) *Proceedings of the 14th International Congress of Phonetic Sciences,* 109-112. Berkeley, CA: Regents of the University of California.

Lehiste, I. and G. E. Peterson. 1961. "Transitions, Glides, and Diphthongs," Ilse Lehiste, ed. 1967. *Readings in Acoustic Phonetics,* pp. 228-237. M. I. T. Press, Cambridge. Also in *JASA* 33: 268-277 (1961).

Lehiste, Ilse. 1964. *Acoustical Characteristics of Selected English Consonants.* Bloomington, IN: Indiana University. Also in *International Journal of American Linguistics* 30.3 (July 1964). Publication 34 of the Indiana University Research Center in Anthropology, Folklore, and Linguistics.

Lindau, Mona, Kjell Norlin and Jan-Olof Svantesson, 1990. "Cross-linguistic Differences in Diphthongs" *Journal of the International Phonetic Association.* 20.1: 10-14.

Lindau, Mona. 1985. "The Story of /r/" V. Fromkin, ed., *Phonetic Linguistics,* 157-168. Orlando, FL: Academic Press.

MacKay, Ian R. A. 1987. *Phonetics: the Science of Speech Production.* Austin, TX: Pro-ed.

Maddieson, 1984. *Patterns of sounds.* Cambridge: Cambridge University Press.

Malmberg, Bertil. 1955. "The Phonetic Basis for Syllable Division," Ilse Lehiste, ed. 1967. *Readings in Acoustic Phonetics,* 293-300. M. I. T. Press, Cambridge. Also in *Studia Linguistica,* Vol. 9, 80-87.

McElhinny, Bonnie. 1999. "More on the Third Dialect of English: Constraints on the Use of Three Phonological Variables in Pittsburgh." *Language Variation and Change.* 11: 171-95.

Merriam-Webster's Collegiate Dictionary. Tenth Edition. 1999. Springfield, MA. Merriam-Webster, Inc. [Brian M. Sietsema, Pronunciation Editor].

Miller, Corey. 1993. "English /r/ and Ambisyllabicity". Talk given at LSA Annual Meeting. L.A. 1993.

Moon, Seung-Jae and Björn Lindblom. 1994. "Interaction Between Duration, Context, and Speaking Style in English Stressed Vowels." *JASA*: 96 (1) : 40-55.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Moore, S. 1951. *Historical Outlines of English Sounds and Inflections.* Ann Arbor, Michigan: George Wahr Publishing Co.

Mossé, Fernand. 1952. *Handbook of Middle English.* Trans. James A. Walker. Baltimore: Johns Hopkins Press.

Moulton, William G. 1962. *The Sounds of English and German.* Chicago: The University of Chicago Press.

Nearey, Terrance M. 1990. "The Segment as a Unit of Speech Recognition." *Journal of Phonetics.* 18: 347-373.

O'Grady, W., M. Dobrovolsky, and M. Aronoff. 1997. *Contemporary Linguistics.* Third Edition. New York: St. Martin's Press.

O'Neil, Wayne. 1980. "The Spelling and Pronunciation of English." In William Mills, Ed. *The American Heritage Dictionary of the English Language.* New College Edition. Boston: Houghton Mifflin.

Olive, Joseph P., Alice Greenwood, and John Coleman. 1993. *Acoustics of American English Speech: A Dynamic Approach.* New York: Springer-Verlag.

Onions, C. T., ed. 1966. *The Oxford Dictionary of English Etymology.* Oxford: Oxford University Press.

Peterson, Gordon E. and H. L. Barney. 1952. "Control Methods Used in a Study of Vowels," Ilse Lehiste, ed. 1967. *Readings in Acoustic Phonetics,* 118-127. Cambridge, MA: MIT Press. Also in *JASA* 24: 175-184 (1952).

Peterson, Gordon, and I. Lehiste. 1960. "Duration of Syllable Nuclei in English," Ilse Lehiste, ed. 1967. *Readings in Acoustic Phonetics,* 183-190. Cambridge, MA: M. I. T. Press. Also in *JASA* 32: 693-703 (1960).

Piir, Hille. 1984. "Acoustics of the Estonian Diphthongs" *Estonian Papers in Phonetics,* 1982-1983.

Pike, Kenneth L. 1947a. "On the Phonemic Status of English Diphthongs." *Language,* 23: 151-159.

Pike, Kenneth L. 1947b. *Phonemics.* Ann Arbor, MI. The University of Michigan Press.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Quilis, Antonio. 1981. Fonética acústica de la lengua española. Madrid: Editorial Gredos, S.A.

Random House Webster's College Dictionary. 1999. New York. Random House, Inc. [Enid Pearsons, Pronunciation Editor].

Regueira, Xosé L. 1999. "Galician". *Handbook of the International Phonetic Alphabet*, 82-85. Cambridge: Cambridge University Press.

Ritchie, James A. 1999. "R Myth-athesis: A Perception Based Approach at Understanding some *r*-Related Sound Changes" Irmengard Rauch and Gerald F. Carr (eds.) *New Insights in Germanic Linguistics I*, 211-222. New York: Peter Lang.

Rosch, Eleanor H. 1973. "On the Internal Structure of Perceptual and Semantic Categories." Timothy E. Moore, ed. *Cognitive Development and the Acquisition of Language* 111-144. New York: Academic Press

Schane, Sanford A. 1971. "The Phoneme Revisited." *Language* 47: 503-21

Shattuck-Hufnagel, Stefanie. 1986. "The Representation of Phonological Information during Speech Production Planning: Evidence from Vowel Errors in Spontaneous Speech." *Phonology Yearbook*. 3: 117-149.

Sommerstein, Alan H. 1977. *Modern Phonology*. Baltimore: University Park Press.

Spencer, Andrew 1996 *Phonology*. Oxford: Blackwell Publishers.

Stevens, Kenneth N., Arthur S. House, & Allan P. Paul. 1966. "Acoustical Description of Syllabic Nuclei: An Interpretation in Terms of a Dynamic Model of Articulation." *JASA* 40 (1): 123-132.

Stutterheim, C. F. P. 1962. "Three Problematic Dutch Diphthongs" *Proceedings of the 4th International Congress of Phonetic Sciences, Helsinki 1961*, 771-772. The Hague: Mouton & Co.

Šuštaršič, Rastislav, Smiljana Komar, and Bojan Petek. 1999. "Slovene" *Handbook of the International Phonetic Alphabet*. Cambridge: Cambridge University Press.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Swadesh, Morris. 1935. "The Vowels of Chicago English." *Language*, 11: 148-51.

Syrdal, Ann K. and H. S. Gopal. 1986. "A Perceptual Model of Vowel Recognition Based on the Auditory Representation of American English Vowels." *JASA* 79 (4): 1086-1100.

Teeter, K. 1966. "A Note on Uniqueness." *Language* 42: 475-478.

ten Havre, B. L. 1975. "One Phoneme or Two?" *Linguistics in the Netherlands 1972-1973*, 251-257.

Thomas, C. K. 1958. *The Phonetics of American English*. New York: The Ronald Press Company.

Thomas, Erik R. 1989 [1993]. "Vowel Changes in Columbus, Ohio." *Journal of English Linguistics*. 22: 205-15.

Thomas, Erik R. 2001. "An Acoustic Analysis of Vowel Variation in New World English." *Publication of the American Dialect Society* 85 (to appear).

Trager, George L. and Bernard Bloch. 1941. "The Syllabic Phonemes of English." *Language*, 17: 223-246.

Trnka, Bohumil. 1968. *A Phonological Analysis of Present-day Standard English*. University, Alabama: University of Alabama Press.

Trubetzkoy, N. S. 1969. *Principles of Phonology*. Berkeley and Los Angeles, CA. University of California Press.

Twaddell, W. Freeman. 1935. "On Defining the Phoneme." *Language Monographs*. Number XVI. Baltimore. Waverly Press, Inc.

Vachek, Josef. 1963. "The Phonematic Status of Modern English Long Vowels and Diphthongs." *Philological Pragensia*. Vol. 6: 59-71.

Veatch, Thomas. 1991. *English Vowels: Their Surface Phonology and Phonetic Implementation in Vernacular Dialects*. Diss. University of Pennsylvania. Ann Arbor: UMI, 1991. 9200398.

Veatch, Thomas. 1992. "Racial Barriers and Phonological merger." Paper given at NWAVE-21, University of Michigan, October 28 1992.

Wardhaugh, Ronald. 1995. *Understanding English Grammar*. Cambridge, MA: Blackwell Publishers.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Webster's Geographical Dictionary. 1949. Springfield, MA: G. & C. Merriam, Co.

Webster's New World Dictionary and Thesaurus. 1996. New York. Simon & Schuster, Inc. [No Pronunciation Editor Listed]

Wells, J. C. 1982. *Accents of English.* (3 vols.) Cambridge: Cambridge University Press.

Wiese, Richard. 1996. *The Phonology of German.* Oxford: Clarendon Press.

Yule, George. 1985. *The Study of Language.* Cambridge: Cambridge University Press.

Zettersten, Arne. 1974. *A Critical Facsimile Edition of Thomas Batchelor.* Lund: C. W. K. Gleerup.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.