UNIVERSITY OF CALIFORNIA

Los Angeles

Topics in Avatime Phonology

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Linguistics

by

Blake Lehman

2024

ABSTRACT OF THE DISSERTATION

Topics in Avatime Phonology

by

Blake Lehman

Doctor of Philosophy in Linguistics

University of California, Los Angeles, 2024

Professor Kie Ross Zuraw, Co-Chair

Professor William Harold Torrence, Co-Chair

This dissertation investigates several aspects of the phonology of Avatime, a Kwa language spoken in the Volta Region of southeastern Ghana. The goal of the dissertation is to use data from original fieldwork conducted by the author to update and supplement the empirical description of Avatime phonology, and to situate several aspects of Avatime phonology in a contemporary theoretical context. The phenomena investigated are (i) the status of the [ATR] contrast in high vowels, (ii) the behavior of the low vowel [a] in [ATR] harmony, and (iii) a tone sandhi process in verbs that is phonologically, morphologically, and lexically conditioned. While these aspects of Avatime phonology have all been investigated in previous work on the language, this dissertation identifies some differences in that are relevant to the description of the language and for phonological theory.

Chapter 1 provides an overview of the dissertation, as well as background on the Avatime language and its speakers.

Chapter 2 addresses the status of the ATR contrast in high vowels in Avatime. This contrast has long been the subject of debate in the study of Avatime. Some earlier work on the language (Ford 1971) did not mark a contrast between [+/-ATR] vowels in surface forms, but a more recent phonetic study (Maddieson 1995) showed a consistent contrast along the dimension of F1. More recent work on the language (van Putten 2014) has suggested that the contrast is disappearing, especially among younger speakers. This chapter replicates and extends Maddieson's study, finding that in aggregate, there is still an ATR contrast among high vowels, even for younger speakers. However, this contrast is not produced by all speakers in all contexts. The implications of the loss of contrast in progress for the phonology of Avatime is discussed, specifically the implications for theories of abstractness in phonology (Kiparsky 1973).

Chapter 3 develops an analysis of the behavior of the low vowel [a] in ATR harmony in Avatime. This vowel shows an asymmetry in whether it participates in ATR harmony or not: in noun class prefixes and subject agreement prefixes, it harmonizes with the ATR value of the root, re-pairing with the mid vowel [e] in these contexts. In enclitics, however, the low vowel is invariant. Additionally, there is a set of verbal prefixes that have an exceptionally invariant [a]. This chapter argues that these facts can be accounted for in Harmonic Grammar (Smolensky 1986; Legendre et al. 1990; 2006). Specifically, it is shown that the behavior of [a] can be explained as a case of *ganging*, in which the weights of multiple constraints that disprefer vowel harmony combine to overcome the weight of the constraint that drives harmony.

Chapter 4 examines a process of tone sandhi affecting verbs. This process consists of the raising of the tone of verb roots and prefixes in a scalar fashion. Taking Ford's (1971, 1986) work as a starting point, the chapter presents an overview of this phenomenon in contemporary Avatime. It is shown that the process is conditioned by phonologically, morphological, and lexical information. This type of process, in which multiple sources of non-phonological are required, resembles the cases discussed by Sande (2020) of *morphologically-conditioned phonology with two triggers*. However, this chapter argues that the tone sandhi process is better analyzed as a case of phonologically-conditioned allomorphy. An analysis is developed using the framework developed by McPherson (2019), in which the lexicon contains generalized frames listing tonal allomorphs for the different classes of verbs. It is shown that this accounts for some previously undocumented aspects of the tone raising process, especially the fact that it may affect words adjacent to the verb itself.

Chapter 5 concludes and discusses future directions for research in Avatime phonology both on and beyond the topics addressed in this dissertation.

The dissertation of Stephen Blake Lehman is approved.

Benjamin J. Eischens

Bruce P. Hayes

William Harold Torrence, Committee Co-Chair

Kie Ross Zuraw, Committee Co-Chair

University of California, Los Angeles

2024

For Madison

TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 Structure of the dissertation 1
1.1.1 Chapter 2 1
1.1.2 Chapter 3 2
1.1.3 Chapter 4 3
1.2 Avatime Background 5
1.2.1 The Avatime people 5
1.2.2 Language background 6
1.2.2.1 Segmental phonology 7
1.2.2.2 Tone 9
1.2.3 Morphology 10
1.2.3.1 Noun classes 10
1.2.3.2 Verbal morphology 11
1.2.3.3 Syntax 13
1.2.4 Data 13
2 ATR IN HIGH VOWELS 15
2.1 Background 17
2.1.1 High vowels and [ATR] contrast 17
2.1.2 [ATR] harmony and abstract phonology 18
2.1.3 High vowels and [ATR] in GTM languages 19
2.1.3.1 Tutrugbu 20
2.1.3.2 Lelemi 21
2.1.3.3 Ikpɔsɔ 21
2.2 Avatime vowel categories and vowel harmony 22
2.2.1 Phonetic bases of ATR contrast in Avatime 25
2.2.2 [ATR] contrast among contemporary speakers 25
2.3 Data 27
2.3.1 Overview 27
2.3.1.1 Excursus on issues in measuring formants 28
2.3.2 Materials 30
2.3.2.1 Nouns 30
2.3.2.2 Verb roots and prefixes 31
2.3.2.3 High vowel prefixes 32

2.3.3 Participants ... 33
2.3.4 Results ... 34
2.3.4.1 High vowels in F1/F2 space ... 36
2.4 Merger in progress? ... 41
2.4.1 Morphological category and variation ... 42
2.4.1.1 Nouns – replicating Maddieson 1995 ... 42
2.4.1.2 Verb roots ... 45
2.4.2 Prefixes ... 48
2.4.3 High vowels as harmony triggers ... 49
2.4.4 High vowels and iterative harmony ... 52
2.5 Discussion ... 53
2.5.1 What's going on in Avatime? ... 55
2.6 Conclusion ... 56
2.6.1 Contrast displacement ... 56
2.6.2 Future directions ... 57
2.6.2.1 Expanded acoustic study ... 57
2.6.2.2 Perception study ... 57
2.6.2.3 Additional interaction between diachrony and abstract phonology: contrastive nasality ... 58
3 ASYMMETRY IN BEHAVIOR OF LOW VOWELS IN ATR HARMONY ... 60
3.1 Data ... 62
3.2 General features of Avatime vowel harmony ... 63
3.3 Behavior of low vowel in [ATR] harmony ... 65
3.3.1 Re-pairing ... 65
3.3.2 Directional asymmetry ... 65
3.3.3 Exceptionality ... 66
3.3.4 Tolerated disharmony ... 67
3.3.5 Opacity ... 67
3.4 Prosodic status of "suffixes" ... 67
3.4.1 Definiteness markers ... 68
3.4.2 Pronominal objects ... 70
3.4.3 Note on underlying forms ... 72
3.4.4 Contrast between root-enclitic boundary and word-word boundary ... 73
3.4.5 Hiatus resolution in Avatime ... 73
3.4.6 Prosodic status of enclitics ... 76

3.5 Invariant morphemes 77
3.5.1 Invariant prefixes 77
3.5.2 Invariant prefixes and diachrony 78
3.5.3 Other invariant verbal prefixes 78
3.5.3.1 Distribution of harmonizing and invariant prefixes 79
3.5.4 Invariant non-low vowel – the locative suffix 80
3.6 Analysis 81
3.6.1 Outline of the problem 81
3.6.2 Constraints 82
3.6.3 Harmony in non-low vowels 85
3.6.4 Harmony and non-harmony in low vowels 86
3.6.5 Checking the weights 90
3.6.6 Compounds and loans 91
3.6.7 Why not ranked constraints? 92
3.6.8 What's so special about low vowels? 94
3.7 Opacity 96
3.7.1 Possible analysis 98
3.7.1.1 Prefix harmony as "[ATR] stability" 98
3.7.2 Complications 100
3.8 Conclusions 102
4 TONE SANDHI AS ALLOMORPH SELECTION 104
4.1 Avatime verbs – tone and morphology 104
4.1.1 Verbal morphology 105
4.2 Tone raising – basic pattern 107
4.2.1 Factors affecting tone raising 109
4.2.1.1 Phonological conditioning 110
4.2.1.2 Lexical conditioning 112
4.2.1.3 Morphological conditioning 115
4.3 Tone classes 116
4.3.1 Monosyllabic roots 117
4.3.1.1 CHEW-class 117
4.3.1.2 CATCH-class 119
4.3.1.3 SLAP-class 121
4.3.1.4 COOK-class 122

4.3.1.5 CHANGE-class ... 124
4.3.1.6 LET GO-class ... 127
4.3.1.7 FIX-class ... 127
4.3.1.8 POUND-class ... 129
4.3.2 Disyllabic roots ... 129
4.3.2.1 SPREAD-class ... 130
4.3.2.2 LIFT-class ... 130
4.3.2.3 BRING-class ... 131
4.3.2.4 TEACH-class ... 132
4.3.2.5 DO-class ... 133
4.3.2.6 SCRATCH-class ... 134
4.3.2.7 SPOIL-class ... 135
4.3.2.8 BITE-class ... 136
4.3.3 Summary ... 137
4.4 Island of regularity – tone 1 roots ... 138
4.4.1 Opacity ... 138
4.4.2 Behavior of low tone prefixes ... 139
4.4.3 Behavior of disyllabic roots ... 140
4.5 Why not phrasal phonology? ... 141
4.5.1 What is the phonological process? ... 141
4.5.2 Applicability across morphological categories ... 143
4.5.3 Reference to arbitrary lexical classes ... 143
4.6 Tone raising and verbal morphology ... 144
4.6.1 Tone 1 monosyllabic roots ... 144
4.6.2 Tone 3 roots ... 145
4.6.3 Partial raising ... 146
4.7 Tone raising as allomorph selection ... 147
4.7.1 Generalizing the tone classes ... 149
4.7.2 Allomorph selection and tone lowering ... 151
4.7.3 Partial raising and interaction with morphology ... 152
4.7.4 Changes in raising behavior ... 153
4.7.5 Prefix raising as a floating tone ... 153
4.7.5.1 Tone 1 prefixes ... 154
4.7.5.2 Cross-word tone raising ... 155

4.8 Alternative approaches 157
4.9 Conclusion 159
5 CONCLUSION 160
5.1 Summary 160
5.1.1 [ATR] contrast in high vowels 160
5.1.2 [ATR] harmony and behavior of low vowel 160
5.1.3 Tone raising 161
5.2 Future directions 162
5.2.1 High vowels 162
5.2.2 Low vowel and [ATR] harmony 163
5.2.3 Tone raising 163
APPENDIX 166
REFERENCES 180

LIST OF FIGURES

Figure 1: Map of Avatime villages, and location of Avatime within surrounding area (Brydon 2008: 25) ... 6

Figure 2: Ikpɔsɔ vowels (Anderson 1999: 188) ... 22

Figure 3: Suspect F1 track for [i] ... 28

Figure 4: Corrected F1 track for /i/ with false F2 (circled) ... 29

Figure 5: Avatime nonlow vowels, 8 male speakers (Maddieson 1995: 73) ... 36

Figure 6: Avatime nonlow vowels, 4 female speakers (Maddieson 1995: 74) ... 37

Figure 7: Non-low vowels, two male speakers ... 38

Figure 8: Non-low vowels, two female speakers ... 38

Figure 9: Overall mean F1/F2, non-low vowels, 1995 vs. 2023 speakers ... 41

Figure 10: Distribution of non-low vowels in Maddieson (1995) nouns, male speakers ... 44

Figure 11: Distribution of non-low vowels in Maddieson (1995) nouns, female speakers ... 44

Figure 12: Mean F1 for high vowel pairs, verb roots, male speakers ... 46

Figure 13: Mean F1 for high vowel pairs, verb roots, Speaker 1 ... 47

Figure 14: Average formant values for Avatime speaker ... 96

Figure 15: Speaker 1 means ... 167

Figure 16: Speaker 1 all vowels ... 168

Figure 17: Speaker 2 means ... 168

Figure 18: Speaker 2 all vowels ... 169

Figure 19: Speaker 3 means ... 170

Figure 20: Speaker 3 all vowels ... 170

Figure 21: Speaker 4 means ... 171

Figure 22: Speaker 4 all vowelss 171

LIST OF TABLES

Table 1: Avatime consonant inventory 8

Table 2: Avatime vowel inventory 9

Table 3: Avatime tones 9

Table 4: Avatime noun class prefixes (partial and adapted from version in van Putten 2014: 36) 11

Table 5: Avatime personal subject agreement prefixes 12

Table 6: Avatime vowel inventory according to Funke (1909) 23

Table 7: Nouns testing [ATR] contrast in high vowels, from Maddieson (1995) 30

Table 8: High vowel verb roots with [ATR] contrast 32

Table 9: Contexts for high vowel verb roots (from Maddieson 1995) 32

Table 10: Items elicited targeting high vowel noun class prefixes 33

Table 11: Speakers, biographical information, total vowel tokens 33

Table 12: Overall F1/F2 means all vowels, male speakers 34

Table 13: Overall F1/F2 means all vowels, female speakers 35

Table 14: Nouns from Maddieson (1995) - Mean F1/F2, contemporary male speakers 42

Table 15: Nouns from Maddieson (1995) - Mean F1/F2, contemporary female speakers 43

Table 16: Mean F1 high front V prefix, high V roots and non-high V roots 48

Table 17: Mean F1 high vowel verb roots, Speaker 3 50

Table 18: Roots used to test clitic harmony 51

Table 19: Height of object clitic /E/ following verb root, Speaker 3 51

Table 20: Height of /E/ prefixes preceding high vowel verb roots, Speaker 3 52

Table 21: High vowel prefixes in iterative harmony 53

Table 22: Avatime harmonic pairs 63
Table 23: Noun class prefixes and definiteness markers (van Putten 2014: 36) 69
Table 24: Summary of hiatus resolution strategies 76
Table 25: Summary of constraints and weights 85
Table 26: Summary of possibilities for non-root vowels in ATR harmony 90
Table 27: Weights learned by MaxEnt grammar 91
Table 28: Avatime possessive pronouns 101
Table 29: Possessed forms of kin terms – Funke 1909 (table adapted from Schuh 1995a) 101
Table 30: Avatime tones, repeated from 1.2.2.2 105
Table 31: Aspect/mood/polarity prefixes in Avatime 106
Table 32: Division of roots by tone raising behavior 109
Table 33: Consonantal conditioning of raising – monosyllabic roots (Ford 1971) 111
Table 34: Phonological (near-)identical roots have different tone raising behavior 114
Table 35: Tonal properties of CHEW-class verbs 118
Table 36: Tonal properties of CATCH-class verbs 120
Table 37: Tonal properties of SLAP-class verbs 121
Table 38: Tonal properties of COOK-class verbs 122
Table 39: Tonal properties of CHANGE-class verbs 125
Table 40: Tonal properties of LET GO-class verbs 127
Table 41: Tonal properties of FIX-class verbs 128
Table 42: Tonal properties of POUND-class verbs 129
Table 43: Tonal properties of SPREAD-class verbs 130
Table 44: Tonal properties of LIFT-class verbs 130

Table 45: Tonal properties of BRING-class verbs 132

Table 46: Tonal properties of TEACH-class verbs 132

Table 47: Tonal behavior of DO-class verbs 133

Table 48: Tonal behavior of SCRATCH-class verbs 134

Table 49: Tonal behavior for SPOIL-class verbs.. 135

Table 50: Tonal behavior of BITE-class verbs... 136

Table 51: Summary of tonal behavior by class.. 137

Table 52: Ford (1971) tone features.. 139

Table 53: Mean formant values, all vowels, Speaker 1 166

Table 54: Mean formant values, all vowels, Speaker 2 166

Table 55: Mean formant values, all vowels, Speaker 3 166

Table 56: Mean formant values, all vowels, Speaker 4 167

ACKNOWLEDGMENTS

First and foremost, I thank the Avatime speakers without whom none of this work is possible. In particular I am grateful to the speakers who offered their time teaching me about the Avatime language: Vincent Azafokpe, Akos Dedume Mawulorm, Peace Awunyama, Divine Agyepong, Gifty Amu, Jones Kwame, Paul Kwawu, Philomena Ewoenam Kumatse, Agbenya Wisdom, Margaret Kpodzro, and Wisdom Ekissi. I am also grateful to the entire Avatime community, especially in Amedzofe, for their generosity, hospitality, and kindness. *Mlɛ wa lixwɛ popopopo!*

Thank you to my committee members, especially my co-chairs, Kie Zuraw and Harold Torrence. Since the beginning of my time at UCLA, Kie has been an outstanding teacher, advisor, and mentor. She has not only provided invaluable insights and feedback about the theoretical aspects of this dissertation, but has always been receptive and helpful when I present her with ever more complicated Avatime data. Beyond that, Kie has been extremely supportive, patient, and helpful, and has been a role model for what a an academic can and should be.

Harold gave me the opportunity to start working in Ghana and has been instrumental in my development as a fieldworker and a linguist. He is always prepared to offer advice, feedback, and support, even on a dissertation that is focused on phonology. He has also always been willing to collaborate with myself and other students across a wide variety of languages and topics, which I greatly admire, and have learned much from.

I also thank Bruce Hayes for his many contributions to both this dissertation and my knowledge of phonological theory in general. His insights and suggestions have not only helped me develop the ideas in this dissertation, but have taught me a lot about how to how to relate the highly-specific data from fieldwork to the big questions in phonology.

I am also grateful to Ben Eischens for agreeing to join the committee at the eleventh hour, and for being willing to provide helpful feedback and suggestions on a project that he was only just finding out about. Ben has also been more than willing to provide helpful advice on other aspects of being an academic, which I have greatly appreciated and benefitted from.

Travis Major has been a wonderful friend, and fieldwork companion in Ghana, as well as a collaborator and someone who I have learned a lot from. Maura O'Leary has been a great friend, collaborator, and fellow small plane passenger in Alaska. Here I would also like to thank the Hän speakers and community members who have been so generous in sharing their language and culture with me during my time as a graduate student.

I am grateful to my family and especially to my parents, Beth Hall and Steve Lehman, for all their support. It is almost certain that they unintentionally set me up to be a linguist by putting me in such close proximity to the study of language and science, respectively, from such a young age.

My deepest thanks go to my wife, Madison. Over these many years, which have had many challenges, setbacks, and changes of plans, she has been a constant source of love, support, and encouragement. Without her partnership, I would never have reached the end of this journey.

VITA

2016 BA in Linguistics and Germanic Languages and Literatures

Washington University of St. Louis

PUBLICATIONS

Czuba, Matthew; Brown, Colin; Chen, Zhuo; Lehman, Blake; Torrence, Harold. (in press). "Varieties of polar questions in Dschang". *Proceedings of the 4th Symposium on West African languages*.

Chen, Zhuo; Lehman, Blake. (2021). "An argument analysis of cognate objects in Dschang (Yemba)". *Proceedings of the Linguistic Society of America*, *6*(1), 913-926. https://doi.org/10.3765/plsa.v6i1.4991.

Devlin, Kerri; Lehman, Blake; Major, Travis; Torrence, Harold. (2021). "A note on wh-questions in Avatime". *Selected Papers from the 50th Annual Conference on African Linguistics*. Bickmore, L., M. Cahill, M. Diercks, L. Downing, J. Essegbey, K. Franich, L. McPherson, and S. Rose (eds.), pp. 55-72. Language Science Press.

O'Leary, Maura; Lehman, Blake. (2019). "Unexpected Athabaskan Pronouns". In Bowler, M., P. Duncan, T. Major, H. Torrence (eds.) *Schuhschrift: Papers in Honor of Russell Schuh*. 122-138.

1 INTRODUCTION

This dissertation is a study of several aspects of Avatime phonology. Avatime, a Kwa language of Ghana, has a wide array of phonological phenomena that are relevant and challenging for phonological theory. The goals of this dissertation are to bring together the important observations made by previous researchers with data from original fieldwork on the language, and to situate several of the phonological phenomena of Avatime in the context of contemporary phonological theory.

1.1 Structure of the dissertation

This dissertation consists of case studies of three phenomena in Avatime phonology that are of great interest for phonological theory. Two of these case studies – on the [ATR] contrast in high vowels, and on tone sandhi in verbs – focus on aspects of Avatime phonology that have undergone change since earlier work.

1.1.1 Chapter 2

Chapter 2 examines a feature of Avatime phonology that has proven elusive in past studies of the language. Among the high vowels, there have been conflicting reports on the existence of a contrast in tongue root advancement. In the early twentieth century, a contrast between [i]/[ɪ] and [u]/[ʊ] was reported, if inconsistently, by Funke (1909). In research conducted in the mid-twentieth century, for example by Ford (1971), this contrast was considered neutralized on the surface. Work in the late twentieth century by Schuh (1995a), and in particular by Maddieson (1995) showed that there was in fact a surface contrast between pairs of high vowels. The most recent work on Avatime (van Putten 2014; Defina 2016) has suggested that the contrast, while still present is being lost from the language. The loss of the [-ATR] high vowels is a widespread diachronic process in African languages (Casali 1995; 2008). Avatime provides an opportunity to study a language in which this process is underway, but not yet complete, and consider what consequences this has for the phonology of the language.

This chapter presents results of an initial phonetic study with younger speakers in Amedzofe attempting to determine to what extent this loss of contrast is complete, and what consequences this has had for the phonology of vowel harmony. I find that, in aggregate, there is still a contrast among high vowel pairs along the dimension of F1, which was found by Maddieson (1995) to be a primary acoustic cue for [ATR] in Avatime. However, when considering specific tasks, I find that some speakers fail to produce a contrast between at least one pair of high vowels in noun and verb roots. Despite the lack of acoustic contrast, all speakers still treat high vowel roots as contrastive for purposes of triggering vowel harmony on prefixes and enclitics. I discuss these findings in the context of opacity and abstractness in phonology (Kiparsky 1973; Baković 2007), as well as in the context of possible effects of perception in maintaining a phonological contrast with a disappearing phonetic contrast.

1.1.2 Chapter 3

This chapter examines the phonology of [ATR] harmony more generally, with a focus on the behavior of the low vowel [a]. The basic pattern that I examine is the asymmetry in harmony behavior of [a] in prefixes and enclitics. In prefixes, such as the noun class prefix in (1), [a] alternates with [e] when attached to a [+ATR] root (roots underlined). However, in enclitics, such as the definiteness clitic in (1), [a] is invariant.

(1) Asymmetry in harmony behavior of [a]

a.	**ka^{3}**-drʊɪ^{1}	‘dog’	[-ATR] root
b.	**ke^{1}**-zi^{3}	‘bowl’	[+ATR] root
c.	ka^{3}-drʊɪ^{1}=**a^{3}**	‘(the) dog’	[-ATR] root
d.	ke^{1}-zi^{3}=**a^{1}**	‘(the) bowl’	[+ATR] root

In the chapter, I argue that this asymmetry can be analyzed in Harmonic Grammar (Smolensky 1986; Legendre et al. 1990; 2006). In this analysis, the constraints driving vowel harmony and resisting vowel harmony are weighted, rather than ranked. The failure of [a] to harmonize in enclitics is the result of *ganging*. In prefixes, the altenration of [a] with [e] only violates one constraint dispreferring harmony, whose weight is not sufficient to overcome the weight of the harmony-driving constraint. However, in enclitics, this alternation violates *two* harmony-dispreferring constraints, whose combined weight overcomes the weight of the harmony-driving constraint. I show that this approach not only accounts for the prefix-enclitic asymmetry, but also account for prefixes with exceptional invariant [a] and suffixes with invariant mid vowels. Among African languages with [ATR] harmony, it is common for the low vowel to lack a [+ATR] counterpart at the same height (Casali 2008). Among languages of this type, there are a variety of ways that this asymmetry in the vowel inventory affects vowel harmony (Baković 2001). This chapter contributes an analysis of a language in which the low vowel has two different behaviors and interacts with both prosodic structure and lexically-specified exceptions.

1.1.3 Chapter 4

Schuh's discussion of Avatime tone begins with the claim that "Avatime tone alone could occupy a monograph length work" (Schuh 1995a: 56). This chapter is a modest contribution to understanding one aspect of Avatime tone that is of great interest for contemporary phonological theory. Since the pioneering work of Ford (1971), who first described the highly complex tonal system of Avatime, including the tone sandhi pattern discussed in this dissertation, it has been recognized that the tone of verb roots and prefixes may undergo a complex set of changes triggered by the tone of the following word. The changes are determined by phonological, morphosyntactic, and lexical factors. For example, we can consider three verb roots of Avatime:

ta^{1} ‘chew’, *tɔ*^{3} ‘cook’, and *to*^{3} ‘pound’. Each of these roots displays different properties with respect to tone sandhi. ‘Chew’ undergoes sandhi of both root and prefix tones when followed by tone 3 (2), but sandhi is blocked in the progressive aspect (2). ‘Cook’ undergoes sandhi of only the root tone when followed by tone 3 (2), but sandhi is not blocked by morphological context (2). ‘Pound’ fails to undergo sandhi in any context, despite its segmental and tonal similarity to ‘cook’

(2) Tone sandhi patterns

a. a^{3}-ta^{1} ɪ^{1}-kpa^{3}=lɛ^{1} ‘S/he ate fish’	d. a^{3}-tɔ^{3} bla^{1}lɪɛ^{3} ‘S/he cooked plantain’	g. e^{3}-to^{3} bla^{1}lɪɛ^{3} ‘S/he pounded plantain’
b. **a^{4}-ta^{3}** kɪ^{3}-dzɛ^{3} ‘S/he ate meat’	e. a^{3}-**tɔ^{4}** ki^{3}-ku=ye^{3} ‘S/he cooked yam’	h. e^{3}-to^{3} ki^{3}-ku=ye^{3} ‘S/he pounded yam’
c. ɛɛ^{14}-**ta^{1}** **kɪ^{3}**-dzɛ^{3} ‘S/he is eating meat’	f. ɛɛ^{14}-**tɔ^{4}** ki^{3}-ku=ye^{3} ‘S/he is cooking yam’	i. ee^{14}-to^{3} ki^{3}-ku=ye^{3} ‘S/he is pounding yam’

In this chapter, I present data from my own fieldwork investigating this pattern of tone sandhi. The basic facts are in general align with those reported by Ford and van Putten. However, I show that some verb classes behave differently than earlier descriptions, and I also describe two previously unreported patterns of tonal behavior. Based on this data, I propose that the Avatime tone sandhi pattern should be analyzed as a case of phonologically-conditioned allomorphy (Paster 2006). Specifically, I outline an analysis based on the framework proposed by McPherson (2019), in which the tone classes are generalized in the lexicon as frames containing a set of allomorphs whose selection is conditioned by phonological and morphological context.

There has been increased attention to complex tonal patterns in African languages that are conditioned by other components of the grammar, especially the morphosyntactic component. Lionnet et al. (2022) provide an overview of much of this recent work. While the Avatime tone sandhi pattern discussed in this dissertation is not a canonical example of grammatical tone, it does fit into the broader definition of a “grammatically restricted tonological pattern” (Lionnet et al. 2022: 391). The analysis of this pattern adds to the growing body of work on this topic in the field of phonology generally, and in African languages in particular.

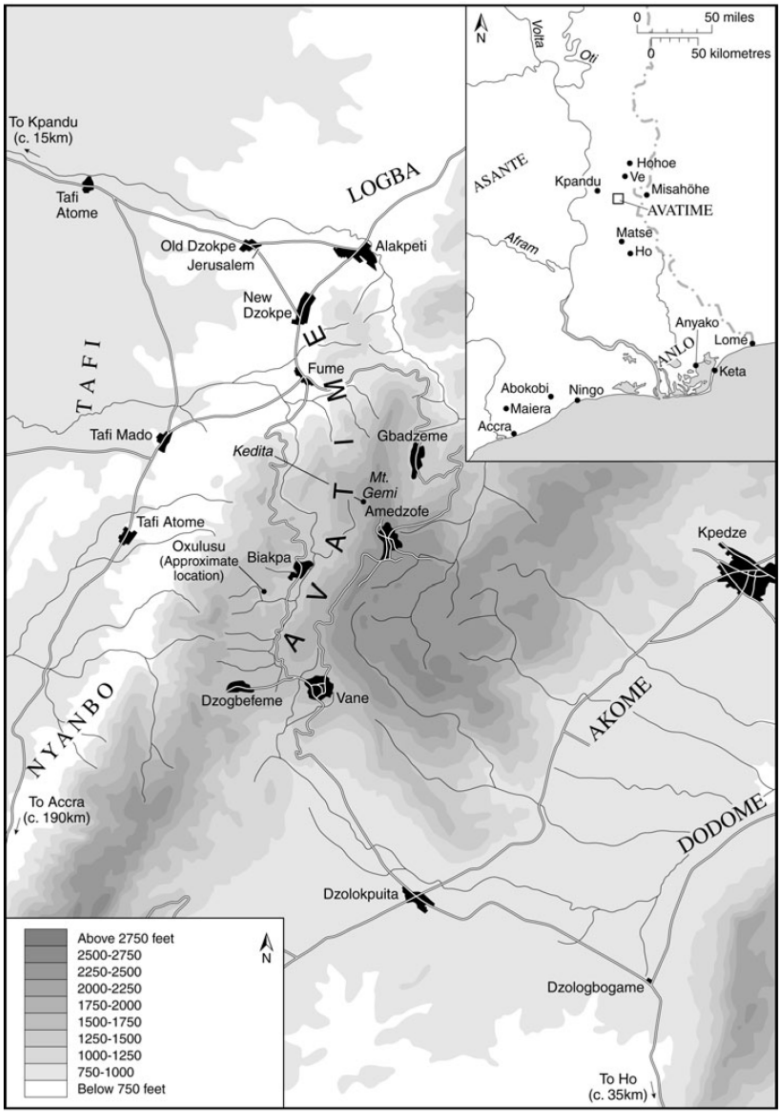
1.2 Avatime Background

In this section, I provide background information on the Avatime people and language, as well as a description of when and how I collected the data discussed in the following chapters.

1.2.1 The Avatime people

The Avatime traditional area is located in the east of the Volta Region of Ghana, just north of the regional capital, Ho and near the border with Togo. This area contains eight Avatime villages: Amedzofe, Biakpa, Dzogbefeme, Fume, Gbadzeme, New Dzokpe, Old Dzokpe, and Vane. The Paramount Chief resides in Vane. According to Avatime oral history, the Avatime people came to settle in this area from an earlier home in the Ahanta region to the west (told by Jones Kwame 2018, see also Brydon 2008). Most Avatime people are employed in subsistence agriculture, traditionally growing rice (*oryza glaberrima*), but contemporarily primarily cassava, maize, and yams. There is some published academic work on Avatime culture and society, most prominently by Brydon (1979; 1981; 1996; 2008, i.a.).

Figure 1: Map of Avatime villages, and location of Avatime within surrounding area (Brydon 2008: 25)



1.2.2 Language background

Avatime is a Kwa language, and is one of the Ghana-Togo Mountain (GTM) languages (formerly Central Togo languages or *Togorestsprachen*). The endonym for the language is *Sìyàsɛ*, or, more recently, also *Sìdemèse*. The name Avatime comes from the surrounding Ewe people. In this dissertation, I follow previous researchers in using the term Avatime, as this word is freely used by members of the community to refer to their language and people when speaking with outsiders, as well as in public-facing materials produced by the community.

There is some dispute about whether GTM languages form a separate branch of Kwa. Heine (1968) and Kropp-Dakubu (2017) claim that they do, and that they can be divided into two branchs: Na- and Ka-Togo. Avatime would be a member of the Ka-Togo branch. Blench (2009) maintains that the GTM languages are actually three separate branches within Kwa, with no common ancestor. Whether they form a genetic or areal grouping, the GTM languages are known for maintaining productive noun-class systems, which is uncommon in the surrounding languages. Based on the estimate of van Putten (2014), there were approximately 15,000 speakers of Avatime in 2014. This differs from the figure of 24,000 found in Ethnologue. The cause for this disparity is unclear. Based on these figures, I would expect the Avatime-speaking population to be near 20,000 today.

There is some degree of dialect variation, although a full account of Avatime dialects must be left for future work. Much of the variation concerns the segmental phonology, particularly the bilabial consonants [b, w, ʋ, β] in intervocalic position. There is also variation the liquids [l, r], as well as some differences in the morphology of the verbal prefix complex. Dialect variation will not be discussed below, unless relevant. However, it is a promising area for future work on the language. Information from this section may be repeated in the following chapters when it is relevant.

1.2.2.1 Segmental phonology

The consonant inventory of Avatime is given in Table 1. I use a system of transcription based on that used in Avatime New Testament (Ghana Institute of Linguistics, Literacy, and Bible Translation 2017) which is itself based on Ewe orthography. For all speakers that I have interacted with, the dental and alveo-palatal affricates <ts, dz> and <tsy, dzy> have merged. Impressionistically, younger speakers always pronounce the affricates as alveo-palatal, while some older speakers pronounce them as dental. However, even for these speakers, there does not appear to be a contrast between affricates produced at difference places of articulation.

Table 1: Avatime consonant inventory[1]

	Bilabial	Labio-dental	Dental	(Alveo-) palatal	Velar	Labiovelar
Stop	p, b		t, d, (ɖ)		k, g	kp, gb
Fricative	(ƒ[2]) [ɸ], ʋ [β]	f, v	s, z		x, h [ɣ]	xw [x^w], hw [$ɣ^w$]
Affricate			ts [tʃ ~ ts], dz [dʒ ~ dz] (tsy, dzy)			
Nasal	m		n	ny [ɲ]	ŋ	ŋw [$ŋ^w$]
Liquid						
Glide	w		l [l/r]	y [j]		

The vast majority of syllables in Avatime are open, with a limited set of morphemes ending in a nasal consonant. Onset clusters are permitted, with the second member of the cluster always being a liquid (rhotic if the initial consonant is coronal, lateral otherwise). All consonants may appear as C1 in an onset cluster, including the labiovelars. Schuh (1995a) takes this as evidence that segments like <ŋw> are truly labiovelar segments, rather than a sequence of [ŋ] + [w]. The vowels of Avatime are given in Table 2. Avatime has a nine-vowel system, with an ATR contrast for both mid and high vowels (Maddieson 1995). It should be noted, though, that the ATR contrast among high vowels seems to be disappearing from the language. There is not yet a definitive study, but van Putten (2014) notes that, especially among younger speakers, there is frequently no distinction between [i/ɪ] or between [u/ʊ]. Impressionistically, my consultants confirm this observation. While the contrast is not fully lost, younger speakers do often fail to

[1] Consonants without IPA symbols in brackets have an orthographic form is identical to their pronunciation.

[2] This sound only appears in loanwords from Ewe.

produce a contrast between the high vowel pairs. The implications of this change in progress will be discussed in extensive detail in Chapter 2. Vowels within words harmonize for the feature [ATR], but see Chapter 3 for detailed discussion of complications in the vowel harmony system.

Table 2: Avatime vowel inventory

	Front		Central	Back	
	+ATR	-ATR	-ATR	-ATR	+ATR
High	i	ɪ		ʊ	u
Mid	e	ɛ		ɔ	o
Low			a		

1.2.2.2 Tone

Avatime has four tone levels, give in Table 3. One of these, the Mid tone (marked here as tone 2), is marginal. Schuh (1995a) found that this tone frequently merged with tone 3 (the high tone), even at the time of his work in Amedzofe. In more recent work, Defina (2016a) and van Putten (2014b) only mark three tones, with the mid tone (tone 2) absent. In my fieldwork, I have found that tone 2 is marginal, but does still appear in a limited set of contexts, although it is much more frequently merged with tone 3. Therefore, I do mark tone 2 where it appears, despite its infrequency. In addition to the level tones, there is a contour tone that rises from tone 1 to tone 4. At least one verbal prefix has a falling contour from tone 4 to tone 1. This contour does not appear elsewhere in the language, and it is unclear whether the vowel of the prefix can be analyzed as a long vowel bearing two level tones, or what the source of this falling tone may be.

Table 3: Avatime tones

Tone	**Representation**
Low (tone 1)	a^1
Mid (tone 2)	a^2
High (tone 3)	a^3
Extra High (tone 4)	a^4

There are limits on the distribution of these tones, especially in the nominal domain. Tone 2 never appears on prefixes, and tone 4 never appears on underived native roots. The tonal system in verbs will be discussed in much more detail in Chapter 4. Additional discussion of tone in the nominal domain, see Ford (1971) and Schuh (1995a)

1.2.3 Morphology

1.2.3.1 Noun classes

Almost all nominals in Avatime are marked by a noun class prefix. The prefixes form singular plural pairs:

(3) a. **li³-**gbo³ 'chair'
CL3S-chair
b. **e³-**gbo³ 'chairs'
CL3P-chair

c. **ɔ¹-**ha¹ 'pig'
CL2S-pig
d. **ɪ¹-**ha¹ 'pigs'
CL2P-pig

Nominal modifiers show concord with the class of the head noun. This can take the form of concord prefixes – which is the case for numerals, demonstratives, and the indefinite article – or class-specific allomorphs, as in the case of the definiteness markers (Schuh 1995; van Putten 2014). The full set of noun class prefixes and definiteness markers is given in Table 4:[3]

[3]Vowels in small caps are underspecified for [ATR] and harmonize harmonize according the [ATR] value of the noun root. Prefixes with a tone 1 marking have an invariant tone 1 for all nouns of that class, while prefixes with no tone marking may have any of tone 1, 3, or 4 (except in the case of class 1 s/p, which cannot have tone 1). Definiteness markers with a small cap onset consonant undergo alternations when the root-final syllable has a nasal onset: /l/ becomes [n], /w/ becomes [m]. This alternation may also be triggered by historically nasalized vowels (see discussion in conclusion of Chapter 2). The definiteness markers for classes 1p and 4p in this table differ from those given by van Putten (2014), as intervocalic [w] is deleted in the Vane dialect.

Table 4: Avatime noun class prefixes (partial and adapted from version in van Putten 2014: 36)

Class	Prefix	Definiteness marker
1 s	O-/∅	=(y)E
1 p	bA-/∅	=Wa
2 s	o[1]-	=lo
2 p	i[1]-	=le
3 s	(l)I-	=le
3 p	a-	=La
4 s	ki-	=(y)E
4 p	bi-	=we
5 s	kU-	=o
5 p	ba[1]-	=a
6 s	kA-	=a
6 p	ku[1]-	=o
7	si-	=se

In this dissertation, I gloss noun class prefixes only as CL, definiteness markers only as DEF, and concord prefixes on verbs only as CNC, unless the distinction between noun classes is crucial.

1.2.3.2 Verbal morphology

Aspect, person, mood, and polarity are marked as prefixes on the verb. These categories are frequently combined in portmanteau morphemes, as in (4) and (5). In (4), we see a change from aorist to progressive aspect marked as a vowel and tonal change on a subject prefix. In (5), negation is also marked by a change in prefix vowel and tone.

(4) a. /mA¹-ta¹ kI³-mɪ³mɪ³ =E¹/
ma¹⁴-ta³ kɪ³-mɪ³mɪ=ɛ¹
1SG.AOR-eat CL-rice=DEF
'I ate rice'

b. /mE¹⁴-ta¹ kI³-mɪ³mɪ³ =E¹/
mɛ¹⁴-ta¹ kɪ³-mɪ³mɪ=ɛ¹
1SG.PROG-eat CL-rice=DEF
'I am eating rice'

(5) a. /A³-ta¹ kI³-mɪ³mɪ³ =E¹/
a⁴-ta³ kɪ³-mɪ³mɪ=ɛ¹
3SG.AOR-eat CL-rice-DEF
'S/he ate rice'

b. /O^{14}-ta^{1} kI^{3}-mɪ^{3}mɪ^{3}=E^{1}/
ɔ^{14}-ta^{1} kɪ^{3}-mɪ^{3}mɪ^{3}=ɛ^{1}
3SG.NEG-eat CL-rice=DEF
'S/he did not eat rice

Defina (2009) shows that the relationship between aspect/mood/polarity and subject prefixes is highly complex. There are three sets of subject agreement prefixes, with prefixes from different sets appearing in different aspect/mood/polarity contexts. There are also concored prefixes for each noun class in addition to the human subject agreement prefixes. In the interest of clarity, I present only the set 1 personal prefixes. Across all three sets of subject agreement prefixes, the initial consonant remains the same, so that person can be recognized from just the set 1 prefixes.

Table 5: Avatime personal subject agreement prefixes

	Singular	Plural
1	ma^{1}-	k(w)I^{3}-
2	wO^{1}-	mlE^{3}-
3	a^{3}-	bE^{3}-

Avatime does not mark tense on verbs. Aspect may be marked by a morpheme that combines with the subject agreement prefix, or by a separate prefix, as may mood and negation. For example, potential aspect is marked by a vowel with a tonal contour which fuses with the person prefix, while intentive aspect is marked by a separate prefix.

(6) Aspect marking – fused prefix vs. separate prefix

a. maa^{41}-wlo^{3}
1SG.POT-bathe
'I will/might/want to bathe'

b. ma^{1}-ta^{4}-wlo^{3}
1SG-INT-bathe
'I will/am going to bathe'

For a more detailed description of the aspect/mood/polarity system of Avatime, see Defina (2009).

1.2.3.3 Syntax

Avatime has basic SVOX word order:

(7) SVO word order

A^{1}ya^{3}pe^1	e^3-dzi^3	ɔ^3-gɛ^3	ni^4	ke^1-dzya^3	mɛ^1
Ayape	3SG.AOR-buy	CL-goat:DEF	LOC	CL-market	inside

‘Ayape bought a goat at the market’

In a limited set of constructions, OV order is also possible:

(8) O-V order in non-finite construction

a.

mɛɛ^{14}-ta^1	kɪ^3-mɪ^{3}mɪ=ɛ^1
1SG.PRG-chew	CL-rice=DEF

‘I am eating rice’

b.

me^1-kpe^{3}se^3	<u>kɪ^3-mɪ^{3}mɪ=ɛ^1</u>	<u>ta^1</u>
1SG.AOR-start	CL-rice=DEF	chew

‘I started to eat rice’

For more discussion of Avatime syntax, see Ford (1971), and especially the van Putten (2014) chapter 2. For discussion of serial verb constructions, see Defina (2016a,b).

1.2.4 Data

The Avatime data in this paper come from two from fieldwork conducted by the author during three field trips to the Volta Region of Ghana between 2018 and 2022. Any examples that are not cited as deriving from another published source come from this field data. I also include examples from published linguistic work on Avatime. There have been several waves of work on the language, beginning in the early twentieth century with Funke (1909; 1910). Additional work on the language was done by Ford, most prominently Ford (1971), which focuses on syntax, but includes a quite extensive discussion of phonology, especially tone. The next published work on Avatime was done by Schuh (1995a, b) and Maddieson (1995), based on field work done in the Avatime village of Amedzofe. The main contemporary works on Avatime that are referenced here are Defina (2009) and van Putten (2014). There is also ongoing work by myself together with Harold Torrence, Travis Major, and Kerri Devlin on topics in Avatime syntax, especially wh-questions (Devlin et al. 2021; Major & Torrence forthcoming).

The data presented here comes from fieldwork with speakers from Amedzofe and Gbadzeme, as well as from previous research (mainly done in Vane; Defina (2009), van Putten (2014)). The large majority of the examples cited in this dissertation come from elicitation sessions targeting specific grammatical features. In future work, I hope to include additional data from more naturalistic speech, as it is likely that this will give insight both into the aspects of phonology I discuss below, but also into how features such as frequency or speech genre may affect those aspects.

2 ATR IN HIGH VOWELS

Avatime has been analyzed as a language with 9 contrastive vowels, divided into two harmonic sets contrasting for the feature [ATR]. Despite some earlier claims to the contrary, Maddieson (1995) shows conclusively that high as well as mid vowels show a surface [ATR] contrast. However, van Putten (2014) makes the following comment regarding the presence of an [ATR] contrast among high vowels in Avatime:

> "The difference between +ATR and -ATR high vowels seems to be disappearing from the language. The -ATR high vowels are often pronounced as +ATR, especially by younger speakers."
>
> *(van Putten 2014: 28)*

All previous accounts of [ATR] harmony in Avatime describe high vowels as triggers of harmony on affixes and clitics. So, the loss of the [ATR] contrast in high vowels would be significant for the organization of synchronic Avatime phonology. Roots with high vowels would no longer display a surface contrast corresponding to the harmony behavior of affixes and clitics. This would make Avatime vowel harmony abstract in the sense that an underlying contrast motivates alternations, but never appears as a contrast in surface forms. This type of abstractness is a form of counterbleeding opacity (Kiparsky 1973; Baković 2007) – neutralization of high [-ATR] and [+ATR] vowels would fail to bleed [ATR] harmony. If Avatime were to represent a case of this type, we would expect to see the following: (a) no phonetic distinction between [±ATR] high vowels in any context, (b) harmony on mid-vowel affixes and clitics attached to high vowel roots, matching the underlying [ATR] specification of the root, and (c) transparent high vowel prefixes – these prefixes would not undergo harmony, but nor would they block harmony.[4]

[4] This would contrast with the behavior of /a/ in certain prefixes. This vowel can fail to harmonize with a root, but triggers [-ATR] harmony on prefixes to its left (see following chapter).

In this chapter, I will show that (a) is not the case in Avatime. Younger speakers are in fact losing the tongue root contrast among high vowels, at least the surface contrast along the dimension of F1, as it exists for older speakers. Specifically, the [-ATR] high vowels are merging with their [+ATR] counterparts. However, the merger of the [±ATR] high vowels along these dimensions is incomplete and uneven – speakers produce these vowels as merged in some cases but not others, and show a small, but still statistically significant contrast between both pairs in aggregate. An additional complication is the direction of the merger. In come cases, as will be seen below, it appears that the result of the merger of the high vowel pairs is that both vowels are produced as closer to [-ATR]. This would be highly unexpected, given the cross-linguistic patterns reported for this type of merger (Casali 1995; 2008). I will show that this has not affected the ability of high vowels to act as triggers of [ATR] harmony on affixes and clitics, even in contexts in which a pair of high vowels has merged. I argue that, although [-ATR] vowels do not have consistent surface realization for younger Avatime speakers, they are still phonologically contrastive. So, while the realization of the feature [-ATR] is not consistent across or within speakers for high vowels, it still acts exceptionlessly as a trigger of harmony. As for (c), the results are less clear. There is some evidence for developing transparency of high vowels in [ATR] harmony, but the [ATR] contrast in high vowels that are targets of harmony is more robust than the contrast in roots.

This chapter is organized as follows: 2.1 provides background on the topic of ATR harmony in African languages generally, with a focus on the issue of the ATR contrast in high vowels specifically. Section 2.2 is an overview of previous scholarship on ATR harmony in Avatime. In 2.3 the study of high vowels is presented, and 2.4 argues that a surface merger of high [-ATR] vowels with their [+ATR] counterparts is in progress for some contemporary

Avatime speakers, although it is incomplete. In 2.5, the implications of this ongoing sound change for Avatime phonology are discussed, and 2.6 and concludes and proposes future directions for understanding how contemporary Avatime speakers produce and perceive the feature [ATR] in their phonological grammars.

2.1 Background

Avatime is one of many sub-Saharan African, languages that has a system of *cross-height* vowel harmony (Stewart 1967; 1971). The non-low vowels can be divided into two sets contrasting in the feature [ATR]. The nature of the articulation of this feature for Avatime is unclear, but its primary acoustic correlate is F1 (Maddieson 1995). Maddieson's work shows a clear [ATR] contrast among both high and mid vowels in Avatime. However, researchers of Avatime at various times have claimed (sometimes implicitly) that the contrast is only among mid vowels, with the high vowel pairs having merged at some point in the history of the language. The implications for this loss of contrast for the phonology of language would be significant. There is much debate on the status of "abstract" (not observable from the surface data) contrasts in phonology (Kiparsky 1973; Baković 2007, i.a.). If Avatime has indeed lost the surface contrast between [±ATR] high vowels, then their behavior in the vowel harmony system could bear on this debate. This section will discuss the issue of high vowels and contrast in [ATR] systems in general, and in the Ghana-Togo Mountain group to which Avatime belongs in particular.

2.1.1 High vowels and [ATR] contrast

Starwalt (2008) conducted a phonetic survey of African [ATR] harmony languages. She found that across a sample of 11 languages with tongue root harmony, the only consistent acoustic cue across both languages and speakers was F1. However, in some languages, and for some contrasts, other measures could also contribute to distinguishing pairs of [+/-ATR] vowels.

These measures included formant bandwidth and spectral center of gravity. Based on Starwalt's data, as well as data from Becker-Kristal (2010), Rose (2018) observes that the F1 differences between pairs of high vowels is significantly smaller than the difference between pairs of mid vowels. In a perceptual study of the [ATR] contrast in Degema, Fulop et al. (1998) find that speakers only reliably distinguish mid vowels on the basis of formant frequencies, suggesting that this may play a role in the widespread shift of languages with [ATR] contrasts to 7-vowel systems, preserving the contrast only in the mid vowels.

2.1.2 [ATR] harmony and abstract phonology

The loss of [-ATR] high vowels in 9-vowel languages like Avatime is common in African languages (Casali 1995). Some such cases have been analyzed as involving the retention of an abstract phonological contrast even after the loss of a surface contrast. A well-known case of this type is Okpẹ (Hoffmann 1973; Omamor 1988; Archangeli & Pulleyblank 1994). This language was claimed to have counterbleeding opacity due to the absolute surface neutralization of the contrast between [-ATR] high and [+ATR] mid vowels, as shown in (9).

(9) Okpẹ harmony and neutralization (adapted from Archangeli & Pulleyblank (1994), based on Hoffman 1973)

High vowels	*Imperative*	*Infinitive*	*Gloss*
/i/	ti [tí]	e-ty-o	'pull'
/ɪ/	**rɪ [ré]**	**ɛ-ry-ɔ**	'eat'
/u/	ru [rú]	e-rw-o	'do, make'
/ʊ/	**rʊ [ró]**	**ɛ-rw-ɔ**	'sing'

In this case, Hoffman argued that the rule enforcing [ATR] harmony was ordered before the rules lowering [-ATR] high vowels (as in the imperative) and the rule for glide formation (as in the infinitive). Okpẹ was later argued to not actually have neutralization of the [-ATR] high vowels and [+ATR] mid vowels – Archangeli and Pulleyblank (1994) cite preliminary data from Omamor (1973) showing that the [-ATR] high vowels and [+ATR] mid vowels are actually distinct in Okpẹ. However, other cases of abstract phonology based on neutralization of [-ATR] high vowels have arisen. More recently, for example, the Dogon language Bondu-So (Hantgan & Davis 2012; Green & Hantgan 2019) has been argued to have a covert (never observed on the surface) [ATR] contrast in high and low vowels, which triggers harmony on mid vowel affixes. For example, Green and Hantgan argue based on the suffixal alternations in (10) that an abstract [ATR] contrast exists for high in Bondu So. Their claim is that the roots trigger harmony on the suffixes, and then are neutralized on the surface.

(10) High vowels and [ATR] harmony in Bondu So (adapted from Green & Hantgan 2019: 5)

a.	**í**b-**éè**	's/he had caught'	
b.	nìŋg-**έὲ**	's/he had shut'	(from underlying /nɪŋg-/)
c.	k**ú**mb-**èè**	's/he had held'	
d.	g**ù**b-**έὲ**	's/he had hung up'	(from underlying /gʊb-/)

However, Sandstedt (2020) argues that harmony in Bondu So is better analyzed as being suffix-controlled, with the alternations in suffix vowel due to verbs like those in (10) falling into different inflectional classes. Under Sandstedt's analysis, high vowels in Bondu So are simply neutral to harmony, with no need to appeal to an abstract contrast. It is unclear to what extent such an analysis could apply to Avatime, whose vowel harmony system is more straightforward and more obviously root-controlled.

2.1.3 High vowels and [ATR] in GTM languages

Avatime is not an isolated case in the wider Ghana-Togo Mountain languages. There has been significant work addressing the role of high vowels in [ATR] harmony in other GTM languages, particularly Ikpɔsɔ (Ka-Togo; Anderson (1999)), Lɛlɛmi (Na-Togo; Schwarz (2007)), and Tutrugbu (Ka-Togo; McCollum & Essegbey (2020)). In two of these languages, Lɛlɛmi and

Tutrugbu, the [-ATR] high vowels are phonetically neutralized on the surface. In Ikpɔsɔ, the high front vowel pair cannot be distinguished acoustically by height, only by voice quality[5].

2.1.3.1 Tutrugbu

In Tutrugbu (often referred to in literature on GTM languages as Nyangbo or Nyagbo), the [-ATR] high vowels have already been completely lost. However, instead of merging with the [+ATR] vowels, they have merged with the [-ATR] mid vowels. Thus, McCollum & Essegbey (2020) analyze the vowel inventory of Tutrugbu as follows:

(11) Tutrugbu vowel inventory (McCollum & Essegbey 2020)

CONTEMPORARY	/i/	/e/	**/ɛ^{H}/**	/ɛ/	/a/	/o/	**/ɔ^{H}/**	/ɔ/	/u/
HISTORICAL	/i/	/e/	**/ɪ/**	/ɛ/	/a/	/o/	**/ʊ/**	/ɔ/	/u/

Crucially, their analysis posits that the mid vowels derived historically from [-ATR] high vowels must be underlying specified as having a [+high] feature in the synchronic phonology of Tutrugbu to account for their behavior in height harmony in that language. This is something of a mirror image of Avatime, in that the [-ATR] high vowels have maintained their tongue root feature while merging in height, while in Avatime, these same vowels are shifting in terms of tongue root, but maintaining their height. So, applying their approach to the most innovative possible form of Avatime, you would have something like the following:

(12) Hypothetical innovative Avatime vowel inventory according to McCollum/Essegbey approach[6]

CONTEMPORARY	/i/	**/i^{R}/**	/e/	/ɛ/	/a/	/o/	/ɔ/	**/u^{R}/**	/u/
HISTORICAL	/i/	**/ɪ/**	/e/	/ɛ/	/a/	/o/	/ɔ/	**/ʊ/**	/u/

[5] Specifically, by a contrast in the difference in amplitude between the first two harmonics. However, the direction of this difference is not consistent across all vowel pairs (Anderson 2003: 88–89).

[6] The diacritic ^{R} is used here to show that the vowels are underlyingly specified as “retracted” or [-ATR].

2.1.3.2 Lelemi

In Lelemi, Schwarz (2007) discusses the outcome of a historical merger of [±ATR] high vowels. In this language, the merger of the harmonic pairs of high vowels led to a situation in which roots no longer contrast for [ATR], but still trigger [ATR] harmony on prefixes. For example, the roots for 'arrive' and 'bite' in (13) are homophonous, but 'arrive' occurs with [+ATR] prefixes, while 'bite' occurs with [-ATR] prefixes.

(13) Merged high vowels in Lelemi trigger harmony on prefixes in Affirmative Simple Past (adapted from Schwarz 2007: 133)

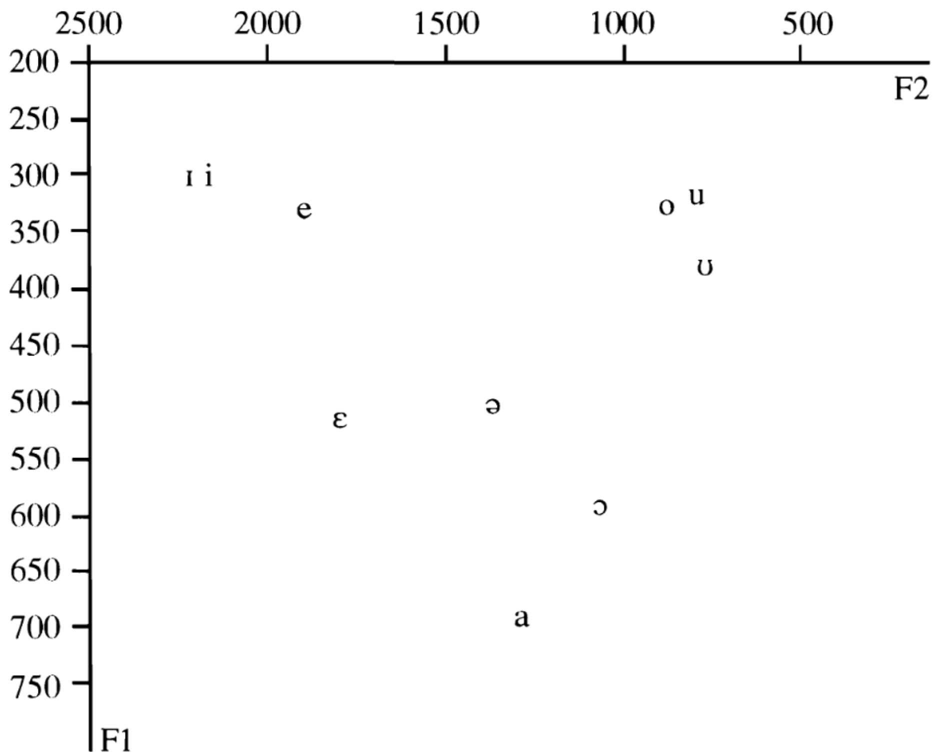
	-dù 'arrive'	-dù 'bite'	
a.	lí-dù	lɛ́-dù	*1sg*
b.	é-dù	á-dù	*2sg*
c.	ú-dù	ɔ́-dù	*3sg (noun class)*

In prefixes, as in Tutrugbu, high vowels in prefixes now pair with [-ATR] mid vowels. This can be seen in (13) and (13) above. Schwarz argues that, when the [-ATR] high vowels were lost in Lelemi, the [ATR] specification on the prefix vowel took precedence over the height specification, leading to a system in which an underlying high vowel in prefixes lowers to mid in order to participate in harmony. Lelemi, then, presents another case of a possible abstract or covert [ATR] contrast in high vowels in a language related to Avatime.

2.1.3.3 Ikpɔsɔ

Anderson (1999) analyzes Ikpɔsɔ as a 10-vowel system, with [ATR] contrasts among high, mid, and low vowels. However, she notes that the high front vowels /i/ and /ɪ/ are perceptually extremely similar. This is due to the fact that they have an identical average F1, and a nearly identical average F2, as shown in Figure 2. This similarity is not present for the high back vowels. This uneven behavior of the different setes of high vowels mirrors that found for the contemporary Avatime speakers discussed in this study. Anderson (2003) examines two other acoustic properties (F1 bandwidth and harmonic differential (H2-H1)), following Hess (1988) on Akan) of Ikpɔsɔ vowels to determine the basis of the [ATR] contrast in the language in light of the essential identity in F1 and F2 between the high front vowels. She finds no conclusive differences between harmonic sets in F1 bandwidth, unlike Hess's findings for Akan.

Figure 2: Ikpɔsɔ vowels (Anderson 1999: 188)



2.2 Avatime vowel categories and vowel harmony

The history of all hitherto existing scholarship on Avatime vowels is the history of a struggle to determine the number of contrastive vowel categories in the language. Among the earliest works on Avatime, Funke (1909) recognizes 9 surface vowels, with 4 pairs of vowels contrasting in tongue root advancement:

Table 6: Avatime vowel inventory according to Funke (1909)

	Front		Central	Back	
	+ATR	-ATR	-ATR	-ATR	+ATR
High	i <i>	ɪ <ė>		ʊ <ů>	u <u>
Mid	e <e>	ɛ <e̱>		ɔ <o̱>	o <o>
Low			a <a>		

He does comment on the [ATR] contrast in high vowels, for example claiming that <ė> (corresponding to [ɪ]) "…lies in the middle between *e* and *i*" (Funke 1909: 288).[7] He transcribes all 9 vowels when explicitly discussing the vowel inventory. However, outside of this, he very rarely transcribes a difference between [+/-ATR] high vowels, using <i> for both high front vowels and <u> for high back vowels, including in the wordlist published as Funke (1910). This is in fact made explicit: "The vowels *ė* and *ů* will not be considered further in the notation of the texts, and written as *i* and *u* respectively[8]" (Funke 1909: 289). There is also at least one case of transcription of [ɪ] as <e> in <kefuie> (/kɪfʊɛ/) 'Feuer' (Funke 1909: 302). Thus, it is unclear to what extent Funke believed [-ATR] high vowels to be active in the phonology of Avatime.

In the second wave of work on the language, Ford (1971) argues for an underlying 10 vowel system, with 5 pairs of vowels contrasting in [ATR], which is neutralized to 7 vowels on the surface. That is, the low and high [+/-ATR] pairs merge, leaving a surface contrast for the feature only in mid vowels. Ford's analysis is the closest to the situation that would obtain if the [ATR] contrast among high vowels really were to be lost. His analysis is derivationally abstract – the [ATR] contrast among high and low vowels is present underlyingly, but these contrasts are absolutely neutralized on the surface.

[7] "…liegt in der Mitte zwischen *e* und *i*."

[8] "Die Vokale *ė* and *ů* werden in der Schreibweise der Texte nicht weiter berücksichtigt und *i* bzw. *u* geschrieben."

(14) Avatime underlying and surface vowel inventories according to Ford (1970[9], 1971a)

UNDERLYING

	[+ATR]			[-ATR]	
i		u	ɪ		ʊ
e		o	ɛ		ɔ
	ɜ[10]			a	

SURFACE

i		u	*merged with [i]*		*merged with [u]*
e		o	ɛ		ɔ
	merged with [a]			a	

Ford's work is focused primarily on syntax, and to a lesser degree, the tonal phonology, so it does not explore the [ATR] harmony system much beyond this. However, in the small verbal lexicon in the appendix of Ford (1971), it seems that he may also have considered something like an inflectional class analysis of the harmony behavior of high vowels, rather than, or in addition to, the absolute surface neutralization analysis. For example, one finds at least one pair of verb roots listed as /^{e}tsi/ 'grate, block, strike [match]' and /^{a}tsi/ 'peel, carve, soar', with the harmonic class indicated by a superscript of the 3rd person singular aorist prefix, rather than a difference in the root vowel.

Schuh (1995a) contains a lengthy discussion of the difficulties non-native speaker linguists have had in perceiving and transcribing the [ATR] contrast in high vowels. In general, the two tendencies are to transcribe all high vowels as the [ATR] member of the pair (e.g. [i] for both [i] and [ɪ]), or to mistranscribe [-ATR] high vowels as [+ATR] mid vowels (e.g. [e] for [ɪ]).

---

[9] Ford (1970) is apparently an unpublished mimeograph titled 'On vowels and vowel-harmony in Avatime', which is cited in Ford (1971) – Schuh (1995a) mentions that he was unable to find this work in the Linguistics Department library of the University of Ghana, so it is unclear whether there are any extant copies of this work.

[10] This additional vowel is posited essentially to recapitulate the history of the language. The idea is that the historical harmonic pairs for high and low vowels remain as underlying forms, but are absolutely neutralized on the surface.

The most recent work on Avatime (Defina 2009 et seq. van Putten 2009 et seq.) identifies nine surface vowels, maintaining the [ATR] contrast in high vowels. However, as shown at the beginning of this chapter, this work found that younger speakers do not always produce an [ATR] contrast for high vowels

2.2.1 Phonetic bases of ATR contrast in Avatime

The only instrumental phonetic study on Avatime vowels is Maddieson (1995). His study shows that, despite Ford's claim that Avatime had neutralized the [ATR] contrast in high vowels, there was a clear acoustic difference between these pairs, with [-ATR] high vowels having significantly lower F1 than their [+ATR] counterpart. In fact, the [-ATR] high vowels [ɪ] and [ʊ] overlapped in height to a much greater degree with the advanced mid vowels [e] and [o] than with the advanced high vowels. However, the [-ATR] high vowels were distinct from both high and mid [+ATR] vowels.

Maddieson does not come to any conclusions about the articulatory basis of the [ATR] contrast in Avatime, as only acoustic data was collected. He does show that for adult speakers in Amedzofe at the time of the study, there is a reliable difference in F1 between advanced and retracted vowels, even among high vowels. He also shows that there are some differences in F2, but that these are not in a consistent direction, nor are the differences significant for every harmonic pair of vowels. The results from Maddieson's study will be returned to in more detail below.

2.2.2 [ATR] contrast among contemporary speakers

As discussed above, some suggestive comments have been made by contemporary researchers on Avatime. As this work is focused on questions of syntax (Defina 2009 et seq.) and semantics/pragmatics (van Putten 2009 et seq.) rather than phonetics or phonology, the claim that the [ATR] contrast among high vowels is not investigated in more detail, at least in the published portion of the work. However, the potential loss of an [ATR] contrast among the high vowels would have significant consequences for the analysis of the phonology of vowel harmony in Avatime. The system of vowel harmony in general will be examined in detail in the following chapter, but the basic facts are as follows: affixes and clitics harmonize for the feaure [ATR] based on the value of this feature in the root to which they are attached, as shown in (15)[11].

(15) a. **ɛɛ**^{14}-tɔ^{4}=**kɛ**^{3} /EE^{14}- + tɔ^{3} + =kE^{3}/[12] -ATR ROOT
3SG.PROG-cook=CL5.OBJ
'She is cooking it (yam)'

b. **ee**^{14}-to^{3}=**ke**^{3} /EE^{14} + to^{3} + =kE^{3}/ +ATR ROOT
3SG.PROG-pound=CL5.OBJ
'She is pounding it (yam)'

If the [ATR] contrast among high vowels has indeed been lost, the speakers would need to deal with this fact when producing forms like (16), which have roots that were historically [-ATR].

(16) historically [-ATR] root /tsɪ/

[??-tsi^{3}=k??] /EE^{14}- + ts? + =kE^{3}/

Defina and van Putten find, and my own data from field research also supports, that high vowel roots still trigger harmony just as mid vowel roots do. This means that, if the [ATR] contrast in high vowels has been lost, Avatime would represent a case in which a contrast that is absolutely neutralized on the surface nevertheless participates in phonological processes. To investigate this issue, I undertook an acoustic study of the vowels What I will show is that the contrast between pairs of vowels differing in [ATR] along the dimensions of F1 and F2 is in flux for contemporary speakers. In certain contexts, speakers produce no difference in F1/F2 for harmonic pairs of high

[11] Throughout, roots will be indicated by underline.

[12] Underlying forms of vowels in affixes and clitics that harmonize with roots for [ATR] will be indicated as /A, E, O, (I, U)/

vowels, while in other contexts, there is a contrast in F1, F2 or both. This direction of these differences is not consistent across or even within speakers. Additionally, speakers are not consistent about which pair of vowels, high front or high back, are neutralized or not. However, regardless of a speaker's production of high vowels, all contemporary speakers of Avatime continue to apply tongue root harmony on the basis of an underlying nine-vowel system with an active [ATR] contrast between high and mid vowels.

2.3 Data

2.3.1 Overview

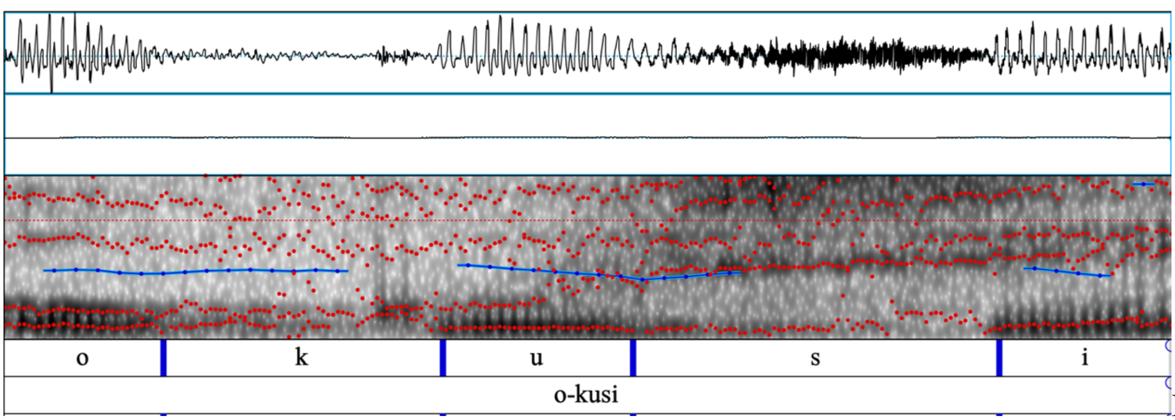
This study includes data primarily from 4 younger (under 30 years old) speakers of Avatime from the village of Amedzofe, collected during fieldwork in Amedzofe in the fall of 2022. It is supplemented by data from older speakers from Amedzofe and other villages in the Avatime traditional area, collected in the summers of 2018 and 2019. Speakers were recorded using a Zoom H4n Pro recorder and Boya BY-M40D omnidirectional lavalier microphone (except in limited cases in which the number of speakers participating in the elicitation session outnumbered the available microphones). Data was segmented and labelled in ELAN (Max Planck Institute for Pyscholinguistics, the Language Archive 2023; Sloetjes & Wittenburg 2008), and vowel formant measurements were extracted in Praat (Boersma & Weenink 2024), using a script adapted from Joseph Stanley and Lisa Lipani (Stanley & Lipani 2019). Unless otherwise noted, all formant measurements discussed below were taken as a mean over the middle third of the vowel. Outliers were excluded by calculating Z-scores for overall mean F1 and F2 measurements for each vowel, as well as each vowel at three points: the first third, midpoint, and second third of each target vowel. Any token with a Z-score over 3 for any of these measurements was excluded. This ensured that only vowels for which a reliable formant track over the middle third of the vowel was available were analyzed.

2.3.1.1 Excursus on issues in measuring formants

Recordings for this study were made in the field, rather than under laboratory conditions. For this reason, ideal recording quality could not always be guaranteed. This led to some difficulties in accurately measuring formants for some speakers. For example, for high front vowels, many cases in which the first formant was measured as implausibly high (as high or higher than the [-ATR] mid vowels. By observing some of these tokens manually, it became clear that this was an artifact of the Praat parameter settings used in extracting formants. For example, the number of formants searched for could cause situations as within a single word as in Figure 3 in which a high back vowel had a (expected) lower F1 than a mid vowel (344 Hz vs. 396 Hz), but a high front vowel had a massively higher F1 (476 Hz) than either of the back vowels.

Figure 3: Suspect F1 track for [i]

Maximum formant: 5500 Hz   Number of formats: 5.0

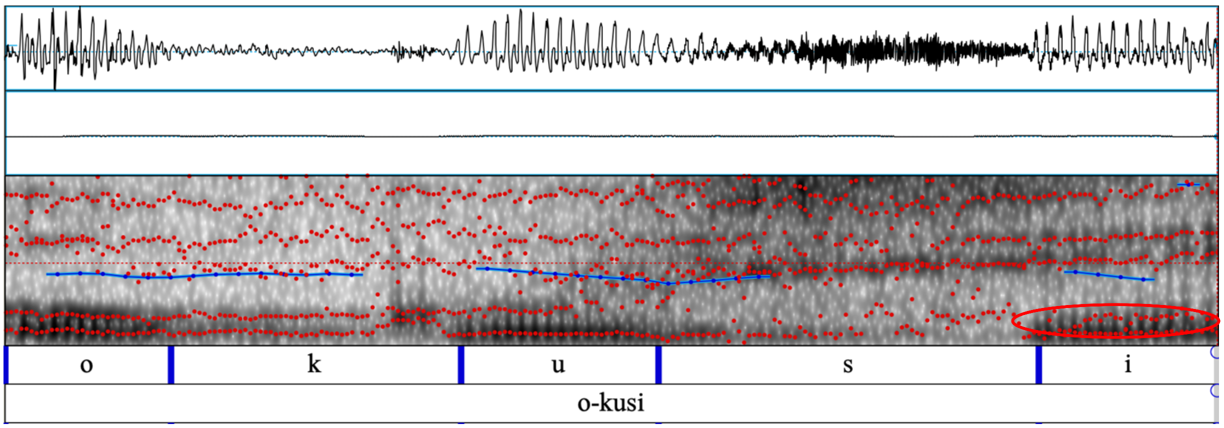


Mean F1 (Hz): 396 344 **476**

The most consistent solution to this issue was to increase the number of formants searched for. However, this frequently caused an additional (false) F2 to appear for high front vowels, as in Figure 4.

Figure 4: Corrected F1 track for /i/ with false F2 (circled)

Maximum formant: 5500 Hz   Number of formants: 6.0



Mean F1 (Hz):

403 342 **379**

In such cases, the formant measurements were checked by hand for any obvious errors. Suspicious tokens were marked, then checked again in Praat with different settings. In cases in which this method produced a plausible measurement, without causing dramatic shifts in other formants within the same word, the new measurement was used, and the token was kept in the analysis. This solution is of course not perfectly objective, but it allowed the most egregious outliers to be corrected without removing the quite significant variability in F1 for high vowels that was actually observed for all vowels across all speakers, and without discarding a large number of tokens.

2.3.2 Materials

The materials used from this study come from a variety of sources. First, I repeated two tasks from Maddieson (1995), in which speakers produced a set of nouns targeting all high and mid vowels, and a set of verb roots targeting high vowels specifically.

2.3.2.1 Nouns

The first task consisted of speakers reading a wordlist with nouns contrasting high and mid vowels with different [ATR] values, the same nouns used by Maddieson in his study of Amedzofe speakers in 1995. The relevant nouns were elicited via a written wordlist as well as in sentential contexts. The sentential contexts varied, but the most common contexts for the nouns were sentence-final and preceding a nominal modifier such as an adjective or numeral. The nouns used for this task are given in Table 7. These items targeted vowels in both noun roots and noun class prefixes, controlling as much as possible for consonantal context.

Table 7: Nouns testing [ATR] contrast in high vowels, from Maddieson (1995)[13]

+ATR			**-ATR**		
Noun	**Gloss**	**Vowels**	**Noun**	**Gloss**	**Vowels**
o-kusi	*chief*	i	kɪ-fʊ	*fire*	ɪ, ʊ
ki-bu	*honey*	i, u	kɪ-gʊ	*war*	ɪ, ʊ
be-bu	*bees*	e, u	bɪ-dɛ	*mortars*	ɛ
o-se	*tree*	o, e	ɔ-sɪ	*spatula*	ɔ, ɪ
o-ze	*thief*	o, e	ɔ-bʊ	*god*	ɔ, ʊ
o-bu	*bee*	o, u			

Speakers read a written wordlist containing these items with two repetitions. There is no standardized orthography for Avatime. However, nearly all younger, and many older, speakers are literate in Ewe, and therefore have intuitions about spelling in Avatime. Additionally, all the speakers I consulted have some familiarity with the translation of the New Testament into

[13] Tones are not marked in the test items.

Avatime (GILLBT 2017). This translation is written in an adapted version of the Ewe orthography. Ewe has a 7-vowel system, which is reflected in the orthography. The [ATR] contrast among mid vowels is indicated using the symbols {<e>/<ɛ>; <o>/<ɔ>} but, since Ewe does not have an [ATR] contrast in high vowels, only <i> and <u> are used. No additional symbols were added for the translation in Avatime, therefore only 7 of the 9 Avatime vowels have a dedicated symbol. Therefore, prior to writing the wordlist, the speakers were consulted on how they would spell each word. The four speakers generally agreed on spelling, including that there should be no difference in the spelling of high [+ATR] and [-ATR] vowels. The wordlist was written with the agreed upon spellings and an English gloss. In addition to reading the wordlist, each of the words was also elicited in sentential contexts.

2.3.2.2 Verb roots and prefixes

The second task replicated from Maddieson (1995) targeted verb stems. Four verb roots were elicited across three aspectual paradigms. The verbs in these paradigms were elicited in sentence-initial position, with a following object. The object varied according to the verb root, and objects for all but 'snore' were consonant-initial[14]. The verb roots contained high vowels contrasting in [ATR] and were controlled for initial consonant within pairs of the same backness. I used a slightly different set of verbs from Maddieson – these verbs proved easier to elicit naturally and are segmentally identical to those used by Maddieson. The verb roots used in this task are given in Table 8 and the paradigms in which they were elicited are given in Table 9. For this task, Speaker 2 only contributed tokens of [ʊ]. For this reason, the table of formant values for this task for female speakers only reports the values from Speaker 1. Speaker 2 is likewise excluded from statistical models of the formant values in verb roots. Formant measurements were taken of the

[14] The object of 'snore' is obligatorily the vowel-initial $ɪ^{1}$-la^{3}-$lɛ^{3}$. Without this object, the root gu^{1} has a general meaning like 'make a rumbling sound'.

verb roots, as well as the prefixes containing the mid front vowel /E/. This second set of measurements will be discussed in 2.4.3 on high vowels as triggers of [ATR] harmony.

Table 8: High vowel verb roots with [ATR] contrast

High Back		*High Front*		
Verb	*Gloss*	*Verb*	*Gloss*	
gu	'snore'	tsi	'block'	**+ATR**
gʊ	'pluck, pick'	tsɪ	'peel, carve'	**- ATR**

Table 9: Contexts for high vowel verb roots (from Maddieson 1995)

	Aorist		**Intentive**		**Progressive**	
	+ATR root	**-ATR root**	**+ATR root**	**-ATR root**	**+ATR root**	**-ATR root**
1sg	me-	ma-	mɪ-tá	mɪ-tá	mèé-	mɛ̀ɛ́-
2sg	wo-	wɔ-	wʊ-tá	wʊ-tá	wèé-	wɛ̀ɛ́-
3sg (class 1)	e-	a-	a-tá	a-tá	èé-	ɛ̀ɛ́-
1pl	kwi-	kwɪ-	kwɪ-tá	kwɪ-tá	kwí-	kwí-
2pl	mle-	mlɛ-	mlɛ-tá	mlɛ-tá	mlèé-	mlɛ̀ɛ́-
3pl (class 2)	be-	bɛ-	bɛ-tá	bɛ-tá	bèé-	bɛ̀ɛ́-

2.3.2.3 High vowel prefixes

The previously described tasks based on Maddieson's study were primarily concerned with the high vowel [ATR] contrast in roots. I also collected data on the behavior of high vowels as *targets* of [ATR] harmony. For this task, I constructed a wordlist similar to the one targeting noun roots, but instead targeting noun class prefixes with roots containing all nine vowels. I used a broad sample of noun class prefixes containing high vowels in an effort to gather a large number of tokens, as some speakers used different lexical items than expected, frequently due to the ambiguity of the English word used (*i.e.* a speaker offering *a*^{3}*-gbɛ*^{3} 'large bowl (for washing)' rather than *ke*^{1}*-zi*^{3} 'bowl (for eating)'. All the words used in this task are shown in Table 10.

Table 10: Items elicited targeting high vowel noun class prefixes

+ATR		-ATR	
Noun	**Gloss**	**Noun**	**Gloss**
ki-ku	*yam*	kɪ-kʊ	*rubber*
li-gli	*wall*	kɪ-bɔ	*money*
i-tsre	*okra*	lɪ-lɪ	*palm nut*
li-po	*doors*	lɪ-ha=lɛ	*pigs*
ke-zi	*bowl*	lɪ-mwɛ=nɛ	*oranges*
ku-do	*road*	lɪ-kpa=lɛ	*fish*
ku-zi	*bowls*	kʊ-lɪ	*palm tree*
ku-nyo	*water*	kʊ-nɔ	*flour*
		kʊ-sa	*cloth*
		kʊ-da	*drink*
		kʊ-ka	*fences*
		kʊ-mʊ	*oil*
		kʊ-nyɔ	*smoke*

2.3.3 Participants

Four speakers of Avatime participated in this study. All four speakers are under 30 years old and have lived most or all of their lives in the village of Amedzofe. Three of the speakers currently live in Amedzofe, while one speaker currently lives in Accra, and has also spent time in Cape Coast. All speakers are fluent speakers of Ewe and English in addition to Avatime, and also have some knowledge of Twi.

Table 11: Speakers, biographical information, total vowel tokens

Speaker	Bio	Total vowel tokens
1	female, born and lives in Amedzofe	897
2	female, born and lives in Amedzofe	246
3	male, born in Biakpa, lived most of life in Amedzofe	608
4	male, born in Amedzofe, lives in Accra	436

2.3.4 Results

I will first present the results for all vowel tokens, with male and female speakers shown separately. Overall data for all vowels for individual speakers can be found in the Appendix. The following tables gives the mean F1/F2 values for all 9 vowel categories for the male and female speakers respectively. These results include all vowels from the controlled studies discussed in 2.3.2, in addition to other vowels drawn from non-target words in sentential contexts used to elicit the target words. The overall means for male speakers for all 9 vowels are shown in Table 12. We see that the mean F1 of the [-ATR] high vowels are in fact lower than their [+ATR] counterparts ([ɪ] 319 > [i] 300; [ʊ] 310 > [u] 290). However, the distance between these pairs (approximately 20 Hz) is much smaller than the distance between the mid vowel pairs (between 130 and 150 Hz). It is also much smaller than the distance in F1 beetween the [-ATR] high vowels and the [+ATR] mid vowels (48 Hz for the front vowels, 53 Hz for back vowels).

Table 12: Overall F1/F2 means all vowels, male speakers

Vowel	Mean F1 (SD)	Mean F2 (SD)
i	**300 (31)**	2059 (250)
ɪ	**319 (35)**	2019 (224)
e	**367 (44)**	1903 (159)
ɛ	501 (67)	1777 (121)
a	742 (104)	1440 (126)
u	**290 (34)**	947 (161)
ʊ	**310 (28)**	845 (151)
o	**363 (54)**	928 (159)
ɔ	508 (73)	993 (120)

The reduced F1 differences for pairs of high vowels is fairly common among nine-vowel ATR-harmony languages (Rose 2018). However, as will be seen below, the F1 differences between the high vowel pairs are much smaller than those found by Maddieson for Avatime speakers in 1995. Additionally, the mean F2 of the high front vowels is not significantly different. However, in a study of this size, it is difficult tone interpret the lack of statistical significance. Despite the decrease in the distance between the high vowel pairs, there is still a statistically significant difference between both pairs for the aggregate data, which will be shown in 2.3.4.1. However, I will show that, while there is still a difference between the categories in aggregate, this difference does not hold in every context or for every individual speaker. When the data is broken down by morphological category and by speaker, we see that a merger of [±ATR] high vowels does indeed seem to be in progress. Both across and within speakers, there is variation in whether high vowels can be distinguished along the dimension of F1. This will be examined in detail in section 2.4.

Table 13 shows the overall mean F1 and F2 of all vowels for the two female speakers. Of immediate interest is the much larger disparity in F1 between the high front vowels [i] and [ɪ] than that seen in the two male speakers. For female speakers, the difference in mean F1 between these categories (37 Hz) is nearly identical to the difference between the mean 1 of [ɪ] and [e]. The same relation holds among the back vowels, although the absolute difference in mean F1 is smaller ([u]/[ʊ]: 23 Hz; [ʊ]/[o]: 29 Hz).

Table 13: Overall F1/F2 means all vowels, female speakers

Vowel	Mean F1 (SD)	Mean F2 (SD)
i	**367 (46)**	2545 (241)
ɪ	**404 (50)**	2509 (316)
e	**447 (59)**	2270 (383)
ɛ	561 (86)	2161 (315)
a	856 (74)	1629 (127)
u	**364 (44)**	922 (207)
ʊ	**387 (47)**	855 (192)
o	**416 (47)**	886 (130)
ɔ	601 (81)	1032 (173)

2.3.4.1 High vowels in F1/F2 space

Figure 5 and Figure 6 show the distribution of formant values of non-low values found by Maddieson for male and female Avatime speakers respectively in 1995. There is a four-way distinction for height (not counting the low vowel [a]) – in addition to the contrast between high and mid vowels, there are height contrasts among pairs of high and mid vowels. The [+ATR] vowels within the high and mid categories are significantly higher (have lower F1) than their [-ATR] counterparts.

There is some overlap in the F1/F2 space occupied by the high vowel pairs, but the [-ATR] vowels [ɪ] and [ʊ] occupy either an intermediate space between [i]/[u] and [e]/[o], or have a greater degree of overlap with the [+ATR] mid vowels.

Figure 5: Avatime nonlow vowels, 8 male speakers (Maddieson 1995: 73)

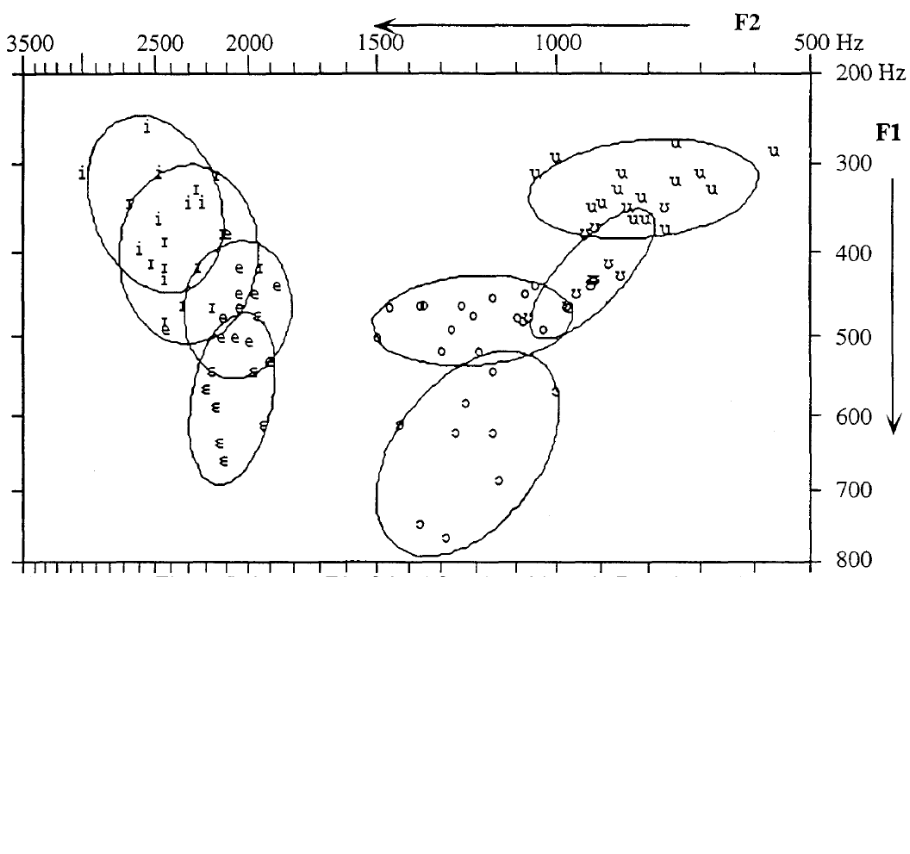
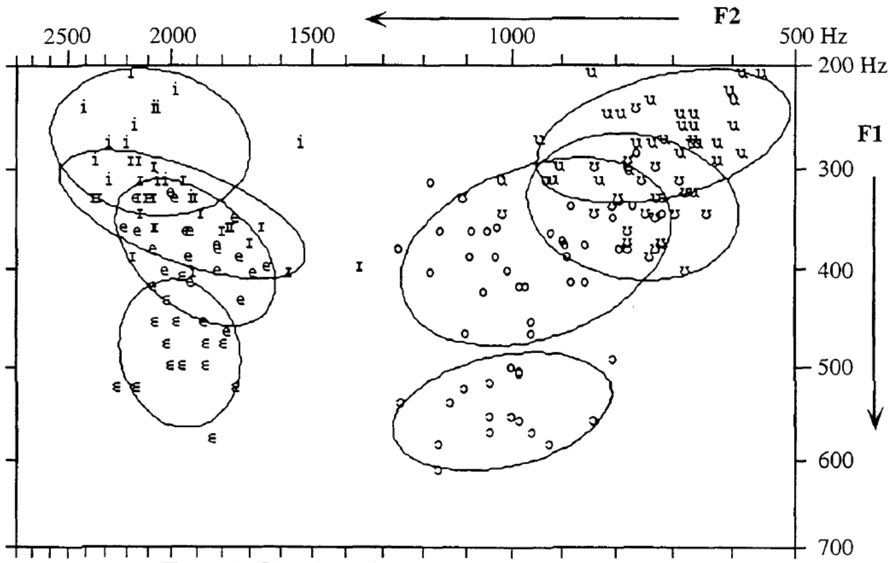


Figure 6: Avatime nonlow vowels, 4 female speakers (Maddieson 1995: 74)



Considering still vowel tokens from all contexts and tasks, the non-low vowels for the two male and two female speakers I recorded are shown in Figure 7 and Figure 8[15]. For the male speakers, the F1/F2 space occupied by the high front vowels [i] and [ɪ] is nearly, but not completely, identical. This contrasts with the lesser degree of overlap found by Maddieson for speakers in 1995. The pattern for back vowels is less clear overall, but is more similar to the pattern shown in Maddieson's study than the pattern for front vowels. For female speakers, the overall pattern for the aggregated data is harder to interpret. Likely due to the large number of tokens taken from different tasks, in addition to some possible remaining issues with formant measurement, the back vowels in particular show an extreme amount of overlap for all categories excluding [ɔ].

[15] Throughout, [-ATR] vowels are indicated in figures by a combination of [+ATR]h, so <ih> = [ɪ], <eh> = [ɛ], etc. This is an artifact of converting transcriptions to a more readily and universally computer-readable form.

Figure 7: Non-low vowels, two male speakers

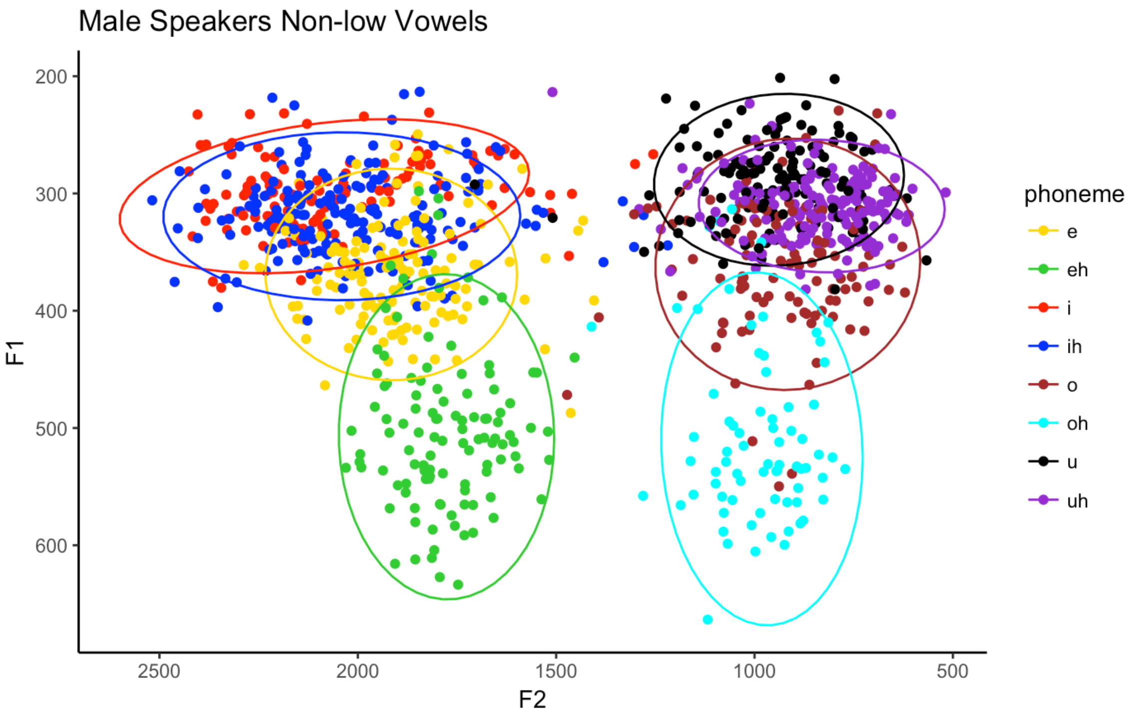
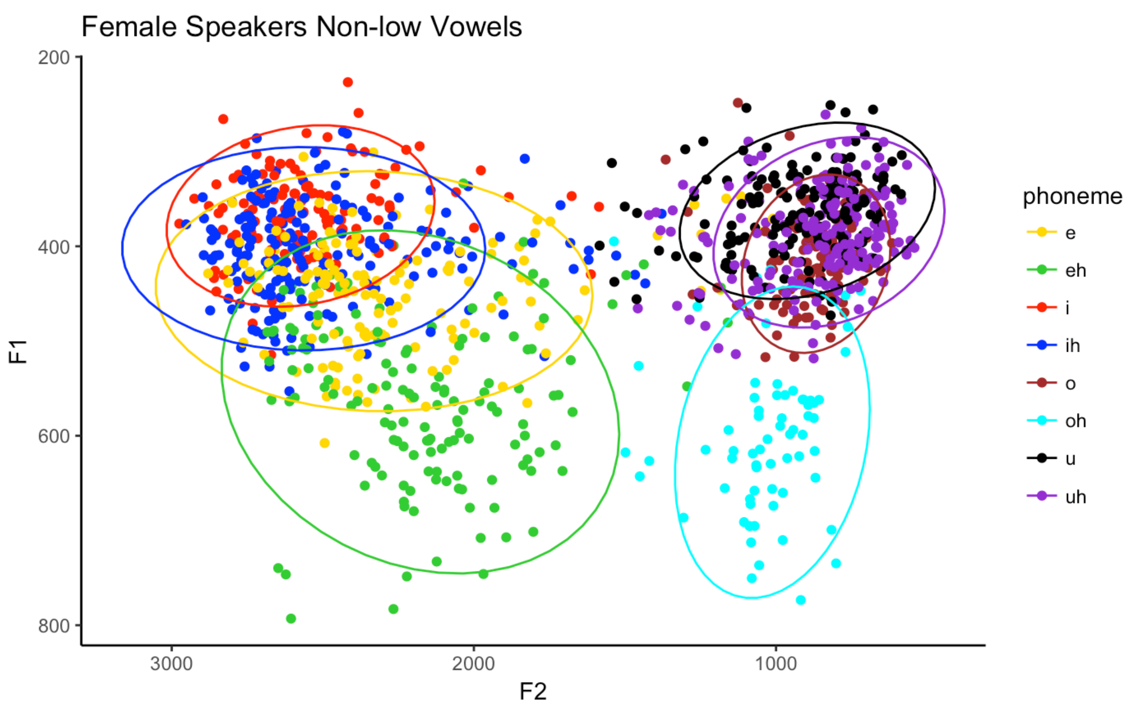


Figure 8: Non-low vowels, two female speakers



The F1 differences between the high vowels, while drastically reduced compared to Maddieson's findings, are still statistically significant. The results for F1 and F2 were modeled by a linear mixed effects regression model. Here, I report separate models for male and female speakers. However, a combined model for all speakers is included in the Appendix, along with the separate models discussed in this section[16]. The models have F1 (or F2) as the dependent variable, with fixed effects of ATR, backness, and morpheme type, as well as interactions between these effects. Separate models for the replication of Maddieson's noun and verb tasks are also reported below. However, these models have fewer observations and they therefore may be underpowered compared to the model with all high vowel tokens.

For both models, the baseline condition was the [+ATR] back vowel [u]. For female speakers, the F1 of the [-ATR] back vowel [ʊ] was found to have a significantly higher F1 ($p < .005$) than the baseline condition. F1 of [+ATR] front vowel [i] was not significantly different than the back vowel, and the interaction of backness and ATR was also not significant ($p = 0.19$). This means that the front vowel pair were also significantly different along the dimension of F1, with the [-ATR] member of the pair having a higher F1. For male speakers, the same pattern holds – the [-ATR] back vowel had significantly higher F1 than the baseline F1 of [u] ($p < 0.05$), and there was no significant effect of backness or interaction between backness and [ATR]. So the front vowel pair [i]/[ɪ] were also significantly different along the dimension of F1, with the [-ATR] vowel having a higher F1. For both groups of speakers, there were no significant differences in F2 for either the front or back high vowel pair.

---

[16] A combined model for all four speakers is included in the Appendix. The combined model also contains a fixed effect and interactions of speaker. In this model, the baseline is the F1 of [u] as produced by Speaker 1. The fixed effect of speaker models the difference of the other three speakers from this baseline, and the interactions with speaker model cross-speaker differences in whether a contrast in F1 exists across backness and morphological category. Results from the smaller models are reported above for clarity.

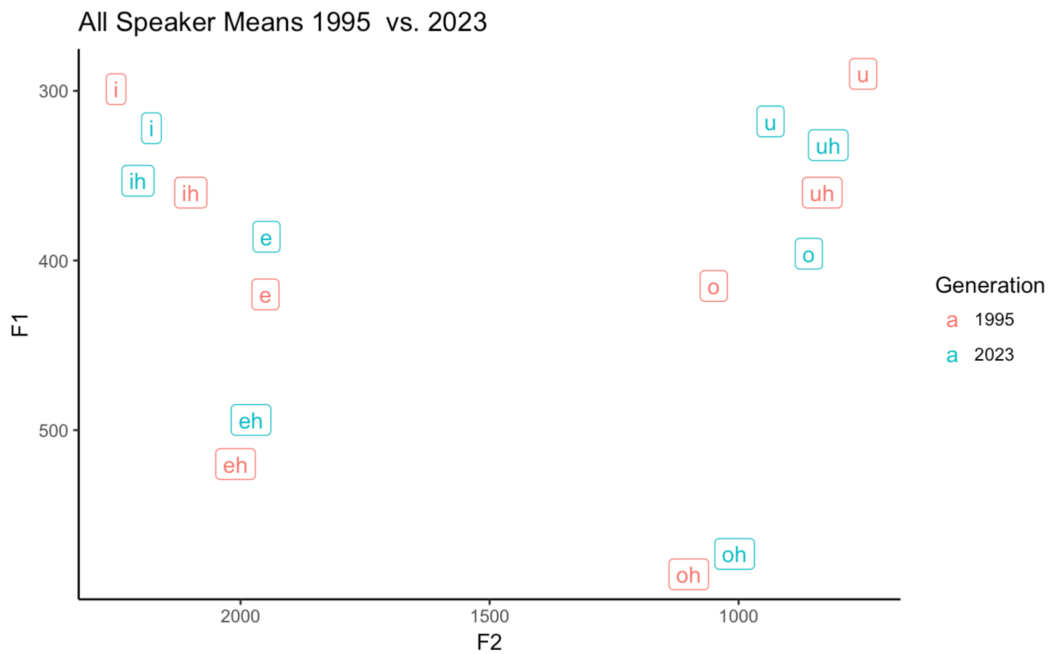
So, in aggregate, for both groups of speakers, there was a contrast between the [+/-ATR] high vowels. However, the effect sizes for both pairs were small. For female speakers, the predicted F1 values of the [-ATR] high vowels were 48 Hz (back [ʊ]) and 26 Hz (front [ɪ]) higher than the corresponding [+ATR] vowels. For male speakers, the corresponding predicted differences in F1 were 25 Hz for both pairs. F1 differences in high vowels contrasting in [ATR] have been observed to be smaller than the difference in mid vowels (Starwalt 2008; Rose 2018). However, the differences between pairs for Avatime are smaller than even the differences in languages cited by Starwalt (and later Rose).

When considering the aggregate data, the merger of the high vowel pairs can be seen as a tendency, rather than a full loss of contrast. This tendency can be seen when considering the mean F1/F2 of the non-low vowels for the contemporary speakers (male and female) compared the to mean F1/F2 of the nonlow vowels for the speakers in Maddieson's 1995 study[17], shown in Figure 9. The mid vowels of the contemporary speakers track the mid vowels of the earlier speakers fairly closely. In particular, the [±ATR] mid vowel pairs are approximately equally distant for both groups of speakers. However, the general trend for the speakers I worked with was for F1 to be lower compared to the speakers who participated in Maddieson's study. For the high vowels, though, the younger speakers show a much smaller distance in F1 in particular. Interestingly, the [+ATR] high vowels have higher F1 for the contemporary speakers, such that it appears that they "lowered" (or "retracted") to come closer to merging with their [-ATR] counterparts. It is unclear if this is the actual mechanism underlying the tendency to reduce the contrast between the high vowel pairs, or whether it just reflects individual differences in speakers' vocal tracts. This increase in average F1 of the [+ATR] high vowels for the

[17] This portion of Maddieson's data also combined male and female speakers.

contemporary speakers is particularly interesting in light of the general pattern for these speakers to lower F1 for the mid vowels.

Figure 9: Overall mean F1/F2, non-low vowels, 1995 vs. 2023 speakers



2.4 Merger in progress?

In aggregate, we see that some younger speakers have drastically reduced the difference in F1 between the pairs of high vowels compared to the speakers surveyed by Maddieson (1995). The distributions of [i]/[ɪ] and [u]/[ʊ] overlap to a much greater extent than they did for the earlier speakers. However, small differences do remain between both [i]/[ɪ] and [u]/[ʊ]. In this section, I will show that, when looking in more granular detail, we see that this aggregate difference between the pairs of high vowels does not reflect a consistent contrast for all categories across all speakers. I focus first on the data across speakers broken down by morphological category, and then considering the variation found within individual speakers.

2.4.1 Morphological category and variation

2.4.1.1 Nouns – replicating Maddieson 1995

The first sign that the high vowel [ATR] contrast among high vowels is in the process of being lost comes from a direct comparison of the contemporary speakers' production of the nouns tested by Maddieson (1995). For this task, the mean F1/F2 values for the male and female speakers, respectively, are given in Table 14 and Table 15. The F1 differences between the high vowel pairs for the nominal vocabulary targeted in this task are siginificantly smaller than those found in the aggregate data. The results for this task were modeled separately from the overall results (see Appendix). However, the number of observations in the models reported in this section is low, so there is the caveat that the models are likely somewhat underpowered.

As in the combined models discussed above, the baseline for each of these models was the F1 of the high back [+ATR] vowel [u]. Along the dimension of F1, neither the front nor back pair were significantly different for the two female speakers[18]. For the two male speakers, there was no significant difference in F1 for the back vowel pair. For the front vowel pair, the [-ATR] vowel had a higher F1 than the [+ATR], a difference which was marginally significant ($p = 0.08$)[19].

Table 14: Nouns from Maddieson (1995) - Mean F1/F2, contemporary male speakers

Vowel	Mean F1	Mean F2
i (n=20)	280	1928
ɪ (n=42)	308	2019
u (n=48)	290	969
ʊ (n=26)	297	877

[18] However, in the combined model for female speakers, the interaction of backness, ATR, and noun root context was significant ($p < 0.05$), with a positive coefficient. While the combined model included noun roots that were not a part of this task, it suggests that there may have been a contrast in the high front pair for female speakers, with the F1 of the [-ATR] vowel being higher than that of the [+ATR] vowel.

[19] As in the case of the model for all high vowel tokens, a combined model with all four speakers is also included in the Appendix.

Table 15: Nouns from Maddieson (1995) - Mean F1/F2, contemporary female speakers

Vowel	Mean F1	Mean F2
i (n=20)	366	2484
ɪ (n=53)	389	2353
u (n=38)	354	894
ʊ (n=28)	364	767

This suggests that, at least in the nominal domain, there is in fact a loss in contrast in progress. For the back vowels in particular, there is no significant F1 difference for either the male or female speakers. The overall distribution of the vowels in F1/F2 space can be seen in Figure 10 and Figure 11. The contrast between [i] and [ɪ] can be seen especially for male speakers – tokens of the

[-ATR] member of the pair groups closer to the [+ATR] mid vowel than the tokens of [i]. The same can be seen, albeit to a lesser extent, for the female speakers. However, for both groups of speakers, there is a near-complete overlap of [u] and [ʊ]. For the male speakers, there is an additional factor to note concerning the high back vowel pair. For the [-ATR] vowel [ʊ], the average F2 is actually somewhat lower that the average F2 of [+ATR] [u] (877 vs. 969). This contrasts with the pattern found by Maddieson, in which the [-ATR] back vowel actually had a *higher* average F2 than its [+ATR] counterpart.

Figure 10: Distribution of non-low vowels in Maddieson (1995) nouns, male speakers

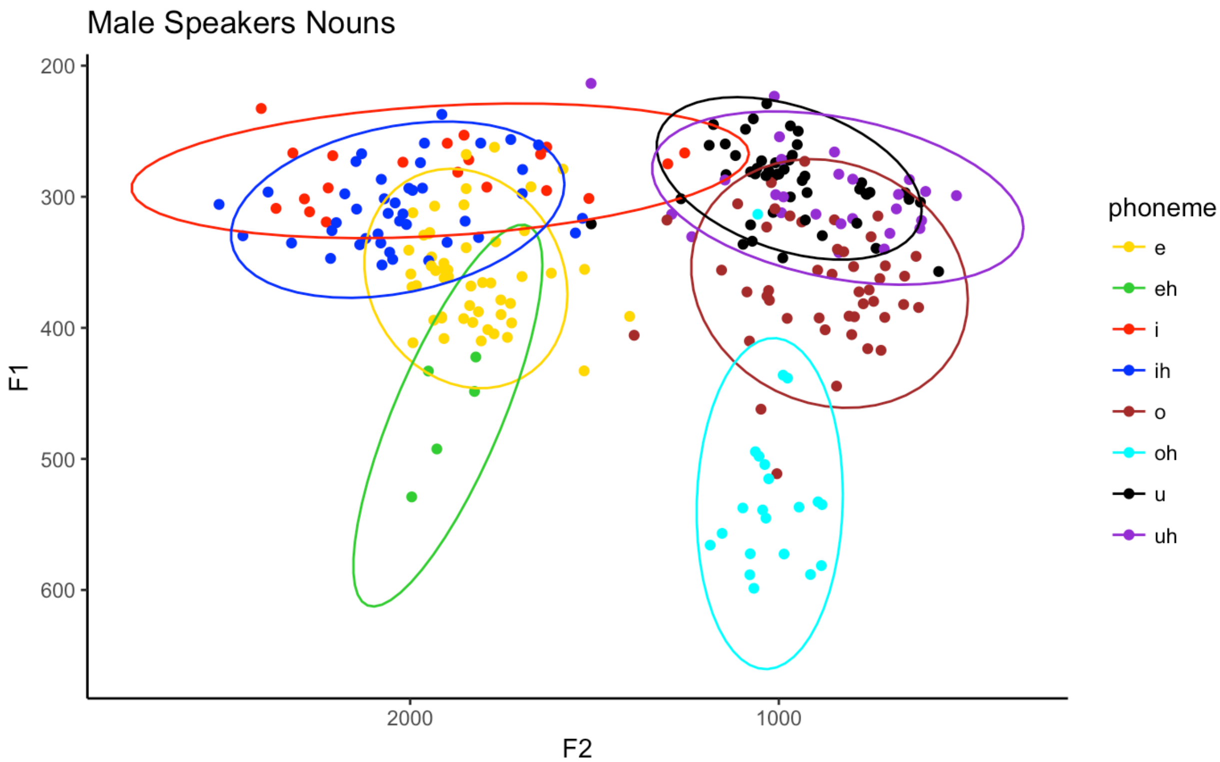
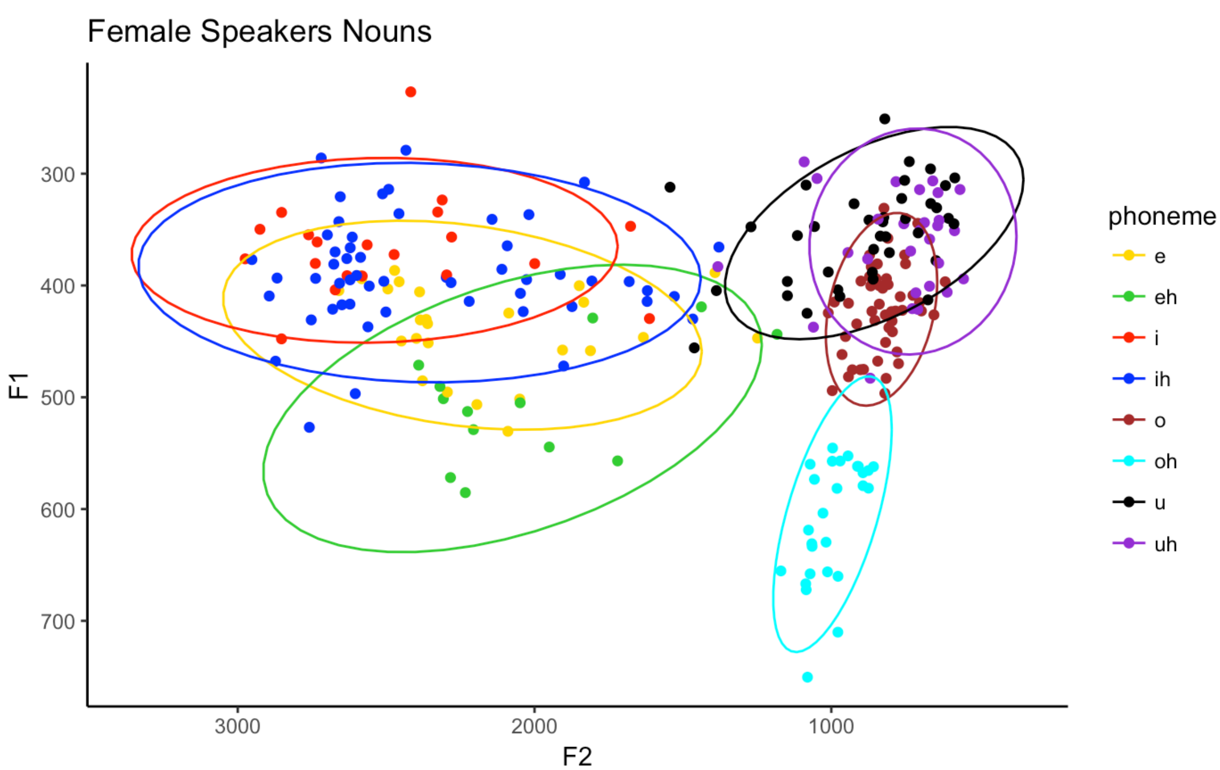


Figure 11: Distribution of non-low vowels in Maddieson (1995) nouns, female speakers

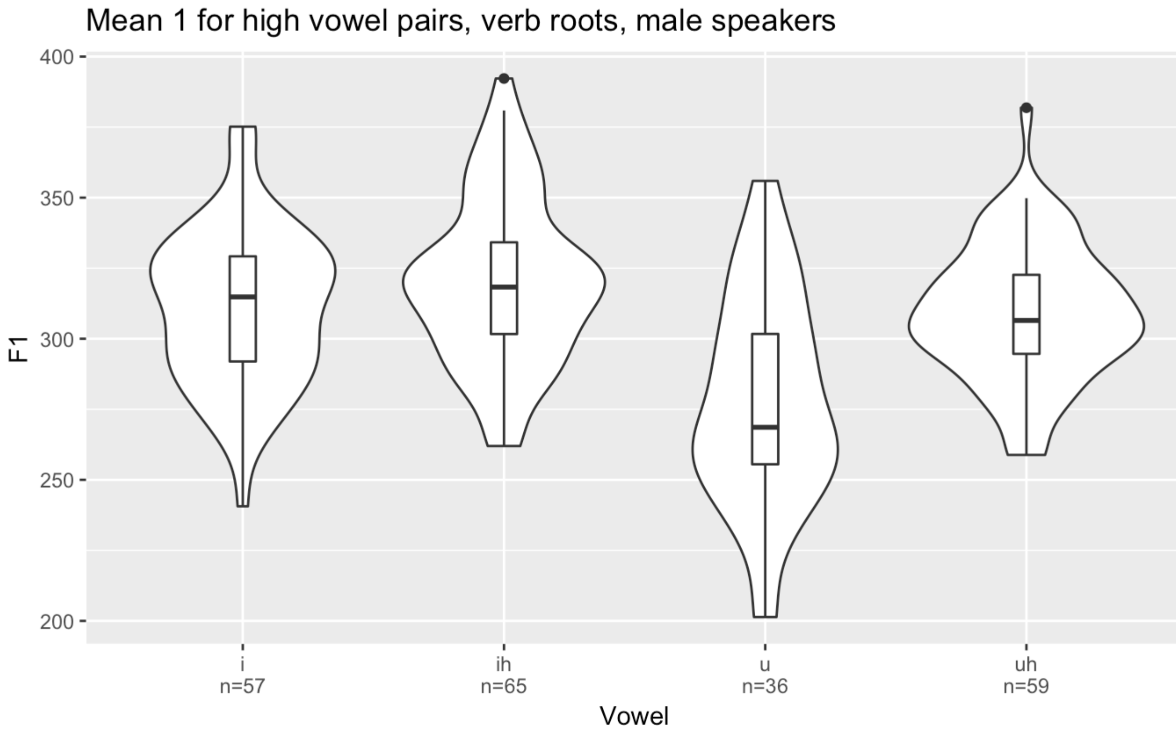


When considering the data from just this set of nouns, we see that the F1 contrast seen in the aggregate data for the pairs [i]/[ɪ] and [u]/[ʊ] is not as clear, and in fact disappears for the back vowel pair. An additional complication will be seen in the following section focusing on verb roots.

2.4.1.2 Verb roots

In the previous section, we saw that, in the task replicating Maddieson's study of nouns, both male and female speakers showed a contrast for the high front vowel pair along the dimension of F1, but no contrast for the high back vowel pair along the same acoustic dimension. When considering just the verb roots from Table 8 (/gu/ 'snore', /gʊ/ 'pluck', /tsi/ 'block', /tsɪ/ 'peel'), the situation changes. The mean F1 of the vowels of these verb roots is plotted in Figure 12 for male speakers. For verb roots, it is the high front pair that tends to merge, with a robust contrast for the high back pair. Here we see the tendency, noted above, for the [+ATR] vowel to "lower"/"retract" and become more similar to its [-ATR] counterpart.

Figure 12: Mean F1 for high vowel pairs, verb roots, male speakers



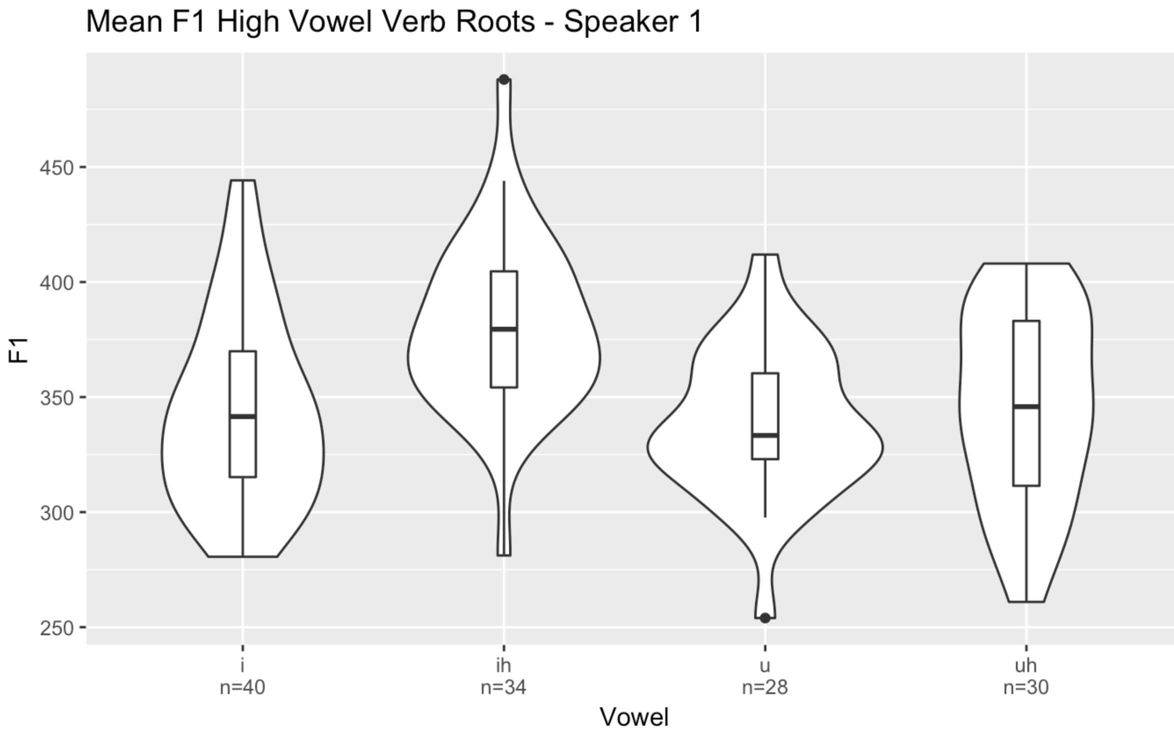
The results of this task were modeled by a separate linear mixed effects regression model, with F1 as the dependent variable and fixed effects of backness and ATR[20]. For the male speakers, there was a significant effect of ATR for the back vowel pair – the [-ATR] vowel had a significantly higher F1 ($p < 0.001$). There was also a significant effect of backness – the high front [+ATR] vowel [i] also had higher F1 than [u]. Finally, there was a significant interaction of backness and ATR – the [-ATR] front vowel [ɪ] had a significantly *lower* F1 with respect to [i] when compared with the difference between [u] and [ʊ] ($p < 0.05$).

Here we see the inconsistency across morphological category – the male speakers contrasted the high front pair in nouns, but merged them in verb roots, and they merged the high back pair in nouns, but contrasted them in verb roots. And additional element of inconsistency is

[20] As in the previous two sections, a combined model for the three speakers who participated in this task is given in the Appendix as well. Like the models for nouns, the models for verb roots also contain relatively small numbers of observations, and are therefore possibly underpowered.

found when considering the female speakers' production of the verb roots, plotted in Figure 13. For these speakers, the front vowel pair contrasted in F1, just as in the nominal domain. For the high back pair, the contrast was lost, but in a different manner than the male speakers. For the female speakers, both [u] and [ʊ] had a mean F1 similar to the [+ATR] front vowel [i]. That is, the [-ATR] member of the pair "raised"/"advanced" to merge with its [+ATR] counterpart.

Figure 13: Mean F1 for high vowel pairs, verb roots, Speaker 1



These results were modeled as for the male speakers. For Speaker 1, there was no effect of backness or ATR. So, the differences in F1 between the baseline [u] and the front [+ATR] vowel [i] and the back [-ATR] vowel [ʊ] were not significant. There was a significant interaction of backness and ATR ($p < 0.05$), with a positive coefficient. This supports the claim that there was a significant difference in F1 for the high front vowel pair.

This pattern is opposed not only to the overall pattern shown by the male speakers for verb roots (contrasted [u]/[ʊ] and merged [i]/[ɪ]), but also the direction of the merger. Overall, this section has shown that a contrast along the dimension of F1 is not consistently produced between high vowel pairs. However, no group of speakers produced a merger for both back and front pairs.

2.4.2 Prefixes

An interesting tendency appears when considering only those high vowel prefixes that immediately precede a non-high vowel root. When contrasting data of the type shown schematically in (17) and of the type shown schematically in (17), for both male and female speakers, it can be seen that the contrast between high vowel pairs along the dimension of F1 is greater when the prefix precedes a non-high vowel root than when it precedes a high vowel root, as shown in Table 16. It can be seen that for both groups of speakers, [i] is higher (has lower F1) when it is in a prefix preceding a non-high vowel root.

(17) Examples of high vowel prefix data including and excluding high vowel roots

Including high V roots		Excluding high V roots	
a.	kI-ku	e.	kI-to
b.	kI-tsɪ mango=e	f.	kI-tɔ
c.	kI-to ki-ku=ye	g.	kI-dɛ
d.	kI-bɔ	h.	kU-sa
	[…]		[…]

Table 16: Mean F1 high front V prefix, high V roots and non-high V roots

		Male speakers	Female speakers
High V roots	mean F1 [i] prefix (Hz)	313 (n=23)	396 (n=26)
	mean F1 [ɪ] prefix (Hz)	323 (n=37)	398 (n=43)
Non-high V roots	mean F1 [i] prefix (Hz)	258 (n=2)	349 (n=3)
	mean F1 [ɪ] prefix (Hz)	326 (n=20)	417 (n=25)

Although additional data targeting this phenomenon more specifically would be needed, this raises the possibility of Avatime developing a system like that found in the Akure dialect of Yoruba (Bamgboṣe 1967; Przezdziecki 2005), which has seven phonemic vowels /i, e, ɛ, o, ɔ, a/, but in which [ɪ ʊ] are produced as allophones when high vowels are targets of [ATR] harmony.

The data in Table 16 suggest that, even when speakers produce an [ATR] contrast in high vowel roots, high vowel prefixes preceding those roots do not show a contrast. However, an [ATR] contrast in high vowel prefixes is triggered by non-high vowel roots. So, Avatime would have a seven vowel system preceding high vowel roots, and nine vowels preceding non-high roots. A remaining question concerns the direction of merger. In Table 16, it appears that high front vowel prefixes are all produced as [-ATR] preceding high vowel roots, as the mean F1 is higher. This type of merger would be extremely unexpected, as the overwhelming majority of cases (and possibly all cases) of the loss of [ATR] contrast in high vowels involve the loss of the [-ATR] variants (Casali 1995; 2008).

The fact that high vowel prefixes may be harmonizing more "completely", in a sense, with non-high triggers also suggests that high vowels in roots, even in when they show an acoustic contrast, may be weaker harmony triggers. This will be explored in more detail in the following section.

2.4.3 High vowels as harmony triggers

In this section, I will focus on the behavior of a single speaker, Speaker 3, to illustrate the behavior of high vowels as harmony triggers. Speaker 3 is a male speaker, and produced no F1 contrast between the high front vowel pair [i]/[ɪ] in verb roots from Table 8. We will see that, while this speaker did not produce a contrast between the [+ATR] and [-ATR] high front vowels in the verb roots examined, he consistently selected verbal prefixes and clitics that harmonize with the underlying [ATR] value of the root. In Table 17, the mean F1 for the 4 verb roots for Speaker 3 are shown.

Table 17: Mean F1 high vowel verb roots, Speaker 3

High Front		*High Back*	
Verb	*Mean F1 (Hz)*	*Verb*	*Mean F1 (Hz)*
tsi	323 (n=28)	gu	278 (n=25)
tsɪ	320 (n=34)	gʊ	308 (n=37)

If the phonological contrast between /i/ and /ɪ/ were lost, or in the process of being lost, it would be expected that the underlying (or former) [-ATR] roots would not consistently trigger harmony on affixes and clitics. So, for example, we might expect to find the forms in (18), with the [+ATR] variants of the first person progressive prefix and the class 5 object clitic.

(18) Hypothetical [+ATR] prefix and object clitic with loss of contrast in 'peel'

a. ***mee^{14}**-tsi^{3} ki^{3}-ku=ye^{3} /mEE-tsi/
1SG.PROG-peel CL-yam=DEF
'I am peeling the yam'

b. *a^{3}-ta^{4}-tsi^{3}=**ke^{3}** /tsi=kE/
3SG-INT-peel=CL5.OBJ
'She peeled it (yam)'

To test whether Speaker 3 selects [-ATR] affixes and clitics even for roots with underlying /ɪ/, which, as shown above was merged completely with /i/ in the verb root task, I constructed a set of verbs with high and mid vowel roots with could take the same object clitic. Specifically, I considered the class 5 object clitic /=kE/. The set of roots used for this task is given in Table 18. Root-initial consonants were kept as consistent as possible given the constraints on which roots were both transitive and semantically compatible with class 5 objects (for example, /gu/ 'snore' could not be used again in this context, and /tsi/ 'block' was difficult to elicit naturally with any class 5 objects).

Table 18: Roots used to test clitic harmony

Root	Gloss
dzi	*buy*
tsɪ	*peel*
zuru	*steal*
sʊ	*light*
tɔ	*cook*
to	*pound*

For Speaker 3, even though the vowels /ɪ/ and /i/ were phonetically neutralized in the verb roots tested in 2.3.2.2, the object clitic always harmonized with the underlying [ATR] feature of the root. The average F1 of the object clitic following the root /tsɪ^3/ 'peel' was nearly identical to the average F1 following unambiguously [-ATR] mid vowel root /tɔ^3/ 'cook'. The high back [-ATR] root exhibited the same behavior, as seen in the results for the verb root /sʊ^1/. Table 19 summarizes the results of this task for all the verb roots considered.

Table 19: Height of object clitic /E/ following verb root, Speaker 3

Root	/E/ Clitic F1
dzi	361 (n=1)
tsɪ	**490** (n=9)
zuru	391 (n=3)
sʊ	460 (n=6)
to	352 (n=4)
tɔ	500 (n=4)

I also measured the mean F1 of verb prefixes containing the mid vowel /E/. For this environment for speaker 3, I did not have a controlled set with 'cook' and 'pound'. However, I collected progressive forms of the verbs /kpo^1/ 'hide' and /bɔ^3/ 'hit' for the study on tone sandhi in Chapter 4, which I use here as the standard of comparison for harmonic behavior of /E/ prefixes. Like for the object clitics, the mid vowel prefixes also harmonized exceptionlessly. As shown in Table 20, mean F1 for the progressive prefix for the [-ATR] high vowel roots was similar to the mean F1 for the progressive prefix preceding /bɔ^{3}/ and mean F1 for the same prefix for [+ATR] high vowel roots was similar to the mean F1 precediung /kpo^{1}/.

Table 20: Height of /E/ prefixes preceding high vowel verb roots, Speaker 3

Root	Mean /E/ prefix F1	Gloss	Speaker
tsi	413 (n=6)	block	3
tsɪ	537 (n=8)	peel	
gu	410 (n=13)	snore	
gʊ	528 (n=11)	pluck	
kpo	442 (n=1)	hide	
bɔ	572 (n=1)	hit	

2.4.4 High vowels and iterative harmony

In 2.4.2, it was shown that high vowels can still participate in [ATR] harmony as targets. In particular, high vowel prefixes preceding non-high vowel roots showed a clear contrast in F1, conditioned by the [ATR] value of the following root. A case that has not yet been considered is iterative harmony. As discussed above, the results for harmony of high vowel prefixes suggested that high vowels may be weaker triggers of [ATR] harmony than non-high vowels. In words with more than one prefix, harmony is iterative for non-high vowels. In such words, the vowel of a medial prefix could act as both target and trigger of [ATR] (depending on the theory of vowel harmony). The verbs in (19) exemplify this environment - a high vowel prefix appears between a root and non-high vowel prefix.

(19) a. ɔ^{4}-sɪ^{4}-pɛ^{4} ka^{3}-drʊɪ^{1}=a^{3}
3SG.NEG-INT.NEG-seek CL-dog=DEF
'He won't look for the dog'

b. ɔ^{4}-wɪ^{4}-pɛ^{4} ka^{3}-drʊɪ^{1}=a^{3}
3SG.NEG-PROG.NEG-seek CL-dog=DEF
'He isn't looking for the dog'

I have not collected enough data on words of this type to have a conclusive answer to the question of how medial high vowels behave. However, for speaker 3 (who, as discussed above, shows a merger of high vowel pairs in a number of contexts) I did collect several repititions of the form in (19). The F1 measurements for the four repititions are given in Table 21. The overall pattern is that the high vowel prefix does undergo harmony, appearing in its [-ATR] form (recall that for male speakers, the mean F1 for high front vowel prefixes before [-ATR] non-high roots was 326). The mid vowel prefix preceding the high vowel prefix also harmonizes, appearing in its [-ATR] form.

Table 21: High vowel prefixes in iterative harmony

/ɔ-	sI-	pɛ/	*repetion*
414	292	389	1
508	334	490	2
528	330	559	3
558	320	512	4
546	319	501	mean

Looking only at repetition 1, we see that the high vowel prefix has an F1 closer to what would be expected in the [+ATR] variant. And to the left, the F1 of the mid vowel prefix is likewise lowered significantly to a value that is much like the F1 of of [+ATR] mid vowels. There are at least two possibilities for this case. It could be that the high vowel prefix fails to harmonize, and, as in the cases of exceptional blocking of [ATR] harmony by low vowels to be discussed in the following chapter, the prefix to its left harmonizes locally with the high vowel prefix rather than the root. However, the F1 of the root vowel in this repetition is also lowered significantly, so this item could equally well be explained as an effect of the speaker have lowered formant values overall for this repetition. Further data will need to be collected to determine how high vowels behave in iterative harmony across speakers and across verb root and prefix contexts.

2.5 Discussion

Van Putten's assessment of the [ATR] contrast among young speakers of Avatime is in a sense borne out – younger Avatime speakers do not always produce a surface contrast between [+ATR] and [-ATR] high vowels, at least along the dimensions of F1 and F2. This contrasts with the pattern described by Maddieson for speakers in the mid-1990s, in which the categories were consistently differentiated by F1. However, the merger in vowel height is both asymmetrical and incomplete. There is variation (perhaps driven by sociolinguistic factors) between individual speakers, within speakers across morphological categories, and even for those speakers who most frequently produce [-ATR] high vowels at the same height as their [+ATR] counterparts, there is still an overall slight, but significant, contrast in F1.

One feature of [-ATR] vowels remains unchanged for all speakers, regardless of their surface categories – these vowels still trigger harmony on non-high vowels in prefixes and clitics without exception. The fact that some speakers maintain a productive phonological contrast between high vowel pairs while frequently losing (or displacing) the surface phonetic contrast has implications for the analysis of vowel harmony in Avatime. If [ATR] harmony involves sharing an articulatory gesture or set of articulatory gestures, then Avatime is a challenging case. Regardless of the direction of the merger, for a speaker that does not have an [ATR] contrast in verb roots, there will be cases in which the articulatory gesture used to produce a verb root vowel will not be the same as the gesture used to produce the vowel of the prefix that harmonizes with it. Without an articulatory study, and without additional acoustic information, it is not possible to say that the [-ATR] high vowels are ever produced as completely identical to the [+ATR] version. However, in the (for some speakers) frequent cases in which [ɪ] is produced with the expected F1 and F2 of [i], it is clear that the combination of articulatory gestures used to produce the high vowel pairs cannot be the same as that used to produce the mid vowel pairs. Consider a case like (20), in which the verb root /tsɪ/ ‘peel’ conditions the [-ATR] variants of the verb prefix and the object clitic:

(20) wɔ[1]-tsɪ[4]=kɛ[3] /wO-tsɪ-kE/
2sg.aor-peel=cl.5.obj
'You peeled it'

For speaker 3, who shows no significant difference in F1 among high vowels in verb roots, [ATR] harmony could not involve the sharing of the exact same set of articulatory gesture across all three vowels.

2.5.1 What's going on in Avatime?

For the speakers and contexts in which the contrast between the high vowel pairs is disappearing, what is their phonological grammar, and how did they acquire it? One possibility is that the phenomenon of speakers who produce merged high vowels, but still correctly apply harmony to roots containing those vowels arises from a mismatch in the perception and production grammars of those speakers (Menn 1983; Hayes 2004). Taking the speakers surveyed by Maddieson in 1995 as an approximation for the learning data contemporary speakers were exposed to, their model of the adult phonology of Avatime would have included an [ATR] contrast among high vowels. Their own production grammars, on the other hand, would not include this contrast (or, alternatively, would include only a small probability of producing the contrast). The stability of the phonological grammar of speakers that produce a reduced, possibly disappearing acoustic contrast between [-ATR] and [+ATR] high vowels is perhaps not surprising. Gouskova and Hall (2009) find that speakers of Lebanese Arabic are able to exploit the small acoustic differences between lexical and epenthetic vowels to correctly identify underlying forms. Even speakers who themselves have complete surface neutralization of lexical and epenthetic vowels are argued to be able to use the differences produced by other speakers to learn a grammar that differentiates the two types of vowel in the phonology. In 2.6.2.2 I will briefly discuss a possibility for testing the role of perception in the current loss of [ATR] contrast in Avatime high vowels.

2.6 Conclusion

The loss of [ATR] contrast in high vowels, at least along the dimension of F1, is in fact occurring among younger Avatime speakers. However, this is a change that is currently in progress. It is unevenly distributed between speakers, and within speakers, to the point that the various tasks involved in this study produced different results for which high vowels contrasted along the dimension of F1 and which did not. The direction of the merger is also not clear. In many cases, it appeared that the [+ATR] vowel "lowered" to merge with its [-ATR] counterpart. However, regardless of the status of the phonetic contrast among high vowels, all speakers maintain a productive phonological contrast. As discussed above, this may reflect speakers' ability to exploit small acoustic differences, even if they don't produce those same differences, to recover underlying forms of high vowel roots. However, another possibility is that all speakers maintain a phonetic contrast among high vowels, but the contrast is no longer primarily associated with differences in F1.

2.6.1 Contrast displacement

An alternative to the loss of [ATR] as a surface phonetic contrast in Avatime is that the contrast is being displaced onto a different acoustic cue for high vowels. There are a variety of other phonetic properties, articulatory and acoustic, that have been proposed as the basis of [ATR] contrasts. Prominent among these are voice quality (Kingston et al. 1997), first formant bandwidth (Hess 1988; 1992), and overall high frequency energy (Maasai; Guion et al. 2004). In fact, Anderson (1999) argues that voice quality is the primary acoustic cue to the [ATR] contrast in high front vowels in another Ghana-Togo Mountain, Ikpɔsɔ, in which the F1 of the high front vowel pair is identical.

If the [ATR] contrast in Avatime high vowels is being displaced rather than lost, this would mean that there is in fact a phonetic basis for the contrast between, for example the verbs [tsi] ‘block’ and [tsɪ] ‘peel’ for all speakers, regardless of any contrast in heigh between the root vowels. However, This raises the question of what the phonetic contrast actually is. For mid vowels, however the [ATR] contrast is produced, it results is a large difference in F1 between [+/-ATR] pairs. Since this difference in F1 is drastically reduced, or absent, for high vowels, it is unclear if the [ATR] contrast could be produced by the same articulatory gesture.

2.6.2 Future directions

The study in this chapter is an initial step in understanding the status of the [ATR] contrast in high vowels in Avatime. Further study will be required to determine to what extent a phonetic contrast exists, and how this contrast behaves in the phonological grammar.

2.6.2.1 Expanded acoustic study

Detailed study of other possible cues to tongue root contrast – F1 bandwidth, harmonic differential, and various other measures of voice quality, and duration, among others, will shed light on whether the [ATR] contrast is being lost in high vowels, or whether the primary cue to this feature has shifted, as reported for other African languages. I also intend to repeat a number of the tasks described in this chapter with a larger number of speakers, including older speakers as a point of comparison.

2.6.2.2 Perception study

Rose et al. (2023) conducted an experiment testing Akan speakers’ perception of [ATR] contrasts. Akan also contrasts [ATR] in both high and mid vowels. However, the [-ATR] high vowels in Akan are acoustically extremely similar to the [+ATR] mid vowels [e] and [o]. Rose et al. report that Akan speakers reliably distinguish vowels that differ only in specification for

[ATR], but have less success perceiving contrasts among the acoustically similar pairs [ɪ]/[e] and [ʊ]/[o]. In Avatime, the [-ATR] high vowels have long been reported to acoustically similar to the [+ATR] mid vowels as well – however, in the ongoing merger affecting high vowels, it is the high vowel pairs that are merging. A perceptual study along the lines of that conduced by Rose et al. could shed light on the source of the ongoing merger in Avatime.

2.6.2.3 Additional interaction between diachrony and abstract phonology: contrastive nasality

Avatime also has a vestigial system of contrastive nasalization on vowels. For example, Funke (1910) gives *vũ* for 'catch'. For contemporary speakers, this is produced with an oral vowel [vu^{1}]. Schuh (1995a) notes that nasal vowels are much less widespread for speakers he worked with than for Funke. However, he does provide some (near) minimal pairs for nasality:

(21) Contrastive nasality – adapted from Schuh (1995a: 46)

a.	ku^{3}tsi^{4}tsĩõ^{1}	'be red'	b.	kʊ^{3}tsɪ^{4}tsɪɔ^{1}	'cut off'
c.	kʊ^{3}za^{4}zã^{1}	'be ripe, fair-skinned'	d.	kʊ^{3}za^{3}za^{1}	'pass'

Despite the fact that nasality is no longer present on most lexical items which historically had nasal vowels, these items still condition alternations. Avatime definiteness clitics vary according to noun class. In some classes, the initial consonant of the definiteness clitic alternates between a non-nasal and a nasal form. This form is conditioned by two types of noun: (1) nouns whose final consonant is nasal, which conditions nasality on the following vowel, (2) nouns which historically had contrastive nasalization.

(22) Nasal alternation in definiteness clitic

a. li^{3}-gbo^{3}=**l**e^{1}
'(the) chair' *Conditioned by synchronic nasal*

b. li^{3}-**ny**i^{3}=ne^{1} [liɲĩnẽ]
'(the) name'

c. e^{3}-gbo^{3}=**l**a^{1}
'(the) chairs' *Conditioned by historical nasal*

d. a^{4}-βa^{3}=**n**a^{1}
'(the) beans'

This is another process in which a historical contrast has been lost, but is still active in the phonology. Gaining an understanding of this process, both in terms of the phonetic status of nasality in Avatime and its phonological behavior, together with further work on the [ATR] contrast in high vowels could contribute to understanding the interaction between diachronic loss of contrast and synchronic phonological behavior and the possibility of abstract contrast in underlying forms being retained without a surface contrast.

3 ASYMMETRY IN BEHAVIOR OF LOW VOWELS IN ATR HARMONY

In Avatime, there is a left-right asymmetry in the application of ATR vowel harmony. Specifically, all vowels in morphemes at the left edge of roots participate in harmony, while the low vowel [a] resists harmony in morphemes to the right of a root. Examples are given below for noun class prefixes (23) and definiteness markers (24):

		-ATR root		*+ATR root*
(23)	a.	**ba^{4}**-dzɛ^{3} CL$_{pl}$-woman.DEF[21] 'women'	b.	**be^{4}**-nyi^{3}me^{3} CL$_{pl}$-man.DEF 'men'
(24)	a.	a^{3}-gba^{3}=**la^{1}** CL-house=DEF 'the houses'	b.	e^{3}-gbo^{3}=**la^{1}** CL-chair=DEF[22] 'the chairs'[23]

This asymmetry between leftward harmony and rightward harmony is consistent across all categories in Avatime. This suggests there is a need for a systematic explanation, rather than analyzing them as exceptions to the regular pattern of [ATR] harmony. I argue there are two factors behind the asymmetry in low vowel harmony behavior:

- Invariant morphemes that appear to be "suffixes" are in fact enclitics
    - The difference in morphological boundary type leads to a difference in harmony behavior
- The low vowel [a] pairs with a mid vowel [e] in [+ATR] contexts
    - The additional feature change as compared to other harmonic pairs prevents harmony across the root-enclitic boundary but allows harmony across the root-prefix boundary

[21] Hiatus resolution is a pervasive process across Avatime in almost every environment. Definiteness morphemes with the shape V often fuse completely with the final vowel of the root.

[22] The rationale for treating DEF as a clitic, using '=', will be discussed below.

[23] The precise meaning and distribution of the 'definiteness' markers in Avatime are still unclear. I refer to this set of morphemes as 'definiteness' for simplicity and consistency with previous Avatime literature only.

In this chapter, I will provide a brief review of the basic characteristics of [ATR] harmony in Avatime in general, and then focus on the behavior of the low vowel [a] in particular. The low vowel in Avatime [ATR] harmony exhibits several behaviors of theoretical interest:

(a) Harmonic re-pairing: the low vowel [a], which lacks a [+ATR] counterpart of the same height, pairs with a mid vowel [e] in [+ATR] contexts

(b) Directional asymmetry: the harmonic repairing in (a) only occurs in prefixes, never in enclitics

(c) Exceptionality: Even among prefixes, some low vowels resist harmony

(d) Tolerated disharmony: disharmony is tolerated in a number of contexts, including compounds and loanwords

(e) Opacity: a sub-case of (d) – disharmony is tolerated between a prefix that harmonizes with [+ATR] root vowel, which is then deleted to avoid hiatus, and an invariant [-ATR] enclitic

Harmonic re-pairing (following the terminology of Baković (2001)) is fairly common in nine-vowel languages with [ATR] harmony. In these languages, there is neither a phonemic nor allophonic low, [+ATR] counterpart to the low vowel [a]. In these languages, [a] alternates with a mid vowel, either [e] or [o]. Casali (2008) observes that it is more common for [a] to re-pair with [e] in West Africa, and more common for [a] to re-pair with [o] in East Africa. Analytically, the relevant feature of re-pairing is that it involves changing (at least) two features rather than one. The change from [a] to [e] in Avatime, for example, requires a change in [ATR], [low], and [front], as compared to other harmonic pairs ([i]/[ɪ], [e]/[ɛ], [o]/[ɔ], [u]/[ʊ]), which require changing only the value of [ATR]. In constraint-based analyses, this means that the markedness constraint(s) driving [ATR] harmony must outrank two faithfulness constraints for [a] to participate in harmony as a target. As will be seen below, the fact that [a] sometimes resists harmony presents challenges for this basic analysis.

Harmony is root-controlled in Avatime, and it affects morphemes to both the left and right of the root. However, in the case of the low vowel, there is an asymmetry – the low vowel can harmonize with the [ATR] value of the root when it is in a prefix to the left of the root, but never harmonizes when it is in an enclitic to the right of the root. Mid vowels in enclitics do undergo harmony with the root to which they attach, so this resistance is a property of the low vowel in particular.

I propose a Harmonic Grammar (Legendre et al. 1990; 2006; Potts et al. 2010) analysis of this asymmetry in prefixes and clitics with respect to [ATR] harmony in which constraints favoring faithfulness to clitics and constraints favoring faithfulness to low vowels are not weighted highly enough on their own to prevent [a] to harmonize in clitics, only their combined weights produce the asymmetry. I show that this analysis, with some additional considerations, also captures the behavior of lexically-specified invariant affixes.

3.1 Data

The main patterns of vowel harmony addressed in this chapter have been previously described by Ford (1971), Schuh (1995a), van Putten (2014b), and Defina (2016b). The analysis developed here is based on these basic patterns. However, most of the data cited in this chapter comes from my own fieldwork with speakers in Amedzofe in the summers of 2018, 2019, and 2022. All examples that are not cited as coming from other sources come from this fieldwork. The speakers I consulted show the same patterns as described in previous work. However, there are some potential dialect or generational differences in the selection of verb prefixes for these speakers. These differences will have implications for how [ATR] harmony should be analyzed for the contemporary Amedzofe speakers with whom I worked. However, further data needs to be collected to address these differences.

3.2 General features of Avatime vowel harmony

Avatime has a system of cross-height ATR harmony (Stewart 1967, 1971), in which the non-low vowels can be divided into two sets which alternate in harmonic environments based on the feature [ATR]. In Avatime, as in some other African languages, the low vowel, while it is not paired with a [+ATR] counterpart at the same height, does participate in harmony in a limited set of contexts. In these contexts, the [+ATR] form of [a] is the mid vowel [e]. The following are the vowels that are paired in ATR alternations:

Table 22: Avatime harmonic pairs

[-ATR]	[+ATR]
ɪ	i
ʊ	u
ɛ	e
ɔ	o
a	**e**

The historical source for the final alternation, [a]~[e] is likely a merger of a vowel like [ɘ/ɜ/æ] with [e]. Monomorphemic roots (excluding loans from Ewe, English, etc.) are always harmonic, and harmony is driven by the ATR specification of the root. (25) and (26) show how harmony applies in prefixes – note that [a] alternates with [e] in both noun-class and verbal prefixes. (26) show that harmony applies iteratively.

(25) Noun class prefixes

a. **ɔ^{1}**-ha^{1} 'pig'
b. **o^{1}**-no^{1} 'soup'

c. **ka^{3}**-drʊɪ^{1}=a^{3} 'dog'
d. **ke^{3}**-ple^{3}kp=a^{1} 'book'

e. **kʊ^{1}**-drʊɪ^{1}=ɔ^{3} 'dogs'
f. **ku^{1}**-ple^{3}kp=a^{1} 'books'

(26) Verb prefixes

a. **a^{3}**-tɔ^{4} (ki^{3}-ku=ye^{3} ka^{3}-kʊ^{1}pa^{3}) ‘3sg cooked (yam slice)’
b. **e^{3}**-to^{3} (ki^{3}-ku=ye^{3} ka^{3}-kʊ^{1}pa^{3}) ‘3sg pounded (yam slice)’

c. **ɔ^{4}**-ga^{1} ‘3sg didn’t walk’
d. **o^{4}**-yo^{1} ‘3sg didn’t dance’

e. **kɪ^{4}**-mɔ^{3} (o^{4}-nyi^{3}me^{3}) ‘We see (the man)’
f. **ki^{3}**-tsri^{1} ‘We hate’

g. **bi^{4}-ze^{14}**-be^{3}fu^{3} ‘They are troublesome (lit. hot)’
h. **bɪ^{4}-zɛ^{14}**-pɔɪ^{3s} ‘They roasted (habitually)’ (van Putten 2014: 51)

Harmony also applies to elements that appear at the right edge of roots. In these elements, all vowels except /a/ participate in harmony – /a/ is invariant as shown in (27) for definiteness markers, and (28) for object pronouns.

(27) Definiteness markers

a. lɪ^{3}-xwɛ^{1}=**nɛ^{3}** ‘work’[24]
b. li^{3}-gbo^{3}=**le^{1}** ‘chair’

c. ɔ^{1}-ha^{1}=**lɔ^{3}** ‘pig’
d. o^{1}-se^{3}=**lo^{1}** ‘tree’

/a/ invariant

e. a^{3}-gba^{3}=**la^{1}** ‘house’
f. e^{3}-gbo^{3}=**la^{1}** ‘chairs

(28) Object pronouns

a. a^{4}-tsrɛ^{3}=**wɛ^{1}** ‘3sg changed it’
b. e^{3}-dze^{3}=**we^{1}** ‘3sg forgot it’

c. a^{4}-mɔ^{3}=**wɔ^{3}** ‘3sg saw you’
d. e^{4}-te^{3}=**wo^{3}** ‘3sg knows you’

/a/ invariant

e. a^{3}-kɪ^{1}=**ba^{1}** ‘3sg gave 3pl (something)’
f. e^{3}-di^{3}=**ba^{1}** ‘3sg saw 3pl’

[24] [l]/[n] alternation of this marker is due to the fact that the root vowel of ‘work’ was historically nasalized

3.3 Behavior of low vowel in [ATR] harmony

This section will provide an overview of the five characteristics of the behavior of low vowels in [ATR] harmony discussed above.

3.3.1 Re-pairing

As discussed above, the low vowel [a] in Avatime does not have [+ATR, +low] counterpart, phonemically or allophonically. In [+ATR] contexts, the counterpart of [a] is the front mid vowel [e]. This can be seen in both noun class prefixes (29) and verbal prefixes (29).

(29) Harmonic re-pairing of [a] with [e]

a. **ka^{3}**-drʊɪ^{1}=a^{3} ‘dog’
b. **ke^{3}**-ple^{3}kpa^{1} ‘book’

c. **a^{3}**-tɔ^{4} (ki^{3}-ku=ye^{3} ka^{3}-kʊ^{1}pa^{3}) ‘3sg cooked (yam slice)’
d. **e^{3}**-to^{3} (ki^{3}-ku=ye^{3} ka^{3}-kʊ^{1}pa^{3}) ‘3sg pounded (yam slice)’

3.3.2 Directional asymmetry

The low vowel participates in [ATR] harmony in nominal and verbal prefixes, but it is invariant in morphemes that appear at the right edge of roots. This is exemplified in the definiteness morphemes /=la^{1}/, /=a^{1}/, and /=wa^{1}/ in (30). The noun roots /gbo^{3}/ ‘chair’ and /gba^{3}/ ‘house’ belong to the same noun class. As /gbo^{3}/ has a [+ATR] vowel, it takes the [+ATR] variant of the noun class prefix /A-/, while /gba^{3}/, with a [-ATR] root vowel takes the [-ATR] variant. However, for both of these roots, the definiteness marker is the [-ATR] [=la^{1}]. The same pattern holds for the pairs in (30).

(30) /a/ harmonizes to left of root, but not right

a. **a^{3}**-gba^{3}=**la^{1}** ‘(the) houses’
b. **e^{3}**-gbo^{3}=**la^{1}** ‘(the) chairs’

c. k**a^{3}**-wɛ^{3}=**a^{1}** ‘(the) axe’
d. k**e^{1}**-zi^{3}=**a^{3}** ‘(the) bowl’

e. b**a^{3}**-ga^{1}=w**a^{3}** ‘(the) goats’
f. b**e^{3}**-ze^{3}=w**a^{1}** ‘(the) thieves’

3.3.3 Exceptionality

Although low vowel prefixes may participate in harmony, there are a number of prefixes with invariant [a]. Two examples of this type of prefix are given in (31) and (32). The intentive prefix /-tá-/ has the same form when it precedes a [+ATR] root like /dzi/ 'buy' and a [-ATR] root /mɔ̀/ 'see'. The potential prefix, which fuses with the person agreement prefix and has the form /-áà-/, does not harmonize with the [+ATR] root /wlo/ 'bathe'. Both prefixes appear immediately adjacent to the root, so it does not appear to be a question of harmony only applying locally.

(31) a. a^{3}-**ta^{4}**-dzi^{3} (cf. **e^{3}**-dzi^{3} 'S/he bought')
3SG-INT-buy
'S/he will buy'

b. a^{3}-**ta^{4}**-mɔ^{1}
3SG-INT-see
'S/he will see'

(32) a. me^{14}-wlo^{3}
1SG.AOR-bathe
'I bathed'

b. m**aa^{41}**-wlo^{3}
1SG.POT-bathe
'I will/want to/might bathe'

The example in (33) shows that it is not the case that harmony fails to apply at all in certain constructions. In (33), the negative progressive prefix /-wI-/ appears in its [-ATR] form, while the noun class agreement prefix is invariant [a].

(33) a. ka^{3}-drʊɪ^{1}=a^{3} **ke^{3}**-ne^{4}mi^{3}=me^{3}
C6S-dog=DEF C6S.AOR-bite=1SG.OBJ
'The dog bit me.'

b. ka^{3}-drʊɪ^{1}=a^{3} **ka^{4}**-wi^{4}-ne^{4}mi^{3}=me^{3}
C6S-dog=DEF C6S.2-NEG.PROG-bite=1SG.OBJ
'The dog is not biting me'

3.3.4 Tolerated disharmony

There are many examples of mono- and polymorphemic words in Avatime in which disharmony is tolerated. In loanwords from Ewe and English, as well as in compounds, [+/- ATR] vowels may co-occur. Examples of these types of tolerated disharmony will be discussed below.

3.3.5 Opacity

An additional type of surface disharmony derives from the interaction between hiatus resolution and [ATR] harmony. For example, consider the definite form of the noun 'house', [ke^{3}pa^{1}]. The root for 'house' is /pe^{3}/, with a [+ATR] vowel. This vowel is deleted when it comes in contact with the definiteness marker /=a^{1}/. However, the noun class prefix appears in its [+ATR] form [ke-]. This pattern will be discussed in greater detail in section 3.7.

3.4 Prosodic status of "suffixes"

Throughout this chapter, I have referred to morphemes at the right edge of verb and noun roots, specifically direct object pronouns and definiteness markers, as clitics, rather than suffixes. In this section, I will argue for why these elements should be treated as clitics rather than suffixes based on their ability to appear non-adjacent to the roots that they modify. I will also argue that, due to this independence, they have a different prosodic status than verbal and nominal prefixes. However, they should be treated as belonging to the same maximal prosodic word as the root to which they attach, based on phonological evidence from hiatus resolution. This prosodic status – separated by a boundary stronger than that separating roots and prefixes, but weaker than that separating different prosodic words – is a crucial part of the explanation for the asymmetry in [ATR] harmony between elements to the left of roots and to the right of roots.

I argue that these morphemes should be analyzed as belonging to a prosodic word with the roots to which they attach. The motivation for this claim comes from the patterns of hiatus resolution strategies at the root-definiteness marker boundary as opposed to the word-word boundary. In Avatime, sequences of heterosyllabic vowels are dispreferred. As noted by Schuh (1995a), and supported by data from my own fieldwork, several strategies to avoid such hiatus configurations are available in the language. There are two major categories of “suffix”:

a. definiteness markers
b. object pronouns

There are additionally a limited number of morphemes that behave differently than the above categories. At least one of these, the morpheme /-lɔ/, used for deriving locative nouns, will be discussed briefly in a later section. However, in this section, I will focus on the definiteness markers and object pronouns, and I will argue that both sets of morphemes are not suffixes, but instead are enclitics.

3.4.1 Definiteness markers

The first type of enclitic we will consider is the so-called definiteness markers. The exact semantic contribution of these morphemes is still not clear, nor is their distribution. They often appear when speakers are asked the citation form of a noun and are often translated into English as indefinites. They differ from the indefinite article in that they do not take a noun-class concord prefix, but rather change based on the class of the head noun. Table 23, reproduced partially from van Putten (2014) shows all noun classes and concord elements. Note the definiteness markers in bold, which all contain a lowercase <a>, signifying that these elements do not participate in ATR harmony.

Table 23: Noun class prefixes and definiteness markers (van Putten 2014: 36)[25]

noun class	prefix	definiteness marker
1 s	O-/ ∅	-(y)E
1 p	bA-/ ∅	**-wa/-ma**
2 s	O^1-	-lO/-nO
2 p	I^1-	-lE/-nE
3 s	lI-	-lE/-nE
3 p	A-	**-la/-na**
4 s	kI-	-(y)E
4 p	bI-	-E
5 s	kU-	-O
5 p	bA^1-	**-a**
6 s	kA-	**-a**
6 p	kU^1-	-O
7	sI-	-sE

These markers appear at first glance to be nominal suffixes. They are most frequently found at the right edge of the nominal root that they modify (34). However, they actually appear at the right edge of the head noun **plus** any other modifiers (34).

(34) a. A^{1}ya^{3}pe^1 e^3-dzi^3 ɔ^1-mwɛ^3**=nɔ^1**
A. 3SG.AOR-buy CL-orange=DEF
'Ayape bought the/an orange'

b. A^{1}ya^{3}pe^1 e^3-dzi^3 ɔ^1-mwɛ^3 ʋi^{1}di^1**=no^3**
A. 3SG.AOR-buy CL-orange big=DEF
'Ayape bought the/a big orange'[26]

Note that the definitess marker *nɔ* harmonizes with the noun root *mwɛ* 'orange' when it is immediately adjacent, but when it occurs adjacent to the adjective *ʋìdì*, it harmonizes with the

[25] Small caps in this table represent harmonizing prefixes, without committing to a particular underlying form. Small cap L is used for morphemes that begin with [l], except when preceded by a nasalized vowel (either synchronic, triggered by a preceding nasal consonant, or diachronic, due to the historical existence of contrastive nasalization (Schuh 1995a) .

[26] This example is also of interest because the definiteness clitic takes its nasal form [no], rather than its non-nassal form [lo], despite the fact that the adjective [ʋi^{1}di^1] does not contain any nasal segments. For definiteness clitics beginning with a liquid [l], there is an alternation when the root to which they attach has a final nasal vowel or a nasal-initial final syllable, which conditions the following vowel to be nasal. For most contemporary speakers of Avatime, unconditioned nasal vowels have been lost completely, or are extremely infrequent. However, historically nasal vowels still trigger the alternation in the liquid-initial enclitics.

[+ATR] vowels of that word instead. In fact, the definite marker can occur quite far from the head noun, shown in (35), taken from van Putten (2014).

(35)	e-boe	kpekpe	ta-ta**=là**	kò
	CL$_{pl}$-matter	short	CNC-three**=DEF**	only
	'only the three short matters'			

(van Putten 2014: 40)

As the definiteness markers appear to attach to the right edge of a syntactic phrase, rather than to the edge of noun roots, I argue that these morphemes should be treated as clitics, rather than as suffixes.

3.4.2 Pronominal objects

Pronominal objects also look initially like verbal suffixes – they appear at the right edge of the verb root, and non-low vowels participate in ATR harmony.

(36)	a.	A^{1}ya^{3}pe^1	e^3-di^3=**wo^3**		[+ATR] root
		A.	3SG.AOR-look.at=2SG		
		'Ayape looked at you'			
	b.	A^{1}ya^{3}pe^1	a^4-kɪ^3=**wɔ^3**	(ke^3-ple^{3}kpa^1)	[-ATR] root
		A.	3SG.AOR-give=2sg	(CL-book)	
		'Ayape gave you (a book)'			

However, object pronouns do not obligatorily occur at the right edge of verbs. They may be moved to the left in focus constructions in the same way as other nominal objects. In (37), we see a basic focus construction in Avatime. Focus is expressed by leftward dislocation of the focused element, along with an extra-high tone at the right edge of that element.

(37)	a.	e^3-ye^3	ɔ^4-gbɪ=ɛ^3
		3SG.AOR-kill	CL-grasscutter=DEF
		'S/he killed the grasscutter'	
	b.	ɔ^4-gbɪ=ɛ^4	e^3-ye^3
		CL-g.c.=DEF:FOC	3-kill
		'S/he killed a GRASSCUTTER'	

Object pronouns can be displaced to the left in the same way, as shown in (38). If object pronouns were verbal suffixes, this would not be expected. It will be seen in (41) that even non-low vowel object pronouns appear as [-ATR] when focused and moved to the left edge, even though they harmonize at the right edge of a verb root.

(38) a. kɪ^{4}-ŋwlɛ^{3}**=ba^{1}**
1PL.AOR-struggle.for=3PL
'We struggled for them'

b. **ba^{4}** kɪ^{4}-ŋwlɛ^{3}
3PL:FOC 1PL.AOR-struggle.for
'We struggled for THEM'

This contrasts with subject prefixes – if a pronominal subject is focused, an independent pronoun appears in addition to the subject agreement prefix.

(39) a. wo^{1}-fe^{3}ke^{3}=lo^{1} mu^{3}no^{1}
2SG-lift=it rise
'You lifted it up'

b. **wɔ^{4}** wo^{1}-fe^{3}ke^{3}=lo^{1} mu^{3}no^{13}
2SG:FOC 2SG-lift=it rise:FOC
'YOU lifted it up'

This suggests that subject pronouns are really affixes on the verb, while object pronouns are clitics. There is additional evidence supporting this claim: object pronouns can also shift in certain multi-verb constructions. Ford (1971) discusses a rule he calls "object shift". In such constructions (which include serial verb constructions), objects can shift to the left. This is possible with both full DP objects, as well as pronominal objects. An example of a shifted pronominal object is given in (40):

monoclausal, V=O Adv
(40) a. a^{3}-ŋwya^{3}=**kɛ^{2}** dzɛ^{1}
3SG.AOR-throw=it$_{CL}$ again
'He threw it again'

multi-clausal, V=O [Inf-V ___]

b. e[3]-dzi[1]ni[1]=**ke[2]** ku[3]-ŋwya[3] ___
3SG.AOR-re-=it$_{CL}$ INF-throw ___
'He threw it back' (Ford 1971: 206)

In (40), we see a single-verb construction with an adverb. In this case, the pronominal object *kɛ[2]* appears at the right edge of the verb *ŋwya[3]* 'throw'. In (40), a multi-verb construction (*dzi[1]ni[1]* is a verb with a meaning like 're-'; it behaves similarly to verbs like "begin"), we see that the object has shifted from its original position as the complement of *ŋywa[3]* to a position between the two verbs. If pronominal object were indeed suffixes, they should not be able to undergo movement in this way.

Also of note: the pronominal object *kɛ[2]* harmonizes with whatever root is to its left. When it follows the [-ATR] root *ŋwya[3]*, it has a [-ATR] vowel. When it is shifted and appears at the right edge of the [+ATR] root *dzi[1]ni[1]*, it appears with a [+ATR] vowel.

3.4.3 Note on underlying forms

Throughout this analysis, clitics are assumed to have underlying [-ATR] vowels. All independent pronouns in Avatime have invariant [-ATR] vowels, and when object pronouns are focused, they also appear with [-ATR] vowels.

(41) a. Ko[1]fi[3] e[3]-me[3]ni[1]=**me[3]**
Kofi 3SG.AOR-deceive=1SG.OBJ
'Kofi deceived me'

b. **Mɛ[4]** Ko[1]fi[3] e[3]-me[3]no[13]
1sg.obj:foc Kofi 3sg.aor-deceive:foc
'Kofi deceived ME'

The fact that there are no invariant grammatical morphemes in Avatime with [+ATR] vowels suggests that [-ATR] is likely the default feature value in the harmony system. I also assume that prefixes displaying an alternation between [a]/[e] have an underlying low vowel. The motivation for this assumption is twofold. First, if the prefix vowels in such forms are underlying

[-high, -low, +front] (/E/), then it is difficult to explain why the harmonic allomorph of these morphemes for [-ATR] roots should be the low vowel [a]. Since [ɛ] exists in the language, it would always incur fewer faithfulness violations to either change (if the prefix vowel is underlyingly fully specified as /e/) or specify the feature value [-ATR] (if the prefix is underlyingly underspecified) than to do this in addition to changing the value of the feature [low]. Second, there are in fact prefixes that alternate between [ɛ] and [e]. For example, the first person progressive prefix is [mɛ̀ɛ́-] when attached to a [-ATR] root and [mèé-] when attached to a [+ATR] root. This suggests that the contrast between this type of prefix and prefixes with an [a]/[e] alternation is a contrast between a [+low] and [-low] vowel in the lexical entries.

3.4.4 Contrast between root-enclitic boundary and word-word boundary

The evidence presented so far in this section has shown that enclitics behave differently from both nominal and verbal prefixes in that they are able to appear non-adjacent to the roots they modify. Noun class prefixes and subject agreement prefixes (in addition to all other categories of verb prefix) are obligatorily adjacent to roots. I take this as evidence that prefixes are prosodically "closer" to the root in Avatime than enclitics. However, enclitics are prosodically "closer" to roots than adjacent words. The evidence for this claim comes from patterns of hiatus resolution at the root-clitic boundary and at the word-word boundary.

3.4.5 Hiatus resolution in Avatime

Avatime disprefers hiatus – adjacent heterosyllabic vowels. Schuh (1995a) identifies four repairs for such sequences:

(42) a. Elision of V1

/ku^{3}-d**e^{1}**=**o^{3}**/ → [ku^{3}d**o^{1}**]
CL-road=DEF ‘(the) road’ (Schuh 1995a: 49)

b. *Elision of V2*

/kʊ^{1}-s**a^{1}**=**ɔ^{3}**/ → [kʊ^{1}s**a^{3}**]
CL-cloth=DEF ‘(the) cloth’ (Schuh 1995a: 49)

c. *Glide formation of V1*

/ke^{1}-z**i^{3}**=**a^{1}**/ → [ke^{1}zya^{3}]
CL-bowl=DEF ‘(the) bowl’ (Schuh 1995a: 49)

d. *Glottal stop insertion*

/e^{3}-vu^{1} **ɔ^{3}**-gɛ^{3}/ → [e^{3}v**u^{1}ʔɔ^{3}**gɛ^{3}]
3-catch CL-animal ‘s/he caught an animal’ (Schuh 1995a: 48)

Schuh claims that only strategy (d) is ever used to resolve hiatus at word boundaries, while it is never used at the root-clitic boundary. Data from my own fieldwork has shown that strategies (a)-(c) are in fact available at word boundaries in casual speech (Lehman & Major 2019). For example, both glide formation (43) and V1 elision (43) are possible at the verb + full DP direct object boundary:

(43) a. me^{1}-dz**i^{3}** **e^{3}**-gbo^{3}=la^{1} → [me^{1}dz**ye^{3}**gbo^{3}la^{1}]
1SG.AOR-buy CL-chair=DEF
‘I bought (the) chairs’

b. ma^{1}-kp**ɛ^{3}** **o^{3}**-no^{1} → [ma^{1}kp**o^{3}**no^{1}…]
1SG.AOR-put CL-soup
(ní kè-zi=a=mɛ̀)
LOC CL-bowl=DEF=LOC
‘I put soup (in the bowl)’

There is some variation in which strategy is used, both within and across speakers. However, even in these cases, strategy (d) – inserting a glottal stop and preserving both vowels – is always available, especially in careful or slower speech. The crucial point in Schuh’s description, is that at this boundary, the choice of hiatus resolution strategy is invariant, regardless of speech rate or formality. Depending on the root-final vowel, the vowel of the definiteness marker, and the specific noun class, hiatus is always resolved at the root-clitic boundary by either elision of V1, elision of V2, or glide formation[27]. The noun root /-de^{1}-/ belongs to a noun class which is marked by a prefix /ku^{3}-/, and is associated with a definiteness marker of form /=o^{3}/. When Avatime speakers produce the word 'road' with the definite morpheme at the right edge, the form is always [kudò], even in the most careful speech. Forms like *[kudeʔo], *[kudyo], and *[kude] are never produced. When an adjective follows the noun, the root vowel is [e], so it is also not the case that the root vowel of 'road' is [o]:

				→	
(44)	a.	/ku^{3}-d**e^{1}=o^{3}**/		→	[ku^{3}d**o^{1}**], *[kudeʔo], *[kudyo], *[kude]
		CL-road=DEF			
		'(the) road'			
	b.	/ku^{3}-de^{1}	vu^{1}vu^{1}=o^{3}/	→	[ku^{3}de^{1} vu^{1}vɥo^{3}][28]
		CL-road	new=DEF		
		'(the) new road'			

While there are some differences between the speakers that I worked with and those discussed by Schuh, the overall contrast remains – hiatus resolution is different at the root-clitic boundary than at the word-word boundary. In Schuh's work, choice of strategy was categorical at both types of boundary, with a contrast between glottal stop insertion between words and elision/glide formation between roots and clitics. In my own fieldwork, I found that there is optionality in choice of hiatus resolution strategy at word boundaries, but no optionality at the root-clitic boundary. The following table summarizes this pattern:

[27] Since all nouns which take class prefixes (some loanwords do not appear with one) are C-initial, there is no data bearing on how hiatus is resolved at the root-prefix boundary.

[28] The final vowel of 'new' is [u]. In some cases of hiatus, the [+ATR] high back vowel becomes a high front rounded glide [ɥ], rather than the expected [w]. This fronting is not exceptionless, but is fairly frequent. In Schuh's discussion of this phenomenon, he describes it as happening "usually, if not always" (Schuh 1995a: 37). My own impressions align with observation, although I do not have frequency counts for this phenomenon.

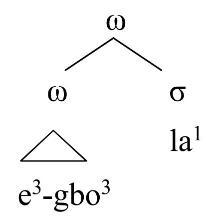
Table 24: Summary of hiatus resolution strategies

Repair strategy	Available across words?	Available at root-clitic boundary?
V1 elision	✓	✓
V2 elision	✓	✓
Glide formation	✓	✓
Glottal stop insertion	✓	✗

3.4.6 Prosodic status of enclitics

I argue that the evidence presented in the preceding section supports a prosodic structure in Avatime in which enclitics adjoin to roots at the prosodic-word level in a recursive structure , (Itô & Mester 1999a; Peperkamp 1997; Vigário 2003). So, the prosodic structure of a word like *e*^{3}*-gbo*^{3}*=la*^{1} 'chairs' would be as in (45).

(45)

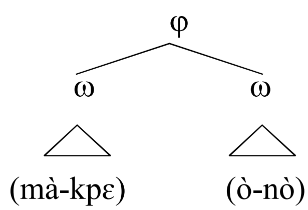


This structure is that same as that proposed for weak object clitics in English by Selkirk (1996). For the analysis of [ATR] harmony developed in this chapter, prosodic adjunction of the clitic at the phrase level would predict the same result. As I will discuss below, the crucial fact for the asymmetry of [a] in [ATR] harmony is that enclitics are separated from roots by some prosodic boundary (i.e. are not in the same minimal prosodic word). This is true whether clitics adjoin at the prosodic word or phonological phrase level[29]. While an analysis of the entire prosodic phonology of Avatime remains for future work, the motivation for proposing a recursive prosodic word structure, rather than adjunction of the clitic at the phonological phrase-level,

[29] However, this distinction could affect how violations of the constraint driving [ATR] harmony are assessed. If the clitic adjoins at the phonological phrase level, then violations of whatever constraint drives harmony would have to be assessed at the phrase level. This could lead to predictions of cross-word harmony, which is not attested in Avatime.

comes primarily from the hiatus resolution facts. I assume that hiatus is resolved between heterosyllabic vowels within the same phonological phrase. So, for example, a verb and following full DP direct object as in the examples in (43) would be contained in the same phonological phrase (φ).

(46) ma^{1}-kpɛ^{3} o^{3}-no^{1} (ni^{4} ke^{1}-zi=a^{3}=mɛ^{1})
1sg.aor-put cl-soup loc cl-bowl=def=loc
'I put the soup in the bowl'



Under this prosodic structure the vowels in hiatus are in the same phonological phrase, but not in the same prosodic word. Clitics, on the other hand, are in the same maximal prosodic word as the roots to which they attach. I argue that it is this contrast that explains the difference in hiatus resolution strategies at the root-clitic and word-word boundaries. For the analysis developed in the remainder of this chapter, the important conclusion from this section is that enclitics are separated from roots by a prosodic word boundary.

3.5 Invariant morphemes

3.5.1 Invariant prefixes

So far, we've seen that low-vowel harmony is **possible** in prefixes. However, in verbs, invariant /a/ actually occurs in the majority of prefixes. This must be accounted for in the analysis of the directional asymmetry in the participation of the low vowel in [ATR] harmony. In this section, a more detailed look at verbal prefixes will show that it is a limited subset of prefixes that actually involve harmonic alternation between [a] and [e].

3.5.2 Invariant prefixes and diachrony

The intentive prefix /-ta⁴-/ does not harmonize with the root, and in fact triggers [-ATR] harmony on the prefixes to its left:

(47) a. a³-**ta⁴**-dzi³ (cf. **e³**-dzi³ '3sg bought')
3-INT-buy
'3sg will buy'

b. a³-**ta⁴**-mɔ¹
3-INT-see
'3sg will see'

This invariant prefix may be explained as a former verb/auxiliary that has been incorporated into the verbal complex. For example, /-ta⁴-/ also has a variant (possibly dialectal or related to age of speaker) /-tra⁴-/, which is very likely related to *tráà* 'come', which is itself the remains of a past serial construction *trɛ ba* 'go come' (Defina 2009: 69). This would explain why this prefix fails to participate in ATR harmony – it was itself a root. While it is no longer a root morphologically, /-ta⁴-/ behaves like a root in the synchronic phonology of Avatime – its vowel is invariant, and it triggers harmony on prefixes to its left. However, since its morphosyntactic distribution is that of a prefix, rather than a root, its phonological behavior must be analyzed differently from roots in compounds, for example.

3.5.3 Other invariant verbal prefixes

While the behavior of the intentive /-ta⁴-/ could be plausibly explained as the result of its former status as a root, there are other invariant prefixes with /a/ in Avatime that are more difficult to explain in the same way. For example, the potential mood (48) is marked by the (if present for the relevant noun class) initial consonant of the subject agreement marker followed by *aa⁴¹*-, regardless of the [ATR] specification of the verb root. Certain subject agreement prefixes from

"Set 2" (see Defina 2009, van Putten 2014 for discussion of the sets of subject agreement markers) are also invariant. For example, for nouns of class 6, the subject agreement that precedes the negative progressive is an invariant /ka^{4}-/.

(48) a. me^{14}-wlo^{3}
1SG.AOR-bathe
'I bathed'

b. m**aa^{41}**-wlo^{3}
1SG.POT-bathe
'I will/want to/might bathe'

(49) a. ka^{3}-drʊɪ^{1}=a^{3} **ke^{3}**-ne^{4}mi^{3}=me^{3}
C6SG-dog=DEF C6S.AOR-bite=1SG.OBJ
'The dog bit me.'

b. ka^{3}-drʊɪ^{1}=a^{3} **ka^{4}**-wi^{4}-ne^{4}mi^{3}=me^{3}
C6S-dog=DEF C6S.2-NEG.PROG-bite=1SG.OBJ
'The dog is not biting me'

The fact that the low vowel **may** participate in harmony in prefixes, but fails to with specific morphemes, must be accounted for in the analysis of the harmony system in general. I will propose below that these morphemes must be lexically specified to not undergo harmony.

3.5.3.1 Distribution of harmonizing and invariant prefixes

There is an additional asymmetry in the distribution of invariant low vowel prefixes. In the nominal domain, all low vowel prefixes (n=4) harmonize without exception. That is, there is no noun class prefix that contains invariant /a/. In the verbal domain, the harmonizing low vowel prefixes are actually a small minority, comprising only the first person singular and third person singular subject agreement prefixes from Defina's "Set 1" (used in the aorist affirmative for most verbs). There are at least eight prefixes with invariant /a/, including those already discussed in this section. As the aorist is the default aspect in Avatime, it is possible that forms with the harmonizing prefixes are more frequent in the input data for Avatime learners, but I do not have frequency data to support this tendency. Future collection of frequencies of harmonizing versus non-harmonizing low vowel prefixes will help determine to what extent Avatime learners are able to make the generalization that low vowel prefixes harmonize, and that the non-harmonizing prefixes must be learned as exceptions.

3.5.4 Invariant non-low vowel – the locative suffix

Schuh (1995a) notes one element that with a non-low vowel that does not participate in ATR harmony. This morpheme, which is a derivational suffix forming locative nouns, has the invariant form [lɔ]. A minimal pair showing this invariant morpheme is shown in (50). The locative suffix fails to harmonize with the root /se/ 'run' (50), which contrasts with the definiteness marker in 'tree' (50), which does harmonize.

(50) a. o^{1}-se^{3}=lo^{1}
CL-tree=DEF
'tree'

b. o^{1}-se^{3}-lɔ^{1}
CL-run-LOC
'place for running' (Schuh 1995a: 39-40)

This derivational suffix is homophonous with the demonstrative /-lɔ^{1}/ (described by van Putten (2014) as the distal demonstrative), which appears with noun class inflection (51), and as a compound with the locative preposition /ni^{4}/ in the relative pronoun /ni^{4}lɔ^{1}/ 'where':

(51)	e^{3}ge^{4}	kɛ^{3}-lɔ^{1}?
	what	CL-DIST
	'What is that (over there)?'	

(52)	Ko^{1}fi^{3}	e^{4}-ʋi^{4}=me^{3}	**ni^{4}lɔ^{1}**	gi^{1}	A^{4}ma^{3}	a^{3}-kla^{1}	ke^{3}-ple^{3}kpa=ɛ^{3}
	K	3SG.AOR-ask=1SG.OBJ	**where**	REL	A	3SG.AOR-read	CL-book=DEF=CL.DET
	'Kofi asked me where Ama read the book'						

Based on the fact that it may take nominal inflection, and form compounds, I argue that /-lɔ¹/ behaves more like the enclitics examined above than a suffix, and therefore is not in the same minimal prosodic word as the roots to which it attaches in nominal derivation, as in [o¹-se-lɔ¹]. In the analysis developed below, I only consider candidates with the prosodic structure argued for in this section, assuming that candidates with alternative structures are ruled out by the relevant prosodic constraints.

3.6 Analysis

3.6.1 Outline of the problem

The order of preferences in Avatime can be thought of schematically as:

(53) *a → e >> do harmony >> *e → ɛ, *o → ɔ …

This solves part of the problem – how to separate [a]~[e] alternation from other harmony alternations. However, harmony isn't absent outright in enclitics. Rather than "turning off" the vowel harmony process, Avatime "turns down" harmony in the stem-clitic domain, as compared to the root-affix domain. Harmony is more strictly enforced in inner brackets - one way to think of this is a reordering of preferences:

(54) Root-affix boundary[30]

do harmony >> *a → e … *o → ɔ …

e^3-gbo^3 >> *a^3-gbo^3

Between roots and affixes, it is more important to fully apply harmony than it is to avoid alternation between [a] and [e]. This means that prefixes will allow /a/ to participate in harmony. The order of preferences is difference in the stem-clitic domain.

[30] This schematic applies to the general case, leaving aside for now the invariant prefixes

(55) Root-clitic boundary

$$*a \rightarrow e >> \text{do harmony} >> *e \rightarrow \varepsilon, *o \rightarrow \text{ɔ} \ldots$$

$$[e^3\text{-gbo}^3]\text{=la}^1 >> *[e^3\text{-gbo}^3]\text{=le}^1$$

Between stems and clitics, it is more important to avoid [a] and [e] than it is to fully apply harmony. This means all other vowels will participate in harmony, but /a/ will resist it. In this section, I have suggested a motivation for the resistance of the low vowel [a] to [ATR] harmony, and outlined the facts that should be accounted for in an analysis. In the following section, I develop an analysis that accounts for the fact that [a] never participates in harmony in clitics, although other vowels do, but [a] does participate in harmony in prefixes, except in lexically-specified morphemes.

3.6.2 Constraints

The Avatime data presented above have shown that there are three properties a vowel can have that resist harmony: (a) they can be low vowels, (b) they can be in enclitics, and (c) they can be lexically-specified to resist harmony. However, just one of these properties alone does not suffice to allow a vowel to resist harmony. Low vowels do participate in harmony in prefixes, and non-low vowels do participate in harmony in enclitics. In this section, I show how a grammar employing weighted constraints can capture the fact that it is only a combination of these factors that allows vowels to resist participation in [ATR] harmony, while a grammar with ranked constraints has difficulty.

Vowel harmony is driven by the constraint AGREE(ATR), as defined below. Since both prefix and enclitic vowels may participate in harmony, this constraint is assessed over the maximal prosodic word. This means that a disharmonic vowel in a prefix or an enclitic will incur a violation of AGREE.

(56) AGREE([ATR], ω_{max}) Assess a violation for each pair of adjacent vowels in an output candidate that do not have the same specification for the feature ATR within a maximal prosodic word

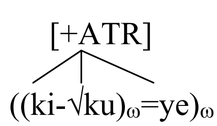
Low vowels are more resistant to harmony than non-low vowels. I propose that this can be captured by the general faithfulness constraint IDENT(low).

(57) IDENT(low) Assess a violation for every surface vowel with a different specification for the feature [low] than the corresponding input vowel

Affixes that display [a]/[e] alternation are analyzed here as being underlyingly specified as [+low] and underspecified for [ATR]. If these affixes do not have an underlying specification for [low], it is unclear why they should show [a]/[e] alternation rather than [ɛ]/[e], which is attested elsewhere in the language. Consider a hypothetical underlying archiphoneme /E/. If an affix like the class 5 singular noun class marker, which displays [a]/[e] alternation ([ke^{3}-ple^{3}kpa^{1}] 'book'/ [ka^{3}-drʊɪ^{1}a^{3}] 'dog'), were to have an underlying form like /kE-/, with the vowel specified for [+front, -high], it would be unclear what would cause it to take the form [ka-] over the form [kɛ-] in [-ATR] contexts.

I assume that, when vowels do participate in harmony, a [+/- ATR] autosegment is associated with these vowels. So, in the word [ki^{3}ku^{1}ye^{3}] 'yam', which consists of the [+ATR] root /-ku^{1}-/, a noun class prefix, and a definiteness marker, would be represented as follows:

(58)



In this case, the feature [ATR] is shared within the boundaries of the minimal prosodic word (the inner parentheses) and across the boundary of the minimal prosodic word (between the root and clitic). A dispreference for this type of feature sharing, I argue, is what drives the resistance to ATR harmony in clitics. This dispreference can be captured by a CRISPEDGE constraint (Itô & Mester 1994; 1999a):

(59) CRISPEDGE(PrWd) Assess a violation for each feature shared across a prosodic word boundary

The potential prefix, as discussed above, is invariantly /-aa^{41}-/. For this prefix, and other invariant /a/ prefixes, I propose that they are marked in the lexicon as exceptional. This will be represented with a subscript E, so that the underlying form of the potential prefix is /-aa$^{41}{}_{E}$-/. The resistance of exceptionally-marked morphemes to [ATR] harmony is captured by a lexically-indexed faithfulness constraint (Fukazawa 1999; Itô & Mester 1999b; 2001; Pater 2000; 2009):

(60) IDENT(ATR) - E Assess a violation for every surface vowel in which a feature differs the corresponding input vowel if the input vowel is in a morpheme marked E(xceptional)

There are two further, highly weighted, constraints necessary for this analysis. These constraints rule out candidates with allophonic [+low, +ATR] vowels and candidates in which the root vowel harmonizes with a clitic or affix vowel.

(61) *LO/ATR Assess a violation for every [+low, +ATR] vowel

This constraint penalizes surface forms with an allophonic [+low, +ATR] vowel. I represent this vowel as [æ] in the tableaux, but this is a stand-in for any [+low, +ATR] vowel. I also assumed high-weighed markedness constraints against other vowel qualities like [ə], which appear as the [+ATR] counterpart to [a] in other languages.

In order to capture the fact that roots are invariant and never harmonize with invariant affixes or clitics, I adopt the positional faithfulness constraint FAITH(root). This is an abbreviation for specific faithfulness constraints for each feature.

(62) IDENT(ATR)-root Assess a violation for any [ATR] feature change in the root

The grammar presented here formalizes the observation that, alone, being a clitic vowel, being a low vowel, or being lexically-specified to resist harmony are not sufficient to avoid harmonizing. This is captured by assigning a slightly higher weight to the constraint enforcing vowel harmony than the constraints that disprefer it:

Table 25: Summary of constraints and weights

PROPERTY	CONSTRAINT	WEIGHT
low vowel	IDENT(low)	2
clitic	CRISPEDGE(PrWd)	2
lexical exception	IDENT(ATR)-E	2
ATR harmony	AGREE(ATR)	3

This accounts for the fact that if undergoing ATR harmony only violates one of the lower-weighted constraints, then a candidate that undergoes will have a lower harmony score than a candidate that does not.

3.6.3 Harmony in non-low vowels

The constraints and constraint weights outlined above account for the fact that harmony affects both prefixes and enclitics for non-low vowels. This can be seen for the word [ki³ku¹ye³] 'yam' in the following tableau. This word has a definiteness clitic with a mid front vowel. The winning candidate (a), in which ATR harmony does apply to the clitic vowel, violates CRISPEDGE. However, the higher weight of AGREE means that a candidate in which the clitic vowel fails to participate in ATR harmony (b) will incur a higher penalty.

(63)

/[kI-√ku]=yɛ/[31] 'CL-yam=DEF'	ID(lo)	CRISPEDGE (PrWd)	AGREE (ATR)	*LOATR	FAITH (ROOT)	H
weight:	2	2	3	10	20	
☞ a. [[ki-ku]=ye]		1				2
b. [[ki-ku]=yɛ]			1			3
c. [[kɪ-ku]=ye]		1	1			5
d. [[kɪ-kʊ]=yɛ]					1	20

[31] The tableaux in this section do not show the autosegmental associations of [ATR] features, but it assumed that any vowel in the input that is not underspecified is linked to a [+/-ATR] autosegment, and any vowel participating in harmony is linked to the [ATR] feature of the root.

The clitic vowel in /ki^{3}-ku^{1}=ye^{3}/ has only one of the properties that resist participation in [ATR] harmony, namely that it is outside the minimal prosodic word that contains the verb root. Since the weight of the constraint dispreferring harmony for each property is lower than the weight of the constraint enforcing harmony, having this single property is not enough for the clitic vowel to resist harmonizing with the [ATR] value of the root.

3.6.4 Harmony and non-harmony in low vowels

However, when a vowel has two of the harmony-resisting properties, the combined weights of the constraints enforcing those properties is enough to overcome the AGREE violation incurred by failing to undergo harmony. The word [e^{3}gbo^{3}la^{1}] 'chairs' provides an example. This word consists of the [+ATR] root /gbo^{3}/, the noun class prefix /A^{3}-/[32], and the definiteness clitic /=la^{1}/. The winning candidate (a) is the candidate in which the prefix vowel undergoes harmony and surfaces as [e], while the clitic vowel fails to harmonize and remains [a]. This candidate incurs one violation of IDENT(low) for the prefix vowel, and one violation of AGREE(ATR) for the failure of the clitic vowel to harmonize. These violations yield a harmony score of 5 (1*2 + 1*3) The candidate (b), in which both the prefix and the clitic harmonize, incurs two violations of IDENT(low), and one violation of CRISPEDGE, for a total harmony score of 6 (2*2 + 1*2). The grammar only disprefers ATR harmony for the clitic vowel. A candidate (c) in which both the prefix and clitic vowels fail to participate in harmony is ruled out by its two violations of AGREE.

[32] For [-ATR] roots in this noun class, the prefix surfaces as [a], as in [a-gba=là] 'houses'.

(64)

/[A-√gbo]=la/ 'CL-chair=DEF'	ID(lo)	CRISPEDGE (PrWd)	AGREE (ATR)	*LOATR	ID(ATR) - root	H
weight	2	2	3	10	20	
☞ a. [[e-gbo]=la]	1		1			5
b. [[e-gbo]=le]	2	1				6
c. [[a-gbo]=la]			2			6
d. [[ə-gbo]=la]				1		10
e. [[ə-gbo]=le]	1	1		1		14
f. [[ə-gbo]=lə]		1		2		20
g. [[a-gbɔ]=la]					1	20

The above tableau demonstrates that a vowel with two of the three properties that discourage participation in ATR harmony will incur enough penalty under this grammar to overcome the overall preference for vowels to harmonize. The following tableau demonstrates the same behavior for the combination of a low vowel and marking as a lexical exception, using the example of the potential prefix /-aa^{41}-/ in the verb [maa^{41}wlo^{3}] 'I will bathe'. The winning candidate, in which the vowel of the potential prefix surfaces faithfully, violates AGREE(ATR), but does not incur any other violations. Since, IDENT(low) has a weight of only 2, there must be another constraint that prevents candidate (b) from emerging as the winner. Since prefixes are in the same minimal prosodic word as the root, the low vowel participation in ATR harmony will not violate CRISPEDGE. Instead, the candidate in which the ATR harmony applies violates the lexically-indexed faithfulness constraint IDENT(ATR)-E. This, combined with the violation of IDENT(low), penalizes the candidate with ATR harmony enough that the attested form [maa^{41}wlo^{3}] is the winner.

(65)

/[m-aa$_E$-√wlo]/	ID(lo)	CRISPEDGE	ID(ATR)-E	AGREE (ATR)	*LOATR	ID(ATR) - root	H
weight	2	2	2	3	10	20	
☞ a. [maa-wlo]				1			3
b. [mee-wlo]	1		1				4
c. [məə-wlo]	1		1		1		16
d. [maa-wlɔ]						1	20

A prediction made by this grammar is that exceptional prefixes should only contain the low vowel [a]. The following tableau shows the output for an underlying from with a hypothetical [-ATR] mid vowel prefix that is marked as a lexical exception. In this case, the single violation of FAITH[E] incurred by the prefix undergoing harmony is not enough to outweight the violation of AGREE incurred by failing to harmonize in candidate (b).

(66)

/[mɛ$_E$-√wlo]/	ID(lo)	CRISPEDGE	ID(ATR)-E	AGREE (ATR)	*LOATR	ID(ATR) - root	H
weight	2	2	2	3	10	20	
☞ a. [me-wlo]			1				2
b. [mɛ-wlo]				1			3

The reverse side of this prediction is that exceptional enclitic [-ATR] morphemes with mid vowels *could* exist, as they would also have two harmony-resisting properties. The locative noun-forming morpheme /-lɔ/ provides such an example. While it is unclear if this morpheme is an enclitic, a suffix, or another type of morpheme, the evidence in (51) and (52) suggests that this morpheme should be treated as prosodically more independent from the root than a prefix. If this is the case, then the behavior of this non-harmonizing mid vowel morpheme falls out from the grammar developed to this point. For example, consider the form [o^{1}se^{3}lɔ^1] ‘place for running’ (Schuh 1995a), in which the locative morpheme is marked as exceptional in the underlying form. The winning candidate (a), in which the locative morpheme fails to harmonize with the [+ATR] root, incurs a single violation of AGREE. In candidate (b), in which the locative morpheme undergoes ATR harmony, both CRISPEDGE and FAITH[E] are violated, which causes the candidate to have a higher overall penalty than the disharmonic candidate.

(67)

/[O-√se]-lɔ$_E$/ 'CL-run-LOC'	ID(lo)	CRISPEDGE (PrWd)	ID(ATR) - E	AGREE (ATR)	*LOATR	ID(ATR) - root	H
weight	2	2	2	3	10	20	
☞ a. [[o-se]-lɔ]				1			3
b. [[o-se]-lo]		1	1				4
c. [[ɔ-sɛ]-lɔ]						1	20

This does not prevent the definiteness clitics from harmonizing with the root, so long as they do not contain low vowels. Since definiteness clitics with mid vowels only have one harmony-resisting property, not belonging to the same minimal prosodic word as the root, it is more harmonic for them to harmonize than not. This is demonstrated for the word [o^{1}se^{3}lo^1] 'tree' in the following tableau. The winning candidate violates CRISPEDGE(PrWd), since the feature [+ATR] is shared across a prosodic word boundary. The candidate in which the clitic surfaces as [-ATR] (faithfully if clitics are underlyingly [-ATR], but the analysis holds even if the clitic is underlyingly underspecified) does not violate CRISPEDGE, but does violate AGREE, which is assessed over the maximal prosodic word. Since AGREE is weighted higher than CRISPEDGE, harmony of the clitic is in this case preferred. Informally, the mid vowel clitic only has one harmony-resisting property, which is not enough to overcome the overall preference for ATR harmony.

(68)

/[O-√se]=lɔ/ 'CL-tree=DEF'	ID(lo)	CRISPEDGE (PrWd)	ID(ATR) - E	AGREE (ATR)	*LOATR	ID(ATR) - root	H
weight	2	2	2	3	10	20	
☞ a. [[ò-se]-lò]		1					2
b. [[ò-se]-lɔ̀]				1			3
c. [[ɔ̀-se]-lɔ̀]				2			6
d. [[ɔ̀-sɛ]-lɔ̀]						1	20

The following table summarizes the logical possibilities for non-root vowels in terms of morphology (prosodic status), vowel height, and lexical exceptionality.

Table 26: Summary of possibilities for non-root vowels in ATR harmony

morphology	vowel height	exceptionality	penalties for harmony	behavior	example
prefix	non-low	non-exceptional		harmonize	(68)
prefix	low	non-exceptional	IDENT(low): 2	harmonize	(64)
prefix	non-low	exceptional	IDENT(ATR) - E: 2	harmonize	(66)
prefix	**low**	**exceptional**	**IDENT(low) + IDENT (ATR)-E: 4**	**no harmony**	(65)
suffix/enclitic	non-low	non-exceptional	CRISPEDGE: 2	harmonize	(63)
suffix/enclitic	**low**	**non-exceptional**	**IDENT(low) + CRISPEDGE: 4**	**no harmony**	(64)
suffix/enclitic	**non-low**	**exceptional**	**CrispEdge + IDENT (ATR)-E: 4**	**no harmony**	(67)
suffix/enclitic	low	exceptional	CrispEdge+Id(lo)+ IDENT (ATR)-E: 6 (hypothetical; indistinguishable from non-exceptional)		

3.6.5 Checking the weights

I chose the weights of the constraints for the analysis developed in this section to demonstrate the ability of constraint ganging to account for the asymmetry in the behavior of [a] in Avatime [ATR] harmony. However, this ad hoc selection of constraint weights does not tell us whether an Avatime learner could arrive at a grammar like the one outlined in this section. In order to check whether the constraint weights chosen could plausibly be learned by an Avatime speaker given the constraints used in the above analysis, I trained a maxent grammar (Smolensky 1986; Goldwater & Johnson 2003) on the constraints and violations in the tableaux from this section. The weights that were learned are given in Table 27.

Table 27: Weights learned by MaxEnt grammar

Constraint	MaxEnt weight	Harmonic Grammar weight
IDENT(low)	26.37	2
CrispEdge(PrWd)	26.64	2
IDENT (ATR)-E	27.06	2
AGREE(ATR)	39.97	3
*LoATR	80	10
IDENT (ATR)-root	80	20

Because MaxEnt grammars are intended to model gradient phenomena, rather than a categorical phenomenon like Avatime harmony, the weights of the constraints are extremely high. However, the proportions of the weights to each other matches the proportions of the weights chosen for the classical Harmonic Grammar analysis. The weights of the three harmony-dispreferring constraints IDENT(low), CRISPEDGE, and FAITH[E] are all nearly identical to each other, and somewhat lower than the weight of the harmony-driving constraint AGREE. The two constraints that are never violated on the surface received the highest possible weight[33].

3.6.6 Compounds and loans

So far, two other types of tolerated disharmony have not been addressed: loan words and compounds. In loans from Ewe, disharmony is allowed:

(69)
a. man⁴go¹ — 'mango'
b. A¹me¹dzɔ¹ʃe⁴ — 'Amedzofe (name of village)
c. a¹bo³lo³ — 'bread'
d. kpa³kpa⁴lo¹ʋwe³ — 'butterfly'

In loanwords, enclitics harmonize with the [ATR] value of the final vowel of the root, so the definite forms of 'mango' and 'bread' are [man⁴go=**e³**] and [a¹bo³lo=**e¹**], respectively, with a [+ATR] definiteness clitic. Loanwords do not have noun class prefixes, but the analysis

[33] An upper limit of 80 was defined for constraint weights, since the weights of these constraints that are never violated on the surface would tend toward infinity since the outputs are categorical.

developed here predicts that any noun class prefix attaching to a loanword would also harmonize locally with the initial vowel of the root.

Dishamony is also tolerated in compounds. Compounding in Avatime is a somewhat restricted process (Schuh 1995b), but is fairly productive in a limited set of semantic areas. Compounds are of the form /class prefix2-N1+N2/. The noun class morphology for the whole compound agrees with N2. However, the noun class prefix still harmonizes with the linearly adjacent root, that is, the root of N1. This leads to cases like (70) in which there is surface ambiguity concerning the noun class prefix.

(70) a. ki^{3}-gu^{1}me^{1}dza=ɛ^{1} (li^{3}-gu^{1}me^{1}=ne^{3} 'cow' + kɪ^{3}-dza=ɛ^{1} 'meat')
'cow meat' (Schuh 1995b, 138)

b. ɔ^{4}-kɔ^{3}nyi^{3}me^{3} (**ɔ^{4}**-kɔ^{3}=lɔ^{1} 'fowl' + **o^{4}**-nyi^{3}me^{3} 'man')
'male chicken'

The tolerated disharmony in loans and compounds is accounted for straightforwardly by this analysis. In both cases, the highly-weighted root faithfulness constraints preserves the disharmonic forms[34]. The fact that prefixes and clitics agree with the adjacent vowel is also predicted by the analysis developed above, since AGREE is assessed over pairs of adjacent vowels. The clitics need only agree in [ATR] with the nearest vowel to satisfy this constraint.

3.6.7 Why not ranked constraints?

If these constraints were ranked, as in classical OT, rather than weighted, it would not be possible to account for resistance to harmony of low vowels in clitics while still allowing harmony for non-low vowel clitics. For the attested surface form of [e^{3}gbo^{3}la^{1}] 'chairs' to surface, CRISPEDGE(PrWd) must outrank AGREE(ATR):

---

[34] A possible complication is that this requires assuming that the inputs for loan words are fully specified for [ATR] for all vowels.

(71)

/[A-√gbo]=la/	*LoATR	Faith (root)	CrispEdge (PrWd)	Agree (ATR)	Id(lo)
☞ a. [e-gbo]=la				*	*
b. [e-gbo]=le			*!		**
c. [a-gbo]=la				**!	

Even though the winning form violates Agree, since it is ranked above Ident(low) it is preferred to the candidate in which neither the prefix nor the clitic harmonize. As the following tableau shows, ranking Agree over CrispEdge prefers full harmony for both the prefix and the clitic vowels:

(72)

/[A-√gbo]=la/	*LoATR	Faith (root)	Agree (ATR)	CrispEdge (PrWd)	Id(lo)
☹ a. [e-gbo]=la			*!		*
💣 b. [e-gbo]=le				*	**
c. [a-gbo]=la			*!*		

However, ranking CrispEdge above Agree yields the wrong form for mid vowel clitics. In this case, since CrispEdge is violated when a feature is shared across a prosodic word boundary regardless of whether there is also a change in the value of [low]:

(73)

/[kI-√ku]=yɛ/	*Lo/ ATR	Faith (root)	CrispEdge (PrWd)	Agree (ATR)	Id(lo)
☹ a. [ki-ku]=ye			*!		
💣 b. [ki-ku]=yɛ				*	
c. [kɪ-ku]=ye			*!	*	
d. [kɪ-kʊ]=yɛ		*!			

What the grammar developed above captures is the fact that a vowel can have one of these properties, but due to the low weight of the constraints associated with these properties, it will not be sufficient for that vowel to “escape” harmony, so to speak. However, if a vowel has any two or more of these properties, the combined weights of the constraints is enough to outweigh the constraint enforcing harmony[35].

3.6.8 What's so special about low vowels?

The analysis developed in this section of the asymmetry in harmony behavior of low vowels is completely driven by phonology – specifically, by a dispreference for the additional feature change involved in the alternation between [a]/[e] as compared to other [ATR] pairs. However, an alterate explanation for the exceptional behavior of [a] in the harmony system of Avatime could appeal to phonetic knowledge. Here there is an interesting parallel to the case of Swedish. Löfstedt (2010) describes the interaction between a process of consonant coalescence and vowel lengthening and tensing. The basic pattern[36] involves the coalescence of /r/ with a following voiced coronal stop, compensatory lengthening of the preceding vowel, which then triggers tensing of that vowel. The process is schematicized in (74):

(74) /V_{LAX}rd/ → [V_{TENSE}:ɖ]

However, for two underlying lax vowels, the process is blocked:

(75)	a.	/b**ø**$_L$rd/	→	[b**ø**$_T$:ɖ]	* [bø$_L$rd]	'table'
	b.	/g**a**$_L$rd/	→	[g**a**$_L$rd]	^{OK}[gɑ$_T$:ɖ]	'guard'
	c.	/k**ɵ**$_L$rd/	→	[k**ɵ**$_L$rd]	*[kʉ$_T$:ɖ]	'Kurd'

For underlying /a/ and /ɵ/, coalescence is either optionally (in the case of /a/) or obligatorily (in the case of /ɵ/) blocked. Löfstedt's analysis is based on the P-Map (Steriade 2001; 2008; Zuraw 2007). Löfstedt shows that, of all the Swedish lax/tense pairs, the perceptual distance (based on

[35]An alternative approach would be to use four conjoined constraints (Smolensky 1993; Kirchner 1996; Gnanadesikan 1997). In this type of analysis ID(lo) would be conjoined with CRISPEDGE, with Faith[E], and with AGREE(ATR). It would also be necessary for FAITH[E] and CRISPEDGE to be conjoined to account for the behavior of the exceptional mid vowels.

[36] For clarity, this explanation is a simplified version of the whole process that Löfstedt describes.

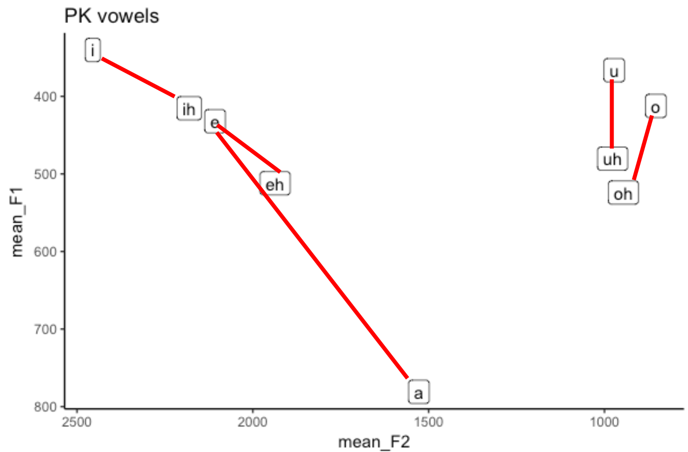
F1/F2) between [a]/[ɑ] and [ɵ]/[ʉ] is the greatest. This means that alternations involving these two pairs will always be more marked than alternation between other tense/lax pairs. He explains the resistance of these vowels to the alternation in (75) by interleaving the preference for consonant coalescence[37] within the fixed hierarchy of preferences for tense/lax vowel alternations. The preference to coalesce is less important than avoiding [a]/[ɑ], [ɵ]/[ʉ] alternation, but more important than avoiding any other vowel alternation. The order of preferences in the Swedish grammar can be thought of as (76):

(76) *a → ɑ >> *ɵ → ʉ >> consonant coalescence >> …*$ø_L$ → $ø_T$ …

A similar approach can be taken for Avatime. Of all the harmony pairs, the perceptual distance between [a]/[e] can safely be assumed to larger than between any other pair. For example, Figure 14 shows a plot of the formant values for a male Avatime speaker. It is clear even from this preliminary analysis that, of all the ATR harmony pairs, [a] and [e] are separated by the greatest distance. While the analysis developed below does not appeal directly to the P-Map as Löfstedt does for Swedish, the perceptual distance between [a]/[e] provides motivation for the resistance to harmony of low vowels in clitics. In my analysis a P-Map constraint such as *MAP(a~e) would take the place of ID(lo) as the constraint dispreferring the re-pairing of [a] with [e] in harmonic contexts.

[37] Captured formally by a number of markedness constraints

Figure 14: Average formant values for Avatime speaker



3.7 Opacity

I've argued for why /a/ resists harmony in post-root material, but **may** undergo harmony in prefixes. The cause for this asymmetry in the possibility of low-vowel harmony is the difference in morphological status of pre-root and post-root material – apparent "suffixes" are actually enclitics. Due to the specific nature of the [a]~[e] harmony pair, the differing prosodic status of clitics is enough to block harmony for only this pair, while allowing other vowels to participate in harmony. In this section, I will discuss an additional complication in analyzing the harmony behavior of [a] – opacity related to the interaction of hiatus resolution and [ATR] harmony in nouns. Beyond providing evidence for the prosodic status of enclitics, hiatus resolution also interacts with [ATR] harmony in creating opaque surface forms. As discussed above in 3.4.5, in nouns, a definiteness clitic of the shape =V can cause a root vowel to be deleted, depending on the noun class and the root and clitic vowels. In noun classes which select the definiteness clitic /=a/, a mid front root vowel ([e] or [ɛ]) is always deleted. In these cases, the noun class prefix still harmonizes with the [ATR] value of the root, rather than with the [ATR] value of the clitic. This is exemplified in the definite form of the word 'house'. The non-cliticized form of house is [ke^3-pe^3], as shown in (77).

(77) trɛ^{3} ni^{4} **ke^{3}-pe^{4}** kɛ^{4}-ya^{3}=mɛ^{1}
go LOC CL-house CL-PROX=inside
'Go to this house' (van Putten 2014: 40)

The noun class prefix associated with the noun class of 'house' is /kA-/. Nouns of this class with [-ATR] root vowels are produced with the prefix [ka-] (e.g. [ka-drʊ̀ɪ] 'dog'). This means that the [+ATR] vowel in the prefix [ke-] in 'house' is derived via harmony with the vowel of the root. As mentioned above, when the definiteness clitic /=a/ appears at the right edge of the root in this noun class, if the root final vowel is [e] or [ɛ], it is always elided. This means that when the noun 'house' appears with the definiteness clitic at the right edge, the root vowel will be elided, leaving the surface form [ke-pà]:

(78) [ke^{3}pa^{1}] '(the house)'
/kA^{3}-pe^{3}=a^{1}/ → ke^{3}-p∅=a^{1}
CL-house=DEF

In the form that is actually pronounced, the syllable adjacent to the noun class prefix has a [-ATR] vowel [a], but the prefix remains in the [+ATR] form. In roots, [a] behaves as [-ATR] – noun class prefixes appear in their [-ATR] forms in roots with this vowel. So, it is unlikely that the enclitic [a] is behaving as a neutral vowel, with the [+ATR] prefix vowel serving as some kind default in the absence of root vowel to harmonize with. The root /-ʊa^{3}-/ 'bean', for example, selects [-ATR] prefixes and enclitics.

(79) a. **a^{4}**-ʊa^{3}=na^{1} (*e^{4}-ʊa^{3}=na^{1})
CL-bean=DEF
'(the) beans'

b. **lɪ^{4}**-ʊa^{3}=**nɛ^{1}** (*li^{4}-ʊa^{3}=ne^{1})
CL-bean=DEF
'(the) bean'

A related class of examples come from roots with high vowels. In these roots, when a definiteness clitic of the shape =V appears at the right edge, the root vowel becomes a glide. This is shown for [+ATR] root ‘bowl’, whose root vowel is [i]. ‘Bowl’ is of the same noun class as ‘house’, and so has class prefix /kA-/ and definiteness clitic /=a/. When the definiteness clitic attaches to the right edge of the noun, the root vowel obligatorily undergoes glide formation. In (80), when ‘bowl’ is followed by a numeral, the root vowel is [+ATR] [i], and the noun class prefix harmonizes with it. In (80), when the definiteness clitic attaches to the right edge of the noun, the root vowel becomes a glide, which is not specific for [ATR]. However, as in the case of ‘house’ above, the noun class prefix still appears in its [+ATR] form.

(80)	a.	me^{1}-dzi^{3}	**ke^{1}**-zi^{3}	tye^{1}le^{3}
		1SG.AOR-buy	CL-bowl	one
		‘I bought one bowl’		
	b.	**ke^{1}**-z**y**=a^{3}	kɛ^{3}-wɔ^{3}lɪ^{1}	
		CL-bowl=DEF	CL.AOR-fall	
		‘The bowl fell’		

The above are cases of counterbleeding opacity – the elision of the root vowel appears to happen too late to prevent the vowel of the noun class prefix from harmonizing with it.

3.7.1 Possible analysis

There are number of possibilities for analyzing these cases of opacity. In this section, I will outline one possible analysis. This analysis depends on two representational devices – harmony as autosegmental spreading of [+/-ATR] features, and underspecification of noun class prefix vowels for the feature [ATR].

3.7.1.1 Prefix harmony as “[ATR] stability”

If [ATR] is treated autosegmentally, as I have assumed in the analysis above, cases such as [kepà] can be analyzed analogously to cases of tonal stability (Goldsmith 1976). In these cases, the noun root is associated with a [+ATR] autosegment. When the segmental timing slot is deleted in order to resolve hiatus with the enclitic, this autosegment is preserved and associates with the prefix. This is shown schematically in (81).

(81)

	[+ATR] | pe
Root lexical entry:	
	[+ATR] ⁄ ke-p∅=a
Hiatus resolution:	

The above is not intended to illustrate the application of a series of autosegmental rules (spreading, deletion of vowel timing slot, etc.), but rather to show what representations are assumed under this analysis for the underlying form of the root and for the candidate preferred by the harmonic grammar developed in 3.6. Under these assumptions, the opacity of harmony in noun class prefixes can be analyzed straightforwardly as faithfulness to an [ATR] specification present in the lexical entry for noun roots. A highly weighted MAX constraint penalizing the deletion of an [ATR] autosegment would predict that this feature would be preserved and associated with the noun class prefix in cases of deletion or glide formation of the root vowel.

(82) MAX-[ATR] Assess a violation for each [ATR] autosegment in the input that does not correspond to an [ATR] autosegment in the output

The effect of this constraint in accounting for the opaque pattern of harmony in noun class prefixes is shown in (83). This tableau assumes a highly weighted *V.V constraint that drives hiatus resolution, so no candidates violating this constraint are shown. In the winning candidate, the [+ATR] autosegment that was associated with the lexical entry of the root is preserved and associates with the vowel of the prefix.

(83)

[+ATR] [-ATR] /kA-√pe=a/	ID(lo)	CRISPEDGE (PrWd)	AGREE (ATR)	*LOATR	IDENT-(ATR) root	MAX (ATR)	H
weight:	2	2	2	10	20	5	
[+ATR][-ATR] ☞ a. [ke-p=a]	1		1				4
[-ATR] b. [ka-p=a]		?[38]				1	5
[-ATR] c. [kɛ-p=a]	1	?				1	7
[+ATR] d. [ke-p=e]	2	?				1	7

The preference to preserve the [ATR] value associated with the root, even when its vowel is elided may be better thought of as a case of positional faithfulness (Beckman 1998), enforced by a root-specific faithfulness constraint, rather than the general faithfulness constraint. If the mechanism of [ATR] harmony is autosegmental spreading, and if (at least direct object) clitics are underlyingly specified as [-ATR], then the straightforward cases of harmony affecting mid vowel clitics would involve the deletion of the [-ATR] feature associated with them.

3.7.2 Complications

There are also cases of hiatus resolution in possessive constructions involving kin terms and postpositional constructions that may complicate the analysis further. Possessive constructions in Avatime are of the form N1 N2, where N1 is the possessor and N2 the possessum. There is no dedicated possessive morpheme. When the possessor is pronominal, one of the independent pronouns (the same set as seen in direct objects and focused subjects) appears as N1. The

[38] I do not take a position on how hiatus resolution interacts with the prosodic word structure argued for above. So, it is left for future study whether the prosodic word boundaries in a form with the morphological structure [ke-p=a] can be misaligned with the syllable boundaries ((ke-p)=a). Crucially, even without violations of CRISPEDGE, candidates (b) and (c) have higher harmony penalties that the winning candidate (a).

possessive pronouns of Avatime are given in Table 28. As mentioned above, all independent pronouns have [-ATR] vowels.

Table 28: Avatime possessive pronouns

	singular	Plural
1	mɛ	blɔ
2	wɔ	mlɔ
3	yɛ	ba

When the possessed noun is vowel initial, or its noun class marker has an initial [b] – which in this context is deleted intervocalically – hiatus between the final vowel of the pronoun and initial vowel of the noun can be resolved by elision of one of the two vowels. Schuh discusses paradigms of nouns with pronominal possessors collected by Funke (1909). Of particular interest are the forms in the columns for ‘mother’. In these forms, the [-ATR] feature associated with the pronoun is deleted in favor of retaining the [+ATR] associated with the noun class prefix [o]. Under the analysis developed above, it is unclear why the [-ATR] feature should be deleted, since the [+ATR] feature associated with the prefix would be the same one associated to the root, and so a form like hypothetical [mɔne] would not violate any version of MAX[39].

Table 29: Possessed forms of kin terms – Funke 1909 (table adapted from Schuh 1995a)

	ba-ka=ba ‘fathers’	o-ne ‘mother’	be-ne=ba ‘mothers’	a-gba ‘houses’	ɔ-nyɔ ‘time’	i-nyɔ ‘times’
1 singular	makaba	mone	mɛneba	magba	mɔnyɔ	mɛnyɔ
2 singular	wɔakaba	wone	wɔeneba	wagba	wɔnyɔ	wɔnyɔ
3 singular	yeakaba	yene	yɛneba	yagba	yɔnyɔ	yɛnyɔ
1 plural	blakaba	blone	blɔenba	blagba	blɔnyɔ	blɔnyɔ
2 plural	mlakaba	mlone	mlɔeneba	mlagba	mlɔnyɔ	mlɔnyɔ
3 plural	bakaba	bane	beneba	bagba	banyɔ	bɛnyɔ

[39] An additional question raised by the possessed forms of ‘mother’ is the prosodic structure. The hiatus resolution pattern is the same as that found within prosodic words, for example in the definiteness markers discussed in 3.4.5. If these possessive markers are within the same prosodic word as the head noun, then it would be expected that their vowels would harmonize. However, [bane] ‘their mother’ shows no harmony of the possessive morpheme. One possibility is that this has to do with the fact that these appear to be inalienable possessive constructions. Other languages (e.g. Ojibwe, (Newell & Piggott 2014) are known to exhibit different phonological behavior in inalienable vs. alienable possessive constructions. In future work, I plan to check these possessive paradigms to determine how they affect the analysis developed here.

The forms for ‘mothers’, on the other hand, show the opposite pattern – the [-ATR] feature associated with the possessive pronoun is retained when hiatus is resolved.

Schuh also discusses forms with the postposition /-ese/ ‘under’ that exhibit this second pattern, in which a vowel in a morpheme that harmonizes with the root is elided. One such form is [sɪwas**e**se], composed of the noun+definiteness clitic [sɪ-wa=s**ɛ**] ‘(the) grass’ and postposition [-**e**se] ‘under’ (Schuh 1995a, 52). In [sɪ-wa=sɛ], the definiteness clitic harmonizes with the [-ATR] root [-wa-], but when the vowel of this clitic is elided to resolve hiatus (/sɪ-wa=s**ɛ-e**se/), the remaining vowel is [+ATR] ([sɪ-wa=s**e**se]).

I have not collected systematic data bearing on these constructions, but it is clear that they will be crucial in extending the analysis of both [ATR] harmony and prosodic structure in Avatime.

3.8 Conclusions

In this chapter, I have shown that the system of [ATR] harmony in Avatime can be analyzed by the interaction of weighted constraints. In particular, the asymmetry in the behavior of the low vowel in prefixes versus enclitics is argued to be the result of an interaction between prosodic structure and a dispreference for the additional feature change required for the low vowel to alternate with its harmony partner, the mid vowel [e]. In prefixes, the low vowel is in the same minimal prosodic word as the root with which it harmonizes, and the weight of the constraint penalizing a change in the feature [low] is insufficient to prevent harmony. Harmony at the root-clitic boundary was argued to cross a prosodic word boundary. The additional harmony penalty incurred by sharing a feature across this boundary explains the failure of the low vowel to undergo harmony in enclitics. I also argued that this same logic can explain low vowel prefixes that exceptionally resist harmony, as well as non-low vowel “suffixes” that also resist harmony.

These morphemes are lexically-specified exceptions, and the weight of a lexically-specific faithfulness constraint combines with the weight of constraints against changing the feature [low] (in the case of exceptional low vowel prefixes) and against sharing features across a prosodic word boundary (in the case of exceptional non-low vowel suffixes). The overall pattern captured by this grammar is that a vowel must have at least two harmony-resisting properties (low vowel, across prosodic word boundary from root, lexical exception) to actually fail to undergo harmony. This type of pattern cannot be captured by ranked constraints, and so provides support for weighted constraints in phonological grammar.

The interaction between hiatus resolution and [ATR] harmony is a promising area for further study, as it will be revealing both for the analysis of opacity in the harmony patterns in noun class prefixes, and for understanding the prosodic structure of Avatime. Extending the analysis to capture the patterns discussed briefly in §3.7 will be of particular interest, since they present cases that could bear on the possibility for prosodic word boundaries to be misaligned with syllabic boundaries.

4 TONE SANDHI AS ALLOMORPH SELECTION

A prominent feature of Avatime tone, which has been noted in earlier work (especially Ford (1971; 1986)), is a sandhi phenomenon affecting verbs. This process is affected by both phonological and morphological context, and applies differently to verbs in (semi-)arbitrary lexical classes. In addition to its conditioning, the sandhi pattern is a chain shift – it involves the raising of tones one "step". I will refer to the process as *tone raising*. The complex interaction between phonological, morphological, and lexical factors in determining the outcome of tone raising present a challenge to phonological theory. This chapter seeks to bring together observations from previous research on Avatime tone raising, update the empirical picture with data from my own fieldwork, and situate this process within contemporary theories of tone and the phonology-morphology interface. In the end I propose that Avatime tone raising is a case of phonologically-conditioned allomorphy, using the framework of McPherson (2019).

4.1 Avatime verbs – tone and morphology

Avatime has four tones, given again in Table 30. One of these, the Mid tone (marked here as tone 2), is marginal. Schuh (1995a) found that this tone frequently merged with tone 3 (the high tone), even at the time of his work in Amedzofe. In more recent work, Defina (2016a,b) and van Putten (2014) only mark three tones, with the mid tone (tone 2) absent. In my fieldwork, I have found that tone 2 is marginal, but does still appear in a limited set of contexts, although it is much more frequently merged with tone 3. Therefore, I do mark tone 2 where it appears, despite its infrequency. In addition to the level tones, there is a contour tone that rises from tone 1 to tone 4. At least one verbal prefix may also have a falling contour from tone 4 to tone 1. This contour does not appear elsewhere in the language, and it is unclear whether the vowel of the prefix can be analyzed as a long vowel bearing two level tones.

Table 30: Avatime tones, repeated from 1.2.2.2

Tone	Representation
Low (tone 1)	a^1
Mid (tone 2)	a^2
High (tone 3)	a^3
Extra High (tone 4)	a^4

There are limits on the distribution of these tones, especially in the nominal domain. Tone 2 never appears on prefixes, and tone 4 never appears on underived native roots. Schuh takes this as suggesting that diachronically, Avatime developed the present four-tone system from an earlier two-tone system:

> "With these distributional facts in mind, an internal reconstruction of the Avatime tone system suggests that Avatime originally had only two tones (corresponding to Ford's tones 1 and 3) and that tones 2 and 4 were originally derived from tones 1 and 3 respectively by register raising processes."
>
> (Schuh 1995a: 60)

This possibility of the introduction of a tone intervening between tones 1 and 3 is interesting given the basic tone raising pattern described below. Even in Ford's description, when tone 2 was presumably still well-established in the language, it was never the output of tone raising. Since, as we will see, tone raising is a chain shift in which the output tone is one "step" higher than the input tone, tone 2 must be "skipped" in the tone raising system. This raises the question of whether the tone raising pattern in Avatime is a case of saltation (Hayes & White 2015).

4.1.1 Verbal morphology

Table 31 summarizes the aspect/mood/polarity prefixes that appear in this chapter. Note that the aorist affirmative affix is included in the table as null. This is because in the aorist affirmative, the only inflection is the subject agreement prefix, which varies by noun class. For all other prefixes, there is both a segmental and a tonal specification, and the tone of these morphemes is invariant – that is, they are not affected by tone raising.

Table 31: Aspect/mood/polarity prefixes in Avatime[40]

Morpheme	Gloss
∅^{4}-	negation
-EE^{14}-/-II^{14}-	progressive
-(i)aa^{41}-	potential
-ta^{4}-	intentive
∅^{4}-zE^{14}-	habitual
-zE^{3}-	recurrent
-∅-	aorist

This is not an exhaustive list of inflectional morphemes in Avatime, but does account for the most frequent forms. For a detailed study of aspect, mood, and polarity in Avatime, see Defina (2009). There are some dialect differences between speakers in different Avatime villages, but the overall verb inflection system is consistent across dialects. Person agreement prefixes in the affirmative aorist can have either tone 1 or tone 3. For non-human subjects, this tone is determined by the noun class of the subject. For human subjects, the tone of the third person singular prefix is tone 3. As also shown by van Putten (2014), the first person singular subject prefix has a polar tone – when the verb root has tone 1, it appears as tone 3 and when the verb root has tone 3, it appears as tone 1. This is one of a number of instances of polar tone in Avatime phonology. However, in my data, speakers vary in their application of tonal polarity for the first person singular subject agreement prefix - it is possible for the first person singular agreement prefix to have tone 1 preceding a tone 1 root. The *tone* of the noun class prefix of the subject may also play a role in determining the tone of the subject agreement prefix. Ford gives the following contrast:

[40] Notation of the form [∅^{4}] represents a floating tone at the level of the superscript numeral. So, negation is marked by a floating tone 4 prefix, while the habitual is marked by a segmental prefix and obligatory tone 4 on the prefix to the left of it, which I analyze as a floating tone.

(84) Tonal concord in subject agreement (Ford 1971: 49)

a.	ki^{3}-ku^{1}	ki^{3}-li^{4}	ni^{4}	ɔ^{1}-kplɔ̃^{2}-nɔ^{1}	a^{3}βa^{1}
	CL-yam	CNC-be	LOC	CL-table-DEF	top
	‘there is a yam on the table’				
b.	ki^{1}-ku^{1}	ki^{1}-li^{4}	ni^{4}	ɔ^{1}-kplɔ̃^{2}-nɔ^{1}	a^{3}βa^{1}
	CL-rubber	CNC-be	LOC	CL-table-DEF	top
	‘there is a piece of rubber on the table’				

‘Yam’ and ‘rubber’ are in the same noun class, but have different tones on the class prefix. The tone of the concord prefix on *-li^{3}* ‘be located’ agrees with the tone of the noun class prefix of the subject. In my initial investigation of this phenomenon, I have found conflicting evidence. In locational verbs like ‘be located’, my preliminary data aligns with Ford’s. However, for other types of verbs, speakers I worked with did not have tonal concord. In the description of the classes of verbs by tone raising behavior below, I will focus on the third person singular aorist form as a constant reference across the classes.

4.2 Tone raising

In this section, I will provide data illustrating the basic features of tone raising in Avatime.

4.2.1 Data

The data presented in this chapter come from elicitation done with speakers in Summer 2019 and Fall 2022. There were two primary contexts in which the verbs were elicited. The majority of examples were elicted in sentential contexts by translation from English. The sentential contexts varied according to the verb – there was not a fixed carrier phrase. However, as much as possible, I attempted to control for the material following the verbs, using the same direct objects and adverbs where pragmatically possible. Some examples were produced by speakers reading a written list of sentences accompanied by English translations.

4.2.2 Basic pattern

Verb roots participate in a sandhi process in certain environments. The basic pattern is: when a root is followed by tone 3 or tone 4, raise tone 1 to tone 3, raise tone 3 to tone 4:

(85) Basic tone raising pattern

a. *Following tone 2 – root tone 1, prefix tone 3*
a^{3}-mɔ^{1}=wɛ^{2}
3SG.AOR-see=it
'He saw it'

b. *Following tone 3 – root tone 3, prefix tone 4*
a^{4}-mɔ^{3}=yɛ^{3}
3SG.AOR-see=3SG
'He saw him'

As shown in (85), raising can affect prefixes as well as roots. The analysis of raising on prefixes will be discussed in more detail below. The pattern shown in (85) demonstrates the basic elements of the tone-raising process. However, this pattern only accounts for a small subset of verb roots. Avatime verb roots (as well as noun roots, with some exceptions such as loanwords and compounds) may have either tone 1 or tone 3 underlyingly[41], and may be either monosyllabic or disyllabic. This means there are 6 possible underlying melodies on verb roots: 1, 3; 1 1, 3 3, 1 3, 3 1[42]. Within these melodies, there is a further division into tone classes based on how tone raising affects the roots in each class. In many cases, the tone class membership of a root is completely arbitrary and unpredictable. Examples of the tone classes and how they participate (or not) in tone raising will be given in 4.3. As an introduction to the division of roots

---

[41] Or, as their elsewhere allomorph, as discussed below.

[42] Ford (1971a) lists two verbs with tone 2 – za^{2} 'pass, overtake' and di^{2} 'be sitting'. For speakers I have worked with, these verbs have tone 3. Verbs of this class do not participate in sandhi regardless of their non-sandhi tone, so they will not be considered further.

by raising behavior, the following table shows the unraised and raised form of a selection of tone classes[43]:

Table 32: Division of roots by tone raising behavior

	Root	/ ___ {1,2}, #	/ ____ {3,4}			Gloss
Raising	a. ta^1	a^3-ta^1	a^4-ta^3	*Root tone(s) raise*	*Prefix tone raises*	chew
	b. ŋa^1	a^3-ŋa^1	a^4-ŋa^3			eat
	c. mɔ^1	a^3-mɔ^1	a^4-mɔ^3			see
	d. kpo^1	e^3-kpo^1	e^4-kpo^3			hide
	e. pe^1	e^3-pe^1	e^4-pe^3			get tired
	f. dze^3	e^3-dze^3	e^4-dze^4			forget
	g. ʋi^3	e^3-ʋi^3	e^4-ʋi^4			ask
	h. bɔ^3	a^3-bɔ^3	a^4-bɔ^4			slap
	i. xwa^{1}lɪ^3	a^3-xwa^{1}lɪ^3	a^4-xwa^{3}lɪ^4			scratch
	j. wa^{1}wɪ^3	a^3-wa^{1}wɪ^3	a^4-wa^{3}wɪ^4			play
	k. zi^{3}zi^1	e^3-zi^{3}zi^1	e^4-zi^4-zi^3			spoil
	l. lʊ^{3}lɔ^1	a^3-lʊ^{3}lɔ^1	a^4-lʊ^{4}lɔ^3			repair
	m. tɔ^3	a^3-tɔ^3	a^3-tɔ^4		*Prefix tone invariant*	cook
	n. pɛ^3	a^3-pɛ^3	a^3-pɛ^4			seek
	o. ne^{3}mi^1	e^3-ne^{3}mi^1	e^3-ne^{4}mi^3			bite
	p. ku^{3}si^1	e^3-ku^{3}si^1	e^3-ku^{4}si^3			beat
	q. tsrɛ^3	a^4-tsrɛ^3	a^4-tsrɛ^3	*Root tone invariant*	*Prefix tone raises*	change
	r. wlo^3	e^4-wlo^3	e^4-wlo^3			swim
Non-raising	s. vu^1	e^3-vu^1	e^3-vu^1			catch
	t. to^3	e^3-to^3	e^3-to^3			pound
	u. ka^{1}ka^1	a^3-ka^{1}ka^1	a^3-ka^{1}ka^1			spread
	v. fe^{3}ke^3	e^3-fe^{3}ke^3	e^3-fe^{3}ke^3			lift
	w. ba^{1}sɛ^3	a^3-ba^{1}sɛ^3	a^3-ba^{1}sɛ^3			teach
	x. me^{3}ni^1	e^3-me^{3}ni^1	e^3-me^{3}ni^1			deceive

4.2.3 Factors affecting tone raising

The number of syllables and underlying tonal melody of a root is the primary determining factor in how a root will be affected by the tone raising process. However, as outlined above, tone raising is subject to three types of conditioning: phonological, morphosyntactic, and lexical. This

[43] Some classes are represented by multiple examples in this table – it is not intended to be an exhaustive listing of the tone classes, but rather an illustration of the range of possible tonal behaviors.

section will provide an overview of the effects of each of the three factors involved in the determination of tone raising.

4.2.3.1 Phonological conditioning

There are two types of phonological conditioning relevant to tone raising. The first is the phonological context in which a root appears. For verbs, the triggering environment for tone raising is a following tone 3 or 4 – that is, a tone that is [+high] according to the feature system in. This can be seen for the root *ŋa^1 'eat'* in 0. When the root is followed by a low tone object (86), the root appears with a low tone, and the prefix with a high tone. When followed by a high tone (86), raising proceeds iteratively, with the root tone and prefix tone raising.

(86)	a.	a^3-<u>ŋa^1</u>	bla^{1}lɪ=ɛ^3	verb followed by low tone, no raising
		3SG.AOR-eat	plantain=DEF	
		'She ate plantain'		
	b.	**a^4-<u>ŋa^3</u>**	ki^3-ku=ye^3	*verb followed by high tone, root and prefix raise*
		3SG.AOR-eat	CL-yam=DEF	
		'She ate yam'		

The second type of phonological conditioning of tone raising involves the root-initial consonant. In many cases, the initial consonant type of a root partially determines which tone raising class it will fall into. The best example of this type of conditioning is found with low toned, monosyllabic verb roots. Among these, tone class membership is determined solely by initial consonant type. Specifically, roots with initial voiceless obstruents (87) or with initial sonorants (87) will participate in raising, while roots with initial voiced obstruents (87) or with initial clusters (87) will never participate in raising. This is a pattern that was first noted by (Ford 1971).

(87) Tone raising by root-initial consonant type

a.	a^{4}-tsa^{3} ki^{3}-ku=ye^{3}	*/tsa^{1}/ 'cut'*
b.	a^{4}-ta^{3} kɪ^{3}-mɪ^{3}mɪ=ɛ^{1}	*/ta^{1}/ 'chew'*
c.	e^{4}-kpo^{3} zĩĩĩĩ^{3333}	*/kpo^{1}/ 'hide'*
d.	a^{4}-ŋa^{3} ki^{3}-ku=ye^{3}	*/ŋa^{1}/ 'eat'*
e.	a^{4}-mɔ^{3} o^{4}-nyi^{3}me^{3}	*/mɔ^{1}/ 'see'*
f.	e^{3}-vu^{1} ɔ^{4}-gbɪ=ɛ^{3}	*/vu^{1}/ 'catch'*
g.	a^{3}-da^{1} a^{4}-βa^{3}=na^{1}	*/da^{1}/ 'sell'*
h.	a^{3}-kla^{1} ke^{3}-ple^{3}kpa^{1}	*/kla^{1}/ 'read'*

Among disyllabic roots and monosyllabic tone 3 roots, consonantal conditioning still maps partially onto tone raising behavior, but it is not the regular, predictable mapping of monosyllabic tone 1 roots - tone class membership for other verbs must be at least partially lexically determined. Table 33 summarizes the relation between root-initial consonant and tone raising behavior for monosyllabic roots. This classification was first outlined by Ford, and my data aligns with his observations.

Table 33: Consonantal conditioning of raising – monosyllabic roots (Ford 1971)

Basic tone	**Root-initial consonant**	**Raising behavior**
1	T, R	raise root and prefix
	D, CR	no raising
3	T, D, CR	no raising
	T	raise root only
	D, R	raise root and prefix
	CR	raise prefix only
	TR	raise root only; lowering
	DR	raise root and prefix; lowering

T = voiceless obstruent; D = voiced obstruent; R = sonorant; CR = cluster (general); TR = voiceless-initial cluster; DR = voiced-initial cluster

The crucial observation or tone 3 roots is that there is one class which may have any type of root-initial consonant and fail to undergo tone raising. So, for tone 3 roots, it is never predictable whether a root will be a tone raising root or not. However, once it is known that a root undergoes tone raising, it is possible – with the exception of complex onset roots – to predict tone raising behavior from root-initial consonant. However, for roots with singleton onsets, tone 3 roots differ from tone 1 roots in the behavior of voiced obstruents and the patterning of sonorants. For tone 1 roots, voiced obstruents are associated with the absence of tone raising, while for tone 3 roots, they are associated with raising both root and prefix tones. Sonorants in tone 1 roots pattern with the voiceless obstruents, but in tone 3 roots they pattern with the voiced obstruents. This complex interaction between consonants and tones is typologically extremely rare, particularly the patterning of sonorants with both voiced and voiceless obstruents. However, this feature is also found in Ewe (Ansre 1961; Stahlke 1971; Bradshaw 1999). Bradshaw (1999) also discusses the unusual fact that consonants may affect the tone of the vowel preceding them in Ewe. This also has a parallel in the Avatime pattern – the initial consonant of tone 3 roots can determine whether the tone of the *prefix* also undergoes raising. While Ewe and Avatime are not extremely closely related (though both are Kwa languages), Ewe is a regional lingua franca, and all Avatime speakers also speak Ewe.

4.2.3.2 Lexical conditioning

Among the tone 3 monosyllables, as well as the disyllabic roots, tone class membership cannot be solely determined by initial consonant type. For example, two roots like /to^3/ *'pound'* and /tɔ^3/ *'cook'*, which have identical root-initial consonants, may fall into different classes with respect to tone raising. The first, /to^3/, is a non-undergoer (88), while /tɔ^3/ (88) falls into the class that undergoes raising of the root, but not of the prefix.[44]

(88) Tone 3 roots - contrasting raising behavior with identical root-initial consonant

a. e^3-to^3 ki^3-ku=ye^3
3SG.AOR-pound CL-yam=DEF
'He pounded yam'

[44] The different classes and their raising patterns will be discussed in more detail below.

b. a³-t<u>ɔ⁴</u> ki³-ku=ye³
3SG.AOR-cook CL-yam=DEF
'He cooked yam'

In fact, it is possible for verbs be differentiated solely by which tone raising class they fall into. For example, the roots for 'get up' and 'get wet' are homophonous in non-raising contexts – both are produced as [yɔ³] (89). However, when there is a following tone 3, 'get up' fails to undergo raising, while the tones of both the root and prefix raise for 'get wet' (90).

(89) Non-raising context – 'get up' and 'get wet' homophonous
a. ma¹-yɔ³
1SG.AOR-get.up
'I got up'

b. ma¹-yɔ³
1SG.AOR-get.wet
'I got wet'

(90) Raising context – 'get up' fails to undergo raising, 'get wet' raises
a. ma¹-yɔ³ ki³-vo=e³
1SG.AOR-get.up CL-yesterday=DEF
'I got up yesterday'

b. ma¹⁴-yɔ⁴ ki³-vo=e³
1SG.AOR-get.wet CL-yesterday=DEF
'I got wet yesterday'

The same phenomenon in exists in other tone raising classes as well. The roots for 'call' and 'shave' are also homophonous in non-raising contexts, where both verbs are pronounced [xwa³] (91). When followed by tone 3, 'call' undergoes raising of only the verb root, while 'shave' does not undergo raising at all (92). The contrast between these roots was first observed by Ford (1971: 41), but holds for speakers I consulted as well.

(91) Non-raising context – ‘call’ and ‘shave’ homophonous

a. ma^{1}-xwa^{3}=wa^{1}
1SG.AOR-call=3PL
‘I called them’

b. ma^{1}-xwa^{3} ɔ^{1}-ta^{1}mɪ^{3}=nɔ^{1}
1SG.AOR-shave CL-beard=DEF
‘I shaved the beard’

(92) Raising context – ‘shave’ fails to raise tone, ‘call’ undergoes root tone raising

a. ma^{1}-**xwa^{4}**=wɔ^{3}
1SG.AOR-call=2SG
‘I called you’

b. ma^{1}-**xwa^{3}** li^{3}-tu^{3}kpo^{3}=le^{1} ki^{4}=yɛ^{3}
1SG.AOR-shave CL-head=DEF BEN=3SG
‘I shaved his head for him’

Although there are no pairs like ‘call’ and ‘shave’ among the disyllabic roots, it is also the case for these verbs that raising behavior is lexically arbitrary, with consonantal conditioning playing a marginal role within certain classes. For example, roots like /ne^{3}mi^{1}/ *‘bite’* and /me^{3}ni^{1}/ *‘deceive’* fall into different classes, despite having identical non-raised tones, and identical consonants (albeit in a different order).

Table 34: Phonological (near-)identical roots have different tone raising behavior

Root	Basic tone	Initial C	Tone raising?	Gloss
to	3	T	No	pound
tɔ	3	T	Yes	cook
yɔ	3	R	No	get up
yɔ	3	R	Yes	get wet
xwa	3	T	No	shave
xwa	3	T	Yes	call
meni	3 1	R R	No	deceive
nemi	3 1	R R	Yes	bite

4.2.3.3 Morphological conditioning

Among the tone classes that do participate in raising, there is a further distinction between those classes in terms of whether they raise in a restricted set of morphological environments, or whether they raise regardless of morphological context. In some verb classes, tone raising is blocked in certain morphological environments. More specifically, raising is blocked in the presence of certain aspect, mood, and polarity prefixes. Both Ford and van Putten discuss morphological restrictions on tone raising, although their descriptions of the contexts in which raising is blocked are not identical. For Ford, the interaction between tone raising and verbal morphology is as follows:

> "Both rules 3 and 6 [3=raising of tone 3 roots to tone 4, 6=raising of prefix tone] are subject to the same tense/aspect/polarity restrictions, and apply as follows:
>
> in all positive 'tenses', except present continuous,
>
> in no negative 'tenses', except the present continuous.
>
> These are the same 'tenses' in which tonal concord between verb and subject noun is kept" (Ford 1971: 54)

Van Putten (2014) also describes restrictions on the raising of tone 1 roots. For her consultants, tone 1 never undergoes raising in the progressive aspect or negated aorist, but there is variation in whether it does in other moods. Since it is not the focus of van Putten's study, data on this variation is not provided.

(93) Raising in affirmative aorist, but not in negated aorist or progressive

a. a^{4}-ta^{3} ki^{3}-dzya=ɛ^{1} ki^{3}voe^{3}
3SG.AOR-chew CL-meat=DEF yesterday
'He ate meat yesterday'

b. ɔ^{4}-ta^{1} ki^{3}-dzya=ɛ^{1}
3SG.NEG-chew CL-meat=DEF
'He did not eat meat'

c. ɛɛ^{14}-ta^{1} ki^{3}-dzya=ɛ^{1}
3SG.PROG-chew CL-meat=DEF
'He is eating meat'

(adapted from van Putten 2014: 32-33)

(94) Raising in affirmative aorist, negated aorist, and progressive

a. kɪ³-tɔ⁴ kɪ³-mɪ³mɪ=ɛ¹
1PL.AOR-cook CL-rice=DEF
'We cooked rice'

b. ɔ⁴-tɔ⁴ kɪ³-mɪ³mɪ=ɛ¹
3SG.NEG-cook CL-rice=DEF
'She did not cook rice'

c. ɛɛ¹⁴-tɔ⁴ kɪ³-mɪ³mɪ=ɛ¹
3SG.PROG-cook CL-rice=DEF
'She is cooking rice'

(adapted from van Putten 2014: 33-34)

An aspect of the interaction between raising and morphology that can be seen from the preceding examples is the correlation between prefix tone raising and blocking of tone raising. Among monosyllabic roots, the verbs that trigger prefix tone raising, like /ta¹/ are also subject to the blocking of tone raising in some morphological contexts. Verbs like /tɔ³/, which never trigger prefix tone raising, are also never blocked from raising by the presence of any aspect/mood/polarity prefixes.

Considering these descriptions, it is perhaps not surprising that the interaction between tone raising and morphology in the speech of my consultants was different than both Ford's and van Putten's descriptions. It is clear that this interaction is a site of considerable variation across speakers in Avatime. However, at this stage the basic factors at play in determining the raising behavior of Avatime verbs can be visualized as

4.3 Tone classes

In this section, the main verbal tone classes are outlined with examples of their raising behavior. Each class is named by a representative member of that class. For each class, a summary of properties is given: the number of syllables in the verb root, the tonal melody in non-raising contexts and tonal melody in raising contexts. I also show whether verbs of each class are blocked from raising in non-aorist affirmative aspect/mood/polarity forms. The implications of this interaction with verbal morphology for the analysis of tone raising is discussed in §4.6 The result of prefix tone raising differs for other person agreement prefixes, so I present the basic patterns in the third person affirmative aorist, as this prefix acts as a baseline against which to compare other forms. The classes identified in this section are broadly the same as those classes identified by Ford (1971; 1986), but the data comes from my own fieldwork. In some classes, the patterns of tone raising used by the speakers I worked with diverge from the patterns described by Ford. Such cases are noted where they occur.

4.3.1 Monosyllabic roots

As mentioned in the previous section, the overwhelming majority (and for younger speakers, possibly all) of monosyllabic roots may have one of two tones in non-raising contexts: low tone 1 or high tone 3. I will begin the overview of the tone raising classes with a description of the behavior of the monosyllabic roots.

4.3.1.1 CHEW-class

The first class I will consider are tone 1 roots that do undergo raising. Beyond their tone-raising behavior, roots of this class are also characterized by their initial consonants. As first noted by Ford, all verb roots of this class have root-initial voiceless obstruents or sonorants. The tonal properties of this class are summarized in Table 35. For each class, I outline the basic, non-raised tone, whether the root and prefix tones undergo raising, the root-initial consonant type, whether tone raising is blocked by verb morphology, the count of the class of verbs in my data, and the count for the corresponding class given in (Ford 1986).

Table 35: Tonal properties of CHEW-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
CHEW	1		T, R	Y	Y	Y	9	47

The examples in (95) and (96) show the tone raising properties of this class for a voiceless obstruent-initial and a sonorant-initial root, 'chew' and 'see', respectively. For both verbs, when followed by tone 1 or 2, the root has tone 1 and the prefix has tone 3. When the following tone is tone 3, the tone of the root raises from 1 to 3, and the tone of the prefix raises from 3 to 4.

(95) /ta^1/ 'chew'

a. Following tone 1 – root tone 1, prefix tone 3
Ko^{1}fi^3 a^3-**ta^1** **ɪ^1**-kpa^3=lɛ^1
Kofi 3SG.AOR-chew CL-fish=DEF
'Kofi ate fish'

b. *Following tone 3 – root tone raises to 3, prefix tone raises to 4*
Ko^{1}fi^3 **a^4-ta^3** **kɪ^3**-dzɛ^3
Kofi 3SG.AOR-chew meat
'Kofi ate meat;

(96) /mɔ^1/ 'see'

a. *Following tone 1 – root tone 1, prefix tone 3*
a^3-mɔ^1=wɛ^2
3SG.AOR-see=it
'He saw it'

b. *Following tone 3 – root tone raises to 3, prefix tone raises to 4*
a^4-mɔ^3=yɛ^3
3SG.AOR-see=3SG
'He saw him'

Tone raising is not solely a property of transitive verbs – intransitive verbs may also undergo raising when followed by a high tone 3 or extra high tone 4. This is exemplified for the verb 'hide' in (97).

(97) /kpo^{1}/ 'hide'

a. Following tone 1 – root tone 1, prefix tone 3
A^{1}bra^{3} e^{3}-**kpo^{1}** gi^{1}di^{1}gi^{1}di^{1}
Abra 3SG.AOR-hide ID.harshly
'Abra hid harshly/loudly'

b. *Following tone 3 – root tone*
A^{1}bra^{3} e^{4}-kpo^{3} zĩĩĩĩ^{3333}
Abra 3SG.AOR-hide ID.quietly
'Abra hid quietly'

Verbs of this class are blocked from undergoing tone raising in at least the progressive and negated aorist. This is demonstrated for 'chew' and 'hide', but applies to all verbs tested from this class. Full paradigms for each root remain to be collected, but for 'chew', there is also evidence of blocking of tone raising in the potential and habitual forms.

(98) Raising blocked for CHEW

a.	Ko^{1}fi^{3} a^{3}-**ta^{1}** ɪ^{1}-kpa^{3}=lɛ^{1}		*Non-raised form*
b.	Ko^{1}fi^{3} **a^{4}-ta^{3}** **kɪ^{3}**-dzɛ^{3}		*Affirmative aorist*
c.	Ko^{1}fi^{3} ɛɛ^{14}-**ta^{1}** **kɪ^{3}**-dzɛ^{3}		*Progressive*
d.	Ko^{1}fi^{3} aa^{41}-**ta^{1}** **kɪ^{3}**-dzɛ^{3}		*Potential*
e.	Ko^{1}fi^{3} ɪ^{4}-dɛ^{14}-**ta^{1}** **kɪ^{3}**-dzɛ^{3}		*Habitual*

(99) Raising blocked for HIDE

a.	e^{3}-**kpo^{1}**	*Non-raised form*
b.	e^{4}-**kpo^{3}** **zĩĩĩĩ^{3333}**	*Affirmative aorist*
c.	o^{14}-**kpo^{1}** **zĩĩĩĩ^{3333}**	*Negated aorist*

4.3.1.2 CATCH-class

The second class of tone 1 monosyllabic roots never undergoes raising of root or prefix tones, regardless of phonological or morphological context. Roots of this type have initial voiced obstruents or complex onsets. Thus, the tonal behavior of these first classes of monosyllabic root is completely predictable by root-initial consonant type. This could be taken as motivation to consider these verbs as a single class, as no lexical encoding of their tone raising behavior is necessary. I separate them in this section, since I am not yet assigning any grammatical meaning to "class", only demonstrating the range of possible tone raising behaviors. The interaction between root-initial consonants and tone raising behavior will be discussed in more detail below. Table 36 summarizes the tonal properties of this class of verb.

Table 36: Tonal properties of CATCH-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
CATCH	1		D	N	N	N/A	3	48

For verbs with initial voiced obstruents (100) and initial clusters (101), the tone of the verb root is always a low tone 1, regardless of the following tone. The tone of the prefix is also unaffected.

(100) /vu^1/ 'catch'

a. *Following tone 1 – root tone 1, prefix tone 3*
e^3-<u>vu^1</u> ɔ^1-ha^1=lɔ^3
3SG.AOR-catch CL-pig=DEF
'He caught the pig'

b. *Following tone 3 – root and prefix tones unaffected*
e^3-<u>vu^1</u> o^3-ze^3
3SG.AOR-catch CL-thief.DEF
'He caught the thief'

(101) /kla^{1}/ 'read'

a. Following tone 1 – root tone 1, prefix tone 3

a^{3}-**<u>kla^{1}</u>** ku^{1}-ple^{3}kpa^{1}
3SG.AOR-read CL.PL-book:DEF
'She read books'

b. *Following tone 3 – root and prefix tones unaffected*

a^{3}-**<u>kla^{1}</u>** ke^{3}-ple^{3}kpa^{1}
3SG.AOR-read CL-book:DEF
'She read the book'

4.3.1.3 SLAP-class

Monosyllabic roots with tone 3 in non-raising contexts show significantly more variation in their tonal behavior. The first class we will consider undergoes raising of both the root and prefix tones when the following tone is tone 3 or 4.

Table 37: Tonal properties of SLAP-class verbs

Example	Root tones		Initial C	Root tone raises?	Prefix tone raises?	Verb morphology blocks?	Count	Count (Ford)
	First syllable	*Second syllable*						
SLAP	3		D, R	Y	Y	Y	6	23

When followed by tone 1 or 2, both the root and prefix have tone 3 (102). When followed by tone 3 or 4, both root and prefix tones raise to tone 4 (102).

(102) /bɔ^{3}/ 'slap'

a. Following tone 1 – root tone 3, prefix tone 3

Ko^{1}fi^{3} **a^{3}-<u>bɔ^{3}</u>**=wa^{1} o^{3}-su^{3}mu=e^{3}
Kofi 3SG.AOR-slap=3PL CL-slap=DEF
'Kofi slapped them'

b. Following tone 3 – root tone 4, prefix tone 4

Ko^{1}fi^{3} **a^{4}-<u>bɔ^{4}</u>=mɛ^{3}** o^{3}-su^{3}mu=e^{3}
Kofi 3SG.AOR-slap=1SG CL-slap=DEF
'Kofi slapped me'

Verbs of this class may also be blocked from raising in non-aorist affirmative contexts. The full range of possible inflectional paradigms remains to be tested, but the following example shows the blocking of tone raising for ‘slap’ in the progressive, intentive and negated aorist forms

(103) Raising blocked for SLAP

a. Ko^{1}fi^{3} εε^{14}-bɔ^{4}=mε^{3} o^{3}-su^{3}mu=e^{3} *Progressive*

b. Ko^{1}fi^{3} a^{3}-tra^{4}-bɔ^{3}=mε^{3} o^{3}-su^{3}mu=e^{3} *Intentive*

c. Ko^{1}fi^{3} ɔ^{14}-bɔ^{3}=mε^{3} o^{3}-su^{3}mu=e^{3} *Negated aorist*

4.3.1.4 COOK-class

Verbs of this class also undergo tone raising of the root, but in contrast with SLAP-class verbs, do not trigger tone raising on prefixes. This pattern was first identified by Ford (1971) and supported by van Putten (2014). The behavior of these roots is summarized in Table 38.

Table 38: Tonal properties of COOK-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
COOK	3		T	Y	N	N	6	20

There is a major difference between the pattern described in previous research and the pattern shown by the speaker I consulted in the behavior of verbs of this class. Previous descriptions show the tone of the verb root only undergoing raising when they are in the same phonological environment that triggers raising for other classes, namely when preceding a tone 3 or tone 4. However, I have found that there is a tendency for these roots to appear with tone 4 even when followed by a morpheme with tone 1 or tone 2. For example, the verb ‘cook’ is frequently produced with tone 4 preceding both a tone 3-initial object as in (104) and preceding a tone 1-initial object as in (104).

(104) /tɔ^{3}/ ‘cook’

a. Following tone 1 – root tone 4, prefix tone 3
a^{3}-**tɔ^{4}** **bla^{1}**li=e^{3}
3SG.AOR-cook plantain=DEF
‘She cooked plantain’

b. Following tone 3 – root tone 4, prefix tone 3
a^{3}-**tɔ^{4}** **ki^{3}**-ku^{1}=ye^{3} ka^{3}-kʊ^{3}pa^{1}
3SG.AOR-cook CL-yam=DEF CL-slice.DEF
‘She cooked yam slice’

This root does not always appear with tone 4. Avatime has wh-movement, and when the wh-object of ‘cook’ is moved to the left edge, it appears with tone 3 (which forms a falling contour with the right-edge low tone associated with wh-questions).

(105) e^{3}ge^{4} a^{3}-tɔ^{31}?
what.FOC 3SG.AOR-cook
‘What did she cook?

Another verb of this class that shows “unconditioned” tone raising is *pɛ^{4}* ‘seek, want’. For this verb, evidence that it is simply a tone 4 root comes from cases in which it takes a CP complement.

(106) ‘want’ with CP complement
ma^{1}-pɛ^{3} si^{1} mɪ^{4}-tɔ^{4} o^{1}-no^{1}
1SG.AOR-want COMP 1.SBJ-cook CL-soup
‘I want to cook soup’

It is unclear how strong the tendency to raise the root tone even before tones 1 and 3 for verbs of the COOK type is, and whether it is a case of inter- or intraspeaker variation, language change, or even related to the elicitation task that is the primary source of the data in this chapter. A trend that I have noted, at least anecdotally, is that unconditioned tone raising seems to be less frequent when the verb is followed by a pronominal clitic object rather than a full nominal object.

Consider for example the verb tones for ‘call’. In these examples, the verb roots are followed by pronominal objects, and the tone of the root only raises when the following tone is a high tone 3.

(107) /xwa^{3}/ ‘call’

a. ma^{1}-xwa^{3}=wa^{2}
1sg.aor-call=3pl
‘I called them’

b. ma^{1}-xwa^{4}=wɔ^{3}
1sg.aor-call=2sg
‘I called you’

Data from additional speakers and other elicitation methods will be needed to determine whether this pattern really is a property of the grammar of Avatime, or even of individual Avatime speakers, and, if it is, whether factors like the prosodic status of the object do in fact have an effect on tone raising.

In contrast to SLAP-class verbs, tone raising is never blocked for verbs of this class, even for speakers that do not exhibit the novel raising pattern. So, for a verb like ‘call’, the root tone will raise to tone 4 when followed by tone 3 or 4 regardless of verbal inflection:

(108) Raising never blocked for CALL

a.	ma^{1}-**xwa^{3}**=wa^{1}	*Non-raised form*
b.	ma^{1}-**xwa^{4}**=**wɔ^{3}**	*Affirmative aorist*
c.	mɛɛ^{14}-**xwa^{4}**=**wɔ^{3}**	*Progressive*
d.	mɪ^{1}-ta^{4}=**xwa^{4}**=**wɔ^{3}**	*Intentive*

4.3.1.5 CHANGE-class

Verbs of the SLAP class and of the COOK class account for two of the logical possibilities for root and prefix tone raising – raising of both root and prefix tones and raising of the root tone only. A third logical possibility is raising the prefix tone only. This is exactly the pattern reported by Ford for roots like *tsrɛ^{3}* ‘change’. This pattern is unexpected – the trigger of tone raising is the tone the right of the verb root, and the target is the tone to the left of the root, with the intervening root tone unaffected. This is a non-local relationship between trigger and target. Ford (1986: 85) reports the following pair of forms for this root:

(109) 'change' as reported in Ford (1986)

a. a^{3}-tsrɛ^{3}=bɛ^{2}
3SG.AOR-change=it
'He changed it'

b. **a^{4}-tsrɛ^{3}**=yɛ^{3}
3SG.AOR-change=3SG
'He changed him'

In this pattern, the verb root is both transparent to tone raising, as it allows the prefix tone to raise, and a non-undergoer of raising. This combination of exceptional transparency and exceptional non-undergoing is argued not to exist for other phonological patterns like vowel harmony (Mahanta 2012). However, for my consultants, the prefix tone for verbs of this class is nearly categorically raised, regardless of context.

Table 39: Tonal properties of CHANGE-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
CHANGE	3		CR	N	Y; any following tone	Y?	4	4

(110) /tsrɛ^{3}/ 'change'

a. *Following tone 1 – **prefix tone raises***
a^{4}-tsrɛ^{3} o^{1}-hu^{3}=lo^{1} ni^{1} mo^{4}to=e^{3}
3SG.AOR-change CL-car=DEF with motorcycle=DEF
'He changed his car for a motorcycle'

b. *Following tone 3 – prefix tone only raises*
a^{4}-tsrɛ^{3} pɛ^{4}nyɛ^{3}
3SG.AOR-change pen
'He changed a pen'

This property holds for intransitive verbs in sentence final position, as in (111) and (112).

(111) /wlo^{3}/ 'swim, bathe'
me^{14}-wlo^{3}
1SG.AOR-bath
'I bathed'

(112) /srɛ^{3}/ 'be plenty'

me^{1}-dzi^{3}	ku^{1}-zi=o^{3}	**kɪ^{4}-srɛ^{3}**
1SG.AOR-buy	CL-bowl=DEF	CNC.AOR-be.plenty

'I bought a lot of/enough bowls'

However, I have observed some cases in which the prefix tone fails to raise. In (113), the tone of the second person aorist affirmative prefix does not raise to tone 4 when the verb is sentence-final in a wh-question. Recall that verbs in the COOK class, which were also characterized by overapplication of tone raising, showed a similar pattern – tone raising failed to apply in wh-question contexts, even though it applied in other contexts in which it was not phonologically conditioned by a following tone 3 or 4.

(113) 'swim' – prefix tone fails to raise in wh-question

nɪ^{4}fɔ^{4}	**wo^{3}**-wlo^{31}?
where:FOC	2SG.AOR-swim:WH

'Where did you swim?'

While not enough data has been collected to establish a definitive pattern regarding the interaction of this class of verbs with aspect/mood/polarity prefixes, there is at least one example of a verb of this class appearing without tone 4 immediately preceding the verb. In (114), the root 'change' appears preceded by the itive prefix *-zɛ^{3}-*. This prefix does not appear with tone 4, nor does the subject agreement prefix to its left.

(114) No raising of itive prefix – 'change'

ma^{1}-zɛ^{3}-tsrɛ^{3}	mo^{4}-to=e^{3}	ni^{1}	o^{1}-hu^{3}=lo^{1}
1SG-IT-change	motorbike=DEF	with	CL-car=DEF

'I went and changed a motorbike for a car'

4.3.1.6 LET GO-class

Two classes of verbs root have an additional property – tone lowering. When they are followed by a low or mid tone, the verb root lowers its tone to tone 1. The first class of roots also trigger prefix tone raising.

Table 40: Tonal properties of LET GO-class verbs

Example	Root tones		Initial C	Root tone raises?	Prefix tone raises?	Verb morphology blocks?	Count	Count (Ford)
	First syllable	*Second syllable*						
LET GO	3		DR	Y; and lowers	Y	?	1	3

Verbs of this class have tone 4 on both root and prefix when followed by a tone 3 or 4. When followed by tone 1 or 2, the verb root tone lowers to tone 1.

(115) /yrɔ³/ 'let go'

a. *Following tone 3 – root and prefix tones raise*
a⁴-<u>yrɔ⁴</u>=yɛ³
3SG.AOR=let.go=3SG
'He let go of him'

b. *Following tone 2 – root tone lowers*
a³-<u>yrɔ¹</u>=wɛ²
3SG.AOR-let.go=it
'He let go of it'

4.3.1.7 FIX-class

Mirroring the distinction between SLAP and COOK class verbs, verbs like 'fix (a time)' also undergo both raising and lowering of the verb root tone, but do not trigger prefix tone raising.

Table 41: Tonal properties of FIX-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
FIX	3		T	Y; and lowers	N	N	2	3

(116) /trɔ^{3}/ ‘carry on back, fix (time)’

a. *Following tone 3 – only root tone raises*
a^{3}-trɔ^{4}=yɛ^{4} ke^{3}-da^{1}
3SG.AOR-carry=3SG:LOC CL-back:DEF
‘He carry him on his back’

b. *Folllowing tone 1 – root tone lowers*
a^{3}-trɔ^{1}=wɛ^{14} ke^{3}-da^{1}
3SG.AOR-carry=it:LOC CL-back:DEF
‘He carried it on his back’

Like the previous class, verbs of this class also undergo tone lowering. The different between FIX-type verbs and LET GO-type verbs is in prefix raising. LET GO-class verbs trigger prefix raising, while FIX-type verbs do not. This mirrors the contrast between SLAP-type verbs and COOK-type verbs. Although clear data was not obtained on the interaction between LET GO-class verbs and inflectional morphology, verbs of the FIX-class do not appear to be blocked from raising by progressive or negative prefixes:

(117) Raising not blocked for kla^{3} ‘announce on the gongo’

a. Ko^{1}fi^{3} a^{3}-kla^{4} li^{3}-bo^{3}li^{1}
Kofi 3SG.AOR-announce CL-issue
‘Kofi announced the news (on the gongo)’

b. ɛɛ^{14}-kla^{4} li^{3}-bo^{3}li^{1}
3SG.PRG-announce CL-issue
‘He is announcing something on the gongo’

c. ɔ^{4}-kla^{4} li^{3}-bo^{3}li^{1} si^{1} bɛɛ^{14}-da^{1} a^{3}de^{3}wi^{3}la^{1}
3SG.NEG-announce CL-issue COMP 3PL.PRG-sell maize
‘He didn’t announce on the gongo that they are selling maize’

4.3.1.8 POUND-class

Table 42: Tonal properties of POUND-class verbs

Example	Root tones		Initial C	Root tone raises?	Prefix tone raises?	Verb morphology blocks?	Count	Count (Ford)
	First syllable	*Second syllable*						
POUND	3		any	N	N	N/A	10	99

The final class of monosyllabic tone 3 roots to consider are those that do not undergo raising of root or prefix tones in any context.

(118) /to³/ 'pound'
a. Following tone 1 – root and prefix both tone 3
e³-<u>to³</u> bla¹lɪ=ɛ³
3SG.AOR-pound plantain=DEF
'She pounded plantain'

b. *Following tone 3 – root and prefix both tone 3*
e³-<u>to³</u> ki³-ku¹=ye³ ka³-kʊ¹pa³
3SG.AOR-pound CL-yam=DEF CL-slice:DEF
'She pounded yam slices'

It is of note that this class, as well as the combine classes of monosyllabic tone 1 roots are by far the largest classes cited by Ford, each with above 90 roots. This predominance of roots whose behavior is completely predictable (for tone 1 roots, raising only when not blocked by initial voiced obstruent; for tone 3 roots no raising) may point to the status of tone raising in earlier varieties of Avatime.

4.3.2 Disyllabic roots

Disyllabic roots may consist of any combination of tones 1 and 3 in non-raising contexts. However, only roots with non-identical tones undergo raising – roots with 1 1 and 3 3 melodies never undergo raising.

4.3.2.1 SPREAD-class

Verbs of this class have invariant tone 1 on both root syllables. The tones are invariant regardless of initial consonant type, in contrast with the monosyllabic tone 1 roots discussed above.

Table 43: Tonal properties of SPREAD-class verbs

Example	Root tones		Initial C	Root tone raises?	Prefix tone raises?	Verb morphology blocks?	Count	Count (Ford)
	First syllable	*Second syllable*						
SPREAD	1	1	any	N	N	N/A	4	27

(119) /ka¹ka¹/ 'scatter'

a. Following tone 3 – both root tones remain tone 1
Ko¹fi³ **a³-<u>ka¹ka¹</u>** li³-bo³li¹
Kofi 3SG.AOR-spread CL-issue
'Kofi spread the news'

(120) /plu¹du¹/ ~ /pru¹du¹/ 'fly'

a. Sentence-final – both root tones 1
ka³-dzɔɪ¹=a³ **ke³-<u>pru¹du¹</u>**
CL-bird=DEF CNC.AOR-fly
'The bird flew'

b. Following tone 3 – both root tones remain tone 1
ka³-dzɔɪ¹=a³ **ke³-<u>pru¹du¹</u>** ki³-vo=e³
CL-bird=DEF CNC.AOR-fly CL-yesterday=DEF
'The bird flew yesterday'

4.3.2.2 LIFT-class

Like SPREAD-class verbs, disyllabic roots with two tone 3 syllables likewise never undergo raising, regardless of tonal context

Table 44: Tonal properties of LIFT-class verbs

Example	Root tones		Initial C	Root tone raises?	Prefix tone raises?	Verb morphology blocks?	Count	Count (Ford)
	First syllable	*Second syllable*						
LIFT	3	3	any	N	N	N/A	3	33

(121) /fe^{3}ke^{3}/ 'lift'

a. *Following tone 3 – both root tones remain tone 3*

e^{3}-fe^{3}ke^{3}	ke^{3}-ple^{3}kpa^{1}
3SG.AOR-lift	CL-book:DEF

'She lifted the book'

b. *Following tone 1 – both root tones 3*

e^{3}-fe^{3}ke^{3}	ku^{1}-ple^{3}kpa^{1}
3SG.AOR-lift	CL.PL-book:DEF

'She lifted the books'

(122) /zu^{3}ru^{3}/ 'steal'

a.

o^{3}-ze^{3}	**e^{3}-zu^{3}ru^{3}**	kʊ^{1}-lɪ^{3}kpɔ^{3}	tu^{1}-ne^{3}
CL-thief	CNC.AOR-steal	CL-palm.fruit.bunch	CNC-four

'The thief stole four bunches of palm fruits'

b.

e^{3}-zu^{3}ru^{3}	ki^{3}-bo=e^{1}
3SG.AOR-steal	CL-money=DEF

'He stole money'

4.3.2.3 BRING-class

Roots with non-identical tones may also be non-undergoers of tone raising. However, for roots with non-sandhi melody 3-1, there is an additional considerations. Of the roots with tone 3-1 that do not participate in raising, all examples that I have tested, and all but one example listed by Ford, end in *-nɪ^{1}*. This ending derives from a no-longer-productive comitative suffix, which is homophonous with the preposition *nɪ^{1}* 'with' (van Putten 2014b). While the semantic relationship is no longer transparent, nearly all of these verbs have a counterpart in Avatime without the *-nɪ^{1}* ending. In addition, these verbs all exhibit the same alternation in the final vowel when they are not followed by their object. However, since the suffix is no longer productive, and speakers treat these roots as monomorphemic, it is unlikely that the tone raising behavior for these verbs can be attributed to the presence of a suffix.

Table 45: Tonal properties of BRING-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
BRING	3	1	any[45]	N	N	N/A	4	11

(123) /ma^{3}nɪ^{1}/ 'bring'

a. *Following tone 1*
a^{3}-<u>ma^{3}nɪ^{1}</u> o^{1}-no^{1}
3SG.AOR-bring CL-soup
'She brought soup'

b. *Following tone 3, no tone raising*
a^{3}-<u>ma^{3}nɪ^{1}</u> kɪ^{3}-dzɛ^{1}
3SG.AOR-bring CL-meat:DEF
'She brought meat'

4.3.2.4 TEACH-class

There is also a small class of verbs with a 1-3 melody that do not undergo raising.

Table 46: Tonal properties of TEACH-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
TEACH	1	3	any	N	N	N/A	2	4

(124) /ba^{1}sɛ^{3}/ 'teach'

mɔka	yɛ^{4}	**a^{3}-<u>ba^{1}sɛ^{3}</u>**=mɛ^{3}	ni^{4}te^{3}	gɪ^{1}	bi^{4}-ze^{3}-ʋe^{1}
1SG:father	3SG:FOC	3SG-teach=1SG	HOW	REL	3PL-HAB-hunt

'My father taught me how to hunt'

[45] This is true of the first root syllable – the second syllable is always sonorant-initial

4.3.2.5 DO-class

Verbs of this class undergo raising, but only of the root-initial syllable. However, the behavior of this class has an additional property differentiating it from other disyllabic verbs. For verbs of this class, the trigger of tone raising is the second syllable of the root itself. So, similar to CHANGE-class verbs, verbs of this class always appear in their raised form. This is notable because, if this were not the case, and tone raising only affected these roots when preceding tone 3 or 4, they would also present a case of a tone that exceptionally failed to undergo raising, but allowed raising on the tone(s) to its left. That is, if these roots had the melody 3-1 3 before tone 1, and 4-3 3 before tone 3, the root-final tone 3 would fail to undergo raising, while the root-initial and prefix tones would undergo. This would, as in the previously described case of CHANGE-class verbs, establish a non-local relationship between the trigger and target of raising.

Table 47: Tonal behavior of DO-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
DO	1	3	any	Y; first syl. only	Y	?	1	5

(125) /bɪ¹tɛ³/ 'do'

a. a⁴-<u>bɪ³tɛ³</u>=wɛ¹ di³
3SG.AOR-do=it before
'He has done it before'

I have not yet collected data on the interaction between verbal morphology and tone raising for this class.

4.3.2.6 SCRATCH-class

Another class of roots with a 1 3 melody in non-raising contexts behave more regularly. For these roots, the root tones do not raise when followed by tones 1 or 2. When followed by tone 3 or 4, both root tones and the prefix tone raise.

Table 48: Tonal behavior of SCRATCH-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
SCRATCH	1	3	C1 - T C2 - any	Y	Y	Partial	3	16

(126) /xwa^{1}lɪ^{3}/ 'scratch'

a. *Following tone 1 – root melody 1 3, prefix tone 3*
Ko^{1}fi^{3} a^{3}-<u>xwa^{1}lɪ^{3}</u>=wa^{1}
Kofi 3SG.AOR-scratch=3PL
'Kofi scratched them'

b. *Following tone 3 – root raises to 3 4, prefix raises to 4*
Ko^{1}fi^{3} a^{4}-<u>xwa^{3}lɪ^{4}</u>=mɛ^{3}
Kofi 3SG.AOR-scratch=1SG
'Kofi scratched me'

(127) /ya^{1}wɪ^{3}/ 'break'

a. *Pre-pausal - root melody 1 3, prefix tone 3*
ke^{1}-zi=a^{3} kɛ^{3}-<u>ya^{1}wɪ^{3}</u>
CL-bowl=DEF CNC.AOR-break
'The bowl broke'

b. *Following tone 3 – root raises to 3 4, prefix raises to 4*
ke^{1}-zi=a^{3} **kɛ^{4}-<u>ya^{3}wɪ^{4}</u>** ki^{3}-vo=e^{3}
CL-bowl=DEF CNC.AOR-break CL-yesterday=DEF
'The bowl broke yesterday'

There is an additional interaction between raising and morphology in this class that has not been previously noted. For verbs of this class, in the morphological contexts in which raising is blocked in other classes, *partial raising* occurs. In these cases, the final root tone raises from 3 to 4, while the initial root tone does not raise and surfaces as a low tone 1.

(128) Partial raising – ‘scratch’

a. Ko^{1}fi^{3} εε^{14}xwa^{1}lɪ^{4}=mε^{3}

b. Ko^{1}fi^{3} a^{3}-zε^{3}-xwa^{1}lɪ^{4}=mε^{3}

c. Ko^{1}fi^{3} ɔ^{14}-xwa^{1}lɪ^{4}=mε^{3} kuŋ^{4}

(129) Partial raising – ‘break’

a. ke^{1}-zi=a^{3} kε^{3}-ta^{4}-ya^{1}wɪ^{3}

b. ke^{1}-zi=a^{3} kε^{3}-ta^{4}-ya^{1}wɪ^{4} ki^{3}-vo^{1}

The implications of this pattern for the analysis of tone raising will be discussed further below

4.3.2.7 SPOIL-class

Among the 3 1 melody roots that do undergo raising, there are two classes. The first of these, represented here by the verb ‘spoil’ also trigger prefix raising.

Table 49: Tonal behavior for SPOIL-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
SPOIL	3	1	any	Y	Y	?	3	13

(130) /zi^{3}zi^{1}/ ‘spoil’

a. *Pre-pausal - root melody 3 1, prefix tone 3*
m(ε) o^{1}-hu^{3}=lo^{1} **e^{3}-zi^{3}zi^{1}**
1SG CL-car=DEF CNC.AOR-spoil
‘My car spoiled’

b. *Following tone 3 – root raises to 4 3, prefix raises to 4*
m(ε) o^{1}-hu^{3}=lo^{1} **e^{4}-zi^{4}zi^{3}** ko^{4}ko^{1}
1SG CL-car=DEF CNC.AOR-spoil already
‘My car already spoiled’

(131) /lʊ^{3}lɔ^{1}/ 'repair'

a. *Following tone 1 – root melody 3 1, prefix tone 3*
a^{3}-<u>lʊ^{3}lɔ^{1}</u> o^{1}-hu^{3}=lo^{1}
3SG.AOR-repair CL-car=DEF
'He repaired the car'

b. *Following tone 3 – root raises to 4 3, prefix raises to 4*
a^{4}-<u>lʊ^{4}lɔ^{3}</u> mɛ^{3} o^{1}-hu^{3}=lo^{1}
3SG.AOR-repair 1SG CL-car=DEF
'He repaired my car'

4.3.2.8 BITE-class

The second class of 3 1 melody verbs also undergo raising of both root tones, but fail to trigger raising of the prefix tone. This mirrors the contrast between FORGET and COOK-class monosyllabic verb roots. In fact, it is only roots with initial tone 3, whether mono- or disyllabic that contrast in whether they trigger prefix tone raising in addition to root tone raising.

Table 50: Tonal behavior of BITE-class verbs

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Verb morphology blocks?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*						
BITE	3	1	any	Y	N	N	3	24

(132) /ne^{3}mi^{1}/ 'bite'

a. *Following tone 2 – root melody 3 1, prefix tone 3*
e^{3}-<u>ne^{3}mi^{1}</u>=we^{2}
3SG.AOR-bite=it
'He bit it'

b. *Following tone 3 – root raises to 4 3, prefix stays tone 3*
e^{3}-<u>ne^{4}mi^{3}</u>=ye^{3}
3SG.AOR-bite=3SG
'He bit him'

(133) /be³mi¹/ 'weep'

a. *Pre-pausal – root melody 3 1, prefix tone 3*

o⁴-bi=e³ e³-<u>be³mi¹</u>
CL-child=DEF CNC.AOR-weep
'The child wept'

b. *Following tone 3 – root raises to 4 3, prefix stays tone 3*

o⁴-bi=e³ e³-<u>be⁴mi³</u> ki³-vo=e³
CL-child=DEF CNC.AOR-weep CL-yesterday=DEF
'The child wept yesterday'

Roots of this class are not blocked from raising by morphological context. In (134), it can be seen that 'bite' still undergoes raising of both root tones in the negated aorist.

(134) Full raising of 'bite' in negated aorist

ka¹-drʊɪ¹=a³ ke¹⁴-<u>ne⁴mi³</u>=me³
CL-dog=DEF CNC.NEG-bite=1SG
'The dog didn't bite me.

4.3.3 Summary

Table 51: Summary of tonal behavior by class

Example	**Root tones**		**Initial C**	**Root tone raises?**	**Prefix tone raises?**	**Count**	**Count (Ford)**
	First syllable	*Second syllable*					
CHEW	1		T, R	Y	Y	9	47
CATCH	1		D	N	N	3	48
SLAP	3		D, R	Y	Y	6	23
COOK	3		T	Y	N	6	20
CHANGE	3		CR	N	Y	4	4
LET GO	3		DR	Y	Y	1	3
FIX	3		TR	Y	N	2	3
POUND	3		any	N	N	10	99
SPREAD	1	1	any	N	N	4	27
LIFT	3	3	any	N	N	3	33
BRING	3	1	any	N	N	4	11
TEACH	1	3	any	Y	Y	2	4
DO	1	3	any	1st syl. only	Y	1	5
SCRATCH	1	3	see Table 48	N	N	3	16
SPOIL	3	1	any	Y	Y	3	13
BITE	3	1	any	Y	N	3	24

4.4 Island of regularity – tone 1 roots

If the tone sandhi system as a whole is not just phrasal phonology, what about the lexical classes that do have phonologically completely predictable behavior? Tone 1 verb roots are completely regular and exceptionless with respect to tone raising. If the root has an initial voiceless obstruent or initial sonorant, then the root tone will raise to tone 3 and the prefix tone to tone 4 when the verb is followed by tone 3 or 4. If the root has an initial voiced obstruent, then it will not undergo tone raising. It would make sense to take these facts as evidence that, while the synchronic tone sandhi system in Avatime largely consists of allomorph selection, at least this portion of the raising grammar is in fact phonological. However, there are challenges to a phonological analysis even for this subset of forms.

4.4.1 Opacity

The basic tone raising pattern is a chain shift: tone 1 raises to tone 3, tone 3 raises to tone 4, but tone 1 never raises to tone 4. Opacity in and of itself is not a motivation to analyze tone raising as anything other than phonology, as opaque patterns are extremely frequent in phonological grammars cross-linguistically. Like other chain shifts, Avatime tone raising can be characterized as a case of counterfeeding opacity (Kiparsky 1973; Baković 2007):

(135) Counterfeeding in tone raising

$1 \rightarrow 3$ / __ {3/4}
$3 \rightarrow 4$ / __ {3/4}
*$1 \rightarrow 4$ / __ {3/4}

Many approaches to analyzing counterfeeding opacity in chain shift in parallel theories of phonology have been taken (see Łubowicz (2011) for a summary). One such approach that would be suited to the basic pattern in Avatime is local constraint conjunction (Smolensky 1993; Kirchner 1996; Gnanadesikan 1997). Consider the feature system for Avatime tones proposed by

Table 52: Ford (1971) tone features

	High	Raised
Tone 1 (low)	-	-
Tone 2 (mid)	-	+
Tone 3 (high)	+	-
Tone 4 (extra high)	+	+

Under this feature system, a conjoined faithfulness constraints IDENT[high] & IDENT[raised] would penalize mapping tone 1 to tone 4. A schematic tableau is given in (136). The ad hoc markedness constraint RAISE is proposed as the driver of tone raising – it is violated when a tone does not raise by one step when followed by tones 3 or 4:

(136) Constraint conjunction in tone raising

/3-1 3/	IDENT[high] & IDENT[raised]	Raise	IDENT[high]	IDENT[raised]
☞ a. [4-3 3]			*	*
b. [4-4 3]	*!			
c. [3-1 3]		*!		

This approach is promising in accounting for the basic raising pattern shown by EAT-class verbs – that is, tone 1 monosyllabic roots. However, it does not account for the full range of data even for tone 1 roots.

4.4.2 Behavior of low tone prefixes

Raising of tone 1 applies differently to roots and prefixes, as shown in the following examples of the verb *kpo¹* 'hide'. In (137), the prefix is the first person affirmative aorist prefix. When the verb is followed by the tone 1 ideophone *gi¹di¹gi¹di¹*, the tone of both verb root and verb prefix are low tone 1[46]. When followed by the tone 3-initial 'yesterday', the tone 1 on the root raises to tone 3, while tone 1 on the subject prefix becomes a 1-4 contour tone.

[46] For this speaker, the first person singular aorist prefix did not exhibit polarity for this lexical item. Tonal polarity for this prefix does appear to vary across speakers, and even within speakers.

(137) Tone 1 prefix becomes 14 contour in raising context

a. **me^{1}**-kpo^{1} gi^{1}di^{1}gi^{1}di^{1}
1SG.AOR-hide ID.harshly
'I hid harshly/noisily'

b. **me^{14}**-kpo^{3} ki^{3}-vo=e^{3}
1SG.AOR-hide CL-yesterday=DEF
'I hid yesterday'

This does not follow the general tone raising pattern of "raise one step". Contrast the previous example with the third person singular prefix, which has tone 3 in non-raising contexts and tone 4 in raising contexts:

(138) Tone 3 prefix becomes tone 4 in raising context

a. A^{1}bra^{3} **e^{3}**-kpo^{1} gi^{1}di^{1}gi^{1}di^{1}
Abra 3SG.AOR-hide ID.harshly
'Abra hid harshly/noisily'

b. **e^{4}**-kpo^{3} zĩĩĩĩ^{3333}
3SG.AOR-hide ID.quietly
'She hid quietly'

This pattern suggests that tone 1 raising cannot be a general phonological process of Avatime, since it would be expected to apply in the same way to both tone 1 morphemes in the above examples (the verb root *kpo^{1}* and the agreement prefix *me^{1}*-). It is clear that there is something about at least tone sandhi on prefixes that is not exclusively phonological, even for the regular and exceptionless class of verb roots.

4.4.3 Behavior of disyllabic roots

While the behavior of monosyllabic tone 1 roots is phonologically predictable, this property does not extend to disyllabic roots. Recall from section 4.3.2 that roots of this type never undergo tone raising. Of particular interest are roots like *ka^{1}ka^{1}* 'spread, scatter'. This root has two syllable-initial voiceless obstruents and two low tones. If tone raising in tone 1 roots is to be analyzed as phonological, even if tone raising for other roots is not, it is unclear why verbs of this class should fail to undergo raising.

4.5 Why not phrasal phonology?

Broadly speaking, I am trying to address the question of the degree to which Avatime tone sandhi is part of the phonological grammar of the language, and to what extent it must be accounted for by other components of the grammar. A starting hypothesis is that in Avatime, as in many languages, tone sandhi is purely a phrasal phonological process. I argue that it should not be treated as such, for a number of reasons outlined here. A phrasal phonological process with no morphological or lexical component would be expected to apply uniformly to instances of the same target, so tone 1 should always raise to tone 3, regardless of (a) whether tone is associated with a root or a prefix, (b) whether the tone is associated with a verb or a word of another syntactic category, and (c) to all instances of tone 1 in the conditioning environment, regardless of the identity of the lexical item that the tone is associated with. In the previous section, it was seen that (a) does not hold – prefix tone 1 behaves differently that root tone 1. In the section, I will discuss the evidence (some of which, concerning lexical conditioning, was introduced earlier in the chapter) that (b) and (c) also do not hold.

4.5.1 What is the phonological process?

So far, I have been referring to the sandhi process simply as “tone raising”. This term is agnostic to the actual phonological mechanism that would be necessary to account for the complex patterns outlined in the previous section. Here, I will consider what mechanisms would need to be involved in a phonological analysis of Avatime tone raising. First, it is necessary to determine how Avatime tones are represented in the phonological grammar. Consider the feature system proposed by Ford (1971), introduced in the previous section. This feature system has two features [high] and [raised] that account for the tonal contrasts. This feature system is given in above in Table 52. Under this feature system, the raising of tone 1 could be thought of as the leftward spread of the tonal feature [+high], or alternatively, assimilation of [-high] tone 1 to the following [+high] tone 3 or 4:

(139)

[-high, -raised] →	[+high] /	___	[+high]	*leftward spread/assimilation of [+high]*
1	3		3/4	

However, the raising of tone 3 to tone 4 cannot be attributed to the same mechanism of leftward spread or assimilation:

(140)

[+high] →	[+raised] /	___	[+high]	*assimilation/dissimilation of ???*
3	4		3/4	

This raises the possibility that raising of tone 1 and raising of tone 3 are phonologically different processes. In a constraint-based grammar, there could not be a single constraint driving both of these processes. A constraint like *[-high][+high], for example, would be violated by a tone sequence of 1 3, but not by a sequence of 3 3. Additionally, the fact that either tone 3 or tone 4 may condition tone raising for tone 3 roots introduces a further complication. If triggered by a following tone 3, raising of a tone 3 root to tone 4 looks like dissimilation. If triggered by a following tone 4, raising of a tone 3 root looks like assimilation.

Alternatively, tone raising could be driven by an anti-identity constraint HIGHER[T], as proposed by Mortensen (2006). This constraint is satisfied only if a tone in a surface form is one step higher on a tonal "scale" than the corresponding tone in the input. However, this approach fails to account for the behavior of tone 1 prefixes – the tone of these prefixes does not raise in a scalar fashion, instead becoming a contour.

4.5.2 Applicability across morphological categories

Tone raising is not general to all morpheme types - it seems to be a property of roots alone. In nouns, raising occurs when a low tone syllable begins with a voiceless obstruent or sonorant, and is both preceded and followed by a high tone. However, when these exact conditions are met for an object pronoun, which is not itself a root, no raising occurs. In (141), we see an object pronoun beginning with a sonorant, with a low tone, and preceded and followed by high tones. These are the same properties that are associated with tone raising in verb roots like *mɔ^{1}*. However, in this form, no raising may occur.

(141) No tone raising in object pronoun

me^{1}-fe^{3}ke^{3}=**lo^{1}**	mu^{3}no^{1}
1SG.AOR-lift=it$_{cl2s}$	rise

'I lifted it (table) up'

If tone raising were purely phrasal phonology, then we would expect [=lo^{1}] to raise in the above example, as the phonological conditions for raising are met. In fact, the phonological conditions for raising are met extremely frequently in the language, but raising only applies to a narrow set of lexical items.

4.5.3 Reference to arbitrary lexical classes

In fact, as seen above in (89)-(92), minimal pairs exist for which the only contrast is whether a verb participates in tone raising. Phonological patterns that apply only to a subset of lexical items are numerous cross-linguistically. However, the lexicon must play a role in such patterns. Speakers must store some information about which verbs do and do not undergo tone raising, since this property cannot be predicted from the phonological form of the verb alone.

4.6 Tone raising and verbal morphology

As introduced in 4.2.3.3, tone raising classes vary in their application across morphological contexts. For some classes, raising is completely blocked in certain aspect/mood/polarity contexts. For others, raising occurs regardless of verbal morphology. For at least one class, there is evidence for a previously unreported *partial* tone raising pattern. In this section, I discuss the implications of the interaction with verbal morphology for the analysis of tone raising.

4.6.1 Tone 1 monosyllabic roots

For all speakers, these roots undergo may undergo raising in the aorist affirmative, as shown in the preceding section. However, in other aspects, moods, and polarities, raising is blocked. The exact set of morphological contexts in which raising is blocked varies from speaker to speaker. The most frequent blockers of raising are the progressive and the negated aorist, but as seen in (142), tone raising may also be blocked in the context of the potential and habitual prefixes:

(142) CHEW (repeated from (98))

a.	Ko^{1}fi^{3}	a^{3}-**ta^{1}**	ɪ^{1}-kpa^{3}=lɛ^{1}	*Non-raised form*
b.	Ko^{1}fi^{3}	**a^{4}-ta^{3}**	**kɪ^{3}**-dzɛ^{3}	*Affirmative aorist*
c.	Ko^{1}fi^{3}	ɛɛ^{14}-**ta^{1}**	**kɪ^{3}**-dzɛ^{3}	*Progressive*
d.	Ko^{1}fi^{3}	aa^{41}-**ta^{1}**	**kɪ^{3}**-dzɛ^{3}	*Potential*
e.	Ko^{1}fi^{3}	ɪ^{4}-dɛ^{14}-**ta^{1}**	**kɪ^{3}**-dzɛ^{3}	*Habitual*

(143) HIDE (repeated from (99))

a.	e^{3}-**kpo^{1}**		*Non-raised form*
b.	e^{4}-**kpo^{3}**	**zĩĩĩĩ^{3333}**	*Affirmative aorist*
c.	o^{14}-**kpo^{1}**	**zĩĩĩĩ^{3333}**	*Negated aorist*

It is difficult to attribute the failure of tone raising in these contexts to the phonological grammar. Consider the progressive form of 'chew' *εε^{14}-ta^{1}*. If the root tone of the verb root were to undergo raising, the result would be **εε^{14}-ta^{3}*. This tonal melody is permitted elsewhere in the Avatime (for example in the tone raised form *me^{14}-kpo^{3}* (137)). One possible motivation for the failure of tone 1 roots to undergo tone raising in these morphological contexts is the preservation of contrast (Łubowicz 2003). Since the specified, invariant tonal melody on the aspect/mood/polarity prefixes block prefix raising, raising just the root tone would cause homophony between tone 1 raising roots (CHEW class) and tone 3 non-raising roots (POUND class) with identical segmental content. However, contrast preservation does not make the correct predictions for tone 3 roots, which will be discussed in 4.6.2.

4.6.2 Tone 3 roots

Tone 3 roots can be broken down into two types with respect to the interaction between morphology and tone raising. As first noted by van Putten (2014), tone 3 roots which also trigger prefix raising are blocked from raising in the progressive, negated aorist, and, for some speakers, the potential and intentive moods.

(144) Raising blocked for 'slap' (repeated from (103))

a.	Ko^{1}fi^{3} εε^{14}-bɔ^{4}=mε^{3} o^{3}-su^{3}mu=e^{3}	*Progressive*
b.	Kòfi a^{3}-tra^{4}-bɔ^{3}=mε^{3} o^{3}-su^{3}mu=e^{3}	*Intentive*
c.	Ko^{1}fi^{3} ɔ^{14}-bɔ^{3}=mε^{3} o^{3}-su^{3}mu=e^{3}	*Negated aorist*

The behavior of this class poses a challenge to an analysis based on contrast preservation. When tone raising for verbs of this class is blocked, it leads to homophony with roots of POUND-class, which do not undergo raising. Roots like 'get wet' and 'get up', both *yɔ^{3}* in non-raising contexts, are illustrative. In the negated aorist, raising the tone of 'get wet' would preserve the contrast between the roots. However, it is blocked from raising its tone, yielding homophony with 'get up'.

(145) Homophony from blocked tone raising

a. 'get wet' – SLAP-class
ma^{14}-yɔ^{3} ki^{3}-vo=e^{3}
1SG.NEG-get.wet CL-yesterday=DEF
'I did not get wet yesterday'

b. *'get up' – POUND-class*
ma^{14}-yɔ^{3} ki^{3}-vo=e^{3}
1SG.NEG-get.up CL-yesterday=DEF
'I did not get up yesterday'

Roots which do not trigger prefix raising are not blocked from tone raising in any aspect/mood/polarity context. This was shown above for COOK and BITE-class verbs. It is clear there is a connection between prefix tone raising and the interaction with verbal morphology. However, as discussed above, there is no clear phonological motivation for avoiding raising the tone of a root across inflectional contexts. One possibility would be that this is a type of "sour grapes" effect: verbal prefixes like the progressive and negative have grammatical tones that can't be raised, so if a verb cannot raise both root and prefix tones, it prefers not to raise any tones at all. Roots which only ever raise their own tone would be unaffected.

4.6.3 Partial raising

However, there is an additional interaction between raising and morphology that has not been previously noted which suggests that this cannot be the case. For SCRATCH-type verbs, in the morphological contexts in which raising is blocked in other classes, *partial raising* occurs. In these cases, the final root tone raises from 3 to 4, while the initial root tone does not raise and surfaces as a low tone 1.

(146) Partial raising – ‘scratch’

a. Ko^{1}fi^{3} εε^{14}-xwa^{1}lɪ^{4}=mε^{3}
Kofi 3SG.PRG-scratch=1SG
‘Kofi is scratching me’

b. Ko^{1}fi^{3} a^{3}-zε^{3}-xwa^{1}lɪ^{4}=mε^{3}
Kofi 3SG-REC-scratch=1SG
‘Kofi was scratching me (repeatedly)’

c. Ko^{1}fi^{3} ɔ^{14}-xwa^{1}lɪ^{4}=mε^{3} kuŋ^{4}
Kofi 3SG.NEG-scratch=1SG at.all
‘Kofi didn’t scratch me at all’

(147) Partial raising – ‘break’

a. ke^{1}-zi=a^{3} kε^{3}-ta^{4}-ya^{1}wɪ^{3}
CL-bowl=DEF CNC-INT-break
‘The bowl will break’

b. ke^{1}-zi=a^{3} kε^{3}-ta^{4}-ya^{1}wɪ^{4} ki^{3}-vo^{1}
CL-bowl=DEF CNC-INT-break CL-tomorrow
‘The bowl will break tomorrow’

These examples show that the blocking of tone raising by morphological context is not necessarily complete. However, partial raising is difficult to account for phonologically – if tone raising is not blocked by the morphological context, why does it not affect the initial tone of these verbs? I will argue in the following section that tone raising is better treated as allomorph selection, with the choice of allomorph determined by both phonological and morphological context.

4.7 Tone raising as allomorph selection

McPherson (2019) develops an analysis of a complex tone sandhi system in Seenku (Mande, Burkina Faso) as allomorph selection. Under this approach, morphemes have multiple listed allomorphs with associated subcategorization frames (Paster 2006). This approach is fairly similar to that taken in Hayes' (1990) Precompiled Phrasal Phonology. The key difference is that, in Precompilation Theory, the various forms of a morpheme are derived by phonological rule in the lexicon, while in this approach they are simply listed. For example, consider a lexical entry for ‘cook’ - there are two allomorphs: the raised form, whose distribution is determine by a subcategorization frame, and an ‘elsewhere’ form:

(148) Lexical entry for ‘cook’

COOK	↔	tɔ^{4}	(/ __ 3/4)
		tɔ^{3}	elsewhere

Under this analysis, the raised allomorph of COOK is inserted when preceding a high or extra high tone, while the default, non-raised allomorph appears in all other contexts. This class of roots raises regardless of morphosyntactic context, so only phonological information need appear in the subcategorization frame. However, other classes of root raise only in certain environments. Again following McPherson (2019), I argue that subcategorization frames in Avatime can also include morphosyntactic context. This makes it possible to account for roots that only participate in raising in a limited set of TAM contexts. For example, see the lexical entry for ‘see’:

(149) Lexical entry for ‘see’

SEE	↔	∅^{4} mɔ^{3}	(aorist /__ 3,4)
		mɔ^{1}	elsewhere

It contains a raised allomorph, restricted to aorist contexts preceding tones 3/4 (the floating tone 4 will be discussed below). The elsewhere form appears in all other contexts. The following examples demonstrate how tonal allomorph selection applies for the root SEE. In a sentence like ‘He saw the man’, we have the following context:

(150) Allomorph selection for SEE

AOR	___	4 3 3	Morphological and tonal context
a^{3}	___	o^{4}-nyi^{3}me^{3}	
3SG.AOR	**SEE**	CL-man.DEF	

The environment for the raised allomorph of SEE is present - there is an aorist aspectual morpheme, and the following tone is extra high. So, the raised allomorph is inserted:

(151) Raised allomorph of SEE selected

AOR		4 3 3	Morphological and tonal context
a	∅^{4} mɔ^3	o^4-nyime	
3SG.AOR	**SEE**	CL-man.DEF	

After the insertion of the appropriate allomorph, the phonological grammar applies - this is how the floating Extra High tone docks to the prefix and overwrites its tone 3. Unlike tone raising, this process of tonal coalescence is completely general in the language (Ford 1971; Schuh 1995a), so it is reasonable to expect that this process is actually a part of the phonological grammar, and need not be accounted for as allomorphy of the prefix itself. Contrasting the entries for COOK and SEE, we note that roots that do not trigger prefix raising do not have an allomorph with a floating tone 4 - they consist solely of the raised and non-raised forms of the root itself. Entries for roots that do not participate in raising at all contain only a single allomorph:

(152) Lexical entry for ‘pound’

pound ↔ to^3

4.7.1 Generalizing the tone classes

Does each Avatime verb root independently develop a set of tonal allomorphs that happen to be identical to the tonal allomorphs of a set of other roots? I argue that the answer is no – the lexicon in Avatime is generative, in the sense of McPherson (2019). As Avatime learners encounter more lexical items with the same pattern of raising behavior, they are able to construct a schema that captures the behavior of an entire tone class. For example, an Avatime-learning child could get the following input:

(153) Possible input encountered by Avatime learner

…	a^4 $mɔ^3$	3	…
…	a^3 $mɔ^1$	1	…
…	a^4 ta^3	3	…
…	a^3 ta^1	1	…
…	a^4 $ŋa^3$	3	…
…	a^3 $ŋa^1$	1	…

Three verb roots, {mɔ, ta, ŋa}, all appearing in the aorist aspect, followed by both tone 3 and tone 1, exhibit identical tonal behavior. They carry a low tone 1 in non-raising environments, and a high tone 3 (plus an extra high tone 4 on the prefix to the left) in raising environments. Under this proposal, the learner notes that the distribution of tonal allomorphs for these three verbs is identical and projects a meta-entry of the form[47]:

(154) Lexical meta-entry for Class I roots

$[V]_{classI}$	↔	$\varnothing^4\ \sigma^3$	(aorist / __ 3,4)
		σ^3	elsewhere

In this sense, the lexicon is generative. For a root in a given class, the meta-entry in the lexicon generates the tonal allomorphs, while the lexical entries for individual roots are significantly simpler, being marked simply for tone class membership:

(155) Simplified lexical entry for SEE

SEE ↔ $[mɔ]_{classI}$

Under this analysis, the fact that sets of verbs share the same behavior with respect to tone raising is a consequence of the organization of the lexicon, not chance. This could help the learner in acquiring the tone raising behavior of new verbs, as they are encountered. If an Avatime learner encounters a sentence with the unknown verb *ta* ‘chew’, they can note that the

[47] The name ‘Class I’ is arbitrary, only designating that it is a unique class in terms of tone raising. Likewise, other class names given later in the section are solely to distinguish them from each other.

verb is in the aorist, is followed by tone 3, the root has tone 3, and the prefix has an tone 4. If they already know other verbs in this class, they can they predict what form *ta* will have in other contexts. So if, a learner has encountered enough data to project the Class I meta-entry, and encounters (156), they will know that in (156), the verb should be produced with a tone 1 on the root and a tone 3 on the prefix, without having encountered the verb in this context before.

(156) a. a^{4}-ta^{3} ki^{3}-mi^{3}mi-e^{1}
b. a-ta bla^{1}lɪ=ɛ^{3}

An additional factor that could aid learners in learning the tone class membership of verbs roots as they are encountered through the learning process is the association between initial consonant type and tone class membership.

4.7.2 Allomorph selection and tone lowering

There are two tone classes that involve not only tone raising, but tone lowering. Verbs of the LET GO and FIX classes have tone 4 when followed by tone 3/4, but tone 1 when followed by tone 1/2:

(157) Tones of 'let go' and 'fix'

a. a^{3}-yrɔ^{1} / __ 1,2
b. a^{4}-yrɔ^{4} / __ 3.4
c. a^{3}-trɔ^{1} / __ 1,2
d. a^{3}-trɔ^{4} / __ 3.4

A phonological analysis of verbs of these classes encounters two difficulties. There is no evidence for a process raising tone 1 to tone 4 anywhere in Avatime, and there is likewise no other case of tone lowering in the language. The most straightforward way to account for the behavior of these verbs phonologically is to, as Ford does, set up an abstract underlying tone 3 for verbs of these classes, which raises when followed by tone 3/4 and lowers when followed by tones 1/2. The analysis developed in this section does away with the need to posit such an abstract underlying form, since the lexical entries for these verbs (or more precisely, the meta-entries for the tone classes) simply contain two allomorphs: one with tone 1, the other with tone 4:

(158) Lexical entry for FIX

a. Schema for FIX-class roots

$[V]_{classV}$	↔	$σ^4$	(/___3,4)
		$σ^1$	(/___1,2)

b. Lexical entry for FIX

FIX	↔	$[trɔ]_{class5}$

4.7.3 Partial raising and interaction with morphology

Roots of the SCRATCH type were shown to have a unique interaction with morphological context. For these roots, tone raising is only *partially* blocked by aspect/mood/polarity context. The root-final tone still undergoes raising, but the root-initial tone and prefix tone are both unaffected by raising. This partial raising behavior poses a challenge to a phonological analysis, as it is a case of non-iterativity.

(159) Non-iterative raising – /xwa^{1}lɪ^3/ 'scratch'

a. (pɔ^{3}nɪ^1=mɛ^3) Ko^{1}fi^3 ɛɛ^{14}-**xwa^{1}lɪ^4**=mɛ^3

b. Ko^{1}fi^3 a^3-zɛ^3-**xwa^{1}lɪ^4**=mɛ^3

c. Ko^{1}fi^3 ɔ^4-**xwa^{1}lɪ^4**=mɛ^3

These roots can be accounted for straightforwardly by the analysis developed here. They have three allomorphs:

(160) Lexical entry for partial-raising verbs

$[V]_{classX}$	↔	$∅^4\ σ^3σ^4$	(aorist __ / 3,4)
		$σ^1σ^4$	(__ / 3,4)
		$σ^1σ^3$	elsewhere

There are two allomorphs whose right phonological context is identical – the fully raised allomorph is selected in the aorist affirmative, since its frame is the most specific frame that matches the context.

4.7.4 Changes in raising behavior

What evidence could decide between an approach in which each morpheme has a set of listed tonal allomorphs, and the approach developed above, in which the lexicon contains generalized schema for tone classes, and morphemes contain only information about which class they belong to? One prediction of the analysis developed here is that the patterns stored in meta-entries should extend to novel items, as long as those items can be easily assigned to a tone class (as is the case for low toned monosyllables). However, wug-testing does not translate easily to the Avatime field situation, and so is not a straightforward option for testing this prediction. Another possibility concerns diachrony - under the analysis developed above, changes in raising behavior are predicted to affect entire classes, rather than individual lexical entries (aside from a lexical item shifting to a different tone class altogether). Consider the lexical entry for 'see', repeated from above. It only specifies segmental content and class membership:

(161) SEE lexical entry

SEE ↔ [mɔ]$_{classI}$

4.7.5 Prefix raising as a floating tone

One aspect of this analysis is located in the phonological grammar. I posit a floating Extra High tone rather than separate raised allomorphs of prefixes for 2 reasons: (a) it provides a better explanation for the tone raising behavior of tone 1 prefixes, and (b) it accounts for the appearance of tone 4 on the final syllable of words to the left of prefix-less tone raising verbs. The formation of rising contour tones from the combination of linked tone 1 and floating tone 4 is pervasive in Avatime phonology, appearing across a wide variety of contexts. So, while the appearance of tone 4 on verb prefixes in tone raising contexts is due to allomorph selection, the realization of this tone is determined by the phonology.

4.7.5.1 Tone 1 prefixes

In 4.4.2, it was shown that tone 1 prefixes participate in tone raising, but their raised form deviates from the chain shift characteristic of tone 1 roots. Instead, the raised form of a tone 1 prefix is a 1-4 rising contour, as in the form *me^{14}-kpo^{3} ki^{3}-vo=e^{3}* 'I hid yesterday'. I propose that this contour is in fact the result of a floating tone 4 associated with the raised allomorph of the verb root. There are two motivations for this proposal. First, prefix raising is a property associated with the verb root – whether or not a prefix undergoes raising is determined by which lexical class the root belongs to. Positing allomorphs, or prefix-specific tone rules or constraints obscures this generalization. Second, the formation of a 1-4 contour tone from the combination of a linked tone 1 and floating tone 4 is a general property of Avatime phonology. Likewise, the coalescence of a linked tone 3 and a floating tone 4 into a single tone 4 is also widely attested in the general phonology of the language (Ford 1971; Schuh 1995a). So, positing a floating tone as part of the raised allomorph of the verb root does away with need for a specialized mechanism to account for the behavior of low tone prefixes – the raised allomorph of the root is selected in the appropriate context, and the resulting tones are the result of the general phonology of the language. For example, 'I hid yesterday' would be derived as follows:

(162) Tone 1 prefix raising with floating tone

a.	me^{1}- ____		ki^{3}-vo=e^{3}	*verb root in aorist affirmative, followed by tone 3*
b.	me^{1}-	<u>∅^{4} kpo^{3}</u>	ki^{3}-vo=e^{3}	*selection of raised allomorph with floating tone 4*
c.	me^{14}-kpo^{3}		ki^{3}-vo=e^{3}	*phonology applies, contour tone formed*

4.7.5.2 Cross-word tone raising

There is also some evidence from serial constructions and other multi-verb constructions that a raised verb root can carry a floating tone with it, independent of the presence of a segmental prefix. The first type of example is a serial verb construction. In (163), we see a FORGET-class verb *we*^{3} 'cover' in a raising environment. The normally low-toned final syllable of *kʊ*^{1}*-sa*^{1} 'cloth' appears with a rising tone.

(163) Tone 4 on adjacent word in serial verb construction

a. kʊ^{1}-**sa**$^{\mathbf{1}}$
CL-cloth
'cloth'

b.

ma^{1}-kɔ^{1}	kʊ^{1}-**sa**$^{\mathbf{14}}$	<u>we</u>^{4}	i^{3}-sui=a^{1}
1SG.AOR-take	CL-cloth	cover	CL-body=DEF

'I covered myself with cloth'

In Defina's (2016b; 2016a) work on serial verb constructions in Avatime, she finds that the second verb bears a reduced form of the normal subject agreement prefix. However, for the speakers I consulted, in casual speech no agreement marker appears at all. However, an alternative analysis of the pattern in (163) could be that the tone 4 that appears at the right edge of 'cloth' could be a tonal reflex of this agreement marker. However, the agreement marker for the first person aorist affirmative in this example would be *e*^{1}-, according to Defina's findings. This does not rule out the possibility of course, that the serial verb agreement marker is elided to resolve hiatus with the preceding vowel, leaving its tone to associate with the preceding vowel. In this case, the low tone 1 associated with the serial verb agreement prefix would have to merge with the final tone 1 of *kʊ*^{1}*-sa*^{1}, and then the tone 4 triggered by the raising of the verb would have to combine with this tone to yield the observed contour. Under my analysis, the tone 4 at the right edge of *kʊ^{1}-sa^{1}* is accounted for straightforwardly. The verb 'cover' has the allomorphs listed in (164).

(164) Lexical entry for 'cover'[48]

COVER	↔	∅^{4} we^{4}	(aorist / __ 3/4)
		we^{3}	elsewhere

In (163), the raised allomorph of 'cover' would be selected, since the verb is followed by tone 3. The floating tone 4 to the left of the verb attaches to the final vowel of *kʊ^{1}-sa^{1}*. As discussed above, this is a general phonological pattern in Avatime – a floating tone four combines with a tone 1 to its left to form a rising tone.

(165)

/ma^{1}-kɔ^{1}	kʊ^{1}-**sa^{1}**	______	i^{3}-sui=a^{1}/
[ma^{1}-kɔ^{1}	kʊ^{1}-**sa^{1}**	<u>∅^{4} we^{4}</u>	i^{3}-sui=a^{1}]

There are other multi-verb constructions in Avatime that exhibit the same behavior:

(166) Cross-word "raising" in control construction

a.

m(ɛ)	o^{1}-hu^{3}=lo^{1}	e^{3}-zi^{3}zi^{1}	
1SG	CL-car=DEF	CNC.AOR-spoil	

'My car spoiled'

b.

m(ɛ)	o^{1}-hu^{3}=lo^{1}	**e^{4}-zi^{4}zi^{3}**	**ko^{4}**ko^{1}
1SG	CL-car=DEF	CNC.AOR-spoil	already

'My car spoiled already'

c.

m(ɛ)	o^{1}-hu^{3}=lo^{1}	e^{3}=kpe^{3}s**e^{4}**	**zi^{4}zi^{3}**	**ko^{4}**ko^{1}
1SG	CL-car=DEF	CNC.AOR-begin	spoil	already

'My car already started to spoil'

---

[48] More precisely, there is a meta-entry for verbs of this class (FORGET-class verbs), which contains the general tonal allomorphs for the class. The lexical entry for COVER would include the label of this class.

(167) Cross-word raising in OV construction

a.

ma^{14}-sa^{3}	bɪ^{3}dɔ^{1}m**ɛ^{3}**	**ŋa^{1}**		(cf. a^{3}-ŋa^{1} bla^{1}lɪ=ɛ^{3})
1SG.AOR-exceed	thing	eat		

'I ate too much'

b.

ma^{14}-sa^{3}	bɪ^{3}dɔ^{1}**mɛ^{4}**	**ŋa^{3}**	ko^{4}ko^{1}	(cf. a^{4}-ŋa^{3} kɪ^{3}-dzɛ^{1})
1SG.AOR-exceed	thing	eat	already	

'I ate too much already'

4.8 Alternative approaches

There are number of other approaches that could be considered to account for the tonal patterns in Avatime verbs. On such alternative would involve the listing of the tonal allomorphs in the lexicon, but selecting them in the phonological grammar, as in the approach of Mascaró (2007) and Bonet et al. (2007). Under this approach, the tonal allomorphs for each verb root would be listed with a partial order of preference. The choice of allomorph would then be selected by the general phonological grammar of the language, plus constraints enforcing the lexical preference. However, this analysis has difficulty in accounting for the division between prefix-raising and non-prefix raising verbs. If the correct allomorph is chosen by general phonological principles, then there must be a general phonological principle preferring tone raising. For example, consider the schematic tableaux for 'slap' and 'cook'. The raised allomorph of 'slap' (with its floating tone) is preferred by a constraint *3 3, which disprefers adjacent tone 3. For 'cook' this same constraint drives the choice of the raised allomorph (without a floating tone). However, since *3 3 is acting as a general phonological principle, the attested form loses to a form in which the prefix tone raises to tone 4, despite the selected allomorph of 'cook' lacking the floating tone of 'slap'.

(168) Allomorph selection by phonological preference fails

/a³-{bɔ³, ∅⁴ bɔ⁴} mɛ³	* 3 3	IDENT[tone]
☞ a. a⁴-bɔ⁴ mɛ³		*
b. a³-bɔ³ mɛ³	*!	
/a³-{tɔ³, tɔ⁴} ki³…/		
☞ a. a⁴-tɔ⁴ ki³…		*
b. a³-tɔ⁴ ki³…	*!	*

Another, more promising alternative is the approach taken by Sande (2020) to account for cases of morphologically conditioned phonology that involve more than one source of non-phonological conditioning. Sande's analysis of these patterns is in the framework of Cophonologies by Phase (Sande 2019), in which the lexical entries for morphemes are associated with the reweighting of phonological constraints. These adjustments to the phonological grammar are evaluated within syntactic phases. For Avatime, this approach could take the following form. Verb roots that undergo raising are associated with a cophonology that increases the weight of the markedness constraints driving raising. Aspect/mood/polarity prefixes that block raising are associated with a cophonology that increases the weight of Faithfulness constraints that disprefer raising. The roots that undergo raising regardless of morphological context would be associated with a cophonology that increases the weight of the constraints driving tone raising by an amount that outweighs the increased weight of faithfulness constraints associated with the inflectional prefix.

This approach still encounters the difficulty of how to account for the unexpected behavior of low tone prefixes. Additionally, under this approach, the trigger of tone raising would have to be within the same syntactic phase as the verb root. While I do not have an analysis of where phase boundaries are located in Avatime, it is not clear whether all tone raising triggers would meet this requirement. For example, tone raising may be triggered by the right edge question particle, which has the form *na³,* or a floating tone 3.

(169) Segmental question particle triggers tone raising

a. e3ge4 <u>wɔ3-ŋa1</u>?
what:FOC 2SG-eat
'What did you eat?

b. e3ge4 <u>wɔ4-ŋa3</u> **na3**?
what:FOC 2SG-eat Q
'What did you eat??'[49]

(170) Tonal question particle triggers tone raising

a. (ee11) <u>e3-pe1</u>
(yes) 3SG-get.tired
'(Yes), he got tired'

b. Kɔ1dzɔ3 <u>e4-pe3</u> **∅3**?
Kodzo 3SG-get.tired Q
'Did Kodzo get tired?'

It is not clear what the syntactic position of this particle is in relation to the preceding verb. With more research on the syntactic structure on Avatime, it will become more clear the extent to which this type of approach may prove to provide a better explanation of the patterns described in this chapter.

4.9 Conclusion

This chapter proposes an analysis of Avatime tone raising as the selection of allomorphs that are generated in the lexicon of Avatime speakers. While it seems clear that tone raising originated as a phonological phenomenon in Avatime, in the contemporary language, the properties of these tonal alternations cannot be captured as part of the phonological grammar.

---

[49] This question particle is used for both polar and wh-questions. When the particle is not present, wh-questions have a right-edge low tone. Speakers report that this particle is used when a question is repeated, however no systematic investigation of its semantics has been conducted.

5 CONCLUSION

5.1 Summary

5.1.1 [ATR] contrast in high vowels

I showed in Chapter 2 that there is still an [ATR] contrast in high vowels in contemporary Avatime, but that this contrast is inconsistent across speaker and morphological category. Some younger speakers do not always produce a constrast between the high vowel pairs [i]/[ɪ] and [u]/[ʊ] along the dimension of F1. However, even for these speakers, the behavior of high vowels in [ATR] harmony is stable – when these vowels appear in roots, they still trigger harmony on prefixes and enclitics. I consider the consequences of this loss of contrast in progress for the phonological grammar of Avatime. One possibility is that the [ATR] contrast in Avatime is in the process of being displaced from being cued primarily by F1 to another acoustic cue. I also considered the possibility that for speakers who do not always produce a contrast in their own speech, the contrast that they perceive in other speakers is sufficient for them to recover the underlying forms necessary to trigger [+/-ATR] prefixes and clitics, as discussed by Gouskova & Hall (2009) for Lebanese Arabic epenthetic vowels.

5.1.2 [ATR] harmony and behavior of low vowel

In Chapter 3, I developed an analysis of the asymmetrical behavior of the low vowel [a] in [ATR] harmony. The basic puzzle is that [a] harmonizes in prefixes, repairing with [e], but does not harmonize in enclitics. I showed that this can be accounted for in Harmonic Grammar (Smolensky 1986; Legendre et al. 1990; 2006). I argue that there are three harmony-dispreferring properties a vowel may have in Avatime: (a) it is a low vowel, (b) it is outside the minimal prosodic word containing the root; and (c) it is a lexically-marked exception. I show that a vowel will only resist harmony if it has two of these three properties. This accounts not only for the basic puzzle – [a] in enclitics has properties (a) and (b), while [a] in prefixes only has property (a) – but for additional facts in Avatime [ATR] harmony. Specifically, low vowels that are marked as lexical exceptions may fail to undergo harmony in prefixes (properties (a) and (c)), and non-low enclitic vowels that are marked as exceptions may also fail to undergo harmony (properties (b) and (c)). My analysis predicts that there should be no harmony-resisting non-low vowels in prefixes, which aligns with the Avatime facts. This analysis shows a case of *ganging* in Harmonic Grammar – on their own, the weights of the constraints associated with harmony-resisting properties (a)-(c) are not high enough to overcome the weight of the harmony-driving constraint. However, when the weight of any two of these constraints is combined, they outweight the harmony-driving constraint. I show that this pattern cannot be accounted for in a strict-ranking grammar as in classical Optimality Theory (Prince & Smolensky [1993] 2004).

5.1.3 Tone raising

In Chapter 4, I presented data on tone raising, using Ford's (1971) work as a starting point. I showed that, while tone raising in verbs is conditioned in part by phonological environment, several aspects of this pattern are challenging to analyze as phonology. In particular, I considered the difference in the output of rasing tone 1 in roots versus prefixes, and two novel patterns – cross-word raising and partial raising – as motivating an analysis of tone raising as phonologically-conditioned allomorphy. I develop an analysis in the framework developed by McPherson (2019), in which the lexicon contains generalized frames for tone classes with listed tonal allomorphs conditioned by phonological and morphological environmeny. Each verb root is specified according to which tone class it belongs to. I propose that the tonal allomorphs contained in these frames may consist not only of the tone that appears on the verb root, but also stipulate that a tone must appear to the left of the verb root, regardless of what element appears to the left of the verb root. This addresses three challenging aspects of the tone raising process – (a) tone raising on prefixes is determined by the lexical class of the root, (b) tone 1 prefixes do not participate in the chain shift pattern seen on roots in raising contexts, but rather appear with rising contours, and (c) the raised "prefix" tone may appear on words to the left of a bare root. In this section, I also address tone raising patterns that I observed to differ from earlier descriptions. One pattern that is of particular interest, but will require further study, is a class of verb roots that may undergo raising in an environment that can only be defined morphogyntactically, rather than phonologically.

5.2 Future directions

5.2.1 High vowels

I intend to carry out additional acoustic studies of high vowels, including more speakers and tokens. I also plan to include data from speakers in generations above the speakers consulted for the study in this disseration in order to approximate the input those younger speakers may have received as they acquired Avatime. An expanded study will give a clearer picture of the status of the contrast for contemporary speakers, which will not only bear on the phonological grammars of these speakers, but also provide a baseline against which to evaluate possible future changes in the vowel inventory and its effects on vowel harmony. Measurement of additional acoustic properties, such as voice quality, would also be useful in determining whether the [ATR] contrast in high vowels is truly being lost, or displaced onto a new primary acoustic cue.

In addition, as mentioned in the conclusion of Chapter 2, it would be fruitful to conduct a perception study on the [ATR] contrasts in Avatime, similar to that conducted by Rose at al. (2023) for Akan. In Akan, the [-ATR] high vowels are acoustically similar to the *[+ATR] mid vowels*, rather than the [+ATR] high vowels, so the results of a perceptual study for Avatime may be revealing about the role of perceptual similarity versus phonemic contrast in perceiving these vowel categories. A study of this kind may also shed light on any possible divergence between Avatime speakers' production grammars and their perception grammars.

5.2.2 Low vowel and [ATR] harmony

The consideration of prosodic structure in the analysis of the behavior of the low vowel [a] in [ATR] harmony points toward additional avenues of research. As seen in the discussion of possessive pronouns and postpositions, there are additional categories of morphemes that must be considered in developing a model of the prosodic structure of Avatime. It was seen that possessive pronouns, at least in inalienable possession, undergo obligatory hiatus resolution with vowel-initial (and even some consonant-initial!) noun class prefix, but the effect on [ATR] harmony is not clear. Additional possessive paradigms must be collected, both replicating those collecting by Funke (1909) and extending the empirical coverage. Additionally, postpositions and indefinite determiners also trigger obligatory hiatus resolution, but behave differently than enclitics with respect to [ATR] harmony. Additional study of these categories will shed light on both the prosodic word structure of Avatime, and refine the analysis of [ATR] harmony developed in this disseratation.

5.2.3 Tone raising

The study of tone raising in this dissertation raises nearly as many new questions as it answers. Future work will investigate the status of the class of verbs for which tone raising no longer appears to be conditioned by phonological environment. If this pattern is widespread among younger speakers, it would be strong evidence that the tone raising process really cannot be analyzed purely as phonology. Additionally, although it was not addressed above, there is some variation in whether speakers apply raisin even in contexts in which it is expected. Further research will be necessary to determine whether this is truly variation, or whether it is wholly or in part an effect of the elicitation method used to collect the data for this dissertation. The vast majority of the data was collected in targeted grammatical elicitation, frequently explicitly targeting tonal phenomena. It is possible that this effected the choice of tonal allomorph in some cases. It will be necessary to consider data from more naturalistic contexts to determine whether tone raising is actually an optional or variable process in the course of normal language use. However, when speakers were directly queried as to whether a raised or non-raised form was acceptable in a given context, their intuition nearly always took the form of a comment like "They are the same thing". And, importantly, speakers consistently rejected tonal forms that were not allomorphs associated with a verb's lexical class, or that involved raising in morphological contexts in which raising was blocked.

Future avenues for research on the tonal phonology and morphology of Avatime are too numerous to discuss here, so I will limit this section to one additional area for future study of tone raising in particular. Ford (1971) shows that tone raising may also affect other categories, including nouns and adverbs. However, the targets and environments for tone raising in these categories are much more specific and limited than those for verbal tone raising. In my limited attempts to target tone raising in nouns, I have not found the patterns identified by Ford. However, one reason for this is that tone raising does not affect nouns when they are followed immediately by a definiteness clitic. As mentioned briefly earlier in the dissertation, bare nouns are quite rare in Avatime, with the definiteness clitics appearing even in most speakers' citation forms for nouns. So, in future research, I plan to identify a set of reliable contexts in which bare nouns may be produced naturalistically to investigate the behavior of tone raising in this category. Understanding how tone raising functions in other categories will yield insights into whether the entire tone raising system must be analyzed as tonal allmorphy, or whether there might be a phonological core that applies across categories and contexts.

APPENDIX

Mean formant values for all speakers

Table 53: Mean formant values, all vowels, Speaker 1

Vowel	Mean F1	Mean F2
i	**370**	**2541**
ɪ	**408**	**2519**
e	**457**	**2278**
ɛ	582	2148
a	870	1655
u	**368**	**935**
ʊ	**397**	**873**
o	**429**	**878**
ɔ	619	1026

Table 54: Mean formant values, all vowels, Speaker 2

Vowel	Mean F1	Mean F2
i	**317**	**2627**
ɪ	**383**	**2456**
e	**396**	**2233**
ɛ	504	2196
a	777	1486
u	**326**	**817**
ʊ	**370**	**828**
o	**380**	**907**
ɔ	546	1051

Table 55: Mean formant values, all vowels, Speaker 3

Vowel	Mean F1	Mean F2
i	**305**	2153
ɪ	**323**	2067
e	**383**	1954
ɛ	496	1747
a	724	1389
u	**295**	926
ʊ	**310**	854
o	**384**	931
ɔ	516	1016

Table 56: Mean formant values, all vowels, Speaker 4

Vowel	Mean F1	Mean F2
i	**295**	1947
ɪ	**314**	1967
e	**351**	1854
ɛ	510	1838
a	766	1512
u	**282**	979
ʊ	**310**	821
o	**343**	925
ɔ	495	954

Plots and means for all speakers – all vowels and non-low vowels

Figure 15: Speaker 1 means

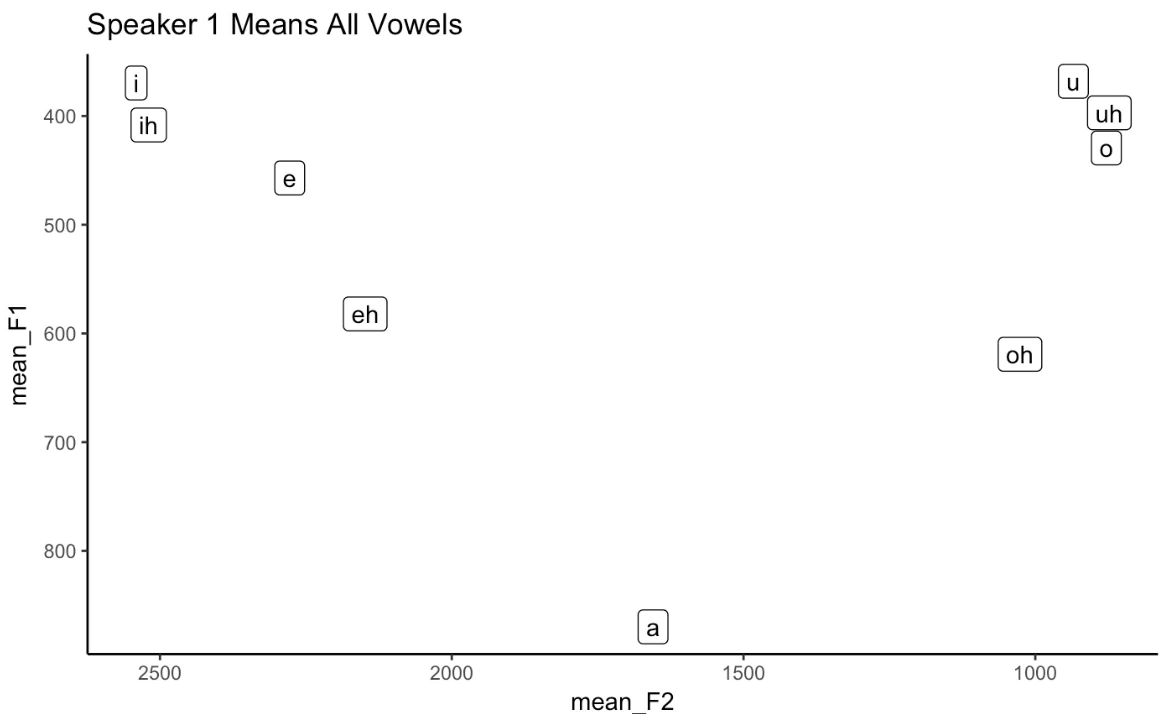


Figure 16: Speaker 1 all vowels

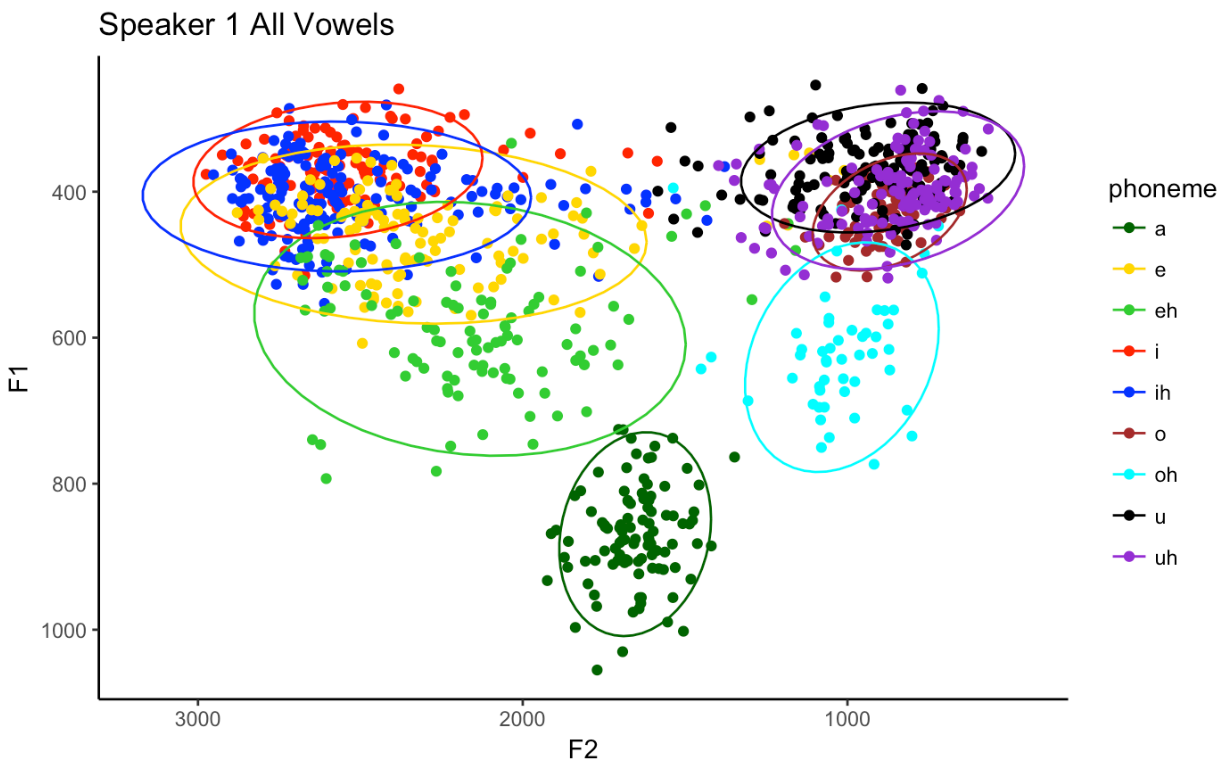


Figure 17: Speaker 2 means

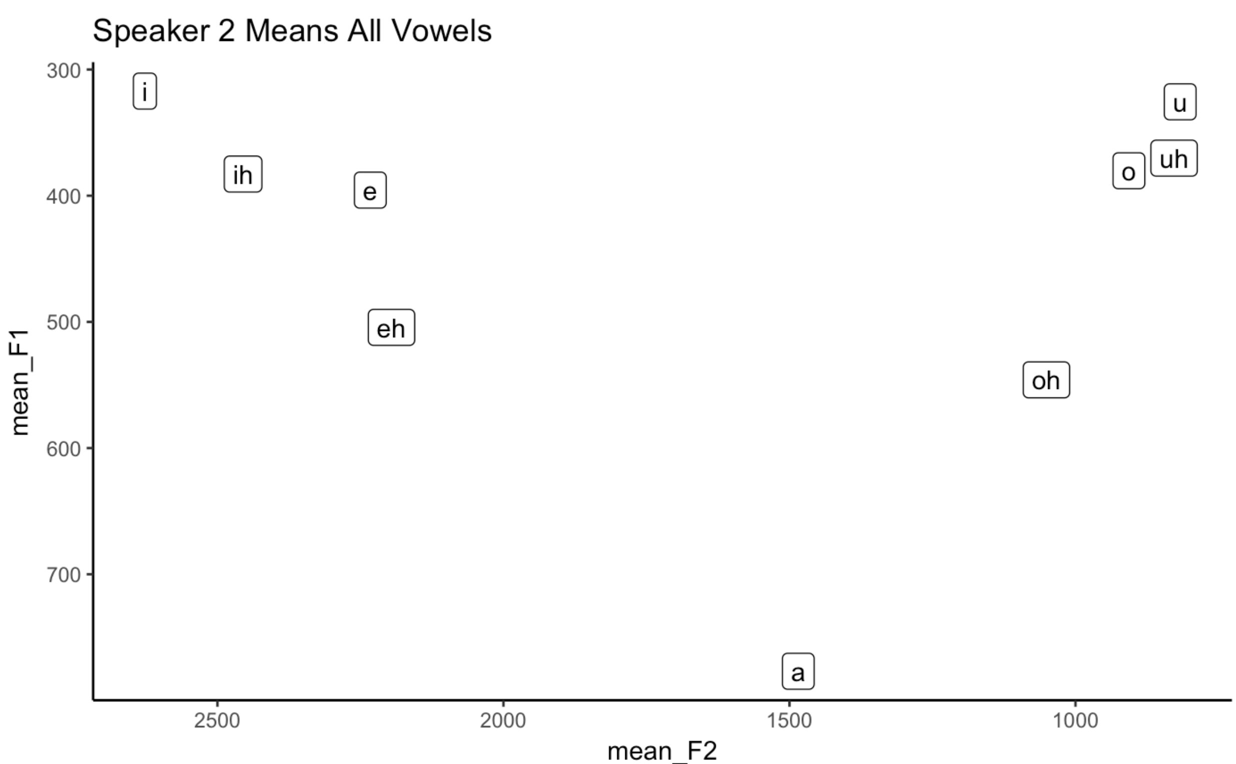


Figure 18: Speaker 2 all vowels

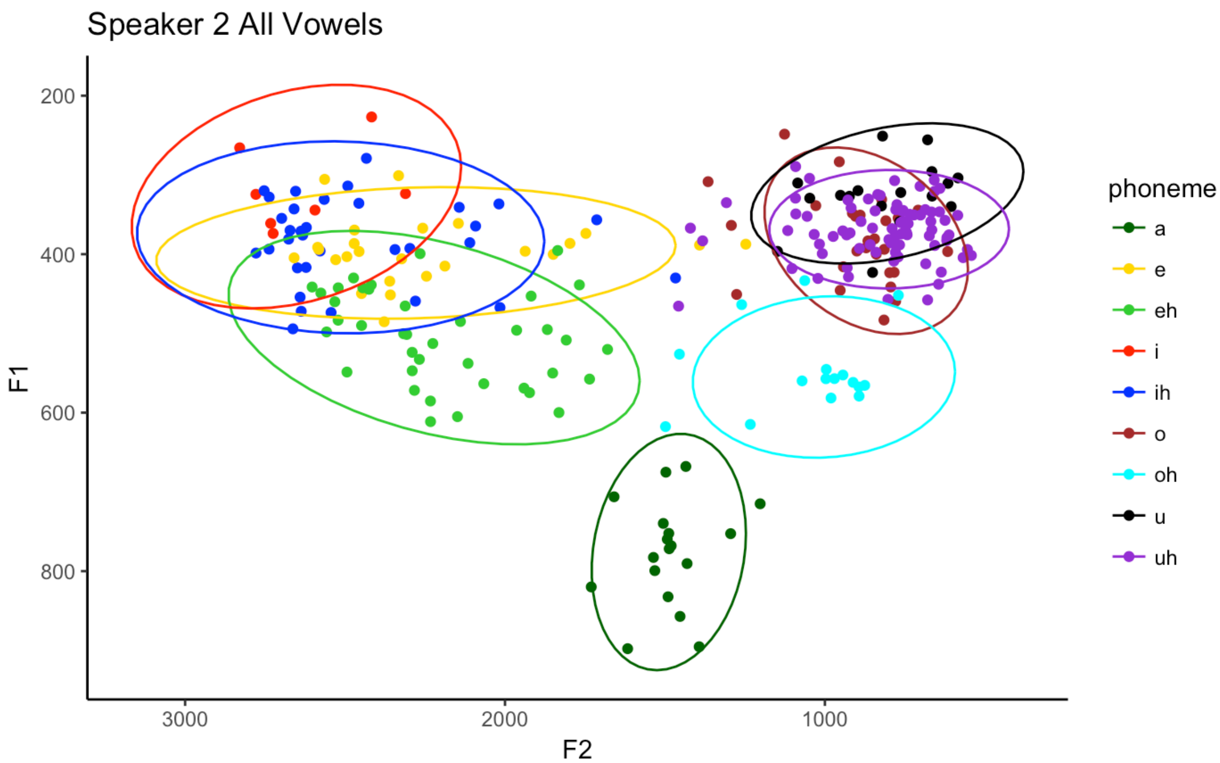


Figure 19: Speaker 3 means

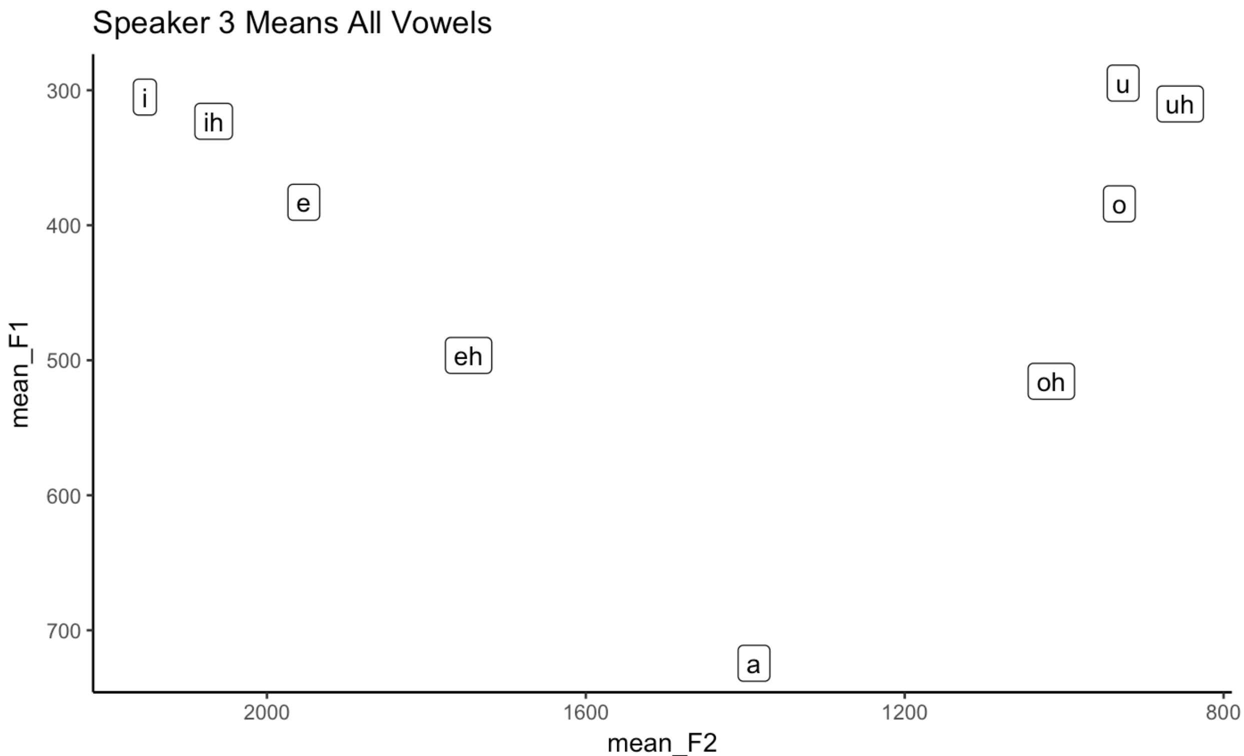


Figure 20: Speaker 3 all vowels

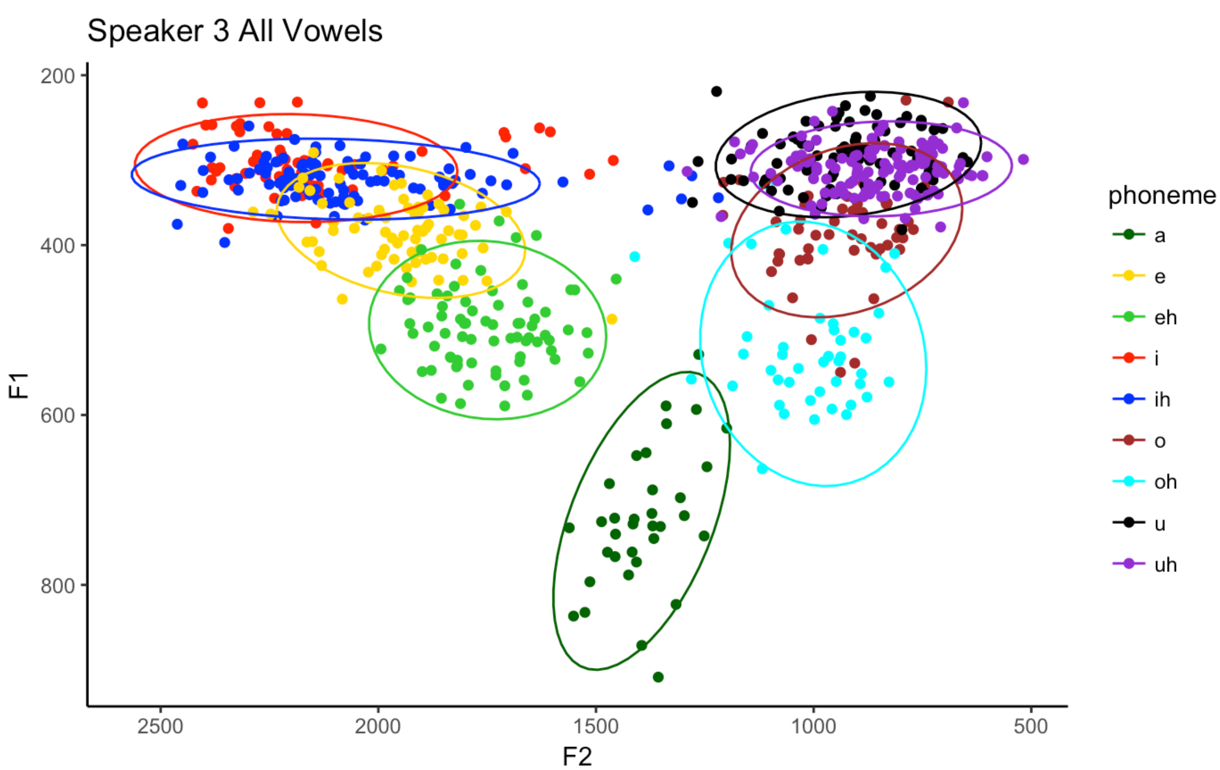


Figure 21: Speaker 4 means

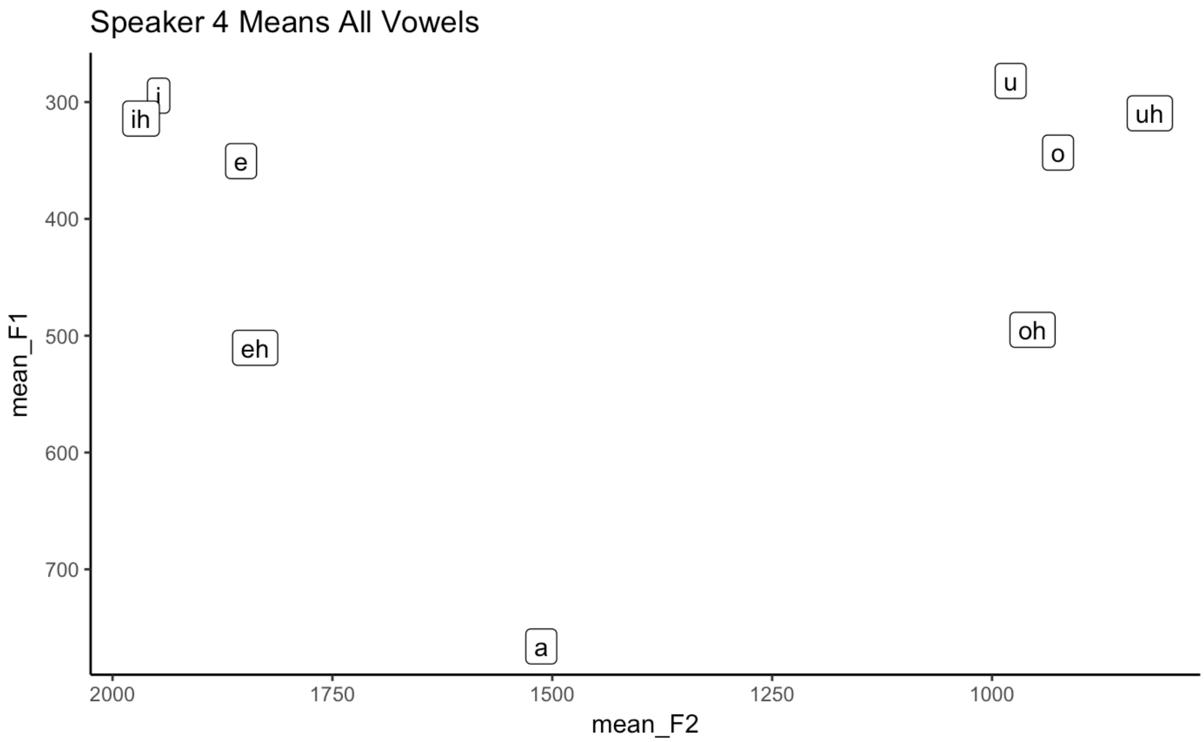
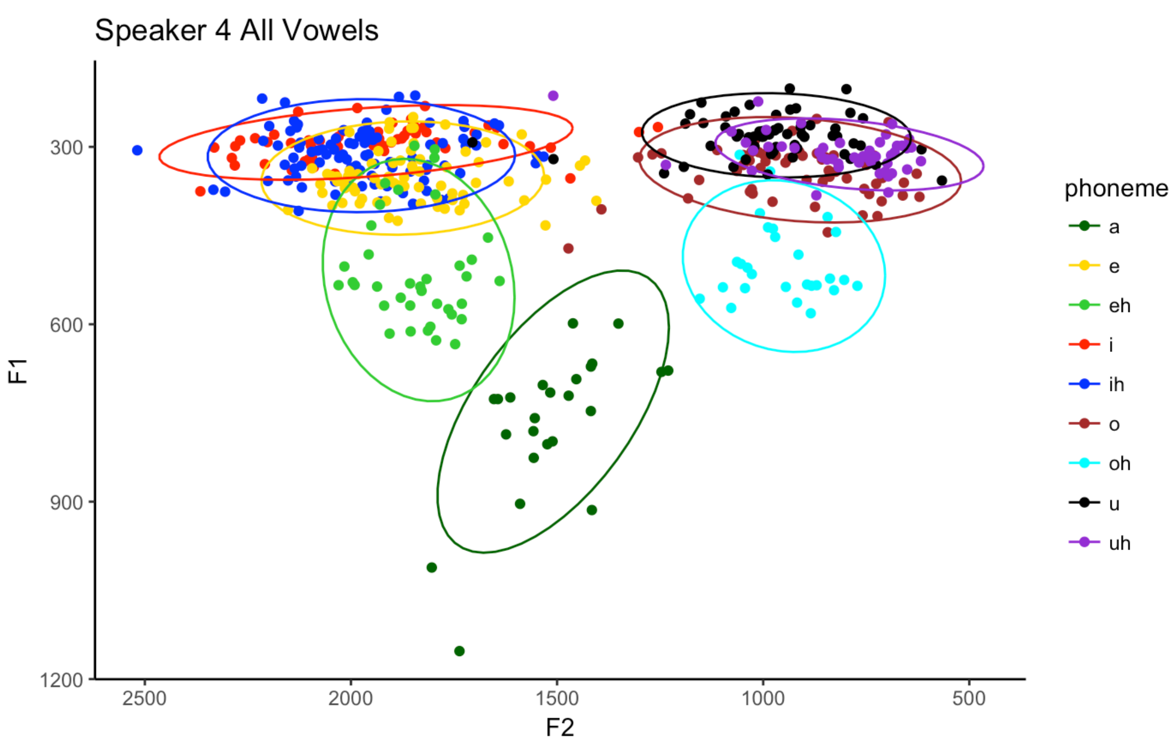


Figure 22: Speaker 4 all vowelss



Statistical results

(1) All high vowel tokens, all speakers, F1

a. F1 ~ back * ATR * morph + (1|word)

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	639.9	25.30
Residual		2388.2	48.87

Number of obs: 1344, groups: word, 239

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	325.587	11.317	230.400	28.769	< 2e-16	***
backnonback	-6.563 1	4.605	293.800	-0.449	0.65351	
ATRR	46.451	14.636 2	05.800	3.174	0.00173	**
morphpn	42.447	43.849	431.400	0.968	0.33357	
morphr	-14.029	13.650	299.700	-1.028	0.30490	
morphvp	44.377	15.020	366.300	2.955	0.00333	**
morphvr	-11.234	13.149	250.200	-0.854	0.39372	
backnonback:ATRR	-21.098	18.546	256.800	-1.138	0.25635	
backnonback:morphr	-0.603	19.345	461.300	-0.031	0.97515	
backnonback:morphvp	4.323	19.177	571.900	0.225	0.82172	
backnonback:morphvr	26.558	17.240	312.100	1.540	0.12446	
ATRR:morphr	-32.912	18.690	303.100	-1.761	0.07925	.
ATRR:morphvp	-46.546	19.292	347.100	-2.413	0.01635	*
ATRR:morphvr	-21.186	16.953	230.300	-1.250	0.21271	
backnonback:ATRR:morphr	78.603	28.527	285.200	2.755	0.00624	**
backnonback:ATRR:morphvp	38.726	24.054	520.000	1.610	0.10802	
backnonback:ATRR:morphvr	18.077	22.259	281.700	0.812	0.41743	

(2) All high vowel tokens, female speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	617.3	24.85
Residual		1512.8	38.90

Number of obs: 705, groups: word, 176

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	358.856171	11.525941	197.000000	31.135	<2e-16 ***
backnonback	12.598078	15.891481	245.400000	0.793	0.4287
ATRR	**48.323824**	**14.775161**	**173.000000**	**3.271**	**0.0013** **
morphpn	-9.982090	38.732820	214.900000	-0.258	0.7969
morphr	-10.965570	14.283096	286.400000	-0.768	0.4433
morphvp	28.340137	14.747195	265.800000	1.922	0.0557 .
morphvr	-15.423552	13.713003	220.100000	-1.125	0.2619
backnonback:ATRR	**-26.365542**	**19.849722**	**213.200000**	**-1.328**	**0.1855**
backnonback:morphr	-15.169857	22.283278	343.000000	-0.681	0.4965
backnonback:morphvp	-2.128425	19.877616	402.400000	-0.107	0.9148
backnonback:morphvr	-0.006326	18.790269	271.200000	0.000	0.9997
ATRR:morphr	-33.192266	19.649710	268.600000	-1.689	0.0923 .
ATRR:morphvp	-35.346078	19.167005	256.400000	-1.844	0.0663 .
ATRR:morphvr	-23.921171	17.533925	202.200000	-1.364	0.1740
backnonback:ATRR:morphr	75.601241	30.870892	240.500000	2.449	0.0150 *
backnonback:ATRR:morphvp	37.127710	24.912254	380.800000	1.490	0.1370
backnonback:ATRR:morphvr	46.565841	24.084543	244.200000	1.933	0.0543 .

(3) All high vowel tokens, male speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	169.8	13.03
Residual		799.6	28.28

Number of obs: 639, groups: word, 176

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	283.647	8.690	94.200	32.641	< 2e-16 ***
backnonback	-1.205	10.794	125.200	-0.112	0.91130
ATRR	**24.828**	**11.127**	**109.500**	**2.231**	**0.02769 ***
morphr	5.971	10.240	106.500	0.583	0.56105
morphvp	47.230	14.294	264.700	3.304	0.00108 **
morphvr	1.445	9.894	114.200	0.146	0.88416
backnonback:ATRR	**-0.175**	**13.676**	**134.400**	**-0.013**	**0.98981**
backnonback:morphr	-8.918	13.988	259.600	-0.638	0.52431
backnonback:morphvp	-13.046	17.427	382.400	-0.749	0.45456
backnonback:morphvr	**26.021**	**12.654**	**146.800**	**2.056**	**0.04152 ***
ATRR:morphr	-12.868	13.961	143.500	-0.922	0.35824
ATRR:morphvp	-33.831	17.322	269.100	-1.953	0.05184 .
ATRR:morphvr	2.719	12.667	128.300	0.215	0.83038
backnonback:ATRR:morphr	23.627	20.697	145.600	1.142	0.25553
backnonback:ATRR:morphvp	31.768	20.973	370.900	1.515	0.13069
backnonback:ATRR:morphvr	-18.410	16.226	156.300	-1.135	0.25828

(4) Nouns from Maddieson (1995), all speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	116	10.77
Residual		1122	33.50

Number of obs: 275, groups: word, 35

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	365.246	19.314	174.020	18.911	< 2e-16	***
backnonback	8.156	13.257	249.230	0.615	0.53895	
ATRR	16.791	26.975	96.000	0.622	0.53513	
morphr	1.883	18.273	162.590	0.103	0.91805	
speakerPA	-44.929	24.537	242.690	-1.831	0.06831	.
speakerVA	-92.794	31.009	252.900	-2.992	0.00304	**
speakerDA	-103.833	20.159	252.090	-5.151	5.23e-07	***
backnonback:ATRR	9.646	20.931	126.480	0.461	0.64569	
ATRR:morphr	5.526	23.528	97.560	0.235	0.81480	
backnonback:speakerPA	-28.027	25.475	239.800	-1.100	0.27236	
backnonback:speakerVA	-13.049	20.282	241.040	-0.643	0.52058	
backnonback:speakerDA	-20.696	17.765	245.190	-1.165	0.24515	
ATRR:speakerPA	-3.846	17.786	249.500	-0.216	0.82898	
ATRR:speakerVA	2.558	40.488	252.430	0.063	0.94968	
ATRR:speakerDA	-23.117	16.800	250.180	-1.376	0.17006	
morphr:speakerPA	-1.937	21.307	240.400	-0.091	0.92764	
morphr:speakerVA	20.205	29.396	253.000	0.687	0.49250	
morphr:speakerDA	22.501	17.834	251.530	1.262	0.20824	
backnonback:ATRR:speakerPA	42.060	33.737	241.690	1.247	0.21371	
backnonback:ATRR:speakerVA	26.218	28.934	244.110	0.906	0.36577	
backnonback:ATRR:speakerDA	30.463	26.463	247.180	1.151	0.25078	
ATRR:morphr:speakerVA	-18.637	36.993	252.320	-0.504	0.61484	

(5) Nouns from Maddieson (1995), female speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	342.2	18.50
Residual		1801.5	42.44

Number of obs: 139, groups: word, 22

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	371.3199	24.8179	79.8300	14.962	<2e-16 ***
backnonback	0.9146	15.3836	132.9900	0.059	0.953
ATRR	-29.0782	34.3166	35.3400	-0.847	0.403
morphr	-18.2128	24.2654	75.4900	-0.751	0.455
backnonback:ATRR	37.7745	25.1421	40.0500	1.502	0.141
ATRR:morphr	33.5332	31.0518	39.7500	1.080	0.287

(6) Nouns from Maddieson (1995), male speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	126.0	11.23
Residual		722.7	26.88

Number of obs: 136, groups: word, 29

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	272.1396	19.3192	100.8200	14.086	<2e-16 ***
ATRR	9.0958	24.2293	44.3200	0.375	0.7091
backnonback	-6.7737	8.4827	128.2700	-0.799	0.4260
morphr	18.8373	19.1462	95.2000	0.984	0.3277
ATRR:backnonback	26.4122	14.7483	23.7600	1.791	0.0861 .
ATRR:morphr	-0.3394	22.6837	49.3000	-0.015	0.9881

(7) High vowel verb roots, Speakers 1, Speaker 2, Speaker 3, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	189.4	13.76
Residual		908.5	30.14

Number of obs: 349, groups: word, 96

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	338.017	6.675	203.1	50.643	< 2e-16	***
backnonback	6.032	8.797	184.0	0.686	0.493748	
ATRR	4.974	9.296	210.4	0.535	0.593193	
speakerVA	-57.633	8.657	313.1	-6.657	1.25e-10	***
speakerDA	-61.832	11.104	298.7	-5.568	5.74e-08	***
backnonback:ATRR	33.284	12.536	194.7	2.655	0.008587	**
backnonback:speakerVA	33.097	11.579	306.8	2.858	0.004550	**
backnonback:speakerDA	17.214	13.466	299.0	1.278	0.202129	
ATRR:speakerVA	21.742	11.715	322.5	1.856	0.064388	.
ATRR:speakerDA	34.045	14.223	305.8	2.394	0.017281	*
backnonback:ATRR:speakerVA	-58.899	16.060	321.8	-3.667	0.000287	***
backnonback:ATRR:speakerDA	-51.993	17.923	304.8	-2.901	0.003992	**

(8) High vowel verb roots, Speaker 1, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	403.4	20.08
Residual		1118.3	33.44

Number of obs: 132, groups: word, 67

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	337.173	8.211	68.210	41.062	<2e-16	***
backnonback	5.640	10.872	61.660	0.519	0.6057	
ATRR	6.136	11.494	67.640	0.534	0.5952	
backnonback:ATRR	31.596	15.571	61.580	2.029	0.0468	*

(9) High vowel verb roots, male speakers, F1

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	41.54	6.445
Residual		804.57	28.365

Number of obs: 217, groups: word, 82

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	278.037	5.032	75.320	55.257	< 2e-16 ***
ATRR	30.822	6.406	68.250	4.812	8.63e-06 ***
backnonback	32.926	6.481	58.640	5.081	4.11e-06 ***
ATRR:backnonback	-21.544	8.492	57.130	-2.537	0.0139 *

(10) All high vowel tokens, female speakers, F2

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	6549	80.93
Residual		51254	226.39

Number of obs: 705, groups: word, 176

Fixed effects:

	Estimat	Std. Error	df	t value	Pr(>|t|)
(Intercept)	841.534	52.744	162.1	15.955	< 2e-16 ***
ATRR	18.497	67.043	161.7	0.276	0.78298
backnonback	1721.079	74.501	198.6	23.102	< 2e-16 ***
morphpn	-487.734	186.993	375.3	-2.608	0.00946 **
morphr	27.516	67.806	210.4	0.406	0.68531
morphvp	92.495	70.141	230.4	1.319	0.18858
morphvr	137.583	63.888	195.6	2.154	0.03250 *
ATRR:backnonback	-103.154	92.027	189.1	-1.121	0.26375
ATRR:morphr	-101.838	93.407	226.8	-1.090	0.27676
ATRR:morphvp	-13.162	91.294	245.5	-0.144	0.88548
ATRR:morphvr	-132.272	81.315	197.6	-1.627	0.10540
backnonback:morphr	-80.792	108.481	269.9	-0.745	0.45707
backnonback:morphvp	4.367	98.931	351.2	0.044	0.96482
backnonback:morphvr	-201.047	89.423	233.3	-2.248	0.02549 *
ATRR:backnonback:morphr	77.643	145.058	206.1	0.535	0.59305
ATRR:backnonback:morphvp	-50.623	123.758	357.3	-0.409	0.68275
ATRR:backnonback:morphvr	327.502	113.868	230.8	2.876	0.00440 **

(11) All high vowel tokens, male speakers, F2

Random effects:

Groups	Name	Variance	Std.Dev.
word	(Intercept)	3646	60.38
Residual		31080	176.29

Number of obs: 639, groups: word, 176

Fixed effects:

	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	950.184	47.272	67.400	20.101	< 2e-16	***
ATRR	4.905	61.168	81.900	0.080	0.936281	
backnonback	1210.052	59.788	92.700	20.239	< 2e-16	***
morphr	-1.271	56.138	76.600	-0.023	0.981996	
morphvp	-150.738	82.474	233.900	-1.828	0.068867	.
morphvr	9.655	54.571	88.000	0.177	0.859975	
ATRR:backnonback	-48.907	76.114	102.800	-0.643	0.521948	
ATRR:morphr	-88.392	77.950	108.400	-1.134	0.259313	
ATRR:morphvp	18.085	99.996	235.800	0.181	0.856632	
ATRR:morphvr	-155.582	70.380	101.700	-2.211	0.029302	*
backnonback:morphr	-296.824	80.439	200.500	-3.690	0.000289	***
backnonback:morphvp	-56.867	102.182	340.600	-0.557	0.578214	
backnonback:morphvr	-97.309	70.805	115.300	-1.374	0.172006	
ATRR:backnonback:morphr	182.378	115.705	111.800	1.576	0.117797	
ATRR:backnonback:morphvp	-54.407	122.816	331.200	-0.443	0.658055	
ATRR:backnonback:morphvr	179.700	91.138	125.800	1.972	0.050832	.

REFERENCES

Anderson, Coleen G. 1999. "ATR Vowel Harmony in Akposso." *Studies in African Linguistics* 28 (2): 185–214. https://doi.org/10.32473/sal.v28i2.107372.

———. 2003. "In Search of an Acoustic Correlate to [ATR] in Ikpɔsɔ." In *The Linguistic Typology and Representation of African Languages*, 5:83–92. Trends in African Linguistics. Athens, OH: Africa World Press.

Ansre, Gilbert. 1961. "The Tonal Structure of Ewe." Master's thesis, The Hartford Seminary Foundation.

Archangeli, Diana, and Douglas Pulleyblank. 1994. *Grounded Phonology*. MIT Press.

Baković, Eric. 2001. "Vowel Harmony and Cyclicity in Eastern Nilotic." In *Proceedings of the Annual Meeting of the Berkeley Linguistics Society*, 1–12.

———. 2007. "A Revised Typology of Opaque Generalisations." *Phonology* 24 (2): 217–59. https://doi.org/10.1017/S0952675707001194.

Becker-Kristal, Roy. 2010. "Acoustic Typology of Vowel Inventories and Dispersion Theory: Insights from a Large Cross-Linguistic Corpus." Doctoral dissertation, University of California, Los Angeles.

Beckman, Jill. 1998. "Positional Faithfulness." Doctoral dissertation, University of Massachussetts, Amherst.

Boersma, Paul, and David Weenink. 2024. "Praat: Doing Phonetics by Computer." http://www.praat.org.

Bonet, Eulàlia, Maria-Rosa Lloret, and Joan Mascaró. 2007. "Allomorph Selection and Lexical Preferences: Two Case Studies." *Lingua* 117 (6): 903–27. https://doi.org/10.1016/j.lingua.2006.04.009.

Blench, Roger. 2009. "Do the Ghana-Togo Mountain Languages Constitute a Genetic Group?" *Journal of West African Languages* 36 (1–2): 19–35.

Bradshaw, Mary. 1999. "A Crosslinguistic Study of Consonant-Tone Interaction." Doctoral dissertation, Ohio State University.

Brydon, Lynne. 1979. "Women at Work: Some Changes in Family Structure in Amedzofe-Avatime, Ghana." *Africa* 49 (2): 97–111. https://doi.org/10.2307/1158668.

———. 1981. "Rice, Yams and Chiefs in Avatime: Speculations on the Development of a Social Order." *Africa* 51 (2): 659–77. https://doi.org/10.2307/1158831.

———. 1996. “Women Chiefs and Power in the Volta Region of Ghana.” *The Journal of Legal Pluralism and Unofficial Law* 28 (37–38): 227–47. https://doi.org/10.1080/07329113.1996.10756481.

———. 2008. “Constructing Avatime: Questions of History and Identity in a West African Polity, c. 1690s to the Twentieth Century.” *The Journal of African History* 49 (1): 23–42. https://doi.org/10.1017/S0021853707003386.

Casali, Roderic F. 1995. “On the Reduction of Vowel Systems in Volta-Congo∗.” *African Languages and Cultures* 8 (2): 109–21. https://doi.org/10.1080/09544169508717790.

———. 2008. “ATR Harmony in African Languages.” *Language and Linguistics Compass* 2 (3): 496–549. https://doi.org/10.1111/j.1749-818X.2008.00064.x.

Defina, Rebecca. 2009. “Aspect and Modality in Avatime.” Master’s thesis, Leiden University.

———. 2016a. “Serial Verb Constructions and Their Subtypes in Avatime.” *Studies in Language* 40 (3): 648–80. https://doi.org/10.1075/sl.40.3.07def.

———. 2016b. “Events in Language and Thought: The Case of Serial Verb Constructions in Avatime.” Doctoral dissertation, Nijmegen: Radboud Universiteit.

Devlin, Kerri, Blake Lehman, Travis Major, and Harold Torrence. 2021. “A Note on Wh-Questions in Avatime.” In *Celebrating 50 Years of ACAL: Selected Papers from the 50th Annual Conference on African Linguistics*, edited by Akinbiyi Akinlabi, Lee Bickmore, Michael Cahill, Michael Diercks, Laura J. Downing, James Essegbey, Katie Franich, Laura McPherson, and Sharon Rose, 55–72. Berlin: Language Science Press. https://doi.org/10.5281/ZENODO.5578772.

“ELAN.” 2023. Nijmegen: Max Planck Institute for Pyscholinguistics, the Language Archive. https://archive.mpi.nl/tla/elan.

Ford, Kevin C. 1971. “Aspects of Avatime Syntax.” Doctoral dissertation, Legon: University of Ghana.

———. 1986. “The Tonal Phonology of Siya (a Central-Togo Language) and the Historical Significance of Its Major Functions.” In *The Phonological Representation of Suprasegmentals: Studies on African Langauges Offered to John M. Stewart on His 60th Birthday*, edited by Koen Bogers, Harry van der Hulst, and Maarten Mous, 79–94. Dordrecht: Foris Publications.

Fulop, S.A., E. Kari, and P. Ladefoged. 1998. “An Acoustic Study of the Tongue Root Contrast in Degema Vowels.” *Phonetica* 55 (1–2): 80–98. https://doi.org/10.1159/000028425.

Fukazawa, Haruka. 1999. “Theoretical Implications of OCP Effects on Features in Optimality Theory.” Doctoral dissertation, University of Maryland, College Park.

Funke, Emil. 1909. “Versuch Einer Grammatik Der Avatimesprache.” In *Mitteilungen Des Seminars Für Orientalischen Sprachen*, 12(3):287–336.

———. 1910. “Deutsch-Avatime Wörterverzeichnis.” In *Mitteilungen Des Seminars Für Orientalischen Sprachen*, 13(3):1–38.

Ghana Institute of Linguistics, Literacy, and Bible Translation. 2017. *Kunyaya Vuvu Yɔ: The New Testament in Sideme*. Tamale, Ghana.

Gnanadesikan, Amalia Elisabeth. 1997. “Phonology with Ternary Scales.” Doctoral dissertation, University of Massachussetts, Amherst.

Goldsmith, John A. 1976. “Autosegmental Phonology.” Doctoral dissertation, MIT.

Goldwater, Sharon, and Mark Johnson. 2003. “Learning OT Constraint Rankings Using a Maximum Entropy Model.” In *Proceedings of the Workshop on Variation within Optimality Theory*, 111–20.

Gouskova, Maria, and Nancy Hall. 2009. “Acoustics of Epenthetic Vowels in Lebanese Arabic.” In *Phonological Argumentation: Essays on Evidence and Motivation*, edited by Steve Parker. Advances in Optimality Theory. Equinox.

Green, Christopher R., and Abbie E. Hantgan. 2019. “A Feature Geometric Approach to Bondu-so Vowel Harmony.” *Glossa: A Journal of General Linguistics* 4 (1). https://doi.org/10.5334/gjgl.793.

Guion, Susan G., Mark W. Post, and Doris L. Payne. 2004. “Phonetic Correlates of Tongue Root Vowel Contrasts in Maa.” *Journal of Phonetics* 32 (4): 517–42. https://doi.org/10.1016/j.wocn.2004.04.002.

Hantgan, Abie, and Stuart Davis. 2012. “Bondu-so Vowel Harmony: A Descriptive Analysis with Theoretical Implications.” *Studies in African Linguistics* 41 (2): 2–26. https://doi.org/10.32473/sal.v41i2.107276.

Hayes, Bruce. 1990. “Precompiled Phrasal Phonology.” In *The Phonology-Syntax Connection*, edited by Sharon Inkelas and Draga Zec, 85–108. Chicago: University of Chicago Press.

———. 2004. “Phonological Acquisition in Optimality Theory: The Early Stages.” In *Constraints in Phonological Acquisition*, edited by Rene Kager, Joe Pater, and Wim Zonneveld. Cambridge: Cambridge University Press.

Hayes, Bruce, and James White. 2015. “Saltation and the P-Map.” *Phonology* 32 (2): 267–302. https://doi.org/10.1017/S0952675715000159.

Heine, Bernd. 1968. *Die Verbreitung Und Gliederung Der Togorestsprachen*. Berlin: Dietrich Reimer Verlag.

Hess, Susan. 1988. "Acoustic Characteristics of Tongue Root Position and Vowel Assimilation in Akan." *UCLA Working Papers In Phonetics* 70: 59–69.

———. 1992. "Assimilatory Effects in a Vowel Harmony System: An Acoustic Analysis of Advanced Tongue Root in Akan." *Journal of Phonetics* 20 (4): 475–92. https://doi.org/10.1016/S0095-4470(19)30651-5.

Hoffmann, Carl. 1973. "The Vowel Harmony System of the Okpẹ Monosyllabic Verb." *Research Notes from the Department of Linguistics and Nigerian Languages* 6: 79–111.

Itô, Junko, and Armin Mester. 1994. "Reflections on CodaCond and Alignment." In *Phonology at Santa Cruz*, 3:27–46.

———. 1999a. "Realignment." In *The Prosody-Morphology Interface*, edited by Rene Kager, Harry van der Hulst, and Wim Zonneveld, 188–217. Cambridge UK: Cambridge University Press.

———. 1999b. "The Phonological Lexicon." In *The Handbook of Japanese Linguistics*, edited by N Tsujimura, 62–100. Oxford: Blackwell.

———. 2001. "Covert Generalizations in Optimality Theory: The Role of Stratal Faithfulness Constraints." *Studies in Phonetics, Phonology, and Morphology* 7: 273–99.

Kingston, John, Neil A. Macmillan, Laura Walsh Dickey, Rachel Thorburn, and Christine Bartels. 1997. "Integrality in the Perception of Tongue Root Position and Voice Quality in Vowels." *The Journal of the Acoustical Society of America* 101 (3): 1696–1709. https://doi.org/10.1121/1.418179.

Kiparsky, Paul. 1973. "Abstractness, Opacity, and Global Rules." In *Three Dimensions in Linguistic Theory*, 57–86. Tokyo: TEC.

Kirchner, Robert. 1996. "Synchronic Chain Shifts in Optimality Theory." *Linguistic Inquiry* 27 (2): 341–50. https://doi.org/10.1002/9780470756171.ch21.

Kropp-Dakubu, Mary Esther. 2017. "Sub-Classifying the Languages of the Lower Volta Valley: Towards Redefining Kwa." *STUF - Language Typology and Universals* 70 (2): 283–301. https://doi.org/10.1515/stuf-2017-0015.

Legendre, Géraldine, Yoshiro Miyata, and Paul Smolensky. 1990. "Harmonic Grammar – A Formal Multi-Level Connectionist Theory of Linguistic Well-Formedness: Theoretical Foundations." In *Proceedings of the Twelfth Annual Conference of the Cognitive Science Society*, 388–95. Mahwah, NJ.

Legendre, Géraldine, Antonella Sorace, and Paul Smolensky. 2006. "The Optimality Theory-Harmonic Grammar Connection." In *The Harmonic Mind*, edited by Paul Smolensky and Géraldine Legendre, 339–402. Cambridge, MA: MIT Press.

Lehman, Blake, and Travis Major. 2019. “Revisiting Hiatus Resolution in Avatime.” Paper presented at the Annual Conference on African Linguistics.

Lionnet, Florian, Laura McPherson, and Nicholas Rolle. 2022. “Theoretical Approaches to Grammatical Tone.” *Phonology* 39 (3): 385–98. https://doi.org/10.1017/S0952675723000179.

Löfstedt, Ingvar. 2010. “Phonetic Effects in Swedish Phonology: Allomorphy and Paradigms.” Doctoral dissertation, University of California, Los Angeles.

Łubowicz, Anna. 2003. “Contrast Preservation in Phonological Mappings.” Doctoral dissertation, University of Massachussetts, Amherst.

———. 2011. “Chain Shifts.” In *The Blackwell Companion to Phonology*, edited by Marc Oostendorp, Colin J. Ewen, Elizabeth Hume, and Keren Rice, 1st ed., 1–19. Wiley. https://doi.org/10.1002/9781444335262.wbctp0073.

Maddieson, Ian. 1995. “Collapsing Vowel Harmony and Doubly-Articulated Fricatives: Two Myths about the Phonology of Avatime.” In *UCLA Working Papers in Phonetics: Fieldwork Studies of Targeted Languages 3*, 91:67–84.

Mahanta, Shakuntala. 2012. “Locality in Exceptions and Derived Environments in Vowel Harmony.” *Natural Language & Linguistic Theory* 30 (4): 1109–46. https://doi.org/10.1007/s11049-012-9173-5.

Major, Travis, and Harold Torrence. forthcoming. “Picking up a Friend Along the Way: A’-Movement Through the v/VP Region in Avatime.” *Linguistic Inquiry*.

Mascaró, Joan. 2007. “External Allomorphy and Lexical Representation.” *Linguistic Inquiry* 38 (4): 715–35. https://doi.org/10.1162/ling.2007.38.4.715.

McCollum, Adam, and James Essegbey. 2020. “Initial Prominence and Progressive Vowel Harmony in Tutrugbu.” *Phonological Data and Analysis* 2 (3). https://doi.org/10.3765/pda.v2art3.14.

McPherson, Laura. 2019. “Seenku Argument-Head Tone Sandhi: Allomorph Selection in a Cyclic Grammar.” *Glossa: A Journal of General Linguistics* 4 (1): 22. https://doi.org/10.5334/gjgl.798.

Menn, Lise. 1983. “Development of Articulatory, Phonetic, and Phonological Capabilities.” In *Language Production*, edited by B Butterworth, 2:2–50. London: Academic Press.

Mortensen, David. 2006. “Logical and Substantive Scales in Phonology.” Doctoral dissertation, University of California, Berkeley.

Newell, Heather, and Glyne Piggott. 2014. "Interactions at the Syntax–Phonology Interface: Evidence from Ojibwe." *Lingua* 150 (October): 332–62. https://doi.org/10.1016/j.lingua.2014.07.020.

Omamor, Augusta. 1988. "Okpe and Uvwie: A Case of Vowel Harmony Galore." *Journal of West African Languages* 18 (1): 47–64.

Paster, Mary. 2006. "Phonological Conditions on Affixation." Doctoral dissertation, University of California, Berkeley.

Pater, Joe. 2000. "Non-Uniformity in English Secondary Stress: The Role of Ranked and Lexically Specific Constraints." *Phonology* 17 (2): 237–74. https://doi.org/10.1017/S0952675700003900.

———. 2009. "Morpheme-Specific Phonology: Constraint Indexation and Inconsistency Resolution." In *Phonological Argumentation: Essays on Evidence and Motivation*, edited by Steve Parker, 123–54. London: Equinox.

Peperkamp, Sharon. 1997. "Prosodic Words." Doctoral dissertation, Universiteit van Amsterdam.

Potts, Christopher, Joe Pater, Karen Jesney, Rajesh Bhatt, and Michael Becker. 2010. "Harmonic Grammar with Linear Programming: From Linear Systems to Linguistic Typology." *Phonology* 27 (1): 77–117. https://doi.org/10.1017/S0952675710000047.

Rose, Sharon. 2018. "ATR Vowel Harmony: New Patterns and Diagnostics." In *Proceedings of the Annual Meeting on Phonology*. Vol. 5. https://doi.org/10.3765/amp.v5i0.4254.

Rose, Sharon, Michael Obiri-Yeboah, and Sarah Creel. 2023. "Perception of ATR Contrasts by Akan Speakers: A Case of Perceptual near-Merger." *Laboratory Phonology: Journal of the Association for Laboratory Phonology* 14 (1): 1–39. https://doi.org/10.16995/labphon.8948.

Sande, Hannah. 2019. "A Unified Account of Conditioned Phonological Alternations: Evidence from Guébie." *Language* 95 (3): 456–97. https://doi.org/10.1353/lan.2019.0053.

———. 2020. "Morphologically Conditioned Phonology with Two Triggers." *Phonology* 37 (3): 453–93. https://doi.org/10.1017/S0952675720000238.

Sandstedt, Jade J. 2020. "A Reanalysis of Abstract Contrasts and Opacity in Bondu-so Tongue Root Harmony." *Glossa: A Journal of General Linguistics* 5 (1). https://doi.org/10.5334/gjgl.1126.

Schuh, Russell G. 1995a. "Aspects of Avatime Phonology." *Studies in African Linguistics* 24 (1): 32–67. https://doi.org/10.32473/sal.v24i1.107410.

———. 1995b. “Avatime Noun Classes and Concord.” *Studies in African Linguistics* 24 (2): 123–50. https://doi.org/10.32473/sal.v24i2.107407.

Schwarz, Anne. 2007. “About the Harmony Disposition of Lelemi Affixes.” In *Afrikanische Horizonte: Studien Zu Sprachen, Kulturen Und Zur Geschichte*, 31:127–39.

Selkirk, Elisabeth. 1996. “The Prosodic Structure of Function Words.” In *Signal to Syntax*, edited by James Morgan L. and Katherine Demuth. Pyschology Press. https://doi.org/10.1002/9780470756171.ch25.

Sloetjes, H., and P. Wittenburg. 2008. “Annotation by Category - ELAN and ISO DCR.” In *Proceedings of the 6th International Conference on Language Resources and Evaluation*.

Smolensky, Paul. 1986. “Information Processing in Dynamical Systems: Foundations of Harmony Theory.” In *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, edited by David Rumelhart, James McClelland, and PDP Research Group, 1, Foundations:194–281. Cambridge, MA: MIT Press.

———. 1993. “Harmony, Markedness, and Phonological Activity.” Paper presented at the Rutgers Optimality Workshop 1, Rutgers University.

Stahlke, Herbert. 1971. “Topics in Ewe Phonology.” Doctoral dissertation, University of California, Los Angeles.

Stanley, Joseph, and Lisa Lipani. 2019. “Automatic Formant Extraction in Praat.”

Starwalt, Coleen Grace Anderson. 2008. “The Acoustic Correlates of ATR Harmony in Seven- and Nine-Vowel African Languages: A Phonetic Inquiry into Phonological Structure.” University of Texas at Arlington.

Steriade, Donca. 2001. “Directional Asymmetries in Place Assimilation: A Perceptual Account.” In *The Role of Speech Perception in Phonology*, edited by Elizabeth Hume and Keith Johnson, 219–50. San Diego: Academic Press.

———. 2008. “The Phonology of Perceptability Effects: The P-Map and Its Consequences for Constraint Organization.” In *The Nature of the Word: Studies in Honor of Paul Kiparsky*, edited by Kristin Hanson and Sharon Inkelas. The MIT Press. https://doi.org/10.7551/mitpress/9780262083799.001.0001.

Stewart, John M. 1967. “Tongue Root Position in Akan Vowel Harmony.” *Phonetica* 16 (4): 185–204.

———. 1971. “Niger-Congo, Kwa.” In *Current Trends in Linguistics*, 7th ed., 179–212. The Hague, the Netherlands: Mouton.

van Putten, Saskia. 2009. “Talking about Motion in Avatime.” Master’s thesis, Leiden University.

———. 2014. “Information Structure in Avatime.” Doctoral dissertation, Nijmegen: Radboud Universiteit.

Vigário, Marina. 2003. *The Prosodic Word in Europea Portuguese*. Berlin: Mouton de Gruyter.

Zuraw, Kie. 2007. “The Role of Phonetic Knowledge in Phonological Patterning: Corpus and Survey Evidence from Tagalog Infixation.” *Language* 83 (2): 277–316. https://doi.org/10.1353/lan.2007.0105.