The Development of pitch in early vocalizations:
A Longitudinal study of infants from two language communities

by

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Abstract

The Development of pitch in early vocalizations: A Longitudinal study of infants from two language communities.

This investigation explored the influence of auditory experience on vocal production. The noncry vocalizations of 10 babies from two different language communities were sampled at 6, 8, and 10 months of age. Five babies came from monolingual English-speaking homes, and five babies came from monolingual Cantonese-speaking homes. All utterances were analyzed acoustically for trends in the fundamental frequency (Fo). Since Cantonese is a tonal language, and English is not, it was hypothesized that group differences would exist in the Fo of early (prespeech) vocalizations.

Nonparametric statistics revealed significant group differences at each age, and in overall scores derived from the three age periods. At 6 months, the English-learning (E-L) babies had greater standard deviations of the Fo, and greater variations in the Fo. At 8 months, the Cantonese-learning (C-L) babies produced lower Fo minima. The overall scores of Fo maxima were higher for the E-L babies. The E-L babies consistently produced greater within-utterance maximum Fo ranges and higher Fo maxima. An additional contribution of this study is documentation of extremely high Fo (up to 1800 Hz) and low Fo (down to 116 Hz) in early noncry vocalizations.

Finally, an unexpected finding was the significant difference between groups in the *amount* of periodic vocalizations produced. The E-L babies produced more periodic sounds at 8 months, 10 months and in the overall scores. Possible reasons for this finding, including cultural differences, are discussed.

Major group differences regarding Fo are taken to reflect the different prosodic systems of the input languages. The tones in Cantonese are numerous perceptually salient changes in pitch, typically below 400 Hz, occurring within each utterance. Results indicate that the C-L infants are guided by the input language towards a restriction of prosodic range, limiting the degrees of freedom for Fo as they focus on low frequencies where tonal information is conveyed. This evidence indicates that the link between speech perception and production is already emergent by 6 months.

Richard M Flower

Richard M. Flower, Ph.D. , Committee Chair

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I. Review of the Literature

1. Introduction

The aim of this study is to obtain evidence for an early auditory-motor linkage. This refers to the influence of what a child hears on what a child produces vocally. Theoretically, an influence in the reverse order may also exist (i.e., what a child produces affects what the child hears); however, this investigation will explore the influence of auditory experience on vocal production. Additionally, it will investigate the emergence of phonatory behavior as a phenomenon in early phonological development. It is hypothesized that early prespeech vocalizations are modified by auditory input.

This period of early infancy is characterized by rapid changes in structures and functions, and an apparent development of sensorimotor organization. During this period, it is possible to identify some of the constraints on speech acquisition (both structural and functional). In addition, it is possible to identify the plasticity of human systems acquiring speech - many of which are generally inaccessible and/or confounded in mature systems. The development of speech processes is determined in large part by perceptuomotor constraints. Nevertheless, this development is exceedingly modifiable because of inherent system plasticity. System constraints and plasticity are recurrent themes throughout this investigation.

This dissertation begins with a review of the literature on the development of speech production and speech perception from the earliest periods of life up to the stage of a 50-word lexicon. Evidence for an early auditory-motor linkage will then be reviewed. Included in this is a discussion of the cross-linguistic research which provides insight into ambient language influences, and a section on the development of laryngeal (vocal) behavior relevant to tonal languages.

Throughout this literature review, a focus is placed on anatomic/neurologic factors in speech development. It is assumed that the child brings with him a motivation to communicate - to establish attachments with other humans, and to empower him within his environment. Psychosocial influences are assumed to play a prominent role in development throughout life. Each child is thought to tackle the challenge of speech and language acquisition anew; hence his communication system not only reflects unique environmental influences and personal learning strategies, but also unique physical endowments.

The review of speech development begins with production and is followed by perception. This is not meant to imply any ontogenetic precedence. Indeed, the relationship between perception and production may not be equivalent for all infants. The purpose of this presentation is to set the backdrop for an investigation of linkage (sensorimotor integration) between the two processes.

2. Development of Speech Production

This review follows the course of speech development from the earliest precursors to the emergence of a multiword lexicon. Both continuities and discontinuities in this development will be discussed relative to anatomical-neuromuscular changes, and the human tendency for rhythmical behaviors (i.e, routines, motor schemata). Both of these appear to constrain the forms of early speech. Some of the phenomena observed during the development of speech production are discussed in terms of system plasticity.

2.1 Changes in the Source: Respiration

Although capable of supporting life at birth, the infant's respiratory system will undergo a number of changes, both structurally and functionally. The respiratory system changes in three distinct ways: 1) lung volume, 2) locus of breathing movements, and 3) inspiratory/expiratory breath patterns.

Lung volume is an index of bronchi development. The newborn's bronchi are one-half their adult size (Kahane, 1988). Additionally, the bronchioles and their alveoli, the terminal dilations where gas exchange occurs, are only one-quarter their adult size. Lung volume is similarly reduced. Using volume-displacement spirograms, Bosma, et al. (1965a) finds newborn tidal volume to be 20-25ml. during normal, quiet breathing. This contrasts sharply with the

0.5 liter exchange in adults (Bordon and Harris, 1984). The reduced amount of air available to infants results in frequent breathing cycles (60-70 breaths per minute compared to 16-18 breaths per minute in the adult, p.3, Kahane), and limits the expiratory air available for egressive vocalizations. Thus, the mean duration of noncry (primarily egressive) vocalizations increases by 50% during the first year (Delack and Fowlow, 1975). Kent and Murray (1982) found some of the comfort-state vocalizations of a 9-month-old to be greater than 5 seconds in duration.

Kahane (1988) indicates that the locus of breathing movements is different for infants than for older children and adults. In the infant, muscle forces involved with posture interact with respiration. The thorax, because of the horizontal extension of the cartilaginous ribs, has a rounded shape from birth through the first two years. Beginning around 6-8 months, a mixed pattern of breathing (diaphragmatic and thoracic) occurs, and continues to age 7 (when thoracic wall movements predominate). The contour of the infant's ribs does not allow for significant increases in the size of the thoracic cavity during breathing. Therefore, diaphragmatic breathing predominates. As the young child begins to walk, the ribs incline dorsally near their attachment to the vertebral column. This modeling effects a more transverse dimension, and results from muscle forces that develop to keep the body erect. These morphological changes facilitate balancing the trunk in the upright position.

Thoracic breathing indicates that the intercostal and abdominal muscles have developed sufficiently to lift the rib cage, giving greater control over air uptake and expiration. During vocalization, subglottic air pressure must vary according to the condition of the glottis. It is significant to note that the emergence of babbling around 6 months coincides with the improved ability to regulate subglottal air pressure variations as a result of emerging thoracic breathing.

The third change in the respiratory system concerns the patterning of inspiration and expiration. In the newborn, the proportion between expiration time and inspiration time during normal, quiet breathing is 1.2 - 1.3 (Kahane, 1988). In contrast, the ratio for adults is 1.2 - 1.8. For crying during infancy, this pattern is adapted so that the expiration phase is prolonged. This trend is consistent with the prolonged expiratory phase observed in adult speech (10% inspiration, 90% expiration; Bordon and Harris, 1984).

2.2 Changes in the Source: Phonation

Laryngeal function changes during the first year of life, due in large part to laryngeal growth and increased neuromuscular control. Studies of infant phonation have generally been of two types: 1) those interested in the prognostic value of infant cry (e.g., Michelsson, 1986), and 2) those interested in the development of prespeech (linguistic) behaviors (e.g., Delack and Fowlow, 1975; Oller, 1976, 1980, 1981; Stark, 1975, 1977, 1980). Both approaches utilize information gleaned from acoustic studies of phonation in combination with information about the anatomic/neurologic status of the growing child. Information from both lines of inquiry is essential to explicate the developmental course of laryngeal function. Kent and Murray (1982) state that individual differences in phonation are observed at birth. These differences may be precursors to some of the individual differences in production that mark early phonology (c.f. Leonard, et al. 1980).

The infant's larynx is different from its adult counterpart both in size and shape (Bosma, 1975). The arytenoid mass, including the cartilage and a thick submucosa, is large in comparison with the chamber of the larynx (see figure 1). The laryngeal chamber expands by enlargement of the major cartilages. The thyroid cartilage enlarges more than the cricoid. The epiglottis becomes firm as it enlarges. The arytenoid cartilages change in shape, although gross dimensions do not change significantly. The vocal and ventricular ligaments and folds lengthen, as do the aryepiglottic folds. As this lengthening occurs,

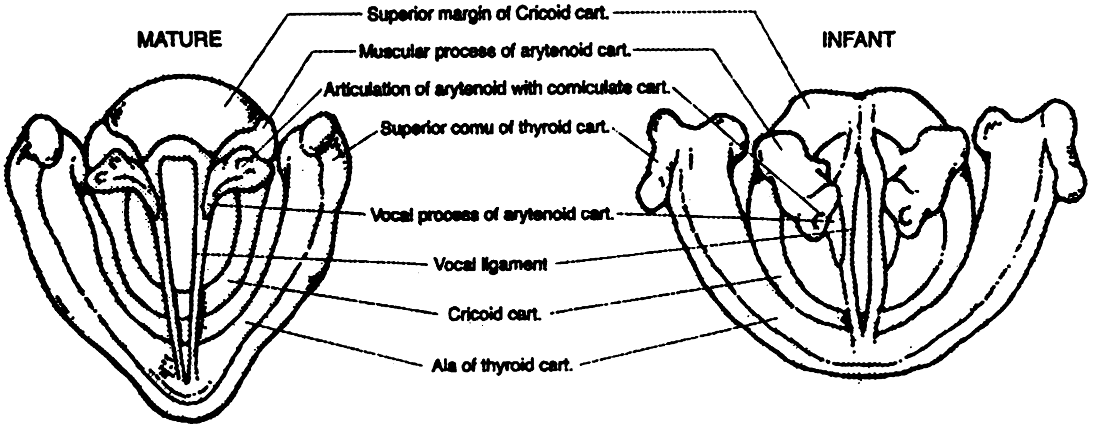


Figure 1. Superior view of skeleton of larynx of mature man and of infant. For demonstration of proportions, these schematics are made dimensionally equivalent at the external diameter of the cricoid cartilage in the midline.

Kent (1976) reported that the mean fundamental frequency (Fo) drops slightly during the first 3 weeks of life (about 25 Hz), then increases gradually until 4 months (to about 485 Hz). The Fo is stable until the end of the first year, but it then decreases sharply to about 300 Hz at age three years. Subsequently, there is a gradual decline in Fo until puberty, when again a sharp decrease occurs. All of these changes are in the context of substantial laryngeal growth during the first three years and during puberty.

The sounds an infant produces at birth have been classified as being of three types: cry sounds, discomfort sounds, and vegetative sounds (Stark, 1975). Of these three, cry and discomfort sounds typically involve the laryngeal sound source. Kent (1976) derives mean Fo values cited above for infants based on cry data. Similarly, Michelsson (1986) found the maximum of a healthy newborn's cry to be 650Hz, and the minimum to be 400Hz. In comparison, Delack and Fowlow (1978) found the mean Fo to be 355Hz in noncry vocalizations. This difference most likely reflects the infant's state of physical arousal, with more overall bodily tension associated with crying.

Delack and Fowlow (1978) also found the within-utterance range of Fo to increase by 20% during the first 6 months (from about 85Hz to 100Hz). Thus, the infant is capable of adjusting his phonatory apparatus to achieve a vocal range with the potential for significant within-utterance frequency contours (prosody, tones). It is interesting to note that in the study by Delack and Fowlow, 4 of the 19 subjects had remarkably high within-utterance ranges. These babies may have exploited this (prosodic) aspect of vocal production during phonological development. Unfortunately, subject profiles for prosodic contours were combined for group analyses.

The falling contour (rise-fall, fall, double rise-fall) has been identified as most predominant in early vocal productions (Delack and Fowlow, 1978; Kent and Murray, 1982; Lieberman, 1967; Stark, 1975). Lieberman (1967) reports that the falling contour results from variations in subglottal air pressure at the end of a respiratory cycle. However, Ohala (1970) finds that the laryngeal muscles actively participate in pitch modulation, no matter where the modulation occurs in the utterance. According to Ohala, the effect of subglottal air pressure changes on pitch are too small to account for most of the pitch changes. His evidence suggests that the speaker (in this case the infant) "programs" his laryngeal muscles to change intonational patterns.

Other contours in infant vocalizations are fall-rise, rise, and level. Delack and Fowlow described minimal changes in the distribution of prosodic contours during the first year. However, the infants in their study used contours differentially depending on the communicative context. The rising contours were observed only during interactions between infant and mother or multisensory objects. The authors stated that this phenomenon reveals the infant's capacity to vocally differentiate environmental events.

An interesting study by Koopmans van Beinum and van der Stelt (1986) revealed that the phonatory function of two infants was characterized by high fundamental frequency, creaky voice, short duration, and flat or falling intonation contours. The creaky voice was only observed during the first five weeks. Similarly, Kent and Murray (1982) noted that several types of laryngeal behavior during infant vocalizations are not seen in older children or adults with normal speech. Many vocalizations produced by the infants were characterized by tremor (slow modulation of vocal intensity and/or frequency), abrupt or rapid Fo shifts, breathiness, and subharmonic components. "All of these characteristics may be taken as evidence of instability of laryngeal control" (p. 362). Although the innervation of the larynx is complete by birth, the myelinization of nerve fibers, which is necessary for speedy and reliable impulse transmission, continues throughout the first year of life. The coordination of laryngeal function with respiration and supraglottal articulation continues throughout childhood. Nevertheless, the infant **is** capable of engaging in the highly discriminate oscillatory motions for phonation at birth, and by six weeks can produce a series of glottal stops in one expiration (Koopmans van Beinum and van der Stelt, 1986).

An interesting contribution regarding phonatory control comes from research into the development of discourse. Ginsburg and Kilbourne (1988) studied the emergence of vocal alternation between mother-infant dyads as a protolinguistic foundation for turn-taking, which is a major rhythmic feature of social interaction. They identified two structurally distinct patterns of dyadic vocalizations: 1. co-active, in which the vocalizations of the mother and infant overlap, and 2. alternating, in which there is no overlap. According to Ginsburg and Kilbourne, there is a transition in the vocal realm from co-active vocalizations (emerging around 2 months) to alternating vocalizations (emerging around 3 months). Alternation predominates by 6 months of age. Whereas co-active vocalizations occur as *vocal contagion,* alternating vocalizations require phonatory control for temporal patterning - involving discrete phonatory onset and offset to achieve synchrony with the dyadic partner.

2.3 Changes in the Vocal Tract

The infant's vocal tract is not simply a smaller version of an adult's vocal tract. It is different in a number of significant ways. The changes in the supralaryngeal region which affect the filter function of an infant's vocalizations are of two types: anatomical orientation and neuromuscular maturation. In this section, the supralaryngeal region will be subdivided into spaces (pharyngeal, oral, and nasal cavities) and articulators (lips, tongue, velum, and teeth). The changing filter function will be discussed following a review of the developmental changes in the spaces and articulators.

2.3.1. Supralaryngeal Spaces

The postnatal changes in the pharynx are primarily related to the growth of the tongue and descent of the larynx. Up until about 18 months, the infant's entire tongue is contained within the oral cavity. Moreover, the larynx is positioned high in the neck such that the tip of the epiglottis and soft palate make contact. This results in a single, relatively linear, path from the nose to the lower respiratory tract. Deglutition is accomplished utilizing the lateral margins of the velar-epiglottic contact. Between 18 and 24 months, the posterior one-third of the tongue begins to descend into the pharyngeal cavity (Kahane, 1988). The soft palate and epiglottis interlock less frequently. The upper airway becomes more angulated, and the single-tube system (nose to larynx) is modified to become a double-tube system (nose to mouth to larynx). The change in resonating systems is illustrated in figure 2.

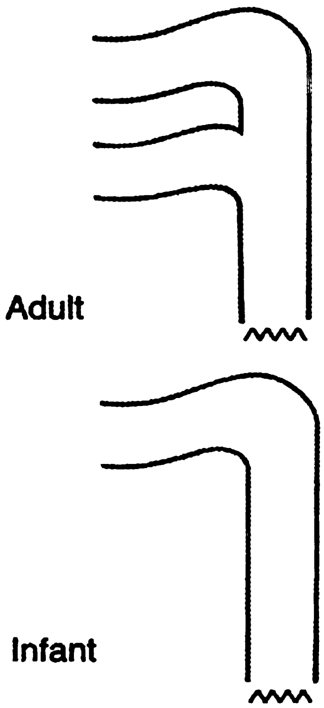


Figure 2. Single-tube and double-tube resonators.

Goldstein (1980) presented a static articulatory model with growth parameters in order to study the effects of anatomy on the production of vowels by men, women, and children. Using her model, Goldstein calculated the vocal tract cavity lengths at yearly intervals for males and females. The average vocal-tract length is 79.05 mm at birth, 92.6 mm at 1 year, and 108.65 mm at 5 years old. The average length of the pharynx is 26.15 mm at birth, 35.5 mm at 1 year, and 44.1 mm at 5 years. Average oral-cavity length is 52.95 mm at birth, 57.1 mm at 1 year, and 64.55 mm at 5 years.

A major difference between the vocal tract of the infant and that of the adult is that the infant's pharynx is shorter relative to the overall vocal tract length. Goldstein's calculations reveal a proportionately larger growth in the pharyngeal cavity than the oral cavity during the first three years. Although some anterior-posterior growth occurs, the primary growth of the pharynx is in the vertical direction.

In addition to the vertical lengthening of the pharynx, maturation effects a modification of pharyngeal function observed during phonatory activities (Fletcher, 1973). The pharyngeal tube itself is made up of three constrictor muscles, with an overall movement pattern of an inferiorly-moving wave of constriction. This movement is necessary for swallowing. During phonatory activities, sphincteric action of the pharyngeal wall below the level of the soft palate ceases, "Hence, the upper pharynx seems to become specialized for the act of phonation, whereas the entire wall continues in essentially the infantile pattern of movement during swallowing" (p. 166). Fletcher did not give an age when this modification in pharyngeal function occurs.

In addition to the anterior growth in the oral cavity, the appearance of teeth increases the vertical dimensions within the cavity. The infant with no teeth has an oral cavity that appears to be flat. Another distinctive difference seen in the infant is the presence of the massive "sucking pad" in the cheeks. This is a fatty deposit contained in the fascia near the buccinator muscle. It is thought to provide stability in the oral cavity for feeding (sucking, swallowing), since it reduces the motility of the cheeks (Bosma, 1975; Fletcher, 1973).

Most of the growth of the nasopharynx occurs within the first 12 years of life. At 3 months, the vertical dimension is 13.3 mm. This increases rapidly during the first 18 months of life, at a rate of at least 1 mm per year. By the age of 18 years, the nasopharynx reaches a vertical dimension of 28.1 mm. The anterior-posterior growth is notably less, approximately 10mm during the period from 3 months to 18 years (Subtelney, 1955).

2.3.2. Supralaryngeal Articulators

As noted earlier, one significant postnatal change in the infant's tongue is its caudal positioning of the posterior one-third, or root, into the pharynx. The second major morphological change is the growth in the physical dimensions of the tongue. The length of the tongue (distance from epiglottis to apex) increases from approximately 40 mm in the neonate to 80 mm in the adult (Hopkin, 1967). Fletcher and Daly (1974) presented measurements the sublingual region (from submandibular duct to apex at midline) of 56 children aged 1 month to 5 years. They found incremental growth from 21.9 mm (SD=4.7 mm) at less than 1 year, to 28.2 mm (SD=3.6 mm) between 1-2 years, and finally to 31.7 mm (SD=5.1 mm) between 3-5 years.

In addition to the anatomic changes in the tongue postnatally, neuromuscular changes are observed as well. The tongue contains both intrinsic and extrinsic muscles. The intrinsic muscles both originate and insert into the body of the tongue. As a group, they alter the shape of the tongue dorsum by narrowing and flattening the blade, and lifting or lowering the tip. The extrinsic muscles insert into the tongue, but originate from some other structure (hyoid bone, mandible, styloid process, or palate). These muscles are responsible for protrusion, retraction, lateralization, elevation, and depression of the tongue. The newborn's tongue is primarily under the control of the extrinsic musculature. Fletcher (1973) stated that the newborn moves his tongue in a whole-organ motion along a horizontal plane, exhibiting two prominent motions: thrusting and rocking. As the tongue matures functionally, the tip and blade of the tongue demonstrate rapid elongation. Accompanying this, "The extrinsic lingual musculature becomes important as a mechanism to provide a stable postural background from which the intrinsic musculature may be released for fine, discriminate movements" (p.169). Fletcher notes that the transition from gross to discrete lingual function is gradual. He gives the example of a young child producing the /t/ and /d/ phonemes, characterized by a broad-contact, thrust-like motion in which the tongue is crudely and indiscriminately approximated to the alveolar ridge and maxillary dentition. In contrast, mature speakers generally move the tongue tip with a deft, rapier-like movement.

A second supralaryngeal articulator is the velum. The velum, or soft palate, works with the pharyngeal walls to vent the nasal cavity. The velum is a muscular structure that consists of several layers. The muscles are sandwiched between glandular layers and a dense capillary network. Subtelney (1955) found that the soft palate increases in length from approximately 20mm at age 3 months to 35mm at age 18 years. The thickness grows only 3 mm during this period, from 6 to 9 mm. In infancy and young childhood, the angle of inclination of the resting velum is horizontal, approximating the roof of the nasopharynx. As the child grows older, the velum assumes a more vertical position that parallels the posterior pharyngeal wall.

A third supralaryngeal articulator is the pair of lips which form the opening of the mouth. The upper and lower lips are made up of an external epithelium, an internal mucosa, and a vermilion border. The epithelium and mucosa are tightly adherent to the connective tissue that covers the perioral muscles, which move the lips. At birth, two reflexes are identified with labial activities: sucking and rooting. Both activities involve a medial direction of movement, and some protrusion of the lips. Thus, it can be stated that the motility exists for at least this range of movement. Fletcher (1973) argued that lateral movements of the lips are limited by physiological immaturity. He indicates that "Physiological maturation will have a medial focus, then progress toward the lateral peripheries" (p. 170). He cites Irwin's 1948 study showing the most prominent sound in infant vocalization to be / ə /, a sound that places no demand on labial participation. The next sound to be acquired was /u/, followed by /i/. Whether this is due to neuromuscular development in the motor patterns (i.e., participation of more/different muscles) or anatomical changes is not known. All of the perioral muscles are innervated by the seventh cranial nerve, but their relative contribution to neonatal labial reflexes is different than that associated with speech sound production.

Furthermore, as the child grows, the lips elongate further from their attachments to the maxilla and mandible, which increases their motility. It is likely that both neuromuscular development and anatomical growth contribute to the increased range of labial movements observed in speech.

Once the young child's teeth emerge, they provide a final source for constriction of the airflow. These articulators, as mentioned earlier, also heighten the oral cavity dimensions. There are ten deciduous, or primary, teeth found in each dental arch. Eruption of the deciduous teeth begins during the second half of the first year of life.

2.3.3. Changes in the Filter Function

As presented in the previous sections, the human vocal tract changes significantly during early ontogeny. The effects of these changes on the way sound is filtered through the vocal tract is the topic of this section.

Perhaps the most significant change postnatally is that from a single-tube to a double-tube resonating system. Until the nasopharynx and larynx begin to disengage around 3 months, the child is an exclusive nasal breather. Oral tidal respiration is not achieved until after the first 3-5 months. Thus, early vocalizations have an obligatory nasal resonance. Virtually no supralaryngeal articulators (except perhaps the pharyngeal walls or nares) participate in the modulation of sound. Furthermore, the vocal tract is short in length (approximately 79 mm in length, Goldstein, 1980), resulting in higher formant structure as well as higher fundamental frequency.

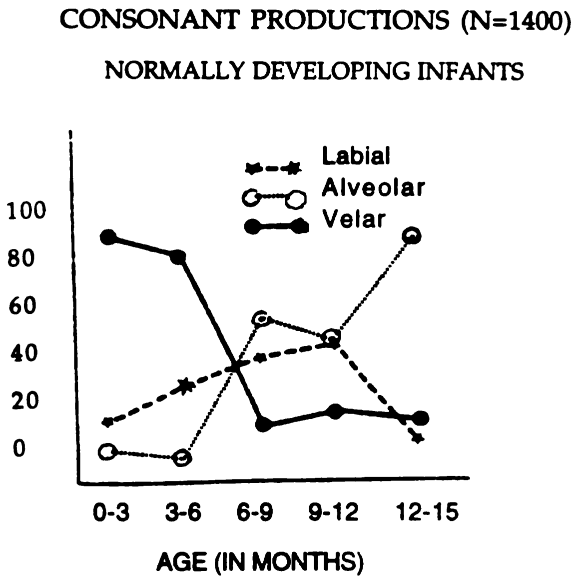
Once the oral cavity has patency, oral resonance can be achieved and the concomitant changes in supralaryngeal articulation are also possible. The velum can be moved posteriorly to achieve velopharyngeal closure, as well as inferiorly to approximate the tongue. Until the root of the tongue begins its descent into the pharynx, dorsovelar contact is frequent. Tongue tip and blade movements rarely modulate vocalizations. These, and other, parallels between phonetic and vocal tract developments up to the age of 6 months are shown in Table 1.

Locke (1983) has argued for a biological/phonetic basis in phonological acquisition. In his discussion of phonetic tendencies in early vocalizations, he plots the development of place of articulation of consonants as a function of age, using data from Smith and Oller (1981). This graph is depicted in figure 3. As can be seen, there are clear trends in the place of articulation. Velar sounds (this includes all postalveolar sounds, even if palatal or pharyngeal) are most frequent over the first three months. They gradually decline as the "alveolar

Table 1. Parallels Between Stages of Phonetic Development and Significant Anatomic Physiologic Changes in Speech Apparatus (from Locke, 1983)

Age of Infant	**Phonetic development**	**Anatomic-physiologic correlate**
0-1 month Phonation stage	Quasi-resonant nucleus	Nasal breathing and nasalized vocalization because of engagement of larynx and nasopharynx. Tongue has mostly back-&-forth motions, nearly fills oral cavity.
2-3 months Gooing stage	Quasi-resonant nucleus plus velar or uvular contractions	Some change in shape of oral cavity and an increase in mobility of tongue, but tongue motion is still constrained by larynx-nasopharynx engagement.
4-6 months Expansion stage	Fully resonant nuclei	Disengagement of larynx and nasopharynx allows increased separation of oral & nasal cavities so that non-nasal vowels are readily produced.
	Raspberry (labial)	The intraoral air pressure necessary for fricative-like productions can be developed with some regularity because of larynx-nasopharynx disengagement. Raspberry results from forcing air through lips, which close after each air burst because of natural restoring forces
	Squeal and growl	Contrasts in vocal pitch are heightened, perhaps because descent of larynx into neck makes the vocal folds more vulnerable to forces of supralaryngeal muscles.
	Yelling	Better coordination of respiratory system & larynx, together with prolonged oral radiation of sound, permit loud voice.
	Marginal babble	Alternation of full opening and closure of vocal tract is enhanced by larynx-nasopharynx disengagement.

take-over" occurs between 6-9 months. This take-over coincides with the larger oral cavity space (tongue root descent and eruption of teeth), increase in length of the lingual frenulum, and neuromuscular development of the intrinsic muscles of the tongue. There are no clear anatomic/physiologic reasons to explain why labial sounds develop the way they do, peaking at 9-12 months and then declining. It is likely that the environmental forces of language typology and segment inventory exert significant influences on phonologic acquisition by 12 months.


CONSONANT PRODUCTIONS (N=1400)

NORMALLY DEVELOPING INFANTS

Figure 3. Place of articulation of consonant sounds in the vocalization of normal infants (from Smith & Oller, 1981)

Having reviewed the changing filter function for consonants, the following section will turn to the changes in vowel production. The work by Irwin (1948; Irwin and Curry, 1941) and Lieberman (1980) report a majority of front vowels in infant vocalizations. Irwin and Curry (1941) state that "It is evident that a fundamental process of development in early speech consists of the mastery of the back vowels" (p.82). Kent (1981) suggests that the weak representation of back vowels such as /u/ and /a/ might be explained by the development of tongue-jaw interaction. Movements of the jaw have a primary effect on F1, and tongue movements have a primary effect on F2. The production of seven front vowels has been shown, through radiographs, to have the same basic tongue shape relative to the mandible. Kent indicates that an infant can produce almost all of his vowels with a fixed relationship between the tongue and the jaw. Different vowels are produced by variations in jaw position. The infant utilizes the articulatory synergy between tongue and jaw that he has discovered. The preference for a front vowel articulation synergy may be due, in part, to the vocal tract anatomy of the infant. In addition, any back vowels that might be produced by an infant would likely be unrounded, and may not be identified by English-speaking listeners as legitimate vowels. Buhr (1980) notes that infants start to produce vowels in a quantal manner around 38-40 weeks (9.5-10 months old). This means that the variations between formant ranges become more stereotyped. Buhr indicates that this coincides with the stabilization of the anatomical configuration of the vocal tract.

MacNeilage & Davis (1995) presented the "Frames, then Content" hypothesis for speech acquisition. Their hypothesis states that much of the patterning in babbling is a direct result of the production of syllabic "frames" by means of rhythmic mandibular oscillation, with relatively little of the intrasyllabic and intersyllabic "Content" of the syllable-like cycles under mandible-independent control. Based on their hypothesis, they predicted that front vowels would preferentially co-occur with front (alveolar) consonants, back vowels with back (velar) consonants, and central vowels with labial consonants. An extensive corpus of utterances collected from 6- to 12-month old infants confirmed their predictions. They proposed that the articulatory basis of babbling is "Frame Dominant". The findings of MacNeilage and Davis support the existence of strong preferences for certain vowel-consonant co-occurrences.

Although front vowels are most frequent in infant vocalizations, it is curious that the high front vowel /i/ is infrequent. This is curious not only because it is a front vowel, but also because it is a quantal vowel that has well-defined acoustic attributes which are relatively insensitive to small perturbations in articulation (Stevens, 1972). Stevens' quantal theory of speech production predicts that individuals (and languages) select quantal vowels over those that are acoustically less salient and more vulnerable to articulatory perturbations. Moreover, Goldstein's (1980) static articulatory model suggested that newborn infants have vocal tracts capable of producing /i/. But the data indicate that infants do not produce this high front vowel. Goldstein stated that infants are not prevented from producing /i/ by their vocal tracts; rather, it is production is linked to proprioceptive, neuromuscular control, and cognitive factors.

2.3.4. Vocal Tract Influences on Sound Patterning

A final consideration in this discussion of vocal tract constraints on production is the way that sounds are patterned during acquisition. Ohala (1983) presented some aerodynamic and anatomical properties of the vocal tract that influence the shape and patterning of speech sounds in languages of the world. For example, velaric egressives, such as those used to imitate animal sounds, do not make good speech sounds. This is because of limiting characteristics of the tongue blade when used as a valve for velaric egressives. The tongue blade can permit high negative pressures to develop and be released in an abrupt fashion before the seal fails. However, high positive pressures are not possible. According to Ohala, the preferred segment types in the world's languages, as well as the voicing status and nasalization of many speech sounds, may be due to vocal tract constraints.

Similarly, Locke (1983) discussed the phonetic nature of phonemic segments and phonological rules. Locke presented data from different populations and conditions to support his thesis that underlying phonetic forces significantly determine speech sound patterning in languages and individuals. During phonological acquisition, singletons are more common than clusters, stops exceed fricatives, final voiceless stops are more frequent than voiced stops, and final consonants are often deleted. Since these patterns correspond to phonological structures in many languages, Locke stated "it follows that some phonological systems must be easier to acquire or 'emerge into' than others" (p. 185). Locke did not develop the vocal tract constraints of these sound patterns to the degree that Ohala (1983) did. However, the correspondence was sufficient for Locke to propose that sound patterning in acquisition is phonetically nonarbitrary.

Both Locke and Ohala attempted to define vocal tract constraints on phonological form. The relevance to speech sound acquisition is that there may be some sound patterns which are relatively easier to acquire. This is not unlike the notions "ease of articulation" or "naturalness"; however the constraints, particularly those identified by Ohala, are principled accounts of why sounds behave the way they do. Kent (1984) stated that children's built-in (articulatory) tendencies are actually useful constraints on language acquisition, which can be viewed as developmental organizing principles that are exploited and expanded in the normal child-environment interaction.

Lindblom (1992) presents an elegant model of phonological development constructed along functionalist lines. His model takes into account assumptions about motoric, perceptual, and cognitive universals, the role of input language and the child's current representation of it. The model derives phonetic forms as adaptions to universal performance constraints as well as to language-specific and child-specific factors. Lindblom discusses the vocal tract in terms of trajectories in phonetic space. In describing the motoric universals, he refers to a motor score, consisting of lip closure, jaw and tongue body postures. He describes phonological units as spontaneously assembled emergent consequences of lexical development. These *emergents* contrast with the notion of *primitives*. Lindblom proposes that phonological emergence offers a spontaneous and unsupervised mechanism for supplementing the input speech. His model avoids attributing too much to the child. As he stated, "The mechanism of emergence makes it unnecessary to 'take loans on' cognition ...(or)... evolution" (p.159). He reviews cross-linguistic regularities that reflect adaptations to universal constraints on the production and perception of speech.

2.4 The Tendency Toward Rhythmic Behavior

One strategy that humans employ in physical expression is the repetition of established motor patterns. Walking, for example, can be viewed as a repetition of a pattern of extensor and flexor muscle sequences. This is particularly the case for walking a straight path with no incline and no obstacles. When the task of walking involves maneuvering curves, inclines or obstacles, a larger pool of motor patterns is required, and choices must be calculated on-line. In this section, the general tendency for rhythmical stereotypes in human performance is discussed, especially as they may apply to the development of speech production.

The view accepted in this thesis is that motor routines are constructed in a hierarchical fashion, with simpler patterns underlying more complex patterns (Grillner, 1981). Once a sequence of movements become automatic, it can be referred to as a routine. The terms scheme and routine are used here interchangeably. A subroutine is characterized by its constructive role in the development of more complex patterns. Stereotypies and rhythmicities refer to recurring sequences of events, that is, routines/subroutines that are performed repeatedly.

2.4.1. Neurobiologic Bases of Rhythmic Motor Acts

The neural circuits that coordinate the different muscles for motor schemes may be located in the cortex, brainstem, cerebellum and/or spinal cord. Complex patterns of behavior can be performed in decorticated cats (Grillner, 1981). This suggests that the circuitry for innate motor acts may exist at different (noncortical) levels in the central nervous system.

In addition to roles played by a central "plan" (i.e., motor scheme) and feedback, both of which will be discussed in the final section of this chapter, the execution of rhythmic motor acts relies on specific mechanisms at the synaptic level. The role of membrane properties of motorneurons that innervate different parts of the muscle are also significant. Work done on the in vitro spinal cord of the Lamprey, a jawless fish, has provided important information about rhythm in vertebrate locomotion (Grillner, 1985). Although the lamprey does not walk as humans do, (but swims), the general neural organization of vertebrate locomotion systems is similar enough to allow us to draw inferences for higher order vertebrates. The motoneurons are regulated by both inhibitory and excitatory premotor interneurons. In the lamprey spinal cord, Grillner induced rhythmic activity by bath-applied excitatory amino acids. He attributed this to the fact that a negative slope conductance can be induced by the application of an excitatory amino acid in some neurons. "This would tend to change a conventional neuron with a linear current-voltage curve to one that would tend to have a bistable or oscillatory membrane potential" (p. 146). It appears that some neurons are more susceptible to extracellular influences that induce membrane potential oscillations. Additional effects would be observed under the influence of variations in extracellular materials such as potassium and calcium. Although these effects are at the level of individual motor units, these oscillatory effects presumably underlie and contribute to the rhythm observed in motor acts.

2.4.2. Infant Rhythmicities

Thelen (1981) described a number of rhythmical stereotypies observed during infancy from an ethological perspective. These repetitive movements include such behaviors as kicking, rocking, waving, bouncing, rubbing, scratching, thrusting and swaying. These behaviors stand out as striking developmental phenomena. They are striking both because of their frequency and their predictability. Thelen's research on rhythmical behavior begins with an ethogram or catalogue of behavior in its natural context, followed by more focused observation and experiments. She has found that the frequency and diversity of repetitious movements seen during infancy are so great that the infant appeared to be following the dictum 'If you can move it at all, move it rhythmically'" (p. 239).

Biweekly observations of 20 infants over a period of one year allowed Thelen (1979) to organize a developmental profile of stereotypical movements. Movements were grouped by body parts and posture, as well as frequency and environmental context. The frequency of stereotypies as a function of age is listed in Figure 4. Thelen noted that the relationship between frequency and age is related to overall motor development, and that rhythmical stereotypes are transition behavior between uncoordinated activity and complex voluntary motor control. If all stereotypies are summed, peak frequency is at the age of 6-7 months. It is probably not a coincidence that babbling, the repetition of syllables before the onset of true words, occurs during this same time.

From an ethological perspective, infant rhythmicities are seen as manifestations of intrinsic neural oscillators, and serve a special function during the development of human performance:

> These are simple, repetitive flexions and extensions or rotations with preprogrammed temporal or topographical relationships among fixed muscle groups. They represent a stage in motor maturation that is more complex than uncoordinated spontaneous motility or simple spinal reflexes, yet that is less variable and flexible than full voluntary behavior... The large number of different rhythmical stereotypies and the nature of their developmental progression further suggest that these oscillations track the emergence of functional synergisms in many muscle groups. Intrinsic rhythmic patterning

> may be a fundamental characteristic...of muscle groups involved in many, and perhaps all, levels of gross and fine motor control and postural maintenance.
>
> As the available motor output at different ages, rhythmical stereotypies may also assume a wide variety of functional ends...(they) may provide a means of self-stimulation, contingent control over people and objects, exercise, and communication. Thus, although originating and sometimes functioning as almost "by-products" of motor maturation, stereotypies may also become instrumental behavior...
>
> (Thelen, 1981, p. 145)

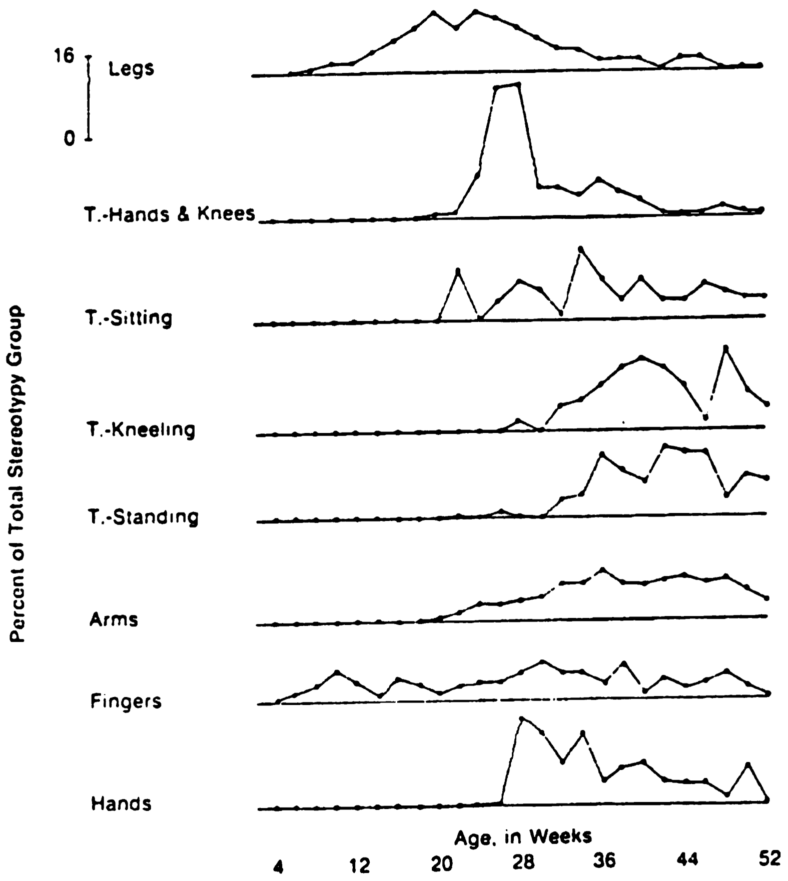


Figure 4. Frequencies of groups of rhythmical stereotypies during the first year. (Frequencies have been expressed at each age as a percentage of the total bouts of that stereotype group seen at that age. Vertical scale indicated on the left is the same for each horizontal axis. Data have been pooled for the sample, N=20, T = torso). (Thelen, 1981).

2.4.3. Prespeech Infant Rhythmicities

The ethological perspective allows for an insightful appreciation for the significance of infant rhythmicities. The recurrence of these motor routines allows the infant to become an active participant in his or her environment through the opportunistic use of the neuromuscular coordination available to him. However, what significance does this have for the development of speech? Wolff (1968) suggested that the common "high frequency" rhythmicities of infancy - sucking, crying, and breathing, as well as gross motor stereotypies - were neurological "timing mechanisms" that formed the "necessary but not sufficient" substrate for later coordinated movement. It is the rhythmical aspects of crying and breathing that appear to contain the earliest substrata of verbal development.

Phonological rhythm has been described as "the structure of a sequence" (Allen and Hawkins, 1980). This definition establishes rhythm as a structure, which can be understood only as a relationship or set of relationships among the units making up that structure. The units can be "features, segments, syllables, words, phrases, or paragraphs, or even sneezes or total eclipses of the moon - all that is important is that they occur in sequence" (p. 228). Despite this all-inclusiveness of potential rhythmic sources in speech, Allen and Hawkins note that some processes play a more dominant role than others in defining what is commonly felt to be the rhythm of a phrase. Most investigations into the patterning of infant vocalizations have a bias towards utilizing established linguistic units, however, the possibility exists that early (prespeech) stereotypies do not have established linguistic labels.

Stark (1977, 1980) has investigated the continuity of crying and later verbal development through analysis of acoustic-phonetic data. Her analyses indicate that the prosodic features of variation in intensity and pitch, rhythmic patterning, and phrasing are all present in infant cry. Additionally, consonantal elements and transitions from a closed to an open vocal tract are found in (noncry) vegetative sounds, and vocalic elements are found in all sound types. According to Stark, the infant can be viewed as "manipulating the features of output available to him in a variety of ways, as acquiring control of vocal fold vibration and of movements of the supraglottal articulators and skill in coordinating these movements with one another. This development is seen as one of practicing subroutines and combining them with one another" (1980, p.90).

A different approach to studying infant sound productions was taken by Koopman-van Beinum and van der Stelt (1986). They chose to look at the early stages in the development of speech movements as part of the total development in the first year of life. By doing this, they freed themselves from the biases and limitations of a linguistic approach. Thus, the units in the rhythmic sequence emerge from the structure, and were identified in terms of phonation and articulation type. The authors tracked the vocalizations of two infants from birth through six months (see Table 2).

Three milestones were identified by Koopman-van Beinum and van der Stelt as essential links between infant sound production and adult speech:

1. the production of a series of glottal stops
2. the onset of articulatory movements
3. the production of repetitive chains of articulatory movements

Clearly, the first and third milestones constitute rhythmic stereotypies. Although the authors did not report the frequency for each, it is likely that the infants engaged in these repetitive behaviors often.

The approach taken by Oller (1980, 1986) is a blend of linguistic (phonetic) and nonlinguistic (acoustic) methods. He proposed a methodology to describe the prelinguistic structure of infant vocalizations. The goal of Oller's metaphonology is to sketch the definition of the syllable, which he believes to be the minimal rhythmic unit of natural languages. Whether or not the

Table 2. Phonatory and articulatory description of sound productions of two infants in the first months of life. Numbers indicate milestones in early speech development, essential because of the syllable-like character of these aspects. (From Koopman-van Beinum and van der Stelt, 1986)

AGE IN WEEKS	01-05	06-09	10-14	15-19	20-26	27-
PHONATION:						
HIGH FUNDAMENTAL FREQUENCY	X					
CREAKY	X	X				
SHORT	X	X	X	X	X	X
FLAT	X	X	X	X	X	X
FALLING INTONATION	X	X	X	X	X	X
ASPIRATED		X	X	X	X	X
RISING INTONATION		X	X	X	X	X
GLOTTAL STOPS IN SERIES		X 1	X	X	X	X
COMPLEX INTONATION			X	X	X	X
VARIATIONS IN LOUDNESS				X	X	X
VARIATIONS IN DURATION					X	X
RHYTHMIC SERIES						X 3
ARTIC.POSITION:						
PHARYNX	X	X				
RAISED VELUM		X				
CLOSED MOUTH		X				
ARTIC.MOVEMENT:						
PHARYNX			X 2	X	X	X
VELUM			X	X	X	X
UVULA			X	X	X	X
BACK OF THE TONGUE			X	X	X	X
LOWER JAW			X	X	X	X
MIDDLE OF THE TONGUE				X	X	X
TONGUE TIP				X	X	X
LIPS				X	X	X
REPETITIVE ARTIC.MOV.						X 3

syllable holds such a high status has not been resolved. Nevertheless, Oller's work provides additional data for a discussion of prespeech rhythmicities. The first syllable-like repetitions are seen in what Oller calls marginal babbling. The peak-to-peak duration of the utterance is >500ms., formant transitions are >120ms., it contains fully resonant nuclei (i.e., it is produced with a periodic sound source and relatively open vocal tract), and it contains a margin of low resonance (relatively closed vocal tract). Marginal babbling is a frequent form of sound production in infants from three to six months of age. This is followed by canonical babbling. In contrast to its predecessor, the duration of peak-to-peak and formant transitions are shorter in canonical babbling. These are utterances that lend themselves to phonetic transcription, such as the reduplicated sequences [bababa], [nanana] and [dɪdɪdɪ]. Both forms of babbling represent prespeech rhythmicities, repetition of established motor routines involving the breathing, phonatory, and articulatory apparatuses.

2.4.4. Transitional Phenomena: Babbling to Speech

Jakobson (1968) argued that there is no connection between babbling and the development of the adult sound system. This discontinuity hypothesis came under attack from child phonologists, who identified striking similarities between the phonological patterning in babbling and first words. Vihman, et al. (1985) compared the sound systems of babbling with that of early words and found continuities in terms of the distribution of consonants, vocalization length, and phonotactic structure. The tendency toward rhythmic behavior is observed to the extent that babbling and early speech gestures are continuous, since speech gestures constitute motor sequences.

Within the range of sounds produced during the period of babbling and early words (stops, nasals, glides, low-front and central vowels), Vihman, et.al. (1985) found a number of individual differences among the nine children they studied. Their evidence suggested that an individual child's babble repertoire is reflected, at approximately the same frequency level, in the choice of adult words to say and in the phonetic rendition of those words. Thus, the individual's collection of phonetic subroutines forms the substratum in the construction of a phonology.

It was the finding of individual differences that led McCune and Vihman (1987) to explore the individual biases in the use of consonants, phonotactic shape, and vocalization length in terms of motor schemes. Their goal was to trace the origins of dominant word shapes back to prelinguistic babbling in 20 children followed from 9 to 16 months of age. Their results found a clear relationship between the extent of well-practiced or frequently used 'vocal-motor-schemes' and lexical advance. They concluded that children establish a limited range of intentional vocal patterns through babble. These vocal motor schemes, which are capable of variation and combination to form larger units, provide a necessary phonetic basis for early word production.

Although not framed within a vocal motor scheme context, other researchers have investigated individual differences and biases in child phonology. Ferguson and Farwell (1975) found that the selection of early words appeared to reflect phonetic constraints. This was supported experimentally by the work by Schwartz and Leonard (1982). In their study, children were found to imitate and produce more word forms including syllables they had already learned to produce in babble than word forms containing novel syllable shapes. These findings are consistent with the continuity hypothesis, and suggest a tendency to utilize established motor subroutines (phonetic gestures) in the construction of a phonological system.

Vihman (1993) reported that not only word-selection but also accuracy in early word production reflect the child's tendency to respond vocally to adult words with already mastered, phonetically similar production plans. According to Vihman, these plans underlie the development of unique word production strategies. These strategies may be partly responsible for what Branigan (1976) termed phonological conspiracies in early speech development. In the child he studied, the pattern of development in speech production between the ages of 16 and 21 months was remarkably constrained. Branigan concluded that production was governed by a set of phonological processes that conspired to limit the child's output to a small set of syllables in which production of 'good'/perceptible segmental contrasts could occur. In other words, the child appeared to make choices based on how well he could articulate certain sounds, and thus be understood. It is likely that human systems tend toward repetition of established motor routines at least in part because they have a high probability of being functional.

2.5 System Plasticity

Whereas the previous sections have identified system "constraints", we now turn this discussion to "plasticity". The term plasticity denotes modifiability, which may apply at any level of analysis of human functioning, from athletic physical behaviors to attitudes. Indeed, James (1890) used this concept to explain habit formation, stating that plasticity was "the possession of a structure weak enough to yield to an influence, but strong enough not to yield all at once" (p.5). Within the neurosciences - as originally proposed by Hebb (1949) - plasticity has attained great heuristic value to account for phenomena observed at the neural level. Neuroplasticity has been studied extensively over the past two decades, and provides an elegant framework for viewing the plasticity of dynamic systems.

Milgram et al. (1987) cite three general types of neural plasticity:

developmental, anatomical (structural), and physiological (functional). Changes that occur early in an organism's development may be instances of developmental plasticity. The second category, anatomical plasticity, refers to changes in cellular structure that occur following experimental induction (e.g., the reattachment of an amputated digit results in new growth at the intersection). The third type, physiological plasticity, refers to changes in the responsiveness, threshold of firing, or pattern of activation which can be related to experienced events. Physiological (functional) changes do not always have underlying anatomical (structural) correlates.

The study of early ontogeny requires special consideration of developmental plasticity, although structural and functional plasticity apply throughout the lifespan. The concepts of critical and sensitive periods are best understood within the context of developmental plasticity. Young neurons are remarkable in their capacity for synaptogenesis. As such, developing systems may be viewed as sensitive to sensorimotor experiences. Hubel and Weisel's (1965) classic study demonstrated that unilateral visual deprivation in 10-day old kittens resulted in an irreversible shift in ocular dominance. This is an example of a critical period. In contrast, the work by Marler (1989) on the acquisition of birdsong provides a good example of sensitive periods.

Critical period is usually defined as the specific time period during which normal input *must* be provided in order for the system to develop normal function. That is, for example, restoration of normal input at a later time will *not* restore normal function, and the reorganization is irreversible. Sensitive period refers to a period in which the system is particularly responsive/impressionable to an input. The distinction between critical and sensitive periods is that deprivation of relevant experiences results in irreversible organization of some neural system for critical periods, whereas it may result in delayed or different organization for sensitive periods.

Many of the phenomena observed during the ontogeny of speech production fall into one of the three categories of plasticity. These instances of system plasticity reflect the process of articulatory-acoustic conversion from articulatory configuration (phonetic posture/movement) to acoustic product (vocal production).

2.5.1. Developmental Plasticity

Studdert-Kennedy (1986) stated that some differences in phonological development arise from the plasticity of an open system "sensitive to environmental contingencies and equipped with a variable repertoire of responses. Adaptive responses to some particular, short-term aspect of the environment lead an individual down an idiosyncratic path, because the precise order in which the part of the system assemble themselves is not preordained" (p. 74). He noted that no single path is prescribed for the development of a phonological system. Furthermore, many paths lead to the same end. Paths are determined by partially fixed, partially variable perceptual, motoric, and environmental (including social) conditions. According to Studdert-Kennedy, there may be a "normal" (typical) path, which is the product of articulatory proclivity and perceptual salience, "But a child can readily be diverted from the path by accidents of the speech it hears or of its physical structure and growth" (p.75).

Regarding the acquisition of speech motor control, Netsell (1986) said that development is most dependent on the individual's nervous system maturation. He utilized the concept of "sensitive period" rather than "critical period" to characterize the interaction of many biological and environmental factors. According to Netsell, the period from 3 to 12 months may be the single most sensitive period with respect to the eventual acquisition of normal speech motor control. During this period, the musculoskeleton undergoes dramatic changes, requiring morphological and functional plasticity. Delays or abnormalities that appear or remain during this period would seem to have extremely serious consequences in effecting the establishment of fundamental speech movement routines that are later refined in the overall coordination of the speech mechanism.

Netsell did not provide any data to support his claim of a sensitive period for motor development. However, there are a number of examples of children who do not follow the "normal" path because of an atypical speech mechanism who eventually end up with a phonological system. MacKain (1984) and Riordan (1978) described how individuals with radical deficiencies in tongue structure (aglossia or microglossia) were able to make the adaptions necessary to produce speech. MacKain reported a dramatic case of a 22-month-old child with complete aglossia who produced most of the consonants and vowels that occur in English. Without a tongue, hypertrophied enlargements of the submandibular glands and sublingual glands and ridges appear to facilitate speech production by changing the size and shape of the vocal tract, and thus to function as compensatory articulators. Additional examples of compensatory articulations can be found in the cleft palate literature (eg., Karnell, Folkins, and Morris, 1985). Of interest here is that young children are particularly adept at utilizing the parts of the system (even if deficient) in the articulatory-acoustic conversion. This contrasts sharply with the laborious speech rehabilitation associated with deficiencies in the speech mechanism that occur in the adult system.

In addition to the plasticity associated with compensatory articulations, the young child appears to have no difficulty learning the phonetics of many languages (Borden and Harris, 1984). Multilingual children can achieve proficiency in pronunciation skills for the languages they learn. However, adults learning a second language frequently encounter difficulty with the phonetics of the new language. The phonotactic structure of the new language may also be problematic for the adult. This difficulty may be related to the motor programming for speech, or to something more cognitive, phonological, perceptual or a combination of these.

2.5.2 Structural Plasticity

The articulatory-acoustic conversion does not typically involve anatomical changes. However, there are instances, particularly when the speech mechanism is atypical, in which structural changes occur. A good example is Passavant's bar. This is a characteristic development of the pharynx in most people with cleft palate or other deficiencies in velopharyngeal valving (Kahane, 1988). It is a discrete transverse bar or ridge on the posterior and lateral pharyngeal wall at approximately the level of the hard palate. It is thought to develop in response to the speaker's attempt to control velopharyngeal valving. An additional anecdotal report of anatomic change is provided by Ohala (personal communication), who suggests that speakers of languages with pharyngeal sounds (such as Arabic) have been found to have enlarged musculature in the pharyngeal region when viewed upon autopsy.

2.5.3 Functional Plasticity

Netsell (1986) underscored the point that the motor actions in speech production are not fixed movement routines or stored patterns of muscle contractions. "The speaker can employ a highly flexible motor program to achieve a highly consistent acoustic product. His or her referent is what it feels and sounds like to produce certain speech movements and acoustics" (p.37). This motor equivalence provides the speaker with flexibility so that the desired output can be reached in a variety of ways (Fowler, 1985). This allows for accommodations to different contexts and to compensate for unforeseen perturbations in the course of speaking.

Gay, Lindblom, and Lubker (1981) found an acoustic equivalence in the production of the vowel [i] when produced with and without a bite-block. The bite-block is a spacer held between the teeth fixing the jaw into a very open position, thus prohibiting the relatively closed jaw position usually required for [i]. The compensatory adjustments made on-line suggest that the speech performance system is indeed flexible; it is goal-directed and comprised of functionally equivalent articulation synergies.

Most of the work done on functional plasticity in speech production has been done with adults. A rare exception is the investigation by Oller and MacNeilage (1983). A 4-year-old boy and an 8-year-old girl were subjected to bite blocks during vowel production. The older child produced relatively stable resonance values; however, the younger child's productions were unstable. Of interest was the within-session adaptation that occurred for both children. Nevertheless, the articulatory adjustments were not always sufficient to eliminate "auditorily identifiable anomalies" in the vowel qualities produced. The authors suggest that the relative inabilities of children (especially younger children) to compensate consistently and effectively provides support for "the contention that systematic childhood sound errors may represent an adaptation to the difficulties of pronouncing various phonetic elements in a wide variety of physical settings" (p. 105). Children need to master speech production in a variety of postures and settings. Eventually, they learn to talk while lying down, sitting up, walking, with food in the mouth, while chewing gum, and even while sucking a thumb.

3. Development of Speech Perception

Speech perception depends not only on the cognitive apparatus that organizes input into linguistic systems, but also on the auditory system that delivers the input. In this section, constraints and instances of plasticity in speech perception are discussed relative to the developing auditory system.

Although much is known about the adult mammalian auditory system, there is a great deal that is unknown. Even less is known about the functional development of the auditory system. This discussion is therefore limited by the incomplete understanding of the auditory system in general, and for ontogenesis in particular.

Assessing auditory function in infancy is not straightforward. There are a number of methodological techniques employed to assess infant audition (see Table 3), each with their own advantages and disadvantages (Aslin, Pisoni, Juscyk, 1983). According to Aslin et al., all of the techniques suffer from the problem of uncertainty associated with measuring auditory function in a developing organism. "When any improvement in performance on an auditory task is documented in the developing infant, it is absolutely essential to ask whether such an improvement could be due to nonperceptual factors, such as improvements in response systems, attentiveness, or familiarity with

Table 3. Response Measures Used to Assess Auditory Function in Infants (from Aslin, et al., 1983).

1. Elicited Motor Responses
    a. gross motor activity
    b. respiration
    c. auropalpebral response (blinking)
    d. head turning
2. Cardiac and Electrodermal Responses
    a. heart rate change: fixed trials
    b. heart rate change: no delay
    c. skin potential
3. Electrophysical Responses
    a. auditory evoked response (AER)
    b. auditory brainstem response (ABR)
    c. electrocochleogram (ECoG)
4. Visual Fixation Responses
    a. habituation-dishabituation
    b. response to novelty
    c. auditory-visual pairing
5. High Amplitude Sucking (HAS)
    a. single stimulus contrast
    b. alternating postshift contrast
    c. multiple preshift tokens
6. Conditioning
    a. classical
    b.two-alternate button press
    c. unidirectional head turn
    d. two-alternative head turn

the testing situation" (p. 585). A similar caution should be heeded when improvements are not observed. Unfortunately, there is no single technique that can be used in precisely the same manner with both infants and adults. The auditory evoked potential is an exception; however, it is limited in the amount of information it provides.

The following discussion utilizes information gleaned from various methodological techniques. Since the human auditory system is similar to that of other mammals, it is appropriate to draw inferences from research in audition with nonhumans such as the cat and monkey. Additionally, other lines of research, such as echo location in the bat, provide insights that are relevant to our understanding of the human auditory system.

3.1 Changes in the Auditory System: Outer Ear

The outer ear consists of the pinna and the ear canal (external auditory meatus). Its functions include protection, amplification (due to ear canal resonances), and localization (figure 7). However, the primary function is to capture and direct airborne sound pressure variations for transmission to the middle ear via the ear drum. Both of the outer ear components grow substantially during infancy and childhood; the effects of each on audition are discussed separately.

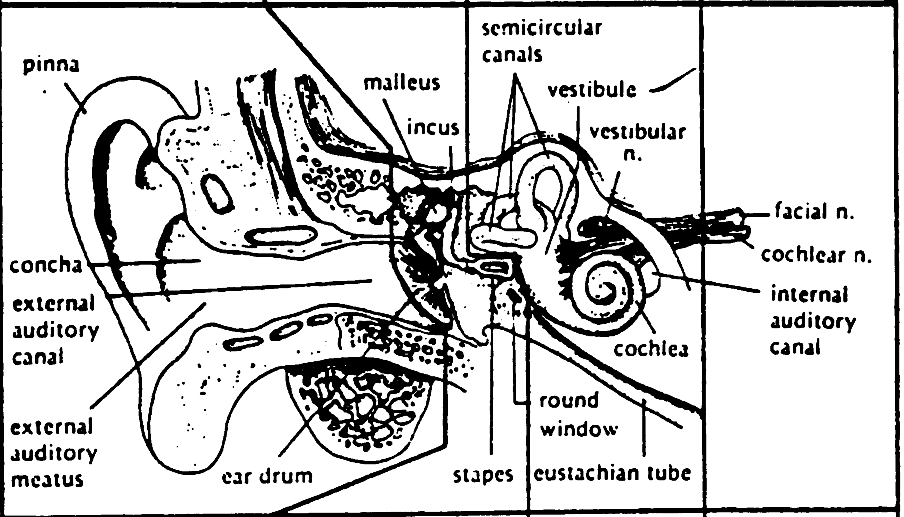
Gross division	Outer ear	Middle ear	Inner ear	Central auditory nervous system
Anatomy				
Mode of operation	*Air vibration*	*Mechanical vibration*	*Mechanical,* *Hydrodynamic,* *Electrochemical*	*Electrochemical*
Function	*Protection,* *Amplification,* *Localization*	*Impedance matching,* *Selective oval window stimulation* *Pressure equalization*	*Filtering distribution,* *Transduction*	*Information processing*

Figure 5. Crosssection of the human ear showing the three major divisions(outer, middle, and inner), their mode of operation, and their presumed function. (From Aslin set. al., 1983).

Since the ear canal is essentially a closed tube, it has a natural resonance. In the adult, the canal is approximately 24 mm long and 7 mm wide. The resonant frequency for the adult ear canal is around 3 kHz, with an amplitude gain of up to 15 dB (Wiener and Ross, 1946). The infant's ear canal is considerably smaller. Aslin, et al. (1983) extrapolated a higher resonant frequency for infants, around 5 kHz. They did not provide any indication of what the amplitude gain might be. However, because the immature ear canal is more compliant than that of the adult, the maximum gain due to resonance will be considerably less in the neonate (Rubel, Born, Deitch, and Durham, 1984).

The pinna may also affect the resonant frequency of the ear canal. However, the size and shape of the pinna are most important for trapping airborne sounds. The pinnae deflect sounds entering the ear canal such that sounds originating from behind are attenuated relative to sounds originating from the front (Aslin, et. al., 1983). Theoretically, a smaller pinna captures fewer sounds in general, but evidence to this effect has not been found.

3.2 Changes in the Auditory System: Middle Ear

The middle ear consists of the ear drum (tympanic membrane) and a chain of three little bones (ossicles). The middle ear functions to match the impedance between the airborne sounds at the tympanic membrane and the inner ear, which is filled with fluid. In order to create the same pressure variation in the fluid as in the air, the middle ear must amplify the sound pressure variations. The lever action of the ossicles, along with the size ratio between the tympanic membrane and stapes footplate, result in a 35 to 40 dB pressure gain (Rubel, et al., 1984). In contrast to the significant postnatal growth in the outer ear, the ossicles in the middle ear reach adult size and shape by the eighth fetal month (Bast and Anson, 1949).

The tympanic membrane (ear drum) reaches adult size by the end of the second year (Ballenger, 1969). However, Aslin et.al. (1983) suggest that the growth in the tympanic membrane has little functional significance because of the differences in compliance. That is, the infant's greater compliance may compensate for the potential loss in amplification relative to the constant size of the footplate.

In addition to transforming the air pressure variations into equivalent pressure variations in fluid, the middle ear is also the site of air pressure equalization. The eustachian tube valves the middle ear space with the nasopharyngeal space. If the eustachian tube becomes blocked, a closed middle ear space is created, and this can result in serous otitis media (middle ear infection with fluid build-up). This affects the mechanical action of the ossicles and can result in a loss of up to 40dB. Since serous otitis media is a common condition throughout childhood (Northern and Downs, 1978), this potential loss should be considered as a possible intermittent constraint in auditory function.

It is interesting that before birth, the middle ear is fluid-filled. The ear canal is also filled with fluid. Sounds that travel through the uterine wall into the amniotic fluid are transmitted with little attenuation. This is particularly true for sounds below 1kHz (Armitage, Baldwin and Vince, 1980). Thus, it is likely that significant auditory influences affect the infant prenatally.

3.3 Changes in the Auditory System: Inner Ear/Cochlea

The cochlea is the auditory portion of the labyrinth in the petrous portion of the temporal bone. It has a snail-shell shape, with 2 -3/4 turns in the adult, and houses the membraneous labyrinth inside. A cross section of the cochlea reveals the details of the membraneous labyrinth and the layout of the cochlea (see Figure 6). Although the size and gross structure of the cochlea are adultlike at birth (Bast and Anson, 1949), the sensory epithelium of the cochlea undergoes a number of postnatal changes.

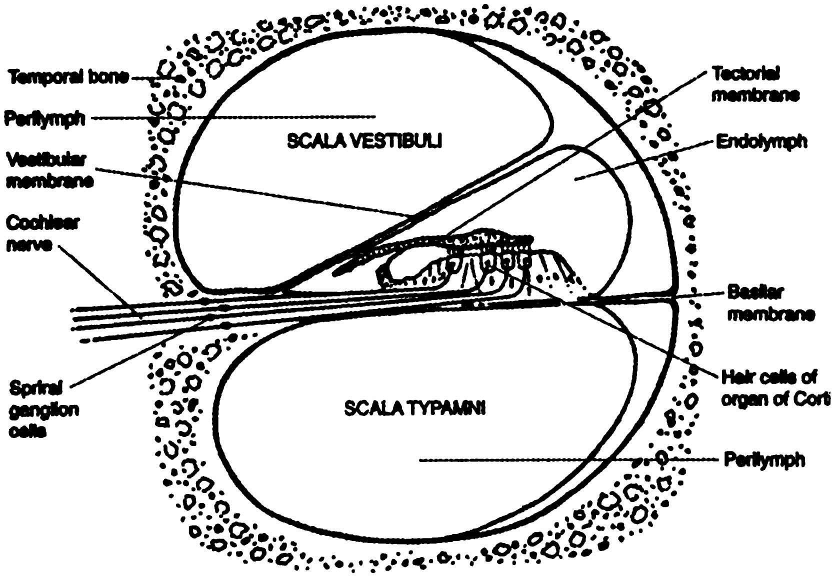


Figure 6. Diagram showing cross-section of cochlea.

If a cochlea could be uncoiled, it might look something like Figure 7. A sound wave is transmitted from the stapes (the innermost ossicle which is positioned in the oval window) to the round window. The pattern of vibration is transmitted to the fluid that fills the labyrinth, and a traveling wave is set up. The sensory cells are located within the organ of Corti on the basilar membrane, and respond to different frequencies at different locations along the cochlea. The cochlea is a spectral analyzer, capable of breaking down complex signals into component frequencies. There is a tonotopic organization in the cochlea, with high frequencies represented at the base and low frequencies at the apex in mature systems.

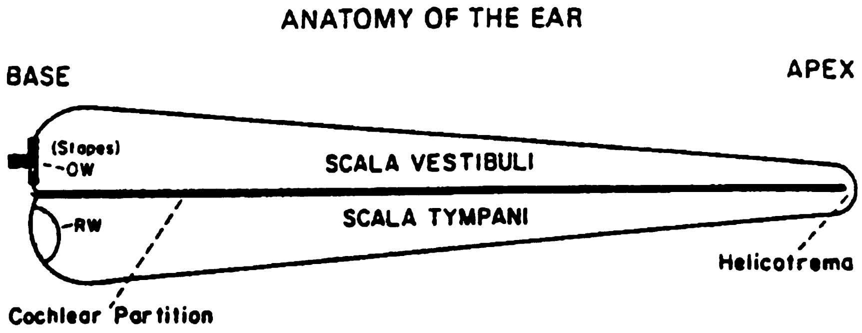


Figure 7. Schematic drawing of the uncoiled cochlea. Oval window: OW, Round window: RW

The anatomical development during embryogenesis proceeds from the midbasal region and spreads in both directions, with the apex maturing last (Bredberg, 1968). This pattern of development is observed across species. On the basis of gross anatomical development, high frequency sensitivity would be expected to precede low frequency sensitivity. However, as is discussed in later sections, the opposite is thought to occur (i.e., low frequency sensitivity precedes high frequency sensitivity).

In addition to anatomical changes in the cochlea, physiological changes have been documented during ontogenesis. A number of parameters characterize the functional status of the cochlea change during early development (Eggermont, 1985). Attributes of auditory nerve fibers include the threshold, firing rate, slope of the input-output curve, degree of tuning and latency. Of these parameters, threshold follows an exponential decrease from birth through maturity (Figure 8).

$$Th(t) - Th(a) = 98.5 \exp(-t/12.2)$$

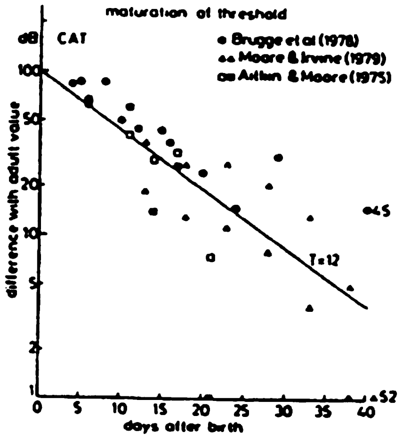


Figure 8. Maturation of threshold. Difference from adult value is plotted as a function of age semilogarithmic coordinates. Open symbols are for frequencies ≤ 1 kHz. Solid symbols are frequencies ≥ 1 kHz. (Eggermont, 1985).

On the other hand, firing rate increases with maturity. In addition, the ability to phase-lock (i.e., the nerve fires to a stimulus period as opposed to its frequency) increases with maturation. Brugge, et al. (1978) found phase-locking in auditory nerve fibers only for frequencies up to 800 Hz in the first postnatal week in the cat; this contrasts with phase-locking up to 3500 Hz in the adult cat. It takes about a month for the cat cochlea to mature completely, and the human cochlea reaches physiological maturity by one month postnatally (Eggermont, 1985). It is important to qualify this comparison by noting that cats are deaf at birth, with a very immature cochlea.

3.4 Changes in the Auditory System: Retrocochlear

The primary method for determining the physiological status of the retrocochlear auditory system is with electrophysiology. This method can never completely describe the system. As Eggermont (1985) noted, it is impossible to determine whether a sound was actually heard (i.e., transmitted from periphery), "Thus, an electrophysiologically normal system is a necessary condition for normal hearing, but it is not a sufficient condition" (p. 21).

A pattern of development similar to that of the cochlea is observed at more central (retrocochlear) locations. The myelination of spiral ganglion cells in the eighth nerve follows the midbasal to apical progression in the kitten (Romand and Romand, 1982). Other studies confirm this pattern of development at more central regions, suggesting that cochlear differentiation is guiding central expression (Rubel, et al., 1984).

In contrast with the cochlea, the retrocochlear auditory system, as measured electrophysiologically, does not reach maturity by the first postnatal month. The brainstem auditory evoked response potential (BAER) measures the electrophysiological responses to a stimulus along the auditory pathway. The presumed generators of the response are:

I. eighth cranial nerve
II. cochlear nucleus
III. superior olive
IV. lateral lemniscus
V. inferior colliculus

The integrity of the auditory pathway is assessed by looking at the interpeak latency and morphology of the waveform. Salamy and McKean (1976) documented the maturational changes in BAER waveform and interpeak latency. At birth, wave I (indicating peripheral auditory transmission time) approaches adult values, but the wave I-V interpeak latency (maturation of central transmission) proceeds more slowly. Between birth and 6 weeks, there is an abrupt decrease in central transmission time. Another significant drop occurs between 6 months and one year. Between 12-18 months, central transmission time is essentially that of an adult.

The amount of time it takes for the BAER morphology to achieve adult values is longer. Waves I, III, and V can be seen at birth. Wave II appears to differentiate clearly at about 4-6 weeks. The characteristic BAER morphology emerges by 3-6 months, however the amplitude of wave V does not achieve adult values until the fourth or fifth year (Salamy and McKean, 1976). Although BAER does not assess the auditory system past the inferior colliculus (IC), it is likely that the prolonged period of maturation applies to IC-thalamo-cortical connections as well.

In addition to the functional status of the cochlea, retrocochlear changes occur which are probably related to myelination of nerve fibers (Eggermont, 1985). Although myelination is the primary maturation process in the central nervous system, additional processes play a role in the functional development of sensory systems. Among these are the gradually increasing efficiency of synapses, the onset of convergent and divergent neural connections that lead to more straightforward connections, and possibly the elimination of some synapses (Purves and Lichtman, 1980).

3.5 Changes in Basic Auditory Capabilities

The development of basic auditory abilities has been studied by a number of investigators. Although a great deal of information has accrued, some basic questions remain unresolved. The three important aspects of audition discussed in this section are: frequency sensitivity and selectivity, temporal acuity and resolution, and auditory memory.

3.5.1 Frequency Sensitivity and Selectivity

As previously noted, the shape of the pinna and the size of the ear canal influence the sounds that reach the ear drum, favoring the transmission of high frequency sounds. In addition, anatomical development of the cochlea predicts a high frequency precedence in spectral sensitivity. In this section, measurements of frequency sensitivity based on behavioral and physiological assessments are presented.

Although the filter functions of the periphery (Aslin, et al., 1983) predict that the higher frequency range should mature before the low frequencies, paradoxically, just the opposite may be true. Rubel et.al. (1984) summarized available data on the frequency range to which animals of a variety of species initially respond, and the adult dynamic range of each species (see Table 4). They emphasized that initial responses are elicited by low or mid-low frequencies for each species, with responsiveness to higher frequencies developing last.

Unfortunately, Rubel et al. (1984) did not provide the source of the data for the initial frequency range of the human infant. Neonatal frequency sensitivity is still controversial, despite numerous investigations in the area. Aslin et.al. (1983) stated that there are two prevailing opinions supported by

Species	Adult Frequency range (kHz)*	Initial frequency range (kHz)
Human	.03-20	0.5-1.0 (Hr.Physiol., Beh)
Cat	.06-75	0.5-2.0 (Physiol) 0.3-0.75 (Beh)
Dog	.04-50	0.5-0.75 (Beh)
Mink	0.1-70	0.5-0.75 (Beh)
Rabbit	.06-50	0.5-3 (Physiol) 0.3-0.75 (Beh)
Rat	0.3-76	0.2-2 (Physiol)
Mouse	1-84	0.6-2 (CM) 1-3 (Beh)
Bat	10-120	7-12 (Physiol)
Chicken	0.1-7	0.1-0.8 (Physiol., Beh)
Duck	0.1-8	0.1-0.5 (CN)

* Approximate range of audiogram at 70dB (SPL); compiled with the help of Henry Hefner and William Stebbins

Table 4. Initial Frequency Ranges (from Rubel et al., 1984)

different sets of empirical data; (1) newborns show elevated thresholds (approximately 40dB relative to adults) at all frequencies, and (2) newborns show elevated thresholds with an additional sensitivity deficit at high frequencies. The latter position is consistent with the developmental pattern observed in other species.

Using a head-turning response technique, Trehub et al. (1980) and Schneider et al (1980) determined thresholds for infants aged 6, 12, and 18 months (see Figure 9). The behavioral technique is not appropriate for infants younger than 6 months. Although infant thresholds are higher, it is possible that the testing did not tap the lower limits of sensitivity due to attentional/motivational confounds. In other words, auditory detection of sound could occur without an overt behavioral response by the infant. Nevertheless, the slope of the results indicates a developmental change in sensitivity as a function of frequency.

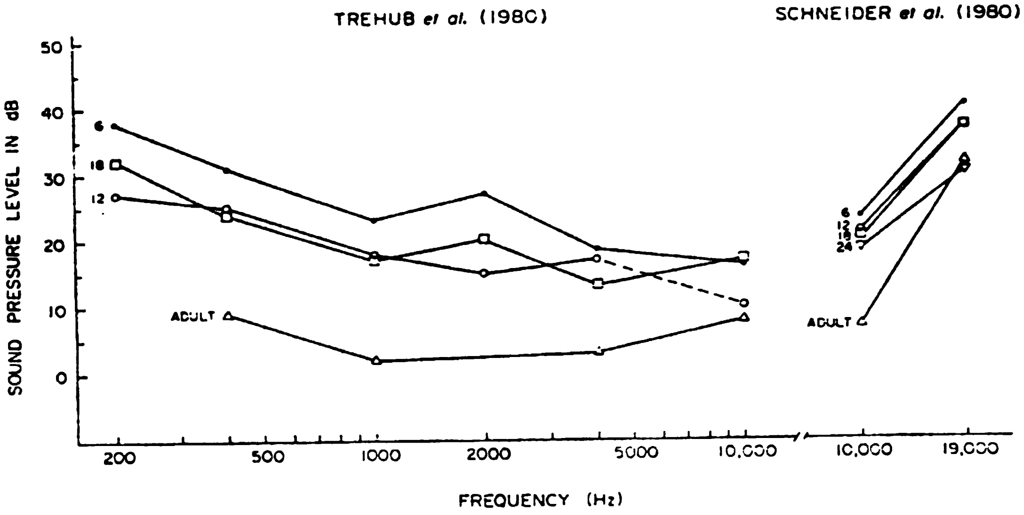
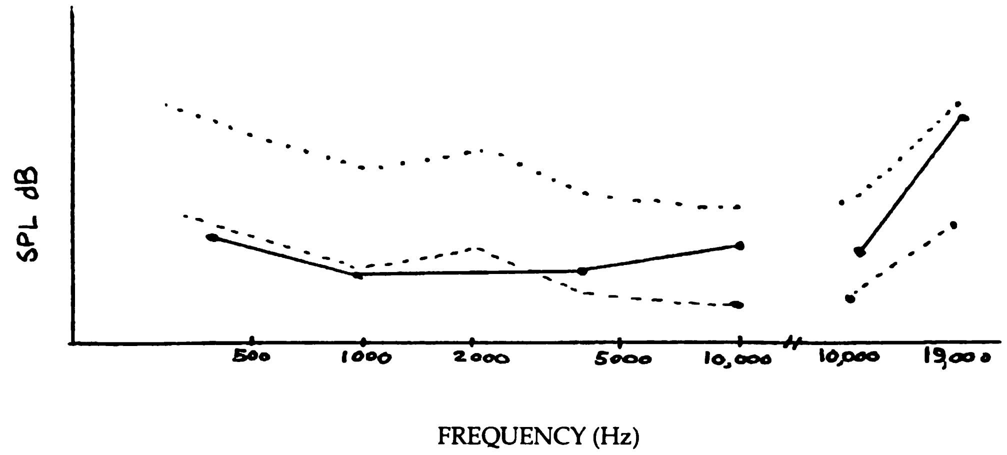


Figure 9. Threshold estimates from infants and adults using octave-band noises at several frequencies. The dashed line for 12-month-olds represents an extrapolated value because their performance was never below 10 dB at 10,000 Hz. From Aslin et. al. 1983.

Aslin et al. (1983) note that it is unclear whether there is an improvement in low frequency sensitivity or whether adults show a loss of high frequency sensitivity after infancy. In support of the high frequency loss hypothesis is the finding that sensory hair cell loss occurs in the basal cochlea during postnatal development (Aslin et al. 1983). If the thresholds were indeed lower for infants, and if the high frequency loss hypothesis is correct, the picture of infant and adult thresholds might look like Figure 10.



Adapted from Trehub, et al. (1980) and Schneider, et al (1980)

Figure10. Threshold estimates from infants and adults if infant thresholds were lower.

A possible method for determining the near-threshold auditory sensitivity may be the use of physiological measures. Berg (1985) suggested that physiological measures of auditory responsivity may be more sensitive than psychophysical techniques. He noted that psychophysical techniques track "attentional thresholds" because they are sensitive to the "significance" of the stimulus rather than the threshold of audibility. Physiological measures include changes in respiratory rate, heart rate, eye blink rate, and skin-conductance. Berg's approach was to measure changes in the heart rate of four sleeping infants subjected to pure tone stimulations. He found an increased auditory responsiveness, especially to low-intensity stimuli. For example, at 250 Hz, the detected stimuli were approximately 15 to 25 dB lower than those of the behaviorally determined threshold in this environment.

Nozza and Wilson (1984) stated that it is important to understand the infant's detection of a signal in noise as well as detection in quiet. In order to understand how the auditory system analyzes auditory input, it is essential to know the effect of noise. The variation of masked thresholds with frequency reflects the changes in auditory filter bandwidth (eg., critical band) as a function of frequency. Using the head-turn response paradigm, Nozza and Wilson assessed detection thresholds for 6- and 12-month-old infants in quiet and in noise. They found masked thresholds of infants to show the same variation with frequency as do those of adults. Thus, the data are consistent with a frequency selectivity mechanism (eg., critical bands) that is proportional to that of adults. Additionally, there is a small degree of difference (5-7 dB) between infants and adults in detecting pure tones in a background of noise. Again, the paradigm may not define the lower limits of sensitivity because of attentional/motivational confounds. Thus, infants are not severely disadvantaged when listening in poor conditions.

3.5.2 Temporal Acuity and Resolution

The ability to resolve two sounds in time (temporal acuity) is an important skill. The development of auditory temporal acuity in children (aged 6-12 years) and adults was studied by Irwin et al. (1985). In order to assess temporal acuity, the minimum detectable duration of a brief cessation of the signal was measured. Using the psychophysical procedure of a two-alternative forced choice paradigm, they investigated the effects of signal amplitude and frequency. Results indicated that higher sound pressure levels yielded significantly shorter durations than the lower levels (Figure 11A), and that age-related differences exist for temporal acuity (Figures 11A-B). Furthermore, the minimum detectable duration depends on signal frequency; the 500Hz signal showed a significant age-related effect (Figure 11B).

These findings are consistent with the observation that children have difficulty in recognizing reverberant or time-compressed speech. Unfortunately no work has been done with infants or very young children on

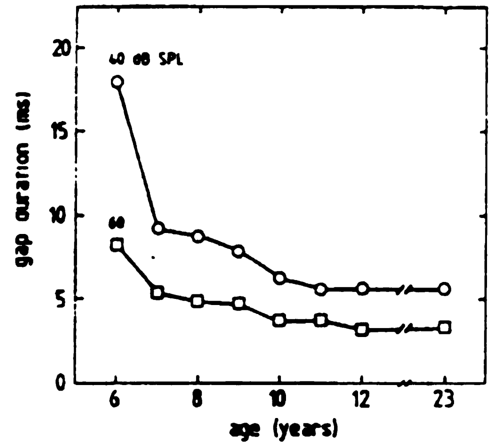


Figure 11A. Minimum detectable gap in a broad-band noise as a function of age. Each point is the average of two estimates from four listeners, and is therefore is based on 400 trials. The parameter is the overall level of the noise.

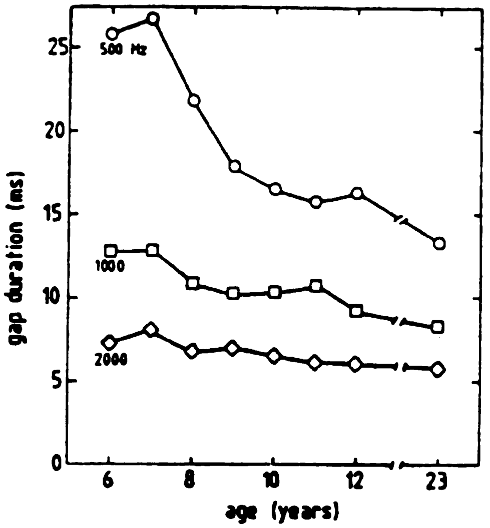


Figure 11B. Minimum detectable gap in three octave-band noise as a function of age. Each point is the average of two estimates from four listeners, and is therefore based on 400 trials. The parameter is the center frequency of the band. (Irwin et al. 1985)

temporal acuity, presumably due to methodological difficulties. Nevertheless, since an age-dependency has been established for 6-year-olds, it is likely that younger children are also limited by their temporal acuity.

The ability to make fine temporal discriminations is important for sound localization and speech perception. In order to study developmental changes in temporal resolution, Morrongiello et al. (1984) employed the precedence effect. The precedence effect is an auditory illusion produced when the same sound is presented with equal intensity at two locations, with one delayed by several milliseconds. The resulting percept is of a single sound image located at the position of the first (lead) sound. The second (lag) sound affects the overall quality of sound, but is not perceived at its true location. If the delay time is increased past threshold, the lag sound is localized correctly. Thresholds for the precedence effect vary as a function of the acoustic characteristics of the stimulus: shorter for spectrally simple sounds and longer for complex sounds such as speech or music. Morrongiello and her colleagues tested the precedence effect thresholds in 6-month-old infants, 5-year-old children, and adults using a simple sound (click) and a complex sound (rattle). Whereas the mean threshold (and threshold ranges) were similar for adults and 5-year-olds, they were significantly longer for infants. The authors suggested the higher thresholds for younger children might be due to longer storage time of the auditory image, slower processing time, or a combination of these. As discussed previously, central auditory processing of auditory information is slower in young children as measured by electrophysiological techniques.

3.5.3 Auditory Memory

The finding by Morrongiello et al. (1984) that young children take more time to resolve temporal cues suggested the possibility of a longer storage time of the auditory image. According to Cowan et al. (1982), one of the earliest stages of information processing, the preperceptual storage of auditory information, is the unanalyzed "echoic" form. Using a masking paradigm, they investigated the development of auditory echoic memory. The nonutritive sucking discrimination (HAS) procedure was used with 8-9-week-old infants. Repeated pairs of brief sounds (vowels) were presented with a change in the first vowel (backward masking), the second vowel (forward masking), or neither vowel (control). Discrimination was indexed by a greater rate of sucking (less habituation), indicating that the stimulus shifts were perceived by the infant.

Because the second sound in a pair interferes with the echoic storage of the first sound at relatively short stimulus onset asynchronies (SOA), performance is usually better with forward masking than with backward masking. In adults, the interference with performance in backward masking decreases to an asymptotic level at an SOA of about 250 msec. (which is thought to be the amount of time for echoic storage).

Results of this investigation indicated that infants discriminated the shifts in the forward masking condition with an SOA of 50 msec., and in the backward-masking condition with an SOA of 400 msec. (but not with an SOA of 250 msec.). This suggests that the infant has a longer echoic memory than does the adult. The authors pointed out that a longer-lasting echoic trace could help the infant overcome a slower sensory processing rate by allowing more time for the analysis of the input.

3.6 Changes in Speech Perception

The question "When does linguistic perception begin?" is not resolved. Although the newborn is capable of discriminating speech sounds in a categorical-like manner, it is unclear as to whether this is a phonetic/linguistic skill or a general auditory skill. Strong evidence against the linguistic mode of perception in infants includes that facts that (1) nonspeech signals are perceived categorically (Pisoni, 1977) and (2) nonhuman animals perceive speech sounds categorically (Kuhl and Miller, 1975). Nevertheless, infants evidence a sophisticated perceptual apparatus that allows them to recognize phonetic equivalence. For example, by at least 6 months of age, infants categorize two versions of the vowel /a/, one produced by a male, the other by a female (Kuhl, 1985). This type of complex task has not been demonstrated in nonhuman animals (yet).

A number of reviews have been written on infant categorical perception (Aslin et al. 1983; Diehl and Kluender, 1988; Eilers and Oller, 1985, 1988; Eimas et al., 1988; Jusczyk, 1985; Kuhl, 1985, 1988). The following summarizes the findings:

1. Shortly after birth, voice onset time (VOT) distinctions are made by the infant. Adult-like distinctions are made for the English voiced/voiceless boundary.

2. Infants can distinguish many place of articulation differences. This occurs for fricatives as well as stops. The discriminations are made on the basis of burst cues, formant transitions, or some combination of the two. Infants also detect differences in these acoustic cues in nonspeech stimuli.

3. Manner of articulation distinctions can be categorized by the infant as well. Differences in the oral/nasal contrast have been detected, and infants can discriminate manner distinctions based on tempo of spectral change (i.e., stops/glides/diphthongs).

4. Vowels can be distinguished categorically ([a]/[i] and [i]/[u]). However, many vowel pairs are distinguished continuously ([I]/[i]), which is consistent with adult vowel perception.

Despite the many abilities at birth, some distinctions seem to develop over time. For example, the discrimination of fricatives on the basis of voicing or place of articulation improves with time. This implies an ease of discriminability of speech sounds. Burnham (1986) suggested that those contrasts which are rare in the world's languages will be the hardest to discriminate. He postulated that the basis for the "fragile"/"robust" dimension is the psychoacoustic salience of the contrasts.

A number of investigators have studied the effects of linguistic experience on perceptual capacities. For example, Eilers et al. (1979) found English 6-month old infants unable to distinguish prevoiced/voiced stops. However, Spanish infants could make the distinction (prevoicing is phonemic in Spanish). More recently, Best et al (1988) suggested that ease of discriminability depends on the role of the stimuli within the phonological system of the native language.

It has been suggested that infants shift developmentally from perception of speech contrasts in prephonological terms (i.e., based on acoustic properties alone) and phonetic terms (i.e., based on how sounds are articulated) to perception in terms of contrasts that occur in the phonological system of their language. This shift to a phonological mode of speech perception occurs around 10-12 months of age (Werker and Tees, 1984). It is around this time that infants stop making distinctions among nonnative contrasts. Best et al. warned that any explanation of language-specific effects on speech perception should take into account the relation of phonetic properties to phonemic contrasts, which are defined by particular combinations of phonetic features. This is because psychoacoustic factors may also play a role in the discrimination of speech contrasts. They suggested four types of nonnative contrasts:

1. Single-category assimilation, in which both members are assimilated to a single phonemic category in the native language. This should be the most difficult type of contrast to discriminate.
2. Opposing category assimilation, in which each member is assimilable to a contrasting native language phonological category.
3. Category-goodness difference, in which one member is easily assimilated to a native language phonological category and the other is not.
4. Non-assimilation, in which neither member is assimilable to a native language phonological category.

Best and her colleagues predicted that non-assimilable contrasts should be easily discriminable throughout infancy and adulthood, because perception of these contrasts focuses purely on auditory or phonetic properties. They compared English-learning infants of four different ages (6,8,10, 12 months), English-speaking adults, and Zulu-speaking adults on their ability to discriminate Zulu clicks. The clicks were nonnative and non-assimilable for the English-environment groups, yet all subjects discriminated them. These findings were interpreted as support for the prediction that nonnative, nonassimilable contrasts are discriminated on the basis of their acoustic/phonetic attributes.

Mehler et al. (1988) report even earlier effects of language experience. Their evidence suggests that infants show a preference for their native language days after birth. Since it is possible for the infant to hear in utero (especially low frequency sounds), there may be specific learning experience with the most global, prosodic aspects of a language. They found infants to respond in the same fashion when the native speech sample was low-pass filtered.

Linguistic perception refers to more than discriminations of same/different contrasts at the segment, clause/phrase, or even prosodic levels. It may start with the identification of these units, but eventually the contrasts must become organized according to similarities as well as differences. The account by Best et al. (1988) of possible ways that listeners may restructure nonnative contrasts in terms of native contrasts invokes linguistic processing, because it assumes that the infant organizes contrasts according to similarities as well as differences in terms of the system of a particular language.

Another example of (probable) early linguistic processing is the work by Bertoncini et al. (1988), which showed that developmental changes in the perceptual representations of speech can be identified in very young children (between birth and 2 months). This was accomplished using a modified HAS procedure which did not permit infants to employ a simple same-different response. Instead, the infants discriminated a stimulus set based on varied phonetic characteristics (i.e., syllables were categorized with increasing phonetic specificity). The change noted was a tendency from global toward more specific representations on the part of older infants.

Ferguson (1978) presented characteristics of 'baby talk', that is, speech directed to infants. According to Ferguson, the most notable characteristics are prosodic modifications. Adults speak to infants with an overall higher pitch and exaggerated intonation contours. He presented cross-linguistic evidence in support of this phenomenon having special status as a *universal* in language development. The elevation and expansion of Fo range has been extensively documented as a robust characteristic of infant-directed speech (e.g., Fernald et al.,1989). Moreover, Fernald (1985) presented evidence indicating that exaggerated pitch contours are acoustically compelling to infants, and that infants show a listening preference for infant-directed speech (also known as *motherese*). Fernald at al. (1989) suggested that the preverbal infant grasps meaning through Fo contours holistically, as meaningful units in themselves. The progression of global prosodic perception towards smallerlinguistic units is continuous and cumulative. Fernald et al. (1989)

indicated that this perspective emphasizes biological predispositions as the primary determinants for the salience of prosodic patterns. Fernald (1992) invoked natural selection for these biologically relevant signals. She stated that the prosodic components of speech use phylogenetically older and simpler auditory processing mechanisms than those which will be used eventually to process linguistic information.

Haith (1980) suggested that the infant auditory system is particularly sensitive to the exaggerated frequency shifts associated with infant-directed speech. Fernald and Kuhl (1987) found that infants' preference for *motherese* is most influenced by Fo modulation. This sensitivity to pitch contours appears to be particularly keen at the age of 4 months (Werker and McLeod, 1989). Infants are able to perceive, differentiate, and abstract information from Fo patterns from the first months of life (Fernald, 1984).

3.7 System Plasticity

Just as phenomena associated with the ontogenesis of production reveal the young child's plasticity, many phenomena associated with the development of perception can also be characterized as plastic events. As discussed in the previous chapter on speech production, there are three types of neural plasticity: developmental, anatomical (structural), and physiological (functional). This framework is useful for describing speech perception phenomena.

3.7.1 Developmental Plasticity

Perhaps the most prominent example of developmental plasticity is that children learn to perceive the speech in their environment. Although the infant comes into the world with the anatomical prewiring for categorical perception of "robust" speech contrasts, he must learn to discriminate the "fragile" contrasts. This learning (fine-tuning) is also apparent in cross linguistic studies which indicate a decline in the discrimination of many nonnative speech contrasts.

A less well-known instance of developmental plasticity is the degenerative process of selective cell death associated with the developing cochlea. Like neurons, the sensory hair cells of the cochlea do not continue to proliferate throughout life (Rubel, et al., 1984). All of the hair cells are produced during embryogenesis. The 4.5-month-old fetus has more hair cells than it will have at birth. Hair cells are gradually lost during the midfetal period and continue through early childhood. The reason for this loss is not known.

3.7.2 Structural Plasticity

Activity-dependent changes in the auditory system can result in anatomical changes. The effects of deafferentation on the integrity of the auditory system have been studied by many investigators using ablation techniques. For example, if a cochlea is removed in a young chick, there is a 20-40% loss in neurons in the brainstem auditory nuclei, and the remaining neurons are reduced in size by 15-25% (Rubel, et al. 1984). Similar findings have been documented in other animals.

In addition to the cell losses associated with deafferentation, reorganization and development of new inputs can also occur. Rubel et al. (1984) reported a case where the cochlea of a mouse was destroyed. Not only was there a profound cell loss in the ipsilateral cochlear nucleus (2nd station along the auditory pathway), but there was also an increase in the input to the ipsilateral inferior colliculus (3rd station along the auditory pathway) from the contralateral cochlear nucleus. In this case, new growth (in the form of redistribution of neural projections from the cochlear nucleus) accompanied loss of afferent input. In another deafferentation study, Parks and Jackson (1986) induced many axons to form permanent synaptic connections with a novel target. However, structural plasticity is not just a matter of synaptic strengthening. Moore and Kitzen (1985) reported actual (new) axonal growth from the cochlear nucleus to the inferior colliculus following ablation of the cochlea in gerbils. This suggests a significant degree of structural plasticity in the auditory system during development.

The structural changes that follow deafferentation are not unique to the auditory system but are common in other sensory systems as well.

3.7.3 Functional Plasticity

The frequency shift of the developing cochlea is an example of functional plasticity in early ontogenesis. As mentioned previously, there is a strict tonotopic organization of the basilar membrane of the cochlea. That is, hair cells respond to different frequencies at different locations along the membrane. In the mature cochlea, high frequencies are represented in the basal region, and the lower frequencies are represented in more apical regions. Rubel et al. (1978) stated that the place code along the cochlea changes during development (refer to Figure 12). According to Rubel, low frequencies are located initially in the basal/midbasal region of the cochlea. They become more apically located as the organism matures. This prediction was tested by inducing cochlear damage (by exposure to high-intensity pure tones) at midrange frequencies to chicks of different ages. Dissection of the cochlea revealed a systematic shift in the position of damage as a function of the chick's age. Hair cell loss shifted toward the apex with increasing age. This shift has usually been attributed to a wide range of maturational changes which influence basilar membrane mechanics, the hair cells themselves are not altered (Leake, personal communication). In addition, the cortical mapping of frequency has also been shown to shift with maturation. The "cochlear shift" is observed in mammals also, and likely occurs in humans as well.

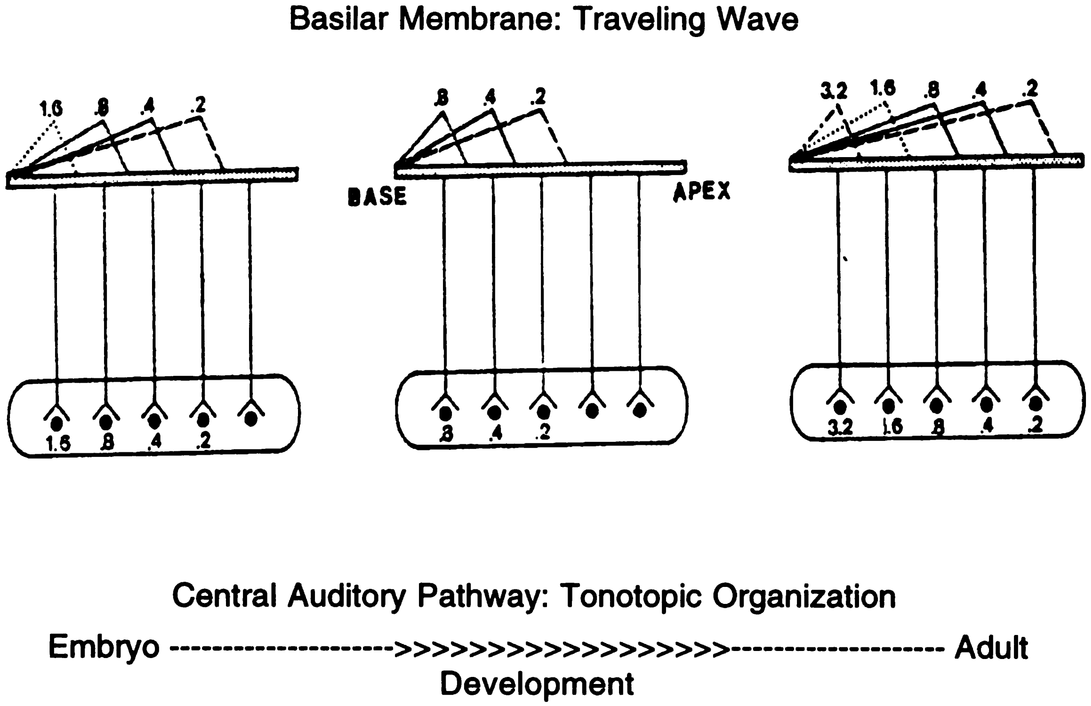


Figure 12. Model of inner ear functional development. The sequence of development is shown from left to right. The basilar papilla (cochlea) is depicted at the top of each section and the positions of the traveling waves produced by pure tones of several frequencies (in kilohertz) are indicated. A region of the central auditory pathways which is tonotopically organized is shown connected to the basilar membrane. The numbers here indicate the "best frequency" (in kilohertz) of neurons at each location. At the beginning of auditory function (left diagram) the basal half of the cochlea is responsive to relatively low frequencies and the central nervous system areas receiving projections from the base respond to low frequencies and the base becomes progressively more sensitive to high frequencies. The cochlear shift is accompanied by a shift in neuronal best frequencies. From Rubel et al., 1984.

A second, and very significant, type of functional plasticity occurs when speech perception occurs with a degraded signal or in the presence of noise. It has been demonstrated that an impoverished signal can be reconstructed through a process known as phoneme restoration (Warren, 1976). In this case, the listener "hears" missing sounds in a word through perceptual synthesis. The developmental course of phoneme restoration is not clear. Another example of functional plasticity is that hearing impaired children can learn to perceive speech. This is particularly true for children with mild hearing losses. However, even children with profound hearing losses make use of whatever auditory information is available (through amplification or cochlear implant) to perceive speech.

4. The Auditory-Motor Linkage

That a linkage exists between what a person hears and what a person says is indisputable. This auditory-motor linkage is evident with the Lombard effect (i.e. a person speaks more loudly when he is unable to hear himself normally) and in the presence of delayed auditory feedback (DAF). Whereas the Lombard phenomenon affects volume, the effect of DAF is to disrupt the fluency of speech (except with stutterers). These phenomena speak to the auditory-motor linkage that exists in *real time* as one speaks. The way we speak depends on what we hear.

The reverse is also true. The way we hear depends on how we speak. However, there is no evidence of this direction of linkage occurring in *real time*. Humans appear to hear speech accurately in the presence of variables that affect speech production skills such as numbness associated with dental work or objects in the mouth (eg. bite block, food, orthodontic appliances). It appears that hearing is not dependent on speaking in *real time*. Yet it is clear that the development of auditory skills for speech is dependent on the language spoken by that person. A good example of this dependency is that many non-native speakers of English fail to perceive the /r/ and /l/ phonemic contrasts (Strange and Jenkins, 1978). It may be argued, appropriately, that there are more than motoric reasons for the lack of development of this contrast. Nevertheless, it must be acknowledged that the absence of motoric representations for /r/ and /l/ contributes to the lack of perceptual development.

An ideal population for studying the effect of motor (speech production) skills on the development of auditory (speech perception) skills would be infants who are incapable of many prespeech motor movements secondary to medical problems, but who are otherwise normal. This would likely be the infants who have undergone tracheostomy and are ventilator-dependent for prolonged periods of time. Thus far, investigations with this population have failed to produce evidence of any significant effect (Locke and Pearson, 1990). That is, these infants do not demonstrate measurable impairment of speech perception skills.

In contrast, the ideal population for studying the effect of auditory skills on the development of speech production skills has been observed and studied extensively with robust results. Children with hearing losses exhibit severely compromised speech production skills (Eilers and Oller, 1994; Kent et al., 1987; Stoel-Gammon, 1988). Every aspect of speech production, segmental and suprasegmental aspects, is affected by a hearing loss. This consistent result indicates that auditory input is <u>necessary</u> for the normal development of speech output.

The age at which sensori-motor linkage begins is not clear, nor is its course of interdependence over time. The nature of the dependencies between audition and motor movements is likely to evolve and change over time. Waldstein (1990) studied the role of auditory input by looking at the effect of postlingual deafness on speech production skills. She studied the changes in the speech properties of seven postlingually deafened subjects (ranging in age from 13 to 62 years old). She found all classes of speech sounds, including prosodic properties, to be affected when compared with normal controls matched for age. Waldstein concluded that normally hearing speakers use auditory feedback in speech maintenance (over the long term) to calibrate the fine phonetic adjustments required to produce high-quality speech. She noted that the effect of postlingual deafness differed as a function of age at onset of the hearing loss. The speakers who became deaf earlier in life deviated from the norm to a greater extent than did subjects who became deaf at later ages. Waldstein's findings suggest that the role of auditory input changes over time: it has a *necessary* role in the acquisition of speech production skills, but plays a *self-regulating* role in mature systems. It appears that once a person develops a degree of maturity with speech production skills, he becomes less dependent on the auditory input.

4.1 Cross-Linguistic Evidence

A very fruitful line of research into the question of *when* this auditory-motor linkage begins has been the cross-linguistic research into speech development. The question of *what* the early perceptual/productive units might be has also been asked, although indirectly. Vihman (1996) stated that this research has been undertaken as a means to decide between two theoretical perspectives on babbling: 1) "The independence hypothesis" (Lennenberg, 1967; Locke, 1983), which maintains that "babbling is simply the natural output of an immature production apparatus, with no link to perceptual mechanisms"; and 2) "The interactional hypothesis", which maintains that the ambient language already exerts a perceptuomotor influence during the prelinguistic/babbling period. While this may be the central goal of cross-linguistic research into speech development, it also affords the opportunity to address the questions of *when* the perceptuomotor linkage begins, and *what* are the units that constitute the early linkage. Given the wealth of evidence that has accumulated in support of the interactional hypothesis, the general consensus among most researchers today is that an auditory-motor linkage does exist during development. The attempt to define universal tendencies for phonetic proclivities in early speech continues, however, with the acknowledgement that language-specific perceptuomotor influences are operative.

A long-term research effort into this topic has been undertaken by Boysson-Bardies and her associates. They have established that adult judges can differentiate the vocalizations of 8-month-old (and some 10-month-old) infants exposed to different languages (Boysson-Bardies, Sagart, and Durand 1984). The three language communities (French, Arabic, and Chinese) were chosen on the basis of their strongly contrasted "dimensions of laryngeal and supralaryngeal settings" and of prosody. In a follow-up to the original study, phoneticians were able to discriminate the vocalizations of 6-month-olds from different language communities. The authors stated that the adult discriminations were based on the prosodic (nonsegmental) features of the utterances (i.e, "phonation type and organization of pitch and intensity contours" p.10).

Boysson-Bardies, Halle, Sagart and Durand (1989) studied the vowel productions of 10-month-olds from four language communities. Acoustic analysis was performed on the first two formants of each vowel. For all groups, they found a strong concentration of vowels in the three main classes for each language: low front, mid central, and low central. There were, however, differences between the groups. Each group demonstrated relatively more tokens of vowels that occur more often in their language: front vowels for English, mid central vowels for French, and low central vowels for

Chinese (Cantonese). Additionally, they found significant differences in mean formant frequencies of vowels between the groups. The F1/F2 ratio, which characterizes vowels on the compact/diffuse dimension, was found to be significantly different. The two most different languages in this respect were English (favoring high, front vowels that are diffuse) and Cantonese (favoring low back vowels that are compact).

Bacri, Boysson-Bardies and Halle (1989) compared the pitch and timing (durational) differences in the utterances of 11 to 14.5 month-old infants from English and French language communities. They found differences in both prosodic features between the two groups. For the English group, where pitch serves a particular linguistic function, the Fo range was wider, the pitch movements were steeper, and the rise-fall contours were not infrequent. In contrast, for the French group, where syllabic duration serves a linguistic function, systematic final syllable lengthening was observed. The differences between the groups were viewed as precursors to English stress and French final accent.

Boysson-Bardies and Vihman (1991) studied the distribution of consonantal place and manner categories in French, English, Japanese and Swedish infants from babbling (9-13 months) to the production of 25 words (16-19 months). Although they found evidence of universal tendencies (predominance of labials, dentals and stops), they found clear evidence of phonetic selection based on specific language influences. The production of labials reflected a difference in the incidence of labials in the adult language. These results complement the earlier work by Boysson-Bardies et al. (1989) on vowel differences observed in the prelinguistic utterances of babies from different language communities.

Whalen, Levitt and Wang (1991) examined the intonation contours of English and French infants. They studied the reduplicated babble from infants ranging from a mean age of 7.10 months to 11.3 months. The French children used significantly more rising intonation and less falling intonation than the English children. This pattern reflects the relative distribution of Fo contours in the adult languages.

Cross-linguistic research into speech perception also contributes to our understanding of the auditory-motor linkage. As noted previously in the discussion on speech perception, Mehler et al. (1988) reported that infants show a preference for their native language days after birth. Since it is possible for the infant to hear in utero (especially low frequency sounds), they posit an early, specific learning experience with the most global, prosodic aspects of a language.

4.2 The Development of Laryngeal Behavior: Pitch/Tone

Anyone who has spent time with a young infant can describe the squeals, goos, cooing and other sounds that the baby produces. These informal accounts describe what can be attributed to laryngeal behavior on the part of the infant. But do these sounds constitute anything more significant than gurgling or burping? Are early laryngeal behaviors modified by the sounds heard in the ambient language? Could the fundamental frequency (Fo) of the infant's voicing constitute units of early linguistic structure, or contrast? Furthermore, does the well-established increase in pitch changes associated with *motherese* confirm a propensity of the infant's auditory system towards pitch?

It has long been noted that very young children imitate adult intonation patterns (Lewis, 1936; Crystal, 1973). There have been recent investigations into mother-child vocal matching (Papousek and Papousek, 1989; Kessen, 1979), each verifying that infants from the age of 2 - 5 months do, in fact, imitate adult intonation patterns. The matches are most accurate and consistent for absolute pitch, but also include pitch contour, duration, vowel-like resonance and rhythm. Boysson-Bardies, et al. (1984) stated that this phenomenon should not be considered atypical performance, but rather reflective of (a) an early general tuning of the vocal tract to conform with the laryngeal and supralaryngeal settings that are specific to the target language, and (b) the fact the certain rhythmic and intonational properties of the target language are beginning to be acquired.

The expansion stage of vocal development, also known as the period of vocal play, occurs around 4-6 months of age. The baby begins to produce squeals, growls, coos, yells, and vowels. As reviewed in the previous chapter on speech production, the anatomical changes coinciding with these vocalizations include the disengagement of the larynx with the nasopharynx and improved coordination with the respiratory system. The descent of the larynx into the neck makes the vocal folds more vulnerable to forces of supralaryngeal muscles, and heightens the contrasts in vocal pitch. Stark (1978, 1980) suggested that cooing is dependent upon an increased control over voicing, and that this voluntary laryngeal control develops in response to both physiological maturation and interaction with the environment.

The main changes observed in the vocal behavior during the first 6 months are the duration of the vocalization and the within-utterance range/variability of pitch (Laufer and Horii , 1977). Utterances increase in duration and increase in Fo range/variability. Kent and Murray (1982) found unusual laryngeal behavior in infants such as vibrato (vocal tremor), abrupt changes in harmonic structure, noise components, and transient deviations from the overall Fo contour. These behaviors, typically avoided by mature speakers, constitute the exploration that infants engage in between 3-9 months.

In an attempt to identify the early intentional use of vocalizations, D'Odorico (1984) studied the Fo contours of infants as young as 4 months old in three situations: calling, discomfort, and requesting. The preliminary results indicated that Fo contours were used in different proportions depending on the emotional state of the infant. D'Odorico and Franco (1991) found consistency in the pitch contour based on situational context for 4 to 8-month-old infants. Higher Fo and rising intonational contours were associated with requesting.

The previous review of cross-linguistic research presented evidence of learning specific intonational aspects of the child's language during the first year. In the Boysson-Bardies et al. (1984) study, phoneticians were able to categorize infants into language groups based on the global prosodic features of their language community at age 6 months. These are the earliest ages at which infant vocalizations suggest an influence from the ambient language. It is clear that by 10 months there are definite differences in both vowel and consonant production as a function of the ambient language.

4.2.1 The Development of a Tonal Language:

Whereas intonation can encompass many linguistic units to indicate such things as stress or question demarcation in a nontonal language, a tonal language gives meaning to *individual syllables* when produced with different tones. The pitch variations are used to convey different lexical meanings at the syllable and word level. Every word has a distinctive tone, and its tone is an essential component of the syllable. The tones are created with variations in the fundamental frequency (Fo) in a systematic way. Typically, a tonal language utilizes patterns of Fo changes (eg: level, rising, falling) as well as relative pitch (eg: high, mid, low). Actual pitch and intervals between tones depend on the individual speaker as well as on prosodic features of stress and intonation. Tone can be used to distinguish segmentally identical words. For example, in Cantonese, /ji/ can mean *clothing, chair, meaning, child, ears,* and *two*, depending on which of the Cantonese tones was used in production (Ching, et al., 1994).

According to Ladefoged (1982), tone languages make two slightly different uses of pitch within a word: lexical and grammatical (morphological). In addition, intonational pitch changes are superimposed to divide utterances into syntactic units such as sentences. The pitch of the voice changes continuously throughout an utterance in a tone language. These constant Fo modulations typically occur between 100 - 400 Hz in the adult Cantonese-speaker (Yuen-Yuen, 1974). The Cantonese tone system is a 'level' or 'register' system with pitch variation patterns that can be defined as relatively high or low falls or rises. There are six lexical tones and three glottalized tones (level tones delivered with a stop coda) in Cantonese (Tse, 1991). The glottalized tones, also known as checked tones, have the same level pitch as three of the lexical tones, but they differ in their shorter duration and the glottal stop component.

Most of the research in the area of suprasegmentals has focused on stress, duration, pitch, and intonation. There is a dearth of information about the acquisition of phonemic tone distinctions. The study of tone acquisition in Mandarin by Li and Thompson (1977) provides much of the information known today about this topic. They studied the development of tone in 17 infants in Taiwan ranging in age from 18-36 months. These children were recorded every 3 weeks, while looking at picture books. Mandarin consists of four tone phonemes: high level, rising, low, and falling (dipping). They provided a framework with which to present their results:

> Stage 1: The child's vocabulary is small. High and falling tones predominate irrespective of the tone of the adult form

Stage 2: The child is still at the one-word stage, but he has a larger vocabulary. The correct 4-way adult tone contrast has appeared, but sometimes there is confusion between rising and dipping tone words.

Stage 3: The child is at the 2-3 word stage. Some rising and dipping tone errors remain. Tone sandhi (changes of tone resulting from surrounding tones) is beginning to be acquired.

Stage 4: Longer sentences are being produced. Rising and dipping tone errors are practically nonexistent.

They continued to present their results with the following summary:

a. The correct tone system is acquired relatively quicker and is mastered well in advance of the segmental system.

b. The high and falling tones are acquired earlier and more easily than the rising or dipping tones.

c. confusion persists in the form of substitution errors throughout stages 2 and 3 between rising and dipping tones.

d. The tone sandhi rules are learned, with infrequent errors, as soon as the child begins to produce his own multi-word utterances.

e. The neutral tone is often misinterpreted as a full tone.

Each of these results was discussed in their paper with data to support it. Unfortunately, the authors failed to include specific data pertaining to the ages associated with each of the stages of acquisition for tone. Nevertheless, their findings of early mastery of high and low tones was confirmed by Tse (1978). Tse presents a diary study of his son's acquisition of Cantonese. In this interesting account, perceptual probes at 11 months suggested that word comprehension was more attuned to tones than to segments. With regard to production, initially high and low level tones were used (at age 1;2 -1:4), followed by the first contour and mid tone (at age 1;5-1;8), and then the final two contour tones (at age 1;9). Of particular interest was the finding, similar to Li and Thompson's (1977) results, that by age 1;10, Tse's son produced few errors in tone, while numerous segmental errors persisted.

Finally, Tse (1991) reported the phonological development of a Cantonese-learning child from age one to three years. His micro-diachronic approach provides a systematic study of phonological acquisition for this one child. Among his findings is that the vowel and tone systems were learned before the consonant system. For example, at 20 months, the child had acquired 30% of tones, 50% of vowels, and only 20% of initial consonants (0% of final consonants).

These studies suggest that infants acquiring speech have earlier success with tone than segmentals, and support what has been repeatedly stated: that infants learn to control absolute and relative pitch prior to segmental controls (e.g., Crystal, 1973). Unfortunately, there are no systematic accounts of the earliest onset of phonemic tone. Crystal states that 6-7 months is the most likely period for the emergence of suprasegmentals (including phonemic tone) in speech production.

5. Summary of the Literature:

The review of literature covering the development of speech processes (production and perception), as well as the linkage between the two processes, provides the context for this investigation. It is clear that the normal infant comes into the world equipped to acquire speech. The structures for speech production and speech perception are adequate to "bootstrap" into the learning process with relative ease. The inherent plasticity of the infant's system allows for significant latitude in terms of the necessary conditions for learning to occur. The motor (production) and auditory (perception) processes develop concurrently, with an apparent sensorimotor interaction. The degree to which these processes develop in a parallel as opposed to an interactive fashion is not clear. Although interaction between speech perception and speech-like productions must emerge at some point in the first year of life, the timing of the onset of that interaction has not been established.

A number of changes occur in the speech mechanism during the first year of life, in terms of both structures and their functions. The respiratory system is remarkable for an increase in lung volume and a change in the locus of breathing movements (from strictly diaphragmatic to a combination of thoracic and diaphragmatic). Additionally, the expiratory phase of breathing is shorter than that seen in the adult. The larynx changes both in size and shape.

The earliest phonatory behaviors include cry sounds, discomfort sounds and vegetative sounds. The average Fo for infants is between 350 - 485 Hz for noncry vocalizations. The within-utterance Fo range increases substantially over the first year, with flat or falling pitch contours predominating. Abrupt Fo shifts, breathiness and subharmonic components suggest laryngeal instability; however, the infant *is* able to produce alternating vocalizations with a communicative partner by age 3 months. With the disengagement of the larynx and nasopharynx between 4-6 months, the vocal tract changes from a single-tube resonator with obligatory nasal resonance to a double-tube resonator with both oral and nasal resonances. The supralaryngeal articulators increase in their discriminate control of the refined articulatory postures involved in speech production. The order of acquisition of speech sound segments follows trends that can be partially explained by anatomic/physiologic factors. The tendency toward rhythmic behavior also provides explanatory insight into early speech acquisition. The coherence between the phonetic gestures observed in babbling with those in first words confirms the continuity of prespeech behaviors with speech behaviors. Instances of plasticity observed in speech production reveal that the system is exceedingly modifiable.

Due to methodological difficulties, it is difficult to measure *precisely* the functional development of the infant's auditory system. The structure of the mammalian middle ear is adultlike at birth; however the inner ear undergoes a number of postnatal changes: auditory thresholds decrease, firing rate increases, and the ability to phase-lock increases. Additionally, the tonotopic organization of the hair cells along the basilar membrane shifts during the first year. Retrocochlear changes include a significant decrease in the amount of time in the transmission of a signal along the auditory pathway, becoming adultlike by 12-18 months. Changes have also been documented in basic auditory capabilities. Frequency sensitivity, although controversial, does show age-dependent changes that include an overall increase in sensitivity to frequencies. Infants appear to have the greatest responsiveness ("attentional threshold") to lower frequencies (around 250 Hz). Young children take more time to resolve temporal cues in the auditory signal and have a longer storage time for the auditory image (echoic auditory memory) than adults. An extensive body of research into categorical perception of speech sounds indicates that infants start with a sophisticated perceptual apparatus. Their perceptual abilities for speech sound discriminations change over time, in part, as a function of linguistic experience. The shift from acoustic/phonetic perception to linguistic/phonological perception occurs around 10-12 months. However, some evidence exists for earlier language experience effects, since infants prefer to hear their native language days after birth. The robust phenomenon of *motherese* and the infants' preference for it suggest a biological determinacy. The elevation of Fo and the increased range of Fo excursion associated with *motherese* are acoustically compelling to infants; however, their preference for *motherese* is most influenced by Fo modulation (i.e., variations in the prosody of short stretches of speech).

The nature of the relationship between speech perception and speech production changes over time. In mature systems, auditory input plays a self-regulatory role. In developing systems, it plays a necessary role, providing the input that becomes organized into a linguistic system. Although numerous plastic events are associated with speech development, auditory input is necessary for the development of normal speech perception and production.

Cross-linguistic research has provided insights into both the question of *when* the sensori-motor linkages begins, and *what* the input/output units might be. Adult judges can differentiate the vocalizations of 8-month olds from different language communities based on their prosodic features, and phoneticians have been able to differentiate the vocalizations of 6-month olds. The pattern of intonation contours, in terms of rise-fall patterns, is different in the vocalizations of 7-month olds from different language communities. The babbling of 9- to 13-month olds shows clear evidence of phonetic selection (for consonants) based on the input language. At 10 months of age, vowel formants reflect the structure of the parent language. By

11 months, infant vocalizations show ambient language influences in pitch (i.e., Fo range and contours) and timing (i.e., syllabic duration).

Pitch and tone are early constituents of speech development. Infants from the age of 2 to 5 months spontaneously imitate adult intonation patterns. This vocal matching is most accurate and consistent for absolute pitch, but also includes pitch contour, duration, vowel-like resonance and rhythm. By 4 months, infants use Fo contours differentially for calling, discomfort, and requesting. Cooing occurs around 4-6 months, and reflects the increased control over voicing. The vocal exploration observed during the 3-9 month period includes an increased within-utterance Fo range and increased utterance duration, as well as abrupt changes in harmonic structure, noise components and transient deviations from the overall Fo contour.

Particularly relevant to this investigation is the literature on tonal languages. This is because tonal languages contrast with nontonal languages in significant ways that are likely to result in differences in early vocalizations. In tonal languages, linguistic contrast is assigned to pitch changes (tones) that occur at the syllable level. These (lexical) tones occur in the frequency range below 400 Hz. Lexical tones make up a part of the phonological system, and occur in addition to the pitch changes associated with syntactic meaning which are found in all languages. Thus tonal languages are replete with constant Fo modulations, which have been shown to be perceptually salient to the infant. Research into the phonological development of tonal languages suggests the mastery of tones before segments. It has been proposed that 6-7 months is the most likely period for the emergence of suprasegmentals (including tone); however, there is no systematic account of the emergence of tone.

II. Research Design & Methods

1. Research Hypothesis:

It is abundantly clear that auditory experience is important in the development of speech production. Furthermore, it is clear that by 6 months the infant has perceptual abilities and productive capabilities that warrant scrutiny. This investigation was designed to obtain evidence of the effect of auditory input upon early vocalizations. Specifically, the intent was to address the following questions: 1.) *when* does the auditory-motor linkage emerge?, and 2.)*what* are the constituent units of early speech production? It was hypothesized that fundamental frequency (Fo) behavior in prespeech infant vocalizations is modified by auditory experience by 6 months of age.

The perceptual salience of Fo modulation for the infant has been clearly documented. For this reason, the auditory input under investigation is change in the Fo. Two language communities that differ in terms of linguistic contrasts regarding Fo behavior were chosen to test this hypothesis. The auditory influence of Cantonese, a tonal language, was chosen to contrast with the influence of English, a nontonal language.

The measure of vocalization (i.e., prespeech production) in this investigation was Fo behavior. Since laryngeal behaviors constitute early articulatory postures, Fo is a rational indicator of ambient language influence on vocalization.

Although previous studies have documented the influence of auditory experience on speech production during infancy, this investigation was designed to document emergence of the effect at an earlier age (6 months) and to establish specific Fo behaviors as constituents of early (pre)speech development.

2. Subjects:

The subjects for this study were recruited through newspaper advertisements or physician referrals. Five babies came from monolingual English-speaking homes and five from monolingual Cantonese-speaking homes. All babies came from families living in the San Francisco Bay Area. The Chinese babies were from immigrant families living in San Francisco Chinatown. All of the English-speaking families learned of the study through the newspaper. One of the Cantonese-speaking families learned of the study through ads placed in Chinese newspapers, and the remaining four families were informed by their physician at the San Francisco County Health Center #4 in San Francisco's Chinatown.

It is important to note that San Francisco's Chinatown is quite large, with a significant immigrant population. It is possible for people to live in Chinatown without learning any English because the community operates primarily in Chinese. There are radio and television stations, newspapers, and stores that are exclusively Chinese. The Health Center #4 in Chinatown is bilingual, with most services to immigrants provided in Chinese. This is an important aspect of the subject selection process for this study. Due to the unique situation of San Francisco's Chinatown, it was possible to locate babies from monolingual Cantonese-speaking homes within the United States.

Communication with the Cantonese-speaking families was facilitated by the Health Center staff initially, and subsequently with an interpreter who scheduled and attended all recording sessions. The interpreter was a businesswoman in Chinatown who read about the position in an ad in a Chinese newspaper. She was fluent in English and Cantonese, and she had a familiarity with Mandarin. The interpreter was paid for her services.

All of the subjects were developing normally as measured by the Bayley Infant Scales of Development. Each baby passed a hearing test at the UCSF Audiology Clinic that included behavioral (play) audiometry and tympanometry for middle ear function. The infants from both language communities were from two-parent households, however the Chinese families also included one or more grandparent. Two babies from each language group had an older sibling (all were toddler or preschool age). The socioeconomic status of the two groups of families was remarkable in that the Chinese families were new immigrants. Educational level for both groups was at least high-school, with community college education for some of the English-speaking families. One or both parents from each family were employed in various blue-collar occupations in the San Francisco Bay Area.

One of the initial E-L babies (Subject 1e) was dropped from the study because the family moved away after the 6-month recording. This subject was replaced with another E-L baby (Subject 6e). All other babies (Subjects 1c, 2c, 3c, 4c, 5c, 2e, 3e, 4e, and 5e) began participation at the same time. Upon completion of the final recording session, each family was paid $100.00 and was provided with a tape recording that sampled the three recording sessions.

3. Data Collection / Audio Recordings:

Each subject was recorded individually at 6-, 8- and 10-months of age. The English-learning (E-L) babies, along with a caregiver, met with this investigator at the UCSF Audiology Clinic on Parnassus Avenue; all recordings were made in an audiological sound suite. The Chinese-learning (C-L) babies were recorded in an examination room at the San Francisco Health Center #4. This examination room had been an audiological sound suite, so it did have acoustic controls (i.e.,. acoustic ceiling and wall tiles, carpeting) not available in typical exam rooms.

For each recording session, the caregiver (mother, father or grandparent) was instructed to interact naturally with the baby. All caregivers were told of the purpose for the study, and were aware of the objective to record infant vocalizations. They were encouraged to elicit vocalizations as they would do at home. Age-appropriate toys were brought to each recording session by this investigator and by the subjects' families to engage the baby and elicit vocalizations. Each recording session lasted 1 hour. In addition to this investigator, the subject and caregiver, the interpreter was present for all recordings of the C-L babies. She interacted with the caregivers and the subjects throughout the recording sessions. This investigator did not speak or understand any of the Cantonese language.

During the 6 month recordings, the babies were seated in infant car seats or on a caregiver's lap. The 8- and 10-month old babies interacted with people and toys while on a carpeted floor or while sitting on a caregiver's lap. One of the E-L babies was cruising on his feet (walking while holding on to furniture) during the 10-month recording session.

Audio recordings were made on a professional quality Marantz PMD 201 portable cassette recorder. All sessions were recorded using the AC power source to ensure an accurate and reliable tape speed. The Realistic FM wireless microphone system was used, with a frequency response range of 70 - 10,000 Hz. The subjects wore a clip-on electret condenser microphone attached to clothing in the chest area. A cord connected the microphone to the remote FM transmitter. The transmitter was small (3"x 2.5"x .6") lightweight (2.5 oz.), and battery operated. It had a belt clip which was attached to the babies' clothing in an unobtrusive location (usually with the cord tucked under the outer-layer of clothing to prevent snagging). The operating range for this microphone system was 200 feet, which exceeded the dimensions of the rooms where recordings took place. An AC power source was used for the sensitive dual-conversion receiver, which provided the line feed into the tape recorder.

4. Data Analysis:

A total of 30 audiotapes were collected for this study (5 each per language group over 3 time periods). The periodic vocalizations produced by the infants were parsed from the audiotapes. Excluded from this study were nonperiodic sounds such as raspberries, voiceless fricative-like sounds and whispers. Also excluded were cries, burps, hiccups, sneezes, grunts and squeals - even if a periodic component was evident. All other vocalizations that contained a periodic component were included. This is consistent with Koopmans-Van Beinum and Van Der Stelt (1986) who included more than just "speech-like" sounds in their investigation. There was no apriori reason to exclude any periodic vocal behaviors as irrelevant in the development of linguistic laryngeal behavior. A small number of infant vocalizations were unusable due to simultaneous speech by the caregiver.

Since this was a naturalistic recording situation, the number of vocalizations varied significantly between infants and between recording sessions. Because nonparametric statistics were chosen for the analysis, only rank order (not actual number of tokens) was necessary to make the comparisons. The range of usable tokens varied from as little as 21 to as many as 100 (note that a limit of 100 was placed on 3 tapes since this amount was deemed to be sufficient to characterize the infants' productions at each age). A total of 1703 usable tokens were collected during this investigation for the acoustic analysis.

All of these utterances were analyzed using the Kay Elemetrics Computerized Speech Lab (CSL) model 4300B (software version 5.X). Six acoustic measures were chosen to assess phonatory function for each utterance: 1. average fundamental frequency (Fo), 2. highest fundamental frequency (Fhi), 3. lowest fundamental frequency (Flo), 4. standard deviation of the fundamental frequency (STD), 5. smoothed pitch period perturbation quotient (Sppq), and 6. variation of the fundamental frequency (vFo).

For each utterance, average Fo is the mean value of all extracted period-to-period fundamental frequency values. The highest Fo and the lowest Fo refer to the maximum and minimum of all extracted period-to-period Fo values within that particular utterance. The standard deviation of the Fo refers to the amount of scatter, or variance, that exists relative to the average Fo. All four of the acoustic measures described thus far are values reported in Hertz (Hz).

The next two measures calculate values in terms of percentages. Smoothed pitch period perturbation quotient (sPPQ) is a measure of *perturbation* of the Fo. It is a relative evaluation of the short- or long-term variability of the pitch period within the analyzed utterance. The smoothing factor is determined by the CSL user. With a small smoothing factor, sPPQ is sensitive to short-term pitch variation of the voice impulses such as those occurring between consecutive pitch periods (typical of hoarse voices). At high smoothing factors (45-65 periods), sPPQ correlates with the intensity of the long-term pitch period variations (typical with frequency tremors - that is, periodic modulation of the voice). It is the long-term pitch period variations that were of interest in this study. However, sPPQ can not be calculated with a high smoothing factor for short signals, because there aren't enough periods for the calculation. A smoothing factor of 35 was chosen, since short utterances could be calculated, yet the long-term pitch variations would be observed.

The variation of the Fo, also calculated in terms of percentage, is a relative standard deviation of the Fo. The difference between vFo and sPPQ is that vFo represents a general evaluation of the Fo (pitch) variation. The vFo value increases regardless of the type of pitch variation, either random or long-term. If both sPPQ and vFo are low, the intensity of pitch variations in the voice is very low. If vFo is high, but sPPQ is low, then there are pitch variations, but not a long-term periodic one. If both vFo and sPPQ are high, there is a long-term periodic pitch variation.

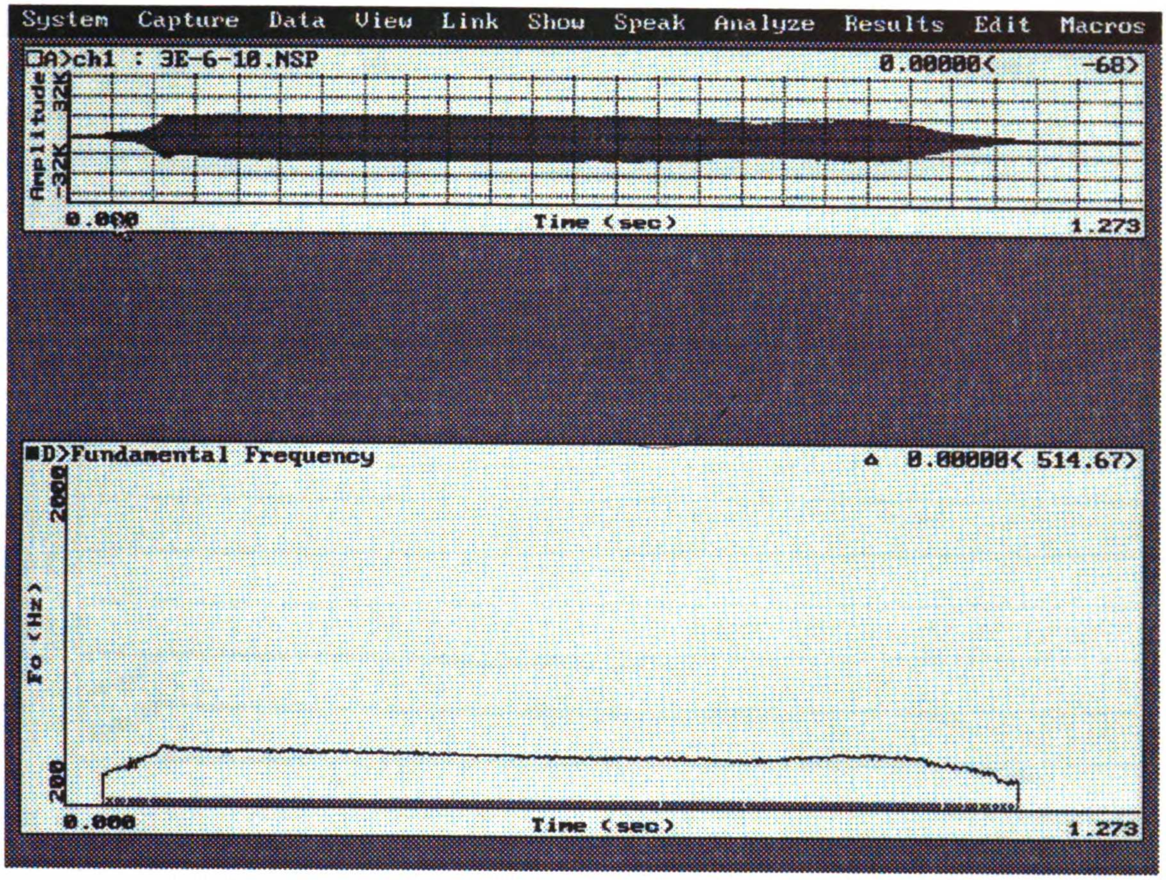
In addition to those measures calculated by the CSL, within-utterance (W-U) Fo range was calculated by subtracting the Fhi minus the Flo for each utterance. For each infant at each age, the *average* W-U Fo range was determined, as was the *maximum* W-U Fo range and *minimum* W-U Fo range. The W-U Fo range reflects the degree of Fo excursion.

Finally, a tally of tokens (periodic utterances) was recorded for each subject at each age. Altogether a total of ten measures were used in the analyses between the E-L and C-L groups: six acoustic measures provided by CSL, three measures of W-U Fo range (average, maximum and minimum) and the tally score.

Initially utterances were analyzed using the Multi-Dimensional Voice Program (MDVP) Model 4305, using the CSL hardware system for signal acquisition, analysis and playback. The MDVP works in conjunction with CSL's built-in voice analysis capabilities. A sampling rate of 50,000 was used to digitize (with a 16 bit digitizer) all vocalizations. The analysis setting included a wide band (high frequency emphasis) filter to capture the high Fo contours. In some cases, it was necessary to use the mid-frequency (i.e., normal) emphasis when the Fo was relatively lower. In MDVP, when the pitch extraction range is defined as *normal*, the search is for periods from 70-625 Hz. When the pitch extraction range is defined as *high*, the search includes periods from 200-1000 Hz. In those cases where the Fo is greater than 1000 Hz, MDVP performs octave reductions in the calculations.

In all cases when the MDVP analysis provided an Fo that was higher than 500Hz or lower than 200Hz, the file was down-sampled using the CSL software and a narrow-band spectrogram was produced to validate or change the Fo value(s). This step was necessary due to the extremely high Fo values found, as well as the presence of unexpectedly low Fo values. Examples of utterances with extremely high Fo values are presented in Appendix A, and utterances with low Fo values are presented in Appendix B. In six (of the total) utterances, it was necessary to hand-edit the spectrogram in order to estimate the Fo values. In those six cases, it was only possible to determine the highest Fo (Fhi) and the lowest Fo (Flo), and subsequently the W-U Fo were range calculated. Averages and standard deviations could not be calculated for these six hand-edited utterances.

Figures 13 and 14 present two analyses of the same utterance (#3e-6-10). Initially, MDVP was used to calculate the Fo measures. The amplitude envelope and Fo tracing, along with the analysis results, are depicted in figure 13. When it was observed that the Fhi (maximum Fo) was greater than 500 Hz, a subsequent analysis was undertaken. The digitized file, originally sampled at 50 KHz, was down-sampled to 10 KHz and a narrow band spectrogram was created (figure 14). By viewing this spectrogram, it was confirmed that the maximum Fo calculated by MDVP was accurate.



```
Sampled Data:  3E-6-10.NSP
Signal Level:  12436
Sampling Rate: 50000
Time Range:    0.00000 sec
               1.27298 sec

Average Fundamental Frequency     Fo   = 466.210 Hz
Highest Fundamental Frequency     Fhi  = 514.668 Hz
Lowest  Fundamental Frequency     Flo  = 337.952 Hz
Standard Deviation of Fo          STD  =  33.875 Hz
Length of Analyzed Sample         Tsam =   1.273 s
Smoothed Pitch Perturb. Quotient sPPQ =   0.817 %
Fundamental Frequency Variation   vFo  =   7.266 %
```

Figure 13. MDVP analysis of utterance #3e-6-10. Amplitude envelope and Fo tracing (pitch plot) are presented along with analysis results.

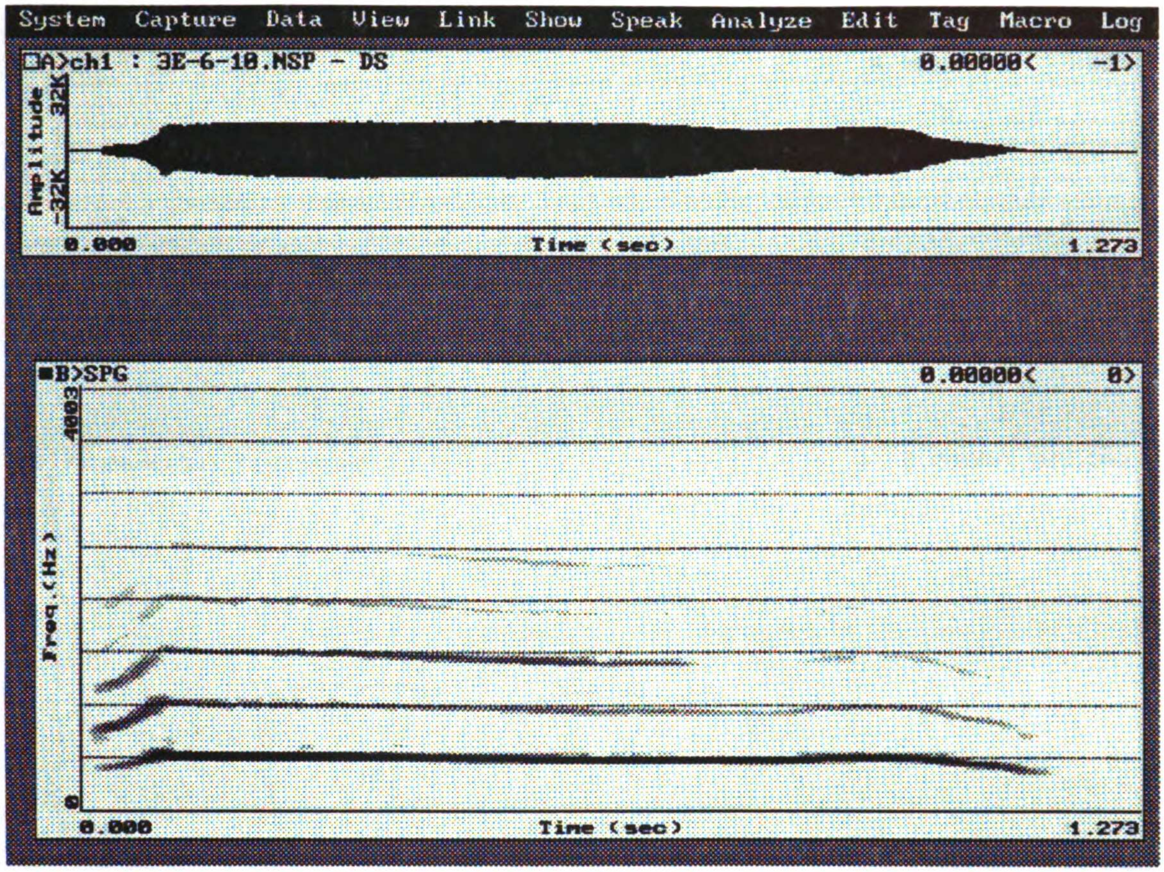
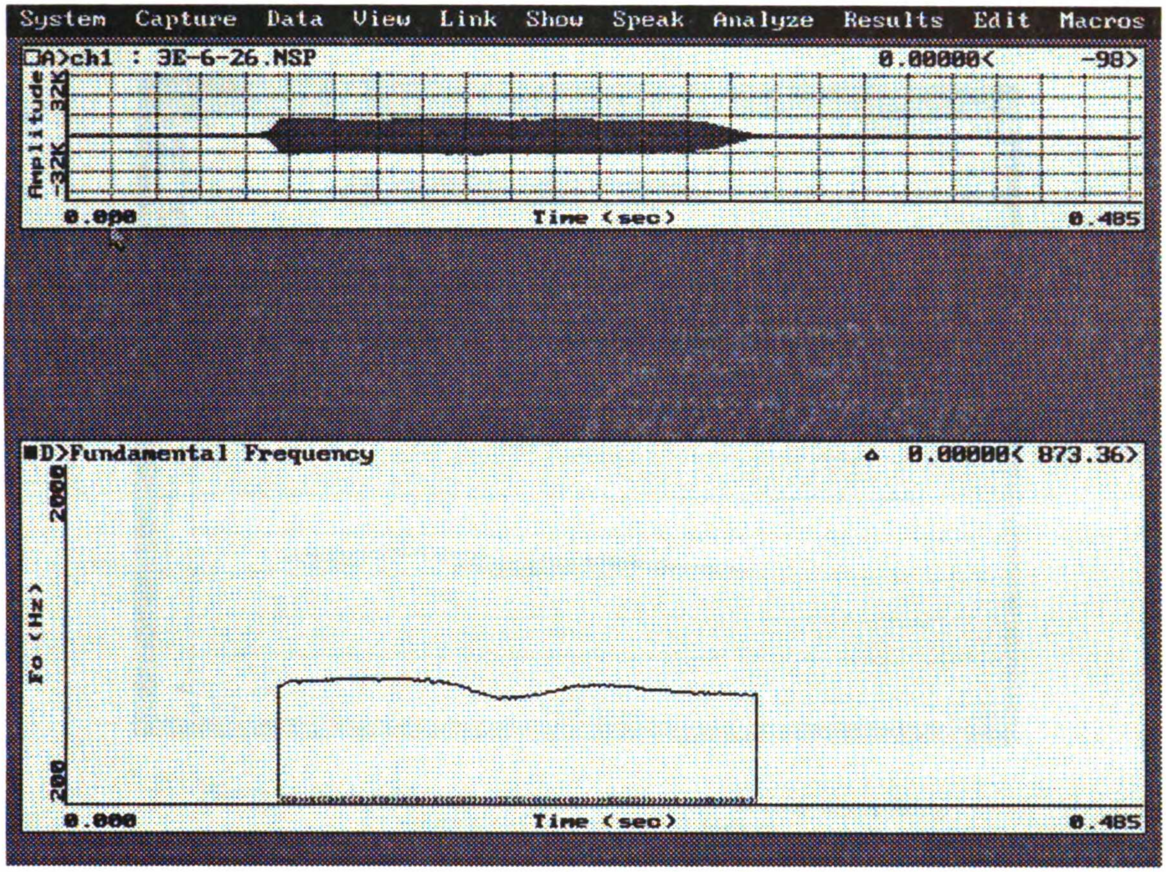


Figure 14. Narrowband spectrogram of utterance# 3e-6-10 confirming Fo values calculated by MDVP analysis

In contrast, figures 15 and 16 present two analyses of the same utterance (#3e-6-26) where the MDVP calculations were in error. As stated previously, when Fo is greater than 1000 Hz, MDVP performs octave reductions in the calculations. In this case, the true Fo of 1800 Hz was not calculated to by MDVP (figure 15). The narrowband spectrogram revealed the accurate Fo values. Figure 17 shows a part of the original utterance with a zoom in the display of the utterance which allowed for easier hand-editing.



```
Sampled Data:   3E-6-26.NSP
Signal Level:   9912
Sampling Rate:  50000
Time Range:     0.00000 sec
                0.48486 sec

Average Fundamental Frequency      Fo   = 826.514 Hz
Highest Fundamental Frequency      Fhi  = 873.362 Hz
Lowest  Fundamental Frequency      Flo  = 766.284 Hz
Standard Deviation of Fo           STD  =  32.885 Hz
Length of Analyzed Sample          Tsam =   0.485 s
Smoothed Pitch Perturb. Quotient sPPQ =   0.848 %
Fundamental Frequency Variation    vFo  =   3.979 %
```

Figure 15. MDVP analysis of utterance #3e-6-26. Amplitude envelope and Fo tracing (pitch plot) are presented along with analysis results.

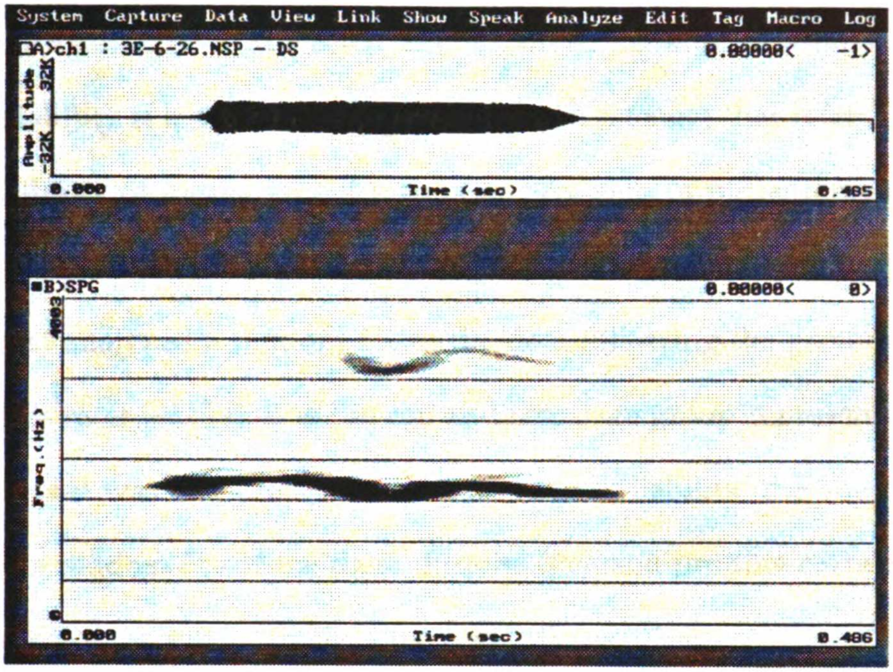


Figure 16. Narrowband spectrogram of utterance# 3e-6-26 discrediting Fo values calculated by MDVP analysis.

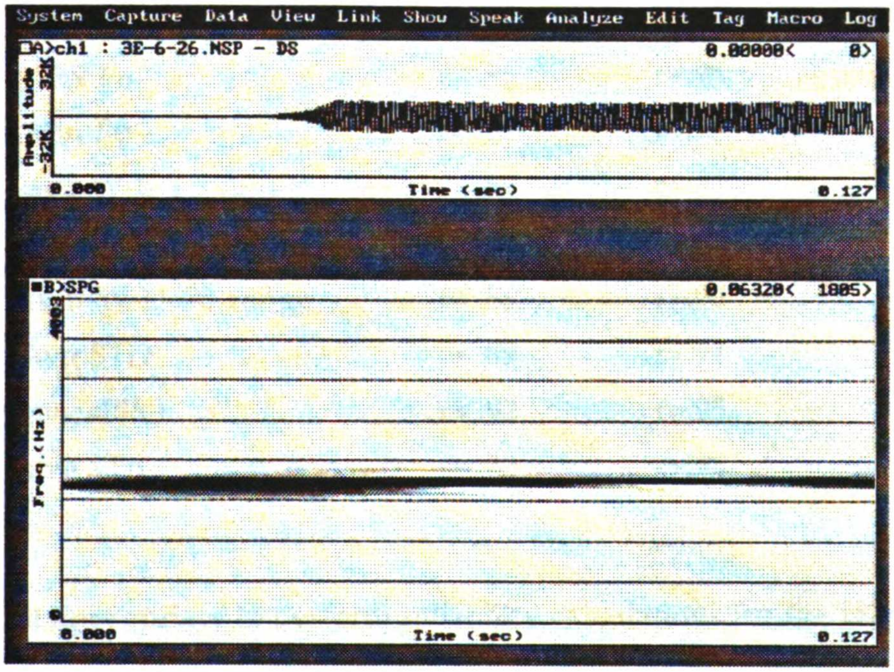


Figure 17. Zoom into portion of narrowband spectrogram of utterance# 3e-6-26 for easier hand-editing.

The author performed all of the analyses on the data. A random 5% of the data (85 utterances) was subjected to both inter-rater and intra-rater reliability tests. Reliability is a measure of agreement (consistency) that refers to the reproducibility of measurement results or precision of measurement. For the *inter-rater* reliability, Carla Gress, an experienced speech scientist/speech pathologist analyzed a random 5% of the data following the protocol outlined above. This rater was blind to the age and language group represented by each utterance that was analyzed. For the *intra-rater* reliability, the author re-analyzed a random 5% of the data. Results (Pearson product correlation coefficients) of the reliability tests were as follows:

Measure	Inter-rater	Intra-rater
avg Fo	r= .99	r=.99
max Fo	r= .96	r=.98
min Fo	r= .92	r=.95
avg W-U Fo range	r= .89	r=.93
max W-U Fo range	r= .87	r=.92
min W-U Fo range	r= .88	r=.93
avg STD	r= .89	r=.94
avg sPPQ	r= .92	r=.95
avg vFo	r= .83	r=.90

It was not appropriate to perform reliability calculations for the tally measure, since the number of utterances analyzed was a fixed 5% of the data. Results of

both inter-rater and intra-rater reliability tests reveal a high degree of consistency. This provides confidence in the measures that were used in the statistical analyses.

5. Statistics:

For statistical analyses, the data were summarized into single values from each recording session. The following 10 measures were calculated for each subject at each age (6-, 8-, and 10-months):

1. average Fo* *(avg Fo)*
2. maximum Fo *(max Fo)*
3. minimum Fo *(min Fo)*
4. average within-utterance Fo range* *(avg W-U Fo range)*
5. maximum within-utterance Fo range *(max W-U Fo range)*
6. minimum within-utterance Fo range *(min W-U Fo range)*
7. average STD* *(avg STD)*
8. average Sppq* *(avg sPPQ)*
9. average vFo* *(avg vFo)*
10. tally *(tally)*

Those five measures with an asterisk represent averages (of averages). The maximum and minimum measures represent the absolute maxima and minima of Fo values and Fo ranges for each subject at each age. The tally measure was calculated by adding the total number of utterances for each subject at each age.

In addition to the 6-, 8-, and 10-month scores, overall scores were calculated for each subject. These overall scores were derived by averaging values, determining absolute maxima/minima values, or adding values across the three ages for each subject. An average of the following measures from each age (6-, 8-, and 10-month) was obtained for each subject: average Fo, average Fo range, average STD, average Sppq, and average vFo. In other words, the overall score for each of these five measures is an average of three averages. The overall scores for maximum Fo, minimum Fo, maximum W-U Fo range and minimum W-U Fo range were determined based on the absolute maxima or minima per measure across the three ages. The overall score for the tally was calculated for each subject by adding the tally values from each of the three ages. The overall tally scores reflect the total number of usable tokens, per subject, across the entire investigation.

Because many of the measures appeared to violate the normality assumptions required for parametric statistics (i.e., t-test), nonparametric statistics were chosen to analyze the data. Group differences at each age (6-, 8-, or 10-month), as well as the overall scores, were calculated using the Mann-Whitney test (two-tailed). This test compares the rank ordering between groups. The Mann-Whitney test was calculated by the approximate method. Since there was a small number of subjects in each group (5 in each group), exact calculations were used in contrast to the usual approximations used with this test. Whenever p-values were significant or suggestive according to the approximate method, exact p-values were calculated, and have been reported in this paper accordingly.

As indicated previously, there were six utterances that required editing by hand due to the extremely high Fo values. In these cases, only the maximum Fo and minimum Fo were obtained from the narrow band spectrogram. The CSL software was unable to calculate the averages and standard deviations as it did for the other utterances. In these six instances, it *was* possible to calculate the W-U Fo range as was the case with all other utterances. Therefore, only four measures (i.e., avg Fo, avg STD, avg Sppq, and avg vFo) were lacking for these six utterances. The calculation of averages for each age took this fact into consideration. Due to the significance of obtaining upper extreme Fo values, the decision was made to proceed with this approach.

III. Results

Results of this investigation, including rank ordering, are presented by age group in Appendix C; individual subject data are presented in Appendix D. At the 6-month age (Table 5), the English-learning (E-L) babies had greater standard deviations (SDT) of the Fo, and greater variations in the Fo (vFo). The average STD of the Fo was 42.57 Hz for the E-L babies, compared with 31.59 Hz for the Cantonese-learning (C-L) babies (p<.056). The percent of variation of the Fo (vFo) averaged 10.94 for the E-L babies, and 8.75 for the C-L babies (p<.032). In addition, a *suggestive* finding was that the maximum Fo produced by the E-L group was 1800Hz, whereas the maximum Fo produced by the C-L group was 1585Hz, however this was not statistically significant (p<.095).

Table 5. 6-Month Results

Measure	Cantonese-learning Babies	English-learning Babies
average Fo	357.8 Hz	368.8 Hz
maximum Fo	1585 Hz	1800 Hz
minimum Fo	149 Hz	115 Hz
average W-U Fo range	173.9 Hz	206.7 Hz
maximum W-U Fo range	1308 Hz	1252 Hz
minimum W-U Fo range	46 Hz	40 Hz
average STD*	31.59 Hz	42.57 Hz
average Sppq	2.20%	3.15%
average vFo*	8.75 %	10.94%
tally	276 (avg 55/baby)	288 (avg 58/baby)

* = statistically significant difference according to rank order

At the 8-month age (Table 6), the C-L group produced a statistically significant minimum Fo, and the E-L babies produced more periodic utterances. The minimum Fo produced by the C-L group was 136Hz, whereas the minimum Fo produced by the E-L group was 191Hz (p<.016). The E-L babies produced a total of 317 periodic utterances, while the C-L babies produced a total of 166 of periodic utterances (p<.0079).

Table 6. 8-Month Results

Measure	Cantonese-learning Babies	English-learning Babies
average Fo	378.9 Hz	367.7 Hz
maximum Fo	1032 Hz	1057 Hz
minimum Fo*	136 Hz	191 Hz
average W-U Fo range	211.2 Hz	181.6 Hz
maximum W-U Fo range	707 Hz	774 Hz
minimum W-U Fo range	34 Hz	37 Hz
average STD	43.01 Hz	37.09 Hz
average Sppq	3.17%	2.72%
average vFo	11.04%	9.6%
tally*	166 (avg 33/baby)	317 (avg 63/baby)

* = statistically significant difference according to rank order

At the 10-month age (Table 7), a significant difference was found for the tally (p<.032). As at the 8-month age, the E-L babies produced more periodic utterances. The E-L babies produced a total of 403 periodic utterances, while the C-L babies produced a total of 253 periodic utterances.

Table 7. 10-Month Results

Measure	Cantonese-learning Babies	English-learning Babies
average Fo	365.8 Hz	377 Hz
maximum Fo	928 Hz	1750 Hz
minimum Fo	189 Hz	190 Hz
average W-U Fo range	190.9 Hz	223.7 Hz
maximum W-U Fo range	589 Hz	1473 Hz
minimum W-U Fo range	36 Hz	33 Hz
average STD	40.24 Hz	47.2 Hz
average Sppq	2.65%	3.22%
average vFo	10.74 %	11.88%
tally*	253 (avg 51/baby)	403 (avg 81/baby)

* = statistically significant difference according to rank order

In the overall scores (Table 8), as described in section 5 of chapter II, the E-L babies produced a higher maximum Fo and produced the most periodic vocalizations. The maximum Fo produced by the E-L group was 1800 Hz, while the maximum Fo produced by the C-L group was 1585 Hz (p<.032). The E-L babies produced significantly more periodic utterances over the entire study (N=1008) compared with the C-L babies (N=695) (p<.0079). A statistically *suggestive* result was found for maximum W-U Fo range. The maximum W-U Fo range for the E-L group was 1473 HZ, and 1307 Hz for the C-L group (p<.095).

Table 8. Overall Results

Measure	Cantonese-learning Babies	English-learning Babies
average Fo	363.7 Hz	374.4 Hz
maximum Fo*	1585 Hz	1800 Hz
minimum Fo	136 Hz	115 Hz
average W-U Fo range	187.7 Hz	208.5 Hz
maximum W-U Fo range	1308 Hz	1473 Hz
minimum W-U Fo range	34 Hz	33 Hz
average STD	37.1 Hz	43.39 Hz
average Sppq	2.64%	2.97%
average vFo	9.96 %	10.95%
tally*	695 (avg139/baby)	1008 (avg202/baby)

* = statistically significant difference according to rank order

In addition to those results with statistical significance, a number of remarkable group trends were identified. The average Fo was different between the groups at each age, as well as across the whole sample (overall scores). With the exception of the 8-month recording, the mean Fo was lower for the C-L babies.

Table 9. Average Fo across ages and language groups.

Age	Avg Fo Cantonese	Avg Fo English
6 mos.	**358** Hz	369 Hz
8 mos.	379 Hz	**368** Hz
10 mos.	**366** Hz	377 Hz
overall	**364** Hz	374 Hz

Observation of the Fo maxima and minima (Table 10) indicates that the E-L group produced the highest Fo values, and that the C-L group produced the lowest Fo values, except at the 6-month recording session. As discussed in section 4 of chapter II, these extremely high and low values were all verified with narrow band spectrogram to ensure accuracy. As reported previously, the minimum Fo was significantly lower for the C-L group at 8 months (p<.016), and the maximum Fo was *suggestive* of statistical significance for a higher Fo in the E-L group at 6 months (p<.095).

Table 10. Fo Maxima and minima by language group across different ages

Age	Maximum Fo (by group) Cantonese / English	Minimum Fo (by group) Cantonese / English
6 mos.	1585 Hz / **1800** Hz	149 Hz / **116** Hz
8 mos.	1031 Hz / **1057** Hz	**137** Hz / 191 Hz
10 mos.	928 Hz / **1750** Hz	**189** Hz / 190 Hz

Measures of the within-utterance (W-U) Fo range indicated a consistent pattern where the E-L infants produced a wider range of Fo excursion (Table 11). The only exception to this trend was the average W-U Fo range obtained from the C-L group at 8 months. The maximum and minimum W-U Fo ranges reflect the extreme values. As noted above, the maximum W-U Fo range was *suggestive* of statistical significance in the overall score (p<.095).

Table 11. Within-utterance (W-U) Fo ranges. *Avg. Fo range* is the average of the babies' averages by group at each age. *Avg.Max. Fo range* is the average of the babies' maximum Fo ranges by group at each age.*Avg.Min. Fo range* is the average of the babies' minimum Fo ranges by group at each age.

	Avg. W-U Fo range	Avg.**Max**.W-U Fo range	Avg. **Min**.W-U Fo range
Age	Cantonese /English	Cantonese/ English	Cantonese/ English
6 mos	174 Hz/**207** Hz	568 Hz/**829** Hz	54 Hz/**50** Hz
8 mos	**211** Hz/181 Hz	442 Hz/**602** Hz	68 Hz/**58** Hz
10 mos	191 Hz/**224** Hz	506 Hz/**752** Hz	60 Hz/**57** Hz
overall	188 Hz/**208** Hz	709 Hz/**1043** Hz	44 Hz/44 Hz

The results of the three measures of Fo variability, STD, sPPQ and vFo, are listed in Table 12. The three measures appear to operate similarly, since the direction of difference is consistently the same across measures at each age. The amount of Fo variability (i.e., STD and vFo) was found to be significant at 6 months. The Fo had more variability for the E-L babies at 6 and 10 months, as well as in the overall scores. The sPPQ values were consistently low when compared to the vFo values, which indicates that the observed Fo variability was not due to pitch (Fo) perturbation factors such as hoarseness or tremors.

Table 12. Measures of Fo variability by language group across ages.

Age	Avg.STD Cantonese /English	Avg.sPPQQ Cantonese/ English	Avg. vFo Cantonese/ English
6 mos	31.59 Hz / **42.57** Hz	2.21% / **3.15%**	8.75% / **10.94%**
8 mos	**43.02** Hz / 37.10 Hz	**3.17%** / 2.72%	**11.04** % / 9.61%
10 mos	40.24 Hz / **47.20** Hz	2.65% / **3.22%**	10.74 % / **11.88%**
overall	37.11 Hz / **43.39** Hz	2.64% / **2.97%**	9.96% / **10.95%**

An unexpected result of this investigation was the robust effect of language community on the number of periodic vocalizations produced each session (Table 13). As noted above, the tally measure was significant at both the 8-month (p<.0079) and 10-month (p<.032) ages, as well as in the overall scores (p<.0079).

Table 13. Tally results across ages and language groups.

Age	Cantonese			English		
	#tokens	avg per infant	SD	#tokens	avg per infant	SD
6 mos.	**276**	55	21.6	**288**	58	24.6
8 mos.	**166**	33	4.4	**317**	63	22.0
10 mos.	**253**	51	15.7	**403**	80	20.4
overall	**695**	139	18.6	**1008**	202	9.4

IV. Discussion

The results of this investigation provide compelling evidence that early prespeech vocalizations are modified by auditory input by 6 months of age. Furthermore, the differences observed in Fo behavior as a function of the parent language confirm that it is an early constituent of the auditory-motor linkage between speech perception and speech production.

Previous investigations have provided evidence that prelinguistic vocalizations are modified by ambient language experience. By 10 months, the frequency of occurrence of segments (vowels and consonants) has begun to reflect the parent language (Boysson-Bardies et al, 1989; Boysson-Bardies and Vihman, 1991). Similarly, the prosodic features of pitch contour and duration reflect the structure of the input language by 11 months (Bacri et al., 1989). An interesting finding by Boysson-Bardies et al. (1984) was that phoneticians could discriminate the vocalizations of 6-month-olds from different language communities. The authors concluded that prosodic attributes were responsible for this discrimination. Whalen et al. (1991) found the distribution of pitch contours to reflect the parent language in the reduplicative babbling of infants (ranging from a mean age of 7.10 months to 11.3 months). Although Whalen and her colleagues included one 5-month old in this study, that infant contributed only 3 of the 80 utterances for that language group. The current investigation provides the earliest documentation of ambient language influence on vocal production based on a group of infants (by age 6 months).

That Fo behavior should constitute an early unit in the auditory-motor linkage is not unexpected. Clearly the infant's perceptual apparatus is well-equipped to receive and process pitch. Infants prefer to listen to speech with increased Fo modulations (Fernald and Kuhl, 1987), and they have increased responsiveness ("attentional threshold") to lower frequencies in the speech signal (Berg, 1985). The tones in Cantonese, replete with Fo modulations in the lower frequencies, must be perceptually salient features to the infant. The baby learning a tone language is afforded the environment to focus on Fo changes earlier than the baby learning a nontonal language.

Furthermore, laryngeal behaviors emerge early on as articulatory postures over which the infant has a degree of control. Infants engage in alternating vocalizations in a dyad by 3 months of age (Ginsburg and Kilbourne, 1988). They are capable of adjusting the phonatory apparatus to match absolute pitch in a dyad by 2-5 months of age (Papousek and Papousek, 1989), and achieve different pitch contours in different communicative contexts between 4-8 months (Delack and Fowlow, 1978). By 6 months, the infant has increased control over pitch contrasts due to the descent of the larynx into the neck

(Locke, 1983). According to Kahane (personal communication), there are no known anatomical reasons why infants from these two language communities (i.e., English and Cantonese) would differ in terms of laryngeal (Fo) behavior based on studies to date.

The period of 4-6 months is characterized by vocal expansion (Oller, 1980). At this time, the infant produces fully resonant nuclei, raspberries, squeals, growls, yelling and marginal babble. Of particular interest to this investigation are the heightened contrasts in pitch, including frequent Fo shifts. The vocal volley observed in alternating vocalizations within a dyad constitute what Thelen (1981) would call an ethogram. The laryngeal postures involved in onset/offset and pitch variations emerge as functional synergisms. As such, this vocal behavior comes to constitute a motor resource for the infant.

When the baby is exposed to auditory input that mirrors or is similar to his or her own vocal productions, there is a *MATCH* . The *match* results in certain elements of the input being highlighted and selectively enhanced as the infant perceives the input. This interpretation extends that proposed by Vihman (1993). She proposes that first words (in early talkers) are the consequence of an idiosyncratic match between a prelinguistic gestural score or articulatory routine and a salient adult word.

The infant's productions are self-reinforced as they form closer approximations of the adult model. Once the child perceives a *match*, it is the opportunistic use of this available motor output (i.e., laryngeal behavior) that forms an initial step to "bootstrap" into the ambient language. Although the mechanism which underlies the infant's motivation to form matches with the environment remains speculative (Locke, 1993), the inevitable sensorimotor linkages that occur during ontogenisis confirm that a motivation exists.

The most striking findings regarding Fo behavior include: 1.) C-L infants have less Fo variability than E-L infants, 2.) C-L infants have lower Fo minima and E-L infants have higher Fo maxima, and 3.) C-L infants have a more restricted within-utterance Fo range than E-L infants. All of these results are taken to reflect the influence of the ambient language. At 6 months, the C-L infant is exerting control over Fo variability as tonal information has become a salient feature of the auditory input. At 8 months, the C-L infant produces lower Fo minima, which is consistent with the fact that tonal changes occur in the lower frequencies. At 6, 8 and 10 months, the E-L infant produces higher Fo maxima and greater maximum within-utterance Fo ranges. This suggests that the E-L infant is not as attuned to the lower frequency information, and has more degrees of freedom for Fo behavior. In contrast, the C-L infant is becoming sensitive to the small Fo changes in the low frequency region since they are frequent in the ambient language. In other words, the C-L infant has perceived a *match* between the auditory input and his vocal productions. The C-L infant then modifies Fo behavior to form closer approximations to the adult model. The modified vocalizations of the C-L infant are interpreted as the first evidence of specific influence from Cantonese.

An interesting study by Papousek and Hwang (1991) may provide some explanatory insight into the limited Fo ranges seen with the Cantonese-speaking infants. Papousek and Hwang compared the prosody of mothers speaking to their infants in Mandarin Chinese with the prosody used by English or German mothers. It was found that although the Mandarin-speaking mothers made prosodic modifications in their speech to infants (e.g., higher mean Fo, slower rate of speech), these mothers produced significantly smaller prosodic modifications than that of their English- or German-speaking counterparts. Although no acoustic measures have been made of the Cantonese-speaking caregivers' speech to the infant subjects in this study, it is reasonable to assume that such an analysis would produce similar findings to those of Papousek and Hwang.

The unexpected significance in the *amount* of periodic vocalizations as a function of language community poses some interesting questions. Vihman and McCune (1994) found an effect in the number of vocalizations produced by babies as a function of the recording situation. Markedly more words were produced when the investigators interacted with the babies and their caregivers. However, if there was an effect of the recording situation on the caregiver or infant (in this investigation) - in terms of comfort level, perhaps due to the presence of an interpreter or this investigator's unfamiliarity with Cantonese - then surely the effect would have been present in the first recording session, which it was not. The same toys and stimuli were used to elicit vocalizations from each group of infants. Both sets of caregivers knew about the purpose of the study, and that the goal in each session was to collect infant vocalizations. The length of the recording sessions were all the same (one hour). One Cantonese-speaking subject produced a substantial series of raspberry sounds during the 8-month recording session, and since these voiceless fricatives are aperiodic, they were all unusable. However, this one case would not account for the robust difference in the tally values between groups.

This investigator did form an impression, however, during the course of the data collection sessions, that the Cantonese-caregiver input was different from the English counterpart. One difference was the degree to which the caregivers *worked* to elicit vocalizations. English-caregivers appeared to elicit vocalizations more often and with a larger repertoire of elicitation techniques.

Fernald and Morikawa (1993) invoked cultural differences to account for the observed differences in Japanese and (American) English caregiver input. They found universal features of infant-directed speech (e.g., exaggerated intonation, linguistic simplification and frequent repetition) in the caregiver input to 6-, 12- and 19-month old babies in both language communities. However, they found input differences that were only partially attributable to structural differences between Japanese and English (i.e., a greater emphasis on nouns in English). According to Fernald and Morikawa, cultural differences in interactional style and beliefs about child rearing strongly influence the structure and content of speech to infants. The American mothers focused more on the target objects, emphasizing the names and providing frequent labels, and constantly playing with the infants. In contrast, the Japanese mothers provided fewer object labels but used more of them in rituals of social exchange such as giving and receiving objects from the baby. Another difference observed was the frequent use of backchannel vocalizations by Japanese mothers. The authors noted it is thought that by signaling the listener's ongoing attention to the speaker, backchannels help to maintain *omoiyari,* a Japanese concept referring to harmony in interactions. Cultural differences regarding child rearing may also account for the differences observed. Whereas Americans place value on fostering independence in their children, the Japanese encourage *amae*, which is mutual dependence. This notion is consistent with the prolonged period of simplified speech observed in Japanese mothers toward their babies.

In the current investigation, cultural differences may have accounted for the disparate amount of infant vocalizations between the two language communities. The interesting observation is that these different patterns of interaction are each sufficient environments for speech processes to develop. There is no reason to assume that the relative sparsity of vocalizations from the C-L infants would result in a delay or disorder in speech development; these were normally developing infants. In fact, the opposite may be true. The results of this investigation indicate a (pre)phonological advance by the C-L babies based on measures of Fo behavior. That is, the C-L infants produced vocalizations reflecting the influence of their language input. This observation begs the question: how much is necessary? And what role does practice really play? As with many aspects of life, there are many paths that lead to the same place.

Directions for future research include more exploration into the development of Fo behaviors. There remain many aspects of early (pre)speech behaviors that are unexplored. Such high Fo values (up to 1800Hz) and such low Fo values (down to 116Hz) have not been documented previously in the literature. Perhaps the most interesting vocal behavior observed during this investigation was babbling with an Fo in the 1600Hz range.

An important contribution to our understanding of speech development will be to capture the *emergence* of tone structure in tonal languages, and further define the differences in early prosodic development between tonal and nontonal languages. Not addressed in the current investigation was the influence of the glottal stop feature in three of the Cantonese tones on the C-L infant vocalizations. However, the influence may manifest itself in Fo behavior such as glottal fry, creaky voice, or abrupt glottal closures.

The relationship between speech perception and production during acquisition warrants additional investigation. This includes cross-linguistic research to further refine our understanding of *when* the perceptuomotor linkage begins and the nature of the relationship between the two processes over time. Replication of this investigation with different languages (one tonal and one nontonal) would further validate the findings of differential Fo behavior as a function of tone status of the input language. An interesting pair of languages to study might be Vietnamese and French, since Vietnamese is a tonal language similar to Cantonese, and French is a nontonal language with fewer prosodic modifications than English.

Finally, the cultural aspects of input to babies is an intriguing area for continued research. This line of inquiry holds the potential to answer basic questions about speech (and language) processes. In particular, the units of acquisition can be addressed by observing, describing and quantifying caregiver input from different cultures. It would be valuable to look at the babies' output in this context. In the Fernald and Morikawa (1993) study, the Japanese infants were clearly being provided with input units that differed from the American infants (i.e., social routines and backchannel vocalizations). The wealth of possible units of acquisition, essentially the "stuff" of communicative behavior, speaks to the inherent system plasticity with which humans have been endowed.

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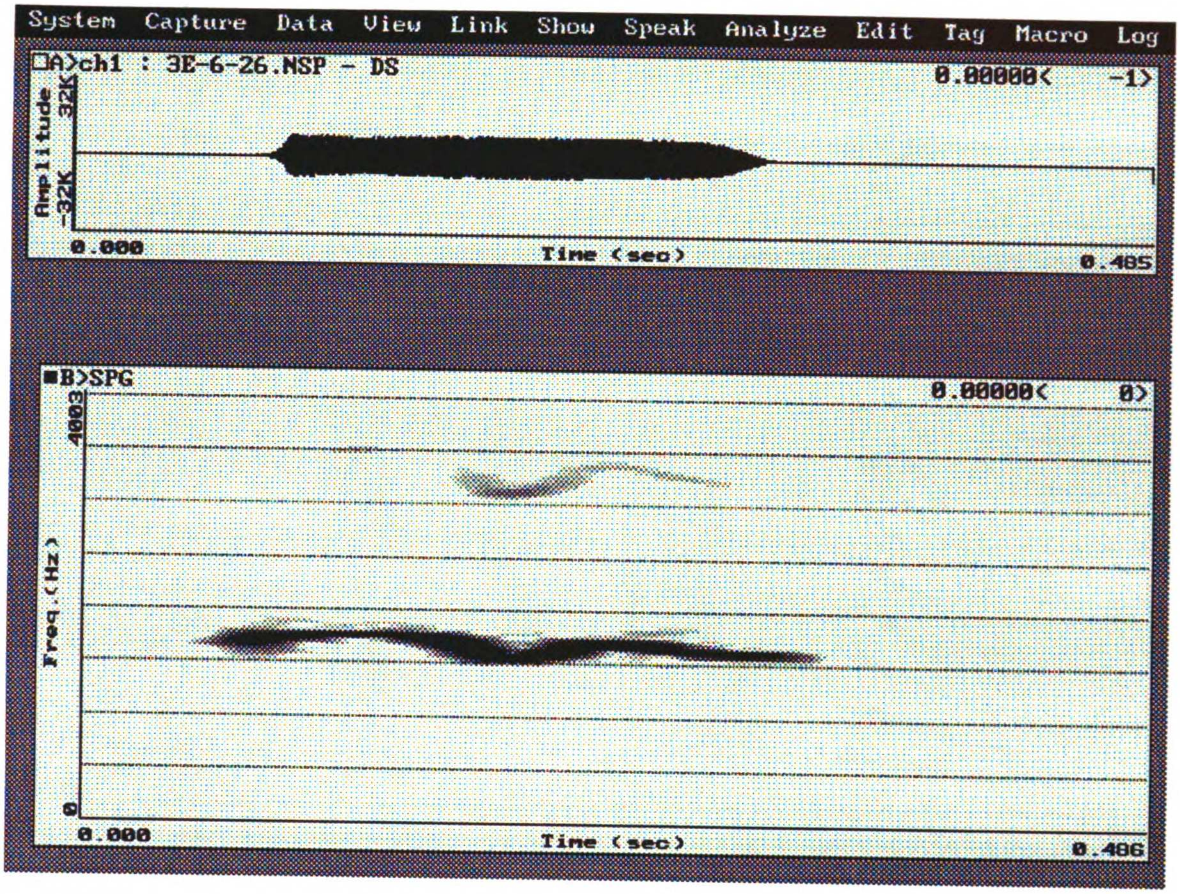
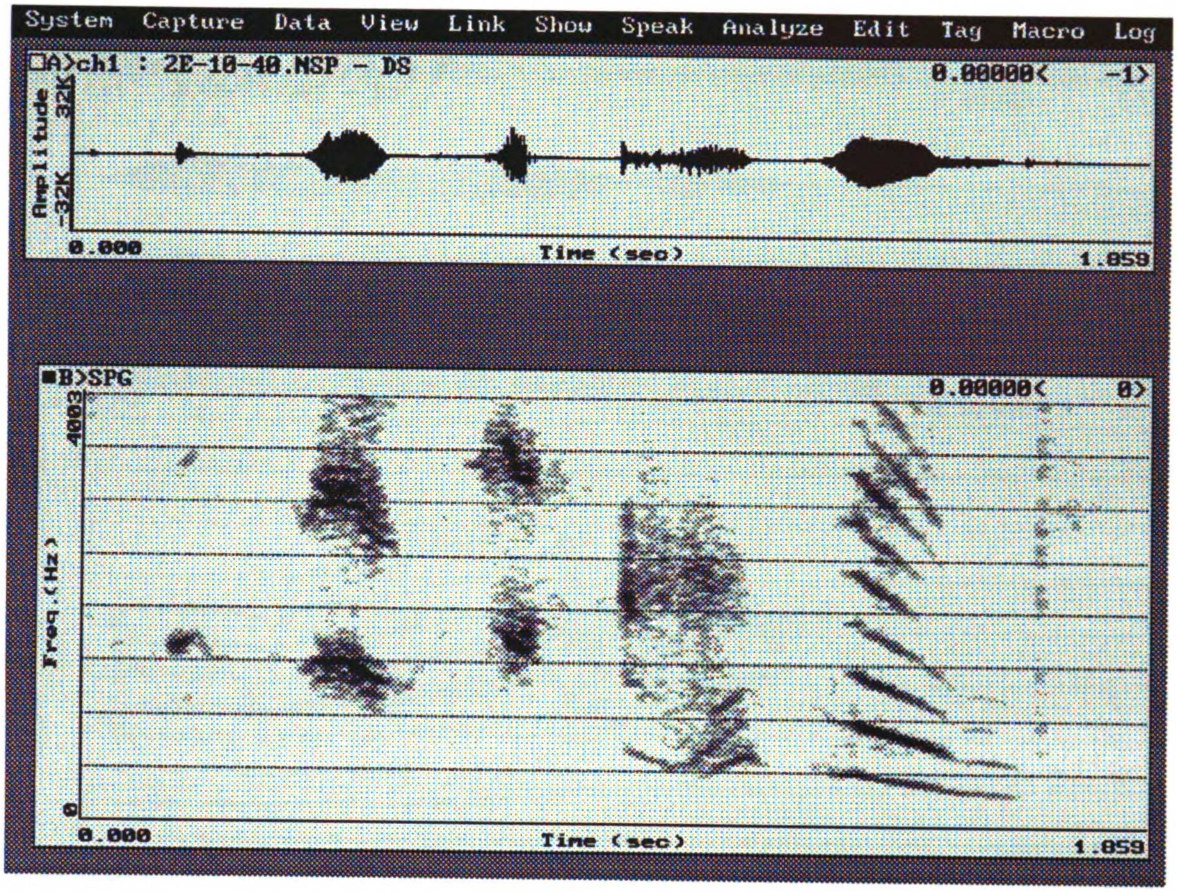
Appendix A:

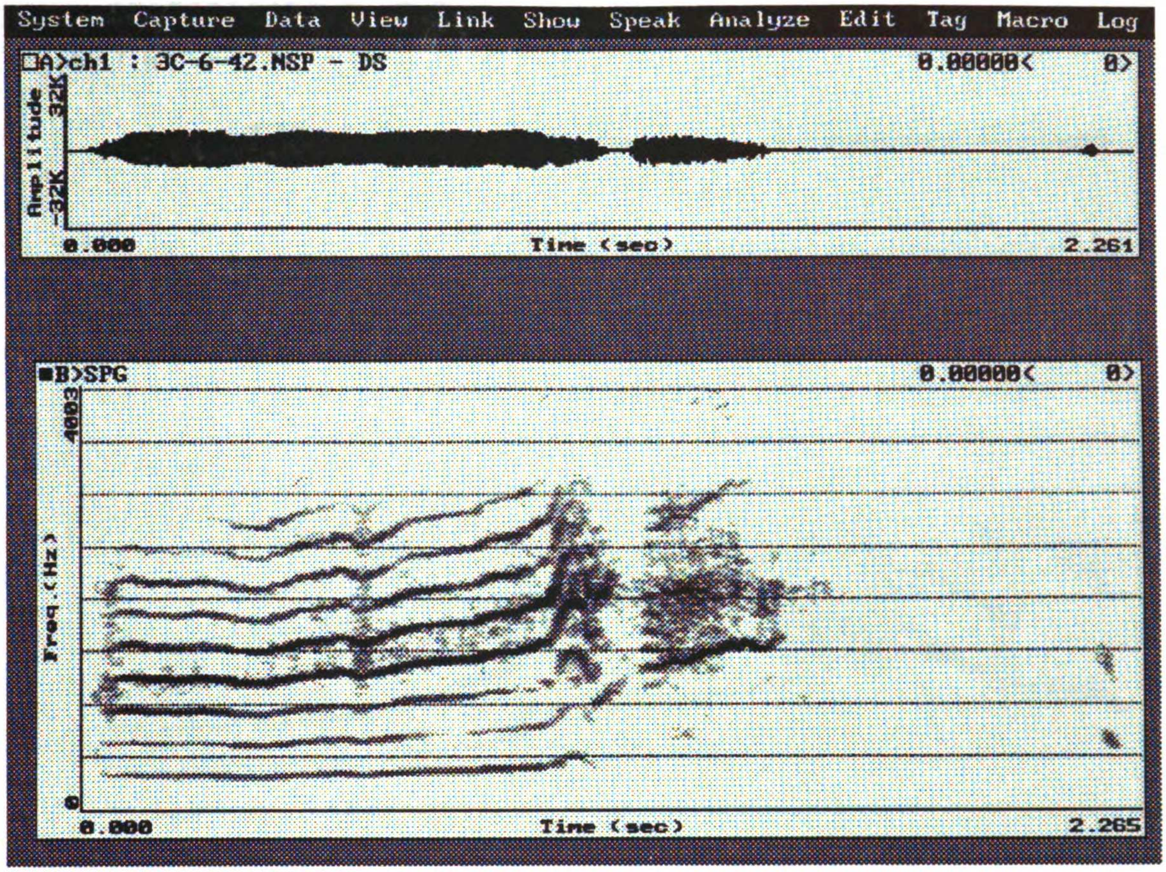
High Fo Utterances



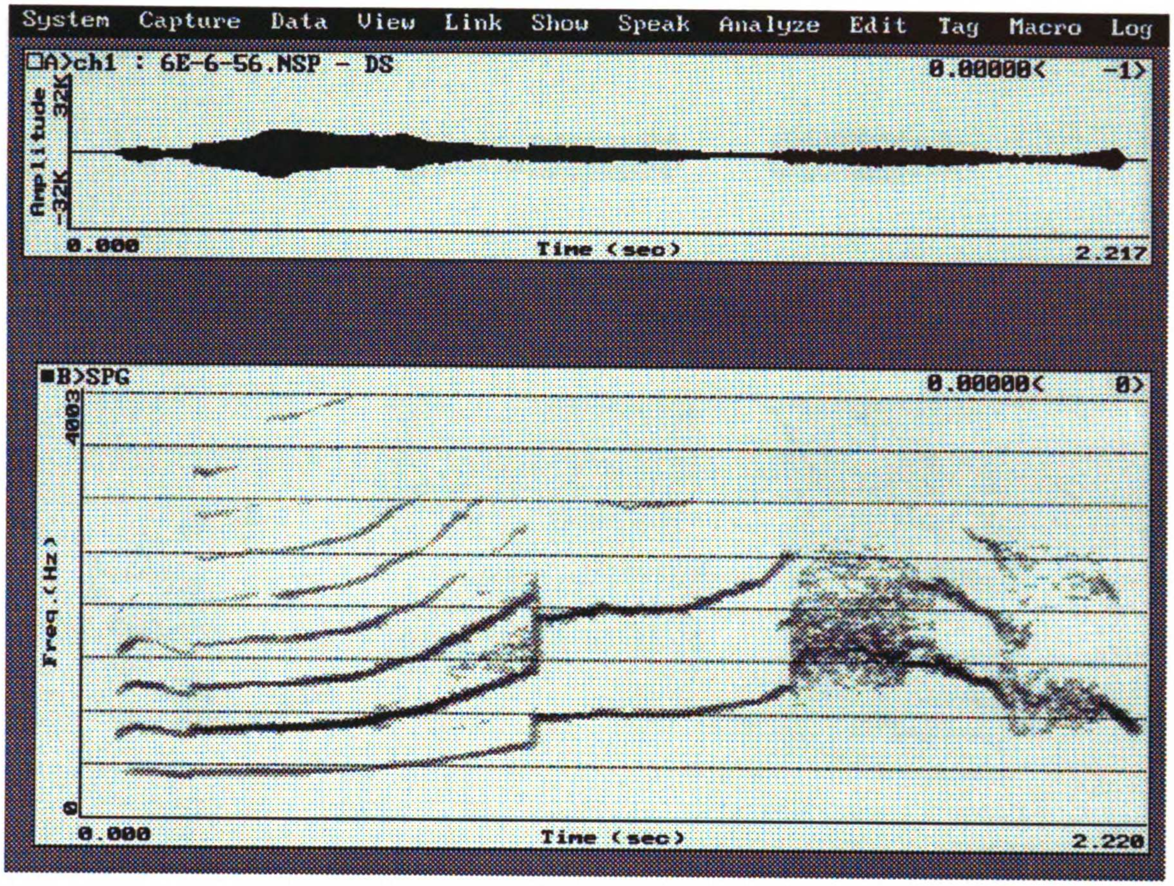
Subject: 3e
Age: 6 months
Utterance#: 26
Fo maximum: 1800 Hz
(No phonetic transcription)



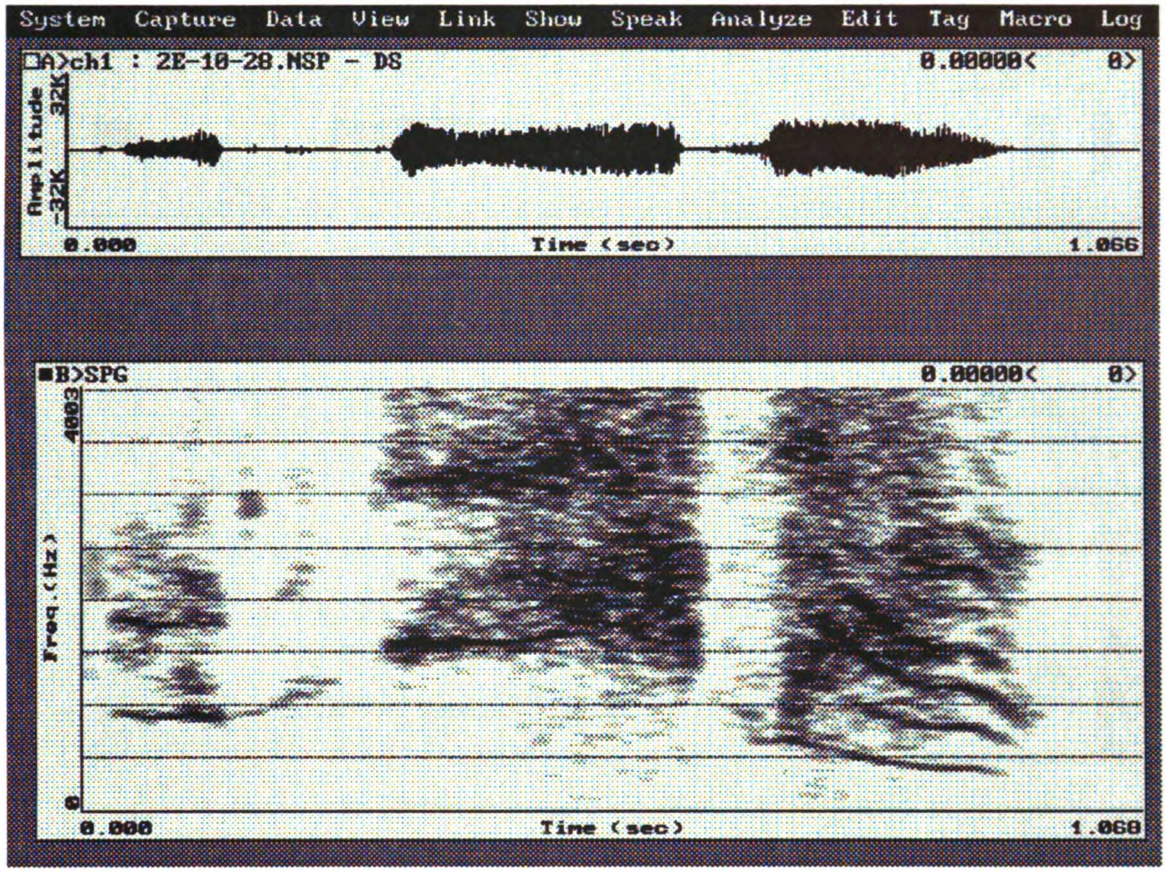
Subject: 2e
Age: 10 months
Utterance#: 40
Fo maximum: 1750 Hz
Transcription: [dədədə ə ħ] *[ħ]=pharyngeal fricative*



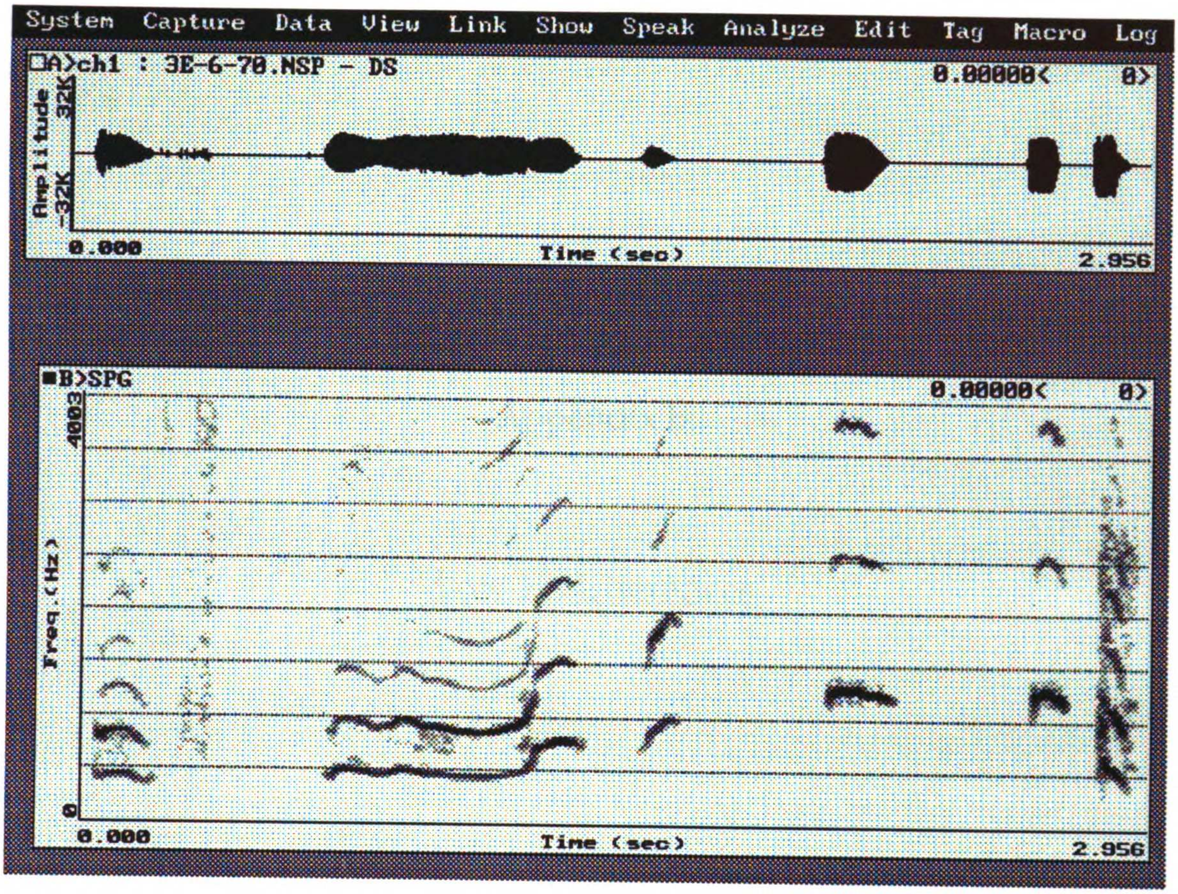
Subject: 3c
Age: 6 months
Utterance#: 42
Fo maximum: 1585 Hz
(No phonetic transcription)



Subject: 6e
Age: 6 months
Utterance#: 56
Fo maximum: 1660 Hz
(No phonetic transcription)



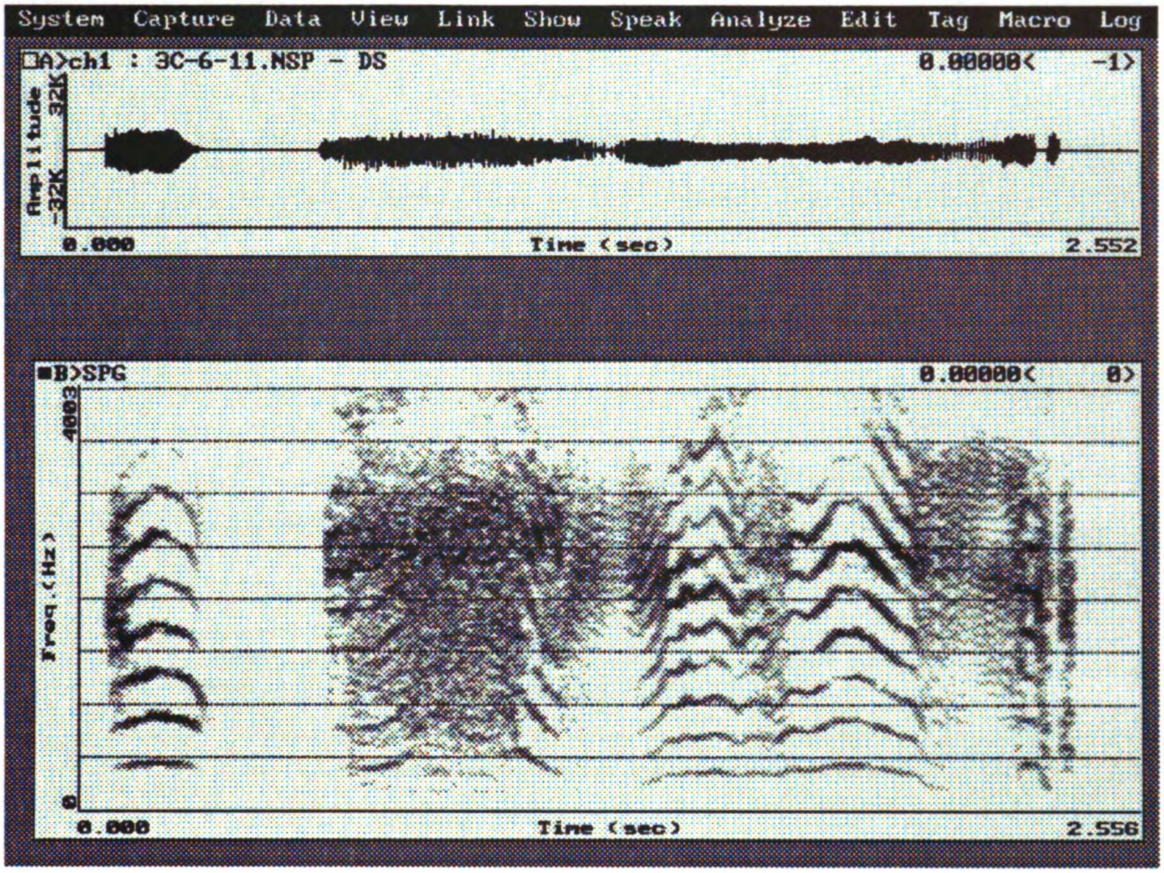
Subject: 2e
Age: 10 months
Utterance#: 28
Fo maximum: 1600 Hz
Transcription:[ə də də]



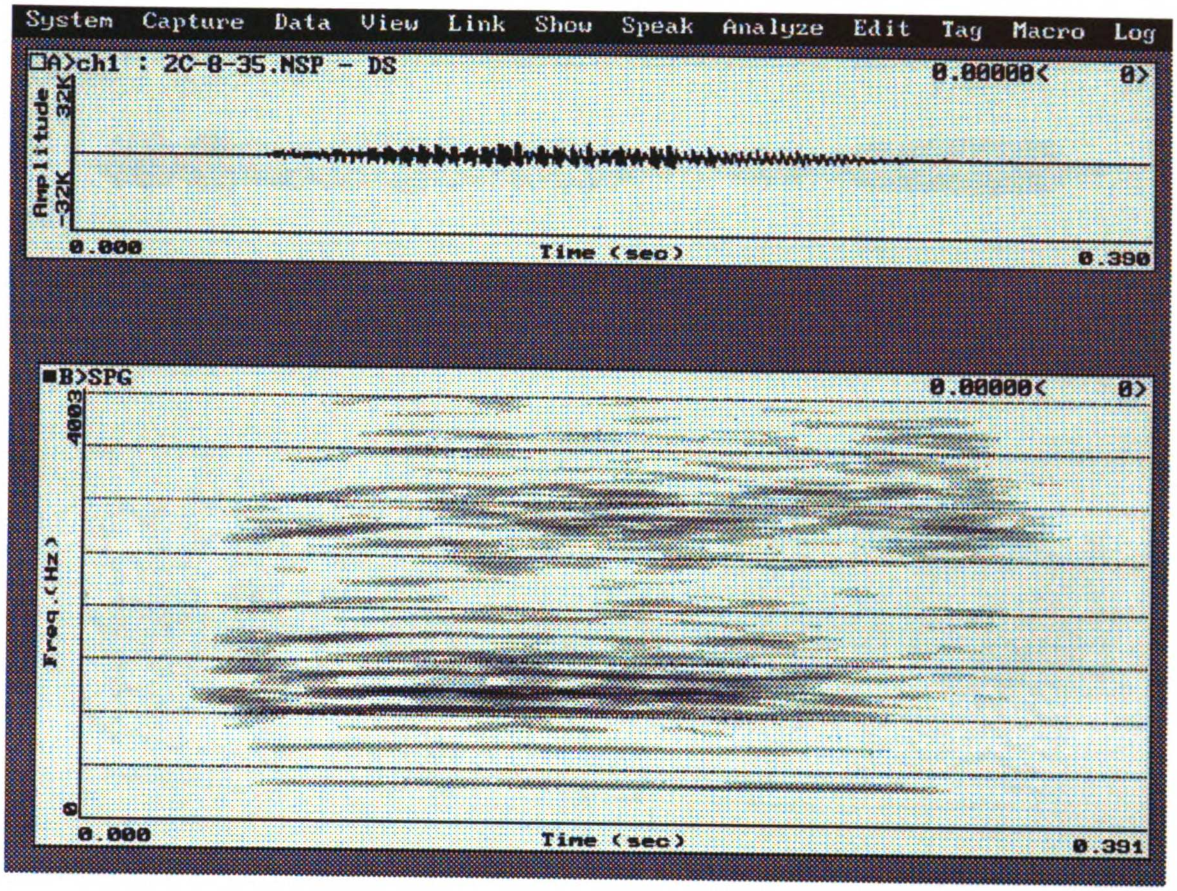
Subject: 3e
Age: 6 months
Utterance#: 70
Fo maximum: 1316 Hz
(No phonetic transcription)

Appendix B:

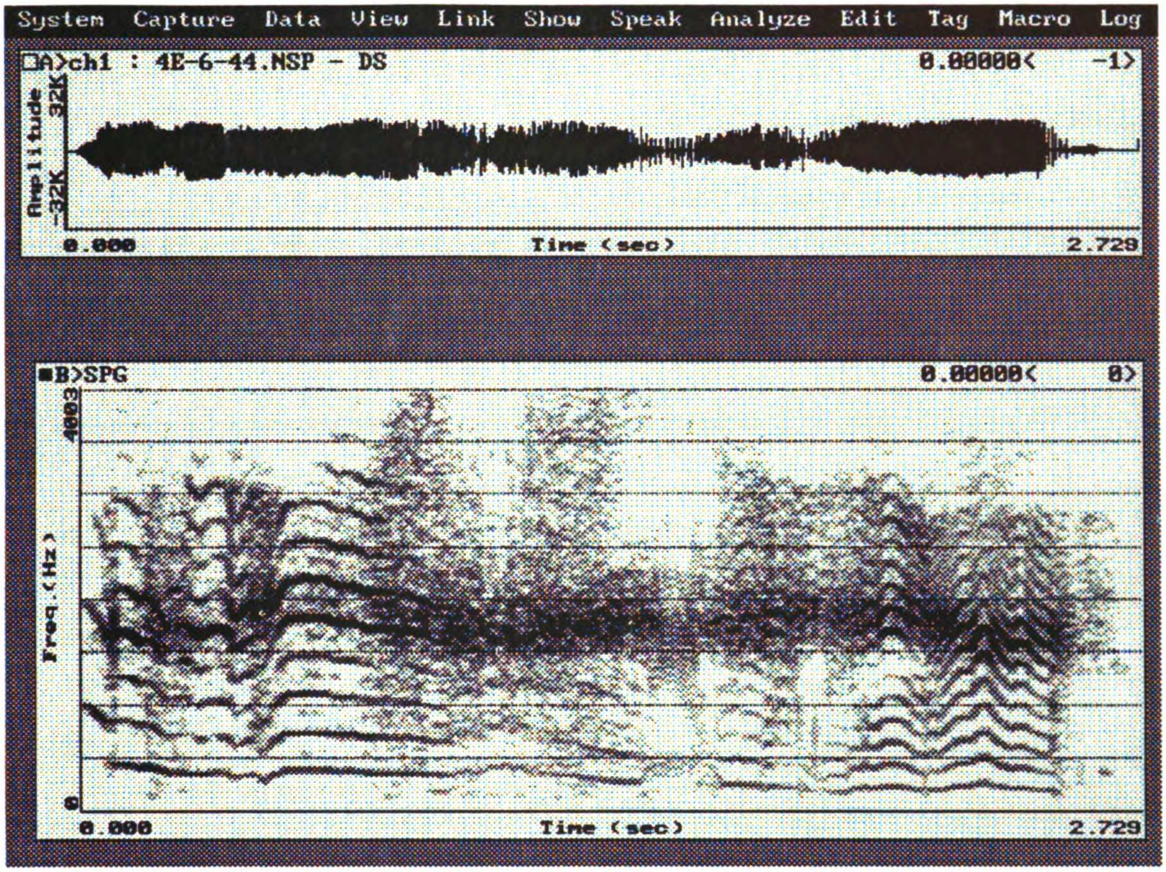
Low Fo Utterances



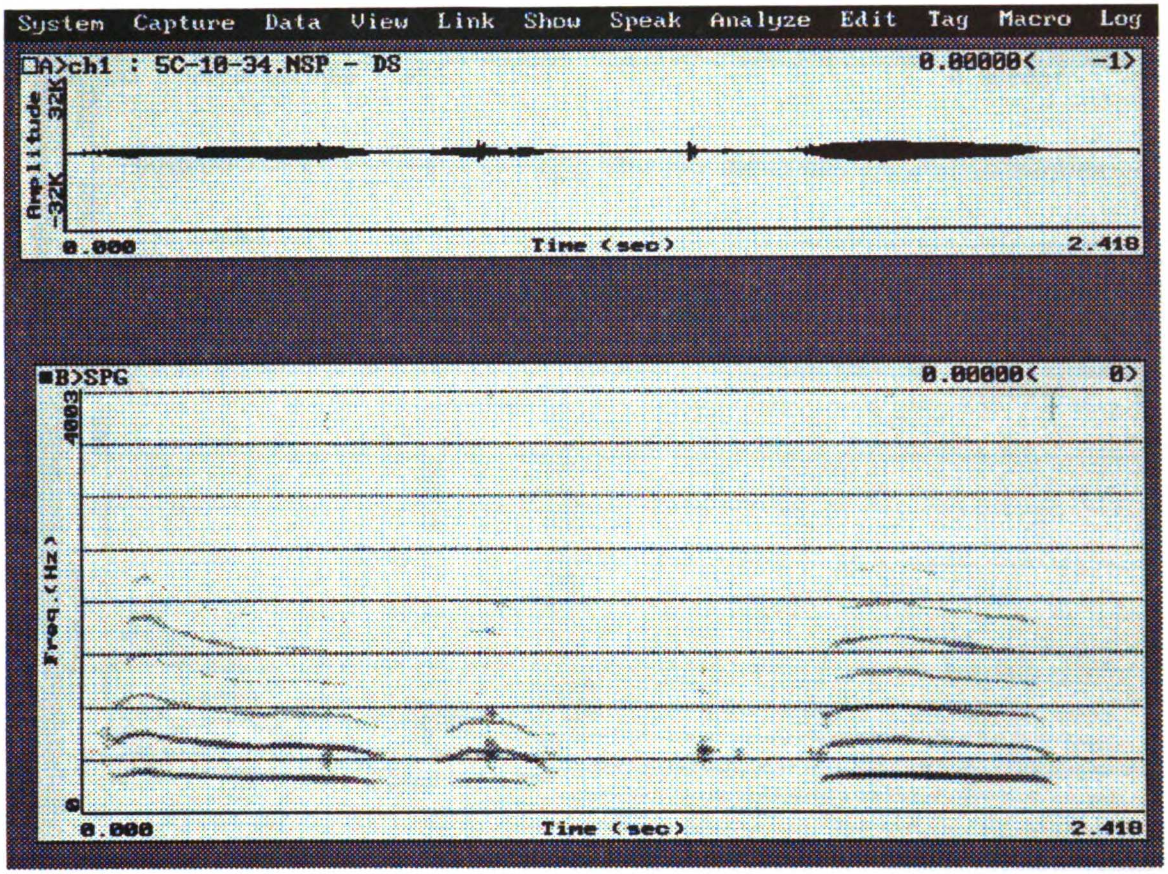
Subject: 3c
Age: 6 months
Utterance#: 11
Fo minimum: 149 Hz
(No phonetic transcription)



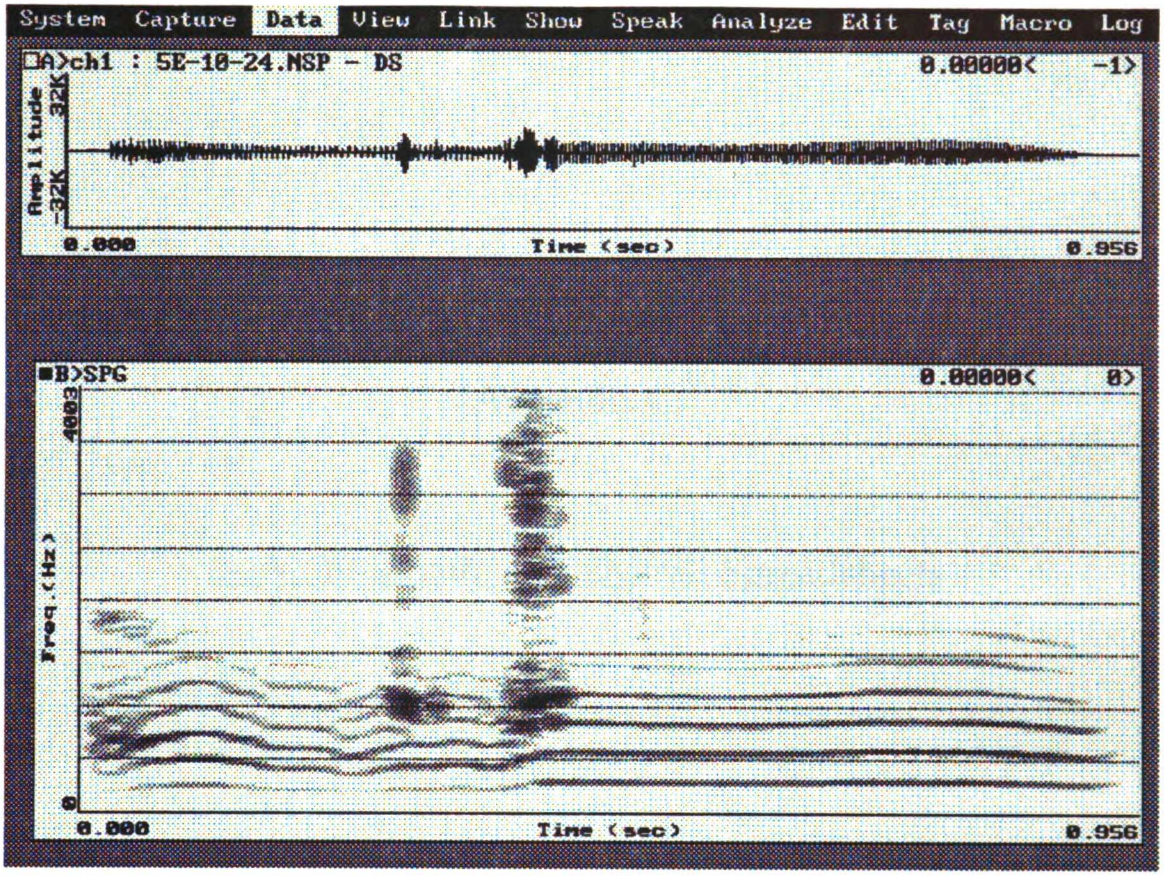
Subject: 2c
Age: 8 months
Utterance#: 35
Fo minimum: 137 Hz
(No phonetic transcription)



Subject: 4e
Age: 6 months
Utterance#: 44
Fo minimum: 116 Hz
(No phonetic transcription)



Subject: 5c
Age: 10 months
Utterance#: 34
Fo minimum: 189 Hz
(No phonetic transcription)



Subject: 5e
Age: 10 months
Utterance#: 24
Fo minimum: 189 Hz
(No phonetic transcription)

Appendix C:

6-, 8-, 10-Month, and Overall Spreadsheets

6-month

								avg W-U		max W-U		min W-U				avg.		avg.			
ID	**Age**	**avg Fo**	*rank*	**max Fo**	*rank*	**min Fo**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**avg STD**	*rank*	**Sppq**	*rank*	**vFo**	*rank*	**tally**	*rank*
Cantonese																					
1c	6	401.075	**9**	892.857	**5**	190.949	**6**	191.214	**6**	589.918	**5**	51.204	**5**	35.915	**6**	2.263	**5**	8.730	**3**	60	**5**
2c	6	348.910	**4**	517.870	**1**	212.950	**10**	169.263	**3**	264.930	**1**	59.009	**9**	28.908	**2**	2.440	**7**	8.200	**2**	21	**1**
3c	6	330.895	**2**	1585.000	**8**	149.000	**2**	208.561	**8**	1307.990	**10**	56.621	**7**	34.724	**5**	2.003	**2**	10.141	**6**	65	**6**
4c	6	356.892	**6**	570.776	**3**	190.006	**4**	173.136	**4**	347.329	**3**	55.027	**6**	34.569	**4**	2.219	**4**	9.853	**5**	51	**4**
5c	6	351.270	**5**	554.017	**2**	192.271	**7**	127.669	**1**	329.751	**2**	46.300	**3**	23.847	**1**	2.107	**3**	6.806	**1**	79	**9**
English																					
2e	6	339.298	**3**	769.231	**4**	190.114	**5**	186.490	**5**	431.740	**4**	45.162	**2**	41.284	**7**	6.031	**10**	11.909	**9**	21	**1**
3e	6	418.240	**10**	1800.000	**10**	192.493	**8**	256.742	**10**	973.417	**8**	59.526	**10**	52.610	**10**	2.309	**6**	11.967	**10**	79	**9**
4e	6	324.002	**1**	933.707	**6**	115.875	**1**	152.929	**2**	743.665	**6**	39.736	**1**	30.943	**3**	1.862	**1**	9.493	**4**	44	**3**
5e	6	385.125	**8**	1012.150	**7**	193.686	**9**	203.405	**7**	746.471	**7**	48.579	**4**	45.326	**9**	2.894	**9**	10.774	**8**	68	**7**
6e	6	377.579	**7**	1660.000	**9**	189.860	**3**	233.934	**9**	1252.000	**9**	57.280	**8**	42.702	**8**	2.645	**8**	10.569	**7**	76	**8**
p-value			0.774		**0.095**		0.774		0.275		0.189		0.631		**0.056**		0.189		**0.032**		0.773
min c		330.895		517.870		**149.000**		127.669		264.930		**46.300**		23.847		2.003		6.806		21	
min e		324.002		769.231		**115.875**		152.929		431.740		**39.736**		30.943		1.862		9.493		21	
max c		401.075		**1585.000**		212.950		208.561		**1307.990**		59.009		35.915		2.440		10.141		79	
max e		418.240		**1800.000**		193.686		256.742		**1252.000**		59.526		52.610		6.031		11.967		79	
med c		351.270		570.776		190.949		173.136		347.329		55.027		34.569		2.219		8.730		60	
med e		377.579		1012.150		190.114		203.405		746.471		48.579		42.702		2.645		10.774		68	
avg c		**357.808**		824.104		187.035		**173.969**		**567.984**		**53.632**		**31.593**		**2.206**		**8.746**		55.200	
avg e		**368.849**		1235.018		176.406		**206.700**		**829.459**		**50.057**		**42.573**		**3.148**		**10.942**		57.600	
sd c		26.073		451.273		23.291		30.251		431.676		4.986		5.113		0.165		1.345		21.638	
sd e		37.633		462.934		33.876		40.486		304.833		8.284		7.830		1.657		1.031		24.643	
																total # tokens c				**276**	
																total # tokens e				**288**	

8-month

								avg W-U		max W-U		min W-U				avg.		avg.			
ID	Age	avg Fo	rank	max Fo	rank	min Fo	rank	Fo range	rank	Fo range	rank	Fo range	rank	avg STD	rank	Sppq	rank	vFo	rank	tally	rank
Cantonese																					
1c	8	500.548	10	1031.990	9	170.097	2	334.531	10	706.962	8	113.103	10	74.708	10	3.428	8	14.880	10	37	5
2c	8	324.287	2	634.520	3	136.540	1	200.902	8	401.580	4	52.952	5	33.539	2	4.769	10	10.153	6	35	3
3c	8	312.610	1	534.474	1	191.278	4	157.984	1	318.724	2	69.197	8	35.577	6	3.233	7	11.247	9	26	1
4c	8	364.763	6	536.193	2	190.694	3	164.117	3	305.323	1	68.936	7	35.043	4	2.595	5	9.790	5	36	4
5c	8	392.650	8	777.001	5	191.424	6	198.524	7	477.600	5	33.860	1	36.211	7	1.828	1	9.130	3	32	2
English																					
2e	8	342.397	3	1002.000	8	191.644	7	189.680	6	716.940	9	42.882	3	39.663	8	3.681	9	11.121	8	99	10
3e	8	410.669	9	732.601	4	202.061	10	213.999	9	377.447	3	100.068	9	46.050	9	2.575	3	10.892	7	61	8
4e	8	346.331	4	885.740	6	193.536	8	158.534	2	567.954	6	37.458	2	30.310	1	2.584	4	8.277	1	63	9
5e	8	348.991	5	1057.080	10	191.314	5	167.102	4	773.716	10	55.537	6	33.980	3	2.127	2	9.185	4	39	6
6e	8	390.236	7	982.318	7	199.283	9	178.908	5	574.155	7	52.945	4	35.475	5	2.629	6	8.570	2	55	7
p-value			0.924		0.122		**0.016**		0.774		0.122		0.497		0.774		0.497		0.275		**0.0079**
min c		312.610		534.474		**136.540**		157.984		305.323		**33.860**		33.539		1.828		9.130		26	
min e		342.397		732.601		**191.314**		158.534		377.447		**37.458**		30.310		2.127		8.277		39	
max c		500.548		**1031.990**		191.424		334.531		**706.962**		113.103		74.708		4.769		14.880		37	
max e		410.669		**1057.080**		202.061		213.999		**773.716**		100.068		46.050		3.681		11.121		99	
med c		364.763		634.520		190.694		198.524		401.580		68.936		35.577		3.233		10.153		35	
med e		348.991		982.318		193.536		178.908		574.155		52.945		35.475		2.584		9.185		61	
avg c		**378.972**		702.836		176.007		**211.212**		**442.038**		**67.610**		**43.016**		**3.171**		**11.040**		**33.200**	
avg e		**367.725**		931.948		195.568		**181.645**		**602.042**		**57.778**		**37.096**		**2.719**		**9.609**		**63.400**	
sd c		75.107		208.941		23.870		71.635		163.542		29.274		17.744		1.091		2.280		4.438	
sd e		30.827		127.453		4.837		21.590		154.156		24.757		6.024		0.575		1.320		22.018	
																total # tokens c				166	
																total # tokens e				317	

10-month																					
								avg W-U		**max W-U**		**min W-U**				**avg.**		**avg.**			
ID	**Age**	**avg Fo**	*rank*	**max Fo**	*rank*	**min Fo**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**avg STD**	*rank*	**Sppq**	*rank*	**vFo**	*rank*	**tally**	*rank*
Cantonese																					
1c	10	475.060	**10**	927.644	**8**	194.480	**8**	252.340	**9**	551.565	**7**	102.845	**10**	54.672	**8**	2.731	**4**	11.505	**5**	27	**1**
2c	10	332.812	**3**	632.110	**1**	202.800	**10**	132.938	**1**	373.780	**1**	35.751	**2**	25.518	**1**	2.199	**1**	7.583	**1**	69	**6**
3c	10	330.282	**1**	717.000	**2**	190.585	**5**	160.076	**2**	476.558	**2**	45.575	**4**	39.814	**5**	2.289	**2**	11.762	**6**	46	**2**
4c	10	331.968	**2**	739.645	**5**	190.042	**3**	209.962	**6**	538.842	**6**	69.135	**8**	43.360	**6**	3.172	**8**	12.999	**9**	52	**3**
5c	10	358.638	**5**	916.590	**7**	189.502	**1**	199.343	**4**	588.539	**8**	48.773	**5**	37.843	**3**	2.852	**6**	9.834	**2**	59	**5**
English																					
2e	10	377.409	**8**	1750.000	**10**	190.367	**4**	305.000	**10**	1472.800	**10**	62.086	**7**	56.472	**9**	3.570	**9**	14.097	**10**	71	**7**
3e	10	373.581	**7**	734.754	**4**	192.160	**7**	212.072	**7**	503.754	**3**	92.542	**9**	45.460	**7**	2.837	**5**	12.057	**7**	52	**3**
4e	10	411.585	**9**	1052.630	**9**	194.932	**9**	233.719	**8**	717.641	**9**	45.244	**3**	57.833	**10**	2.942	**7**	12.709	**8**	100	**9**
5e	10	353.417	**4**	793.021	**6**	189.897	**2**	163.079	**3**	538.244	**5**	32.604	**1**	37.018	**2**	2.299	**3**	10.004	**3**	100	**9**
6e	10	369.270	**6**	717.875	**3**	190.730	**6**	204.577	**5**	526.962	**4**	50.420	**6**	39.219	**4**	4.431	**10**	10.520	**4**	80	**8**
p-value			0.189		0.378		0.924		0.275		0.497		0.774		0.378		0.189		0.378		**0.032**
min c		330.282		632.110		**189.502**		132.938		373.780		**35.751**		25.518		2.199		7.583		27	
min e		353.417		717.875		**189.897**		163.079		503.754		**32.604**		37.018		2.299		10.004		52	
max c		475.060		**927.644**		202.800		252.340		**588.539**		102.845		54.672		3.172		12.999		69	
max e		411.585		**1750.000**		194.932		305.000		**1472.800**		92.542		57.833		4.431		14.097		100	
med c		332.812		739.645		190.585		199.343		538.842		48.773		39.814		2.731		11.505		52	
med e		373.581		793.021		190.730		212.072		538.244		50.420		45.460		2.942		12.057		80	
avg c		**365.752**		786.598		193.482		**190.932**		**505.857**		**60.416**		**40.241**		**2.649**		10.737		**50.600**	
avg e		**377.052**		1009.656		191.617		**223.689**		**751.880**		**56.579**		**47.200**		**3.216**		11.877		**80.600**	
sd c		62.216		130.103		5.565		46.150		84.137		26.648		10.496		0.404		2.093		15.726	
sd e		21.353		435.199		2.037		52.168		411.914		22.720		9.610		0.816		1.659		20.391	
																total # tokens c				253	
																total # tokens e				403	

Overall Scores

								avg W-U		max W-U		min W-U				avg.		avg.			
ID	**Age**	**avg Fo**	*rank*	**max Fo**	*rank*	**min Fo**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**Fo range**	*rank*	**avg STD**	*rank*	**Sppq**	*rank*	**vFo**	*rank*	**tally**	*rank*
Cantonese																					
1c	all	446.865	**10**	1031.990	**4**	170.097	**4**	247.287	**10**	706.962	**4**	51.204	**8**	51.575	**10**	2.712	**6**	11.169	**8**	124	**1**
2c	all	333.129	**2**	634.520	**1**	136.540	**2**	158.071	**1**	401.580	**1**	35.751	**3**	28.333	**1**	2.959	**8**	8.406	**2**	125	**2**
3c	all	327.165	**1**	1585.000	**7**	149.000	**3**	182.683	**4**	1307.990	**9**	45.575	**6**	36.609	**3**	2.335	**2**	10.901	**6**	137	**3**
4c	all	349.607	**3**	739.645	**2**	190.006	**8**	184.577	**5**	538.842	**2**	55.027	**9**	37.980	**4**	2.876	**7**	11.014	**7**	139	**4**
5c	all	361.617	**5**	916.590	**3**	189.502	**5**	165.881	**2**	588.539	**3**	33.860	**2**	31.032	**2**	2.313	**1**	8.294	**1**	170	**5**
English																					
2e	all	354.835	**4**	1750.000	**9**	190.114	**9**	232.200	**9**	1472.800	**10**	42.882	**5**	45.980	**8**	3.902	**10**	12.295	**10**	191	**6**
3e	all	403.587	**9**	1800.000	**10**	192.160	**10**	231.064	**8**	973.417	**7**	59.526	**10**	48.550	**9**	2.539	**4**	11.647	**9**	192	**7**
4e	all	373.109	**7**	1052.630	**5**	115.875	**1**	193.664	**6**	743.665	**5**	37.458	**4**	43.741	**7**	2.604	**5**	10.677	**5**	207	**8**
5e	all	362.999	**6**	1057.080	**6**	189.897	**7**	177.084	**3**	773.716	**6**	32.604	**1**	39.175	**5**	2.462	**3**	10.103	**4**	207	**8**
6e	all	377.729	**8**	1660.000	**8**	189.860	**6**	208.460	**7**	1252.000	**8**	50.420	**7**	39.482	**6**	3.321	**9**	10.027	**3**	211	**10**
p-value			0.189		**0.032**		0.275		0.275		**0.095**		0.924		0.122		0.497		0.497		**0.0079**
min c		327.165		634.520		**136.540**		158.071		401.580		**33.860**		28.333		2.313		8.294		124	
min e		354.835		1052.630		**115.875**		177.084		743.665		**32.604**		39.175		2.462		10.027		191	
max c		446.865		**1585.000**		190.006		247.287		**1307.990**		55.027		51.575		2.959		11.169		170	
max e		403.587		**1800.000**		192.160		232.200		**1472.800**		59.526		48.550		3.902		12.295		211	
med c		349.607		916.590		170.097		182.683		588.539		45.575		36.609		2.712		10.901		137	
med e		373.109		1660.000		189.897		208.460		973.417		42.882		43.741		2.604		10.677		207	
avg c		**363.677**		981.549		167.029		**187.700**		**708.783**		**44.283**		**37.106**		**2.639**		**9.957**		**139.00**	
avg e		**374.452**		1463.942		175.581		**208.494**		**1043.120**		**44.578**		**43.386**		**2.966**		**10.950**		**201.60**	
sd c		48.448		370.764		23.964		35.141		352.408		9.306		9.003		0.301		1.470		18.615	
sd e		18.557		376.801		33.391		23.864		314.391		10.660		4.077		0.626		0.992		9.370	
																total # tokens c				**695**	
																total # tokens e				**1008**	

Appendix D:

Individual Subject Spreadsheets

Subject 1c - Cantonese						6-month			
ID	Age	#	Avg. Fo	High Fo	Low Fo	Fo range	STD	Sppq	vFo
1c	6	1	387.785	530.223	253.485	276.738	61.212	10.446	15.785
1c	6	2	353.854	389.560	290.782	98.778	22.455	1.543	6.346
1c	6	3	367.112	446.628	322.061	124.567	16.980	1.337	4.625
1c	6	4	342.516	376.081	261.780	114.301	25.108	1.212	7.330
1c	6	5	391.997	426.439	375.235	51.204	7.816	.749	1.994
1c	6	6	367.975	438.212	323.520	114.692	17.225	.883	4.681
1c	6	7	379.871	407.166	213.265	193.901	33.019	.985	8.692
1c	6	8	377.626	407.166	312.989	94.177	14.297	1.283	3.786
1c	6	9	354.490	480.307	228.990	251.317	65.939	6.668	18.601
1c	6	10	427.103	466.418	263.089	203.329	39.291	1.283	9.199
1c	6	11	384.678	431.220	297.177	134.043	26.728	1.256	6.948
1c	6	12	381.068	443.459	334.225	109.234	24.096	2.403	6.323
1c	6	13	384.914	426.803	323.206	103.597	23.469	.926	6.097
1c	6	14	408.445	559.597	268.673	290.924	39.511	1.086	9.673
1c	6	15	390.301	423.549	314.465	109.084	27.087	.793	6.940
1c	6	16	376.337	401.606	314.465	87.141	17.474	.778	4.643
1c	6	17	367.553	494.805	289.268	205.537	31.970	5.396	8.698
1c	6	18	402.023	481.696	237.417	244.279	44.007	1.725	10.946
1c	6	19	379.142	448.430	273.149	175.281	19.315	1.030	5.094
1c	6	20	380.196	416.840	311.042	105.798	19.675	.732	5.175
1c	6	21	381.880	475.285	301.205	174.080	22.036	1.090	5.770
1c	6	22	399.279	463.822	241.955	221.867	49.026	4.694	12.279
1c	6	23	384.808	460.193	219.539	240.654	43.634	3.088	11.339
1c	6	24	397.798	483.325	235.571	247.754	36.132	1.258	9.083
1c	6	25	388.999	469.704	346.141	123.563	17.888	1.537	4.598
1c	6	26	364.632	559.910	220.264	339.646	53.199	6.969	14.590
1c	6	27	368.581	396.668	305.530	91.138	16.101	1.466	4.368
1c	6	28	399.855	430.293	328.623	101.670	20.016	1.375	5.006
1c	6	29	388.833	447.828	190.949	256.879	65.757	6.773	16.911
1c	6	30	412.363	522.193	345.304	176.889	23.127	.811	5.608
1c	6	31	379.264	506.073	236.742	269.331	29.796	1.144	7.856
1c	6	32	407.652	478.011	301.114	176.897	22.335	1.200	5.479
1c	6	33	394.003	434.972	368.324	66.648	13.259	1.231	3.365
1c	6	34	381.149	563.698	312.500	251.198	20.892	1.636	5.481
1c	6	35	491.386	665.336	436.110	251.198	27.457	1.761	5.588
1c	6	36	577.266	759.878	429.000	330.878	74.861	1.865	12.968
1c	6	37	386.952	585.480	219.010	366.470	39.503	2.367	10.209
1c	6	38	409.156	623.441	259.605	363.836	59.671	1.325	14.584
1c	6	39	398.670	470.810	255.820	214.990	28.164	2.089	7.064
1c	6	40	417.817	479.157	197.122	282.035	102.205	4.183	24.462
1c	6	41	400.414	425.351	349.040	76.311	14.661	.928	3.662
1c	6	42	407.041	481.232	262.950	218.282	31.517	1.415	7.743
1c	6	43	409.454	448.833	306.748	142.085	23.750	.820	5.800
1c	6	44	399.708	450.857	253.614	197.243	44.695	.912	11.182
1c	6	45	425.830	467.290	321.337	145.953	33.411	.769	7.846
1c	6	46	377.768	425.894	249.626	176.268	26.763	.930	7.084
1c	6	47	399.746	458.926	242.777	216.149	37.652	1.106	9.419

1c	6	48	394.903	503.525	306.185	197.340	28.857	4.581	7.307
1c	6	49	464.155	518.941	408.497	110.444	17.927	1.221	3.862
1c	6	50	411.972	491.642	257.865	233.777	36.509	1.739	8.862
1c	6	51	433.221	511.509	264.061	247.448	37.625	2.136	8.685
1c	6	52	359.058	430.108	210.305	219.803	71.735	3.269	19.979
1c	6	53	626.603	892.857	302.939	589.918	192.108	17.933	30.659
1c	6	54	386.879	450.450	194.363	256.087	48.423	1.962	12.516
1c	6	55	369.957	391.389	323.939	67.450	11.561	1.087	3.125
1c	6	56	418.745	536.193	315.060	221.133	37.013	1.448	8.839
1c	6	57	452.634	488.759	347.947	140.812	28.651	.616	6.330
1c	6	58	399.485	444.642	322.477	122.165	24.233	.845	6.066
1c	6	59	402.844	451.264	299.491	151.773	41.452	.897	10.290
1c	6	60	388.727	417.885	311.042	106.843	24.639	.778	6.338
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**401.075**	480.997	290.150	**191.214**	**35.915**	**2.263**	**8.730**
STD			45.715	86.490	55.040	94.016	27.161	2.791	5.249
			max:	**892.857**		**589.918**			
			min:		**190.949**	**51.204**			

Subject 1c - Cantonese						***8-month***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
1c	8	1	637.940	939.850	357.015	582.835	150.912	4.193	23.656
1c	8	2	912.677	1031.992	694.440	337.552	89.863	2.540	9.846
1c	8	3	537.766	621.891	465.766	156.125	25.524	.981	4.746
1c	8	4	453.378	600.962	370.370	230.592	22.105	1.104	4.876
1c	8	5	464.819	608.643	366.032	242.611	32.943	1.449	7.087
1c	8	6	506.401	653.595	375.657	277.938	65.030	2.318	12.842
1c	8	7	270.187	394.945	190.913	204.032	37.292	8.250	13.802
1c	8	8	552.007	617.665	350.140	267.525	40.737	1.259	7.380
1c	8	9	424.918	653.595	190.949	462.646	180.762	3.767	42.540
1c	8	10	332.005	495.050	262.192	232.858	36.210	2.825	10.906
1c	8	11	560.930	665.336	290.444	374.892	94.003	1.944	16.758
1c	8	12	500.734	704.225	293.169	411.056	80.971	3.413	16.170
1c	8	13	486.654	619.963	273.598	346.365	74.239	1.388	15.255
1c	8	14	332.772	400.481	198.886	201.595	41.775	1.752	12.554
1c	8	15	472.685	671.141	386.548	284.593	65.569	4.193	13.872
1c	8	16	464.057	611.247	385.802	225.445	41.402	1.232	8.922
1c	8	17	462.466	602.773	369.004	233.769	38.264	1.519	8.274
1c	8	18	414.897	572.082	341.413	230.669	42.723	4.095	10.297
1c	8	19	541.966	809.061	361.402	447.659	37.916	.958	6.996
1c	8	20	493.081	680.735	291.630	389.105	68.426	4.328	13.877
1c	8	21	488.706	700.771	220.264	480.507	81.957	1.353	16.770
1c	8	22	444.140	576.369	190.803	385.566	146.474	4.932	32.979
1c	8	23	460.653	511.509	398.406	113.103	22.678	2.515	4.923
1c	8	24	434.272	542.299	196.696	345.603	101.196	1.349	23.302
1c	8	25	588.553	694.927	448.632	246.295	35.120	1.314	5.967
1c	8	26	528.730	685.401	191.828	493.573	127.255	.827	24.068
1c	8	27	750.348	911.577	594.884	316.693	57.105	5.467	7.611
1c	8	28	394.632	492.611	227.687	264.924	51.595	2.165	13.074
1c	8	29	482.048	723.589	210.084	513.505	135.327	11.338	16.570
1c	8	30	598.606	818.331	409.333	408.998	99.190	11.338	16.570
1c	8	31	499.093	660.502	371.333	289.169	49.207	4.557	9.859
1c	8	32	457.842	632.511	231.589	400.922	121.699	5.952	26.581
1c	8	33	511.277	608.643	219.684	388.959	101.588	1.327	19.870
1c	8	34	391.981	582.411	170.097	412.314	97.555	5.732	24.888
1c	8	35	554.886	722.022	429.000	293.022	58.406	5.631	10.526
1c	8	36	518.165	629.327	451.671	177.656	32.337	1.612	6.241
1c	8	37	593.990	1005.025	298.063	706.962	178.851	5.910	30.110
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
average			**500.548**	**660.893**	**326.363**	**334.531**	**74.708**	**3.428**	**14.880**
STD			112.458	142.474	117.496	125.834	44.047	2.674	8.697
			max:	**1031.992**		**706.962**			
			min:		**170.097**	**113.103**			

Subject 1c - Cantonese						**_10-month_**			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
1c	10	1	412.473	485.437	355.745	129.692	22.444	2.641	5.441
1c	10	2	413.365	481.232	354.233	126.999	21.885	2.818	5.294
1c	10	3	570.737	709.220	358.809	350.411	58.823	1.116	10.307
1c	10	4	733.247	927.644	400.160	527.484	155.837	.891	21.253
1c	10	5	784.488	912.409	552.792	359.617	96.349	1.375	12.282
1c	10	6	740.392	871.840	483.092	388.748	93.339	1.533	12.607
1c	10	7	403.383	656.168	276.472	379.696	74.136	3.818	18.379
1c	10	8	297.803	396.511	214.454	182.057	36.868	8.127	12.380
1c	10	9	332.439	427.716	233.318	194.398	25.876	1.637	7.784
1c	10	10	441.765	591.716	362.582	229.134	40.118	3.908	9.081
1c	10	11	384.340	445.038	226.501	218.537	43.122	1.679	11.220
1c	10	12	287.484	334.672	209.336	125.336	30.321	2.068	10.547
1c	10	13	380.626	490.196	284.657	205.539	47.396	2.619	12.452
1c	10	14	340.215	384.615	281.770	102.845	22.600	3.970	6.643
1c	10	15	383.362	493.340	324.044	169.296	40.396	2.545	10.537
1c	10	16	360.501	419.639	241.488	178.151	43.594	2.561	12.093
1c	10	17	541.824	790.514	238.949	551.565	155.807	6.041	28.756
1c	10	18	493.249	616.523	389.560	226.963	40.317	1.480	8.174
1c	10	19	471.800	577.367	297.796	279.571	60.031	1.427	12.724
1c	10	20	445.652	596.659	194.477	402.182	91.871	1.159	20.615
1c	10	21	446.246	588.928	385.802	203.126	46.342	1.465	10.385
1c	10	22	812.563	876.424	671.141	205.283	38.031	1.544	4.680
1c	10	23	446.716	542.888	349.162	193.726	30.437	3.152	6.813
1c	10	24	446.718	502.513	376.081	126.432	29.773	2.217	6.665
1c	10	25	329.416	588.928	221.680	367.248	65.718	6.018	19.950
1c	10	26	347.920	441.112	261.780	179.332	33.016	4.515	9.489
1c	10	27	777.762	879.507	669.792	209.715	31.688	1.415	4.084
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**475.055**	**593.658**	**341.321**	**252.336**	**54.672**	**2.731**	**11.505**
STD			158.206	177.361	127.977	121.387	36.156	1.767	5.835
			max:	**927.644**		**551.565**			
			min:		**194.477**	**102.845**			
Subject 1c - Cantonese						**_Overall Scores_**			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages:			**446.865**	559.207	312.097	**247.287**	**51.575**	**2.712**	**11.169**
STD			109.813	150.112	97.157	125.769	38.481	2.597	7.044
			max:	**1031.992**		**706.962**			
			min:		**170.097**	**51.204**			

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Subject 2c - Cantonese						***6-month***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
2c	**6**	1	316.573	352.361	273.000	79.361	11.602	1.782	3.665
2c	**6**	2	317.595	434.483	242.483	192.000	25.749	3.865	8.108
2c	**6**	3	339.659	517.866	254.712	263.154	38.487	3.873	11.331
2c	**6**	4	322.331	448.029	225.073	222.956	28.724	1.646	8.911
2c	**6**	5	296.138	382.263	250.752	131.511	27.664	1.675	9.342
2c	**6**	6	351.651	447.227	269.469	177.758	31.656	2.076	9.002
2c	**6**	7	370.805	431.593	325.945	105.648	20.168	2.215	5.439
2c	**6**	8	389.290	461.894	342.466	119.428	19.034	2.972	4.889
2c	**6**	9	311.367	352.609	293.600	59.009	12.803	1.745	4.112
2c	**6**	10	353.670	426.621	262.329	164.292	27.579	1.895	7.798
2c	**6**	11	301.521	402.414	237.925	164.489	34.029	4.290	11.286
2c	**6**	12	340.666	459.348	217.297	242.051	28.281	1.377	8.302
2c	**6**	13	312.607	399.680	269.833	129.847	26.894	1.865	8.603
2c	**6**	14	382.749	504.032	283.206	220.826	32.473	3.986	8.484
2c	**6**	15	367.779	422.833	268.240	154.593	26.342	1.155	7.162
2c	**6**	16	395.796	476.872	324.465	152.407	24.662	.677	6.231
2c	**6**	17	398.958	480.769	215.843	264.926	43.611	2.899	10.931
2c	**6**	18	391.645	473.485	296.912	176.573	38.172	2.481	9.747
2c	**6**	19	408.649	458.085	232.558	225.527	55.065	4.161	13.475
2c	**6**	20	381.335	436.872	238.436	198.436	42.017	3.396	11.018
2c	**6**	21	276.321	322.685	212.947	109.738	12.045	1.204	4.359
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**348.910**	432.953	263.690	**169.263**	**28.907**	**2.440**	**8.200**
STD			39.182	50.298	37.290	58.010	10.853	1.110	2.678
			max:	**517.866**		**264.926**			
			min:		**212.947**	**59.009**			

Subject 2c - Cantonese						*8-month*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
2c	**8**	1	368.582	539.374	269.179	270.195	55.286	12.889	15.000
2c	**8**	2	314.080	634.518	232.937	401.581	60.991	12.629	19.419
2c	**8**	3	382.654	606.796	290.613	316.183	52.080	9.393	13.610
2c	**8**	4	338.882	467.071	236.911	230.160	45.991	8.293	13.571
2c	**8**	5	342.878	364.964	312.012	52.952	9.835	1.431	2.868
2c	**8**	6	343.423	506.842	277.469	229.373	22.268	2.825	6.484
2c	**8**	7	391.133	583.090	281.057	302.033	52.860	8.508	13.514
2c	**8**	8	375.020	516.529	256.937	259.592	54.071	10.779	14.418
2c	**8**	9	327.581	448.430	244.918	203.512	38.935	3.956	11.886
2c	**8**	10	302.441	427.168	250.313	176.855	31.952	4.913	10.565
2c	**8**	11	340.322	539.665	270.124	269.541	40.858	6.700	12.006
2c	**8**	12	325.490	445.236	232.019	213.217	41.236	8.714	12.669
2c	**8**	13	324.966	494.805	237.756	257.049	47.289	12.242	14.552
2c	**8**	14	336.150	472.144	230.010	242.134	35.659	3.350	10.608
2c	**8**	15	360.099	534.474	267.666	266.808	36.626	4.249	10.171
2c	**8**	16	413.543	546.448	277.162	269.286	90.605	15.330	21.909
2c	**8**	17	304.285	484.496	240.732	243.764	32.207	3.267	10.584
2c	**8**	18	315.901	467.508	225.938	241.570	37.881	6.427	11.991
2c	**8**	19	328.949	437.445	231.803	205.642	26.215	2.588	7.980
2c	**8**	20	298.793	323.206	255.167	68.039	11.017	.905	3.687
2c	**8**	21	300.167	376.364	214.179	162.185	26.656	1.468	8.881
2c	**8**	22	305.947	348.311	276.319	71.992	20.336	2.121	6.647
2c	**8**	23	293.947	426.985	272.331	154.654	14.558	1.088	4.953
2c	**8**	24	315.249	403.877	255.363	148.514	26.207	1.182	8.313
2c	**8**	25	290.561	358.295	215.471	142.824	24.629	3.773	8.476
2c	**8**	26	276.200	329.924	226.860	103.064	14.211	2.688	5.145
2c	**8**	27	311.799	433.651	232.666	200.985	25.870	2.066	8.297
2c	**8**	28	299.701	442.282	215.843	226.439	35.631	1.746	11.889
2c	**8**	29	311.762	372.856	235.682	137.174	29.639	2.176	9.507
2c	**8**	30	328.410	492.854	242.365	250.489	26.740	2.176	9.507
2c	**8**	31	363.746	439.174	308.071	131.103	31.831	1.258	8.751
2c	**8**	32	315.790	347.222	259.538	87.684	17.485	1.626	5.537
2c	**8**	33	293.470	409.836	244.798	165.038	14.648	1.822	4.991
2c	**8**	34	331.297	493.340	280.662	212.678	24.802	1.013	7.486
2c	**8**	35	176.841	253.807	136.537	117.270	16.762	1.312	9.479
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
average			**324.287**	450.542	249.640	**200.902**	**33.539**	**4.769**	**10.153**
STD			40.363	85.195	31.960	77.707	16.789	4.121	4.154
			max:	**634.518**		**401.581**			
			min:		**136.537**	**52.952**			

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Subject 2c - Cantonese						***10-month***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
2c	10	1	416.870	489.956	216.310	273.646	63.414	1.737	15.212
2c	10	2	461.610	530.504	312.891	217.613	66.089	.647	15.317
2c	10	3	267.633	310.849	226.244	84.605	22.798	2.681	8.518
2c	10	4	345.660	514.403	288.434	225.969	36.137	5.631	10.454
2c	10	5	300.858	323.729	265.252	58.477	12.858	1.661	4.274
2c	10	6	360.044	434.783	310.752	124.031	30.117	1.464	8.365
2c	10	7	409.892	577.701	280.034	297.667	54.980	3.765	13.413
2c	10	8	332.669	383.730	267.380	116.350	28.084	.796	8.442
2c	10	9	371.179	541.126	331.236	209.890	26.905	.700	7.248
2c	10	10	298.939	333.890	248.016	85.874	20.450	1.409	6.841
2c	10	11	294.559	338.295	241.255	97.040	22.064	1.719	7.490
2c	10	12	262.806	331.675	216.216	115.459	19.459	5.942	7.404
2c	10	13	261.149	285.959	230.840	55.119	13.750	3.687	5.265
2c	10	14	291.072	324.254	253.036	71.218	12.606	1.136	4.331
2c	10	15	270.807	389.257	208.377	180.880	26.927	5.857	9.947
2c	10	16	264.615	293.341	213.311	80.030	17.094	3.895	6.460
2c	10	17	380.500	400.641	342.466	58.175	10.826	1.027	2.845
2c	10	18	380.435	424.268	310.270	113.998	14.643	1.129	3.849
2c	10	19	278.356	351.247	233.536	117.711	28.484	2.779	10.233
2c	10	20	295.160	341.064	249.750	91.314	20.134	1.082	6.822
2c	10	21	291.430	421.053	260.892	160.161	16.747	1.673	5.747
2c	10	22	360.150	391.083	289.101	101.982	16.061	.648	4.460
2c	10	23	312.761	393.236	225.887	167.349	37.421	2.032	11.965
2c	10	24	447.551	484.966	383.877	101.089	24.772	.523	5.535
2c	10	25	498.029	561.798	317.763	244.035	33.678	1.163	6.762
2c	10	26	346.479	441.891	290.276	151.615	23.996	2.222	6.926
2c	10	27	483.799	512.033	438.404	73.629	17.772	2.363	3.673
2c	10	28	340.888	429.553	274.499	155.054	37.633	7.436	11.040
2c	10	29	311.450	358.809	284.010	74.799	15.247	1.880	4.896
2c	10	30	320.851	385.951	285.796	100.155	22.137	1.761	6.899
2c	10	31	336.983	361.664	310.463	51.201	9.172	1.762	2.722
2c	10	32	313.625	374.392	292.826	81.566	19.648	.898	6.265
2c	10	33	322.758	357.526	251.319	106.207	19.238	2.878	5.961
2c	10	34	319.095	361.795	289.771	72.024	14.961	3.773	4.688
2c	10	35	278.497	366.569	203.335	163.234	23.647	3.209	8.491
2c	10	36	294.324	330.360	264.410	65.950	9.876	1.165	3.356
2c	10	37	394.558	488.043	357.782	130.261	14.588	.861	3.697
2c	10	38	303.795	322.893	251.067	71.826	9.032	.848	2.973
2c	10	39	289.598	349.040	213.675	135.365	18.113	2.208	6.255
2c	10	40	311.411	377.501	233.481	144.020	18.727	2.015	6.014
2c	10	41	287.231	348.918	202.799	146.119	23.158	2.931	8.062
2c	10	42	275.418	348.675	205.381	143.294	20.924	2.717	7.597
2c	10	43	292.967	385.505	253.100	132.405	20.173	1.454	6.886
2c	10	44	301.077	335.683	247.709	87.974	16.138	1.358	5.360
2c	10	45	306.271	369.140	238.834	130.306	23.214	3.079	7.580
2c	10	46	304.999	426.076	266.809	159.267	25.113	1.752	8.234
2c	10	47	301.672	330.360	251.319	79.041	17.295	1.773	5.733

2c	**10**	48	348.853	403.226	275.482	127.744	27.183	3.575	7.792
2c	**10**	49	401.499	429.553	217.817	211.736	43.078	1.112	10.729
2c	**10**	50	385.130	495.050	216.357	278.693	65.786	3.426	17.081
2c	**10**	51	334.043	355.240	319.489	35.751	5.287	.568	1.583
2c	**10**	52	325.216	356.633	294.464	62.169	14.618	1.706	4.495
2c	**10**	53	334.503	370.096	305.810	64.286	12.953	1.661	3.872
2c	**10**	54	273.055	324.254	242.660	81.594	9.750	1.372	3.571
2c	**10**	55	368.451	632.111	258.331	373.780	83.868	4.204	22.762
2c	**10**	56	357.517	466.418	265.111	201.307	36.316	1.602	10.158
2c	**10**	57	371.678	438.789	331.895	106.894	24.308	.830	6.540
2c	**10**	58	312.473	332.447	227.480	104.967	22.042	2.802	7.054
2c	**10**	59	318.416	345.304	272.331	72.973	16.144	1.938	5.070
2c	**10**	60	351.465	508.647	251.446	257.201	70.062	2.244	19.934
2c	**10**	61	325.688	454.339	228.311	226.028	52.186	3.060	16.023
2c	**10**	62	272.610	346.260	230.521	115.739	23.098	2.980	8.473
2c	**10**	63	319.199	379.363	281.452	97.911	24.914	1.240	7.805
2c	**10**	64	335.810	393.927	259.538	134.389	19.843	1.497	5.909
2c	**10**	65	301.592	331.016	258.732	72.284	14.706	1.552	4.876
2c	**10**	66	450.484	520.833	381.243	139.590	12.014	.659	2.667
2c	**10**	67	305.481	379.075	232.288	146.787	34.518	4.947	11.300
2c	**10**	68	380.891	520.562	289.771	230.791	32.137	1.473	8.437
2c	**10**	69	297.479	366.569	241.429	125.140	19.645	2.152	6.604
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
average			**332.812**	401.230	268.292	**132.938**	**25.518**	**2.199**	**7.583**
STD			53.856	75.826	46.513	67.930	15.754	1.422	4.046
			max:	**632.111**		**373.780**			
			min:		**202.799**	**35.751**			
Subject 2c - Cantonese						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
average			**333.129**	420.367	262.296	**158.071**	**28.333**	**2.959**	**8.406**
STD:			48.468	77.709	41.909	74.963	15.637	2.694	4.014
			max:	**634.520**		**401.581**			
			min:		**136.540**	**35.751**			

Subject 3c - Cantonese						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3c	6	1	323.700	458.085	221.779	236.306	31.990	.907	9.883
3c	6	2	314.343	598.086	258.131	339.955	38.642	3.767	12.293
3c	6	3	336.560	470.146	214.408	255.738	46.534	2.390	13.826
3c	6	4	363.785	532.198	204.123	328.075	92.982	3.985	25.560
3c	6	5	349.619	484.027	244.918	239.109	26.183	1.484	7.489
3c	6	6	364.581	435.540	338.181	97.359	15.202	1.409	4.170
3c	6	7	287.766	311.139	254.518	56.621	15.536	.718	5.399
3c	6	8	289.590	350.508	251.067	99.441	15.308	3.606	5.286
3c	6	9	341.464	431.779	251.953	179.826	30.269	3.568	8.865
3c	6	10	370.037	440.335	295.946	144.389	26.077	2.482	7.047
3c	6	11	364.543	568.000	149.000	419.000	78.991	8.250	21.669
3c	6	12	349.597	484.731	272.554	212.177	29.124	4.213	8.331
3c	6	13	303.701	358.809	277.316	81.493	15.006	1.006	4.941
3c	6	14	380.109	429.369	226.449	202.920	51.729	1.061	13.609
3c	6	15	338.540	367.512	217.014	150.498	25.153	.689	7.430
3c	6	16	360.970	399.361	200.280	199.081	53.047	.960	14.696
3c	6	17	384.879	482.859	205.931	276.928	51.546	3.934	13.393
3c	6	18	382.810	444.840	226.449	218.391	63.351	.933	16.549
3c	6	19	368.790	413.394	216.497	196.897	48.304	.832	13.098
3c	6	20	345.382	402.576	211.506	191.070	37.096	.603	10.741
3c	6	21	328.252	528.262	231.857	296.405	52.409	2.533	15.966
3c	6	22	406.209	645.995	288.046	357.949	57.996	5.256	14.277
3c	6	23	353.636	415.628	303.859	111.769	17.219	1.213	4.869
3c	6	24	351.039	405.680	266.099	139.581	30.127	1.907	8.582
3c	6	25	360.722	632.911	323.625	309.286	28.589	1.182	7.926
3c	6	26	273.122	298.418	238.834	59.584	12.257	1.041	4.488
3c	6	27	305.968	345.901	260.552	85.349	25.686	.890	8.395
3c	6	28	281.438	335.570	243.665	91.905	13.977	2.039	4.966
3c	6	29	334.696	430.849	274.198	156.651	37.913	1.528	11.328
3c	6	30	348.114	439.754	261.233	178.521	54.846	1.399	15.755
3c	6	31	329.819	399.521	273.224	126.297	17.406	1.368	5.278
3c	6	32	311.596	481.000	221.729	259.271	41.596	1.025	13.349
3c	6	33	318.516	420.698	294.204	126.494	15.438	1.020	4.847
3c	6	34	354.551	407.997	307.598	100.399	31.009	.796	8.746
3c	6	35	353.492	507.099	276.319	230.780	35.187	3.931	9.954
3c	6	36	477.110	670.691	214.316	456.375	145.151	6.048	30.423
3c	6	37	329.005	402.576	284.738	117.838	25.212	.685	7.663
3c	6	38	339.267	415.800	292.569	123.231	21.917	1.601	6.460
3c	6	39	304.716	393.546	208.725	184.821	31.859	3.445	10.455
3c	6	40	313.375	370.096	235.516	134.580	34.396	1.497	10.976
3c	6	41	321.162	430.849	256.213	174.636	21.092	1.139	6.567
3c	6	42		1585.000	277.008	1307.992			
3c	6	43	373.450	613.121	301.296	311.825	40.481	2.350	10.840
3c	6	44	312.749	418.936	234.192	184.744	20.420	.783	6.529
3c	6	45	307.775	425.532	278.940	146.592	14.239	.972	4.626
3c	6	46	364.103	488.043	228.938	259.105	54.011	1.343	14.834
3c	6	47	345.505	557.103	196.502	360.601	56.615	2.578	16.386

3c	**6**	48	309.001	338.524	233.427	105.097	13.455	1.228	4.354
3c	**6**	49	298.005	330.033	236.630	93.403	30.656	.637	10.287
3c	**6**	50	293.276	361.272	215.054	146.218	39.849	1.469	13.588
3c	**6**	51	303.575	386.548	246.731	139.817	18.203	.605	5.996
3c	**6**	52	282.191	327.976	196.580	131.396	14.149	.846	5.014
3c	**6**	53	297.878	403.714	215.460	378.568	21.575	1.630	7.243
3c	**6**	54	344.900	538.213	243.605	294.608	39.034	4.515	11.318
3c	**6**	55	317.010	374.672	257.666	117.006	15.995	.922	5.046
3c	**6**	56	290.540	382.555	236.798	145.757	11.994	1.754	4.128
3c	**6**	57	288.800	332.116	209.952	122.164	21.330	1.560	7.386
3c	**6**	58	292.686	402.739	195.963	206.776	28.324	4.471	9.677
3c	**6**	59	306.570	341.530	242.660	98.870	17.248	2.157	5.626
3c	**6**	60	325.824	388.651	205.973	182.678	55.619	1.276	17.070
3c	**6**	61	281.557	346.981	222.222	124.759	31.467	4.146	11.176
3c	**6**	62	323.583	443.262	196.155	247.107	44.590	1.393	13.780
3c	**6**	63	302.310	328.407	228.571	99.836	23.927	.905	7.915
3c	**6**	64	309.924	359.971	191.939	168.032	34.355	1.145	11.085
3c	**6**	65	328.652	503.271	266.738	236.533	31.462	1.173	9.573
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**331.507**	**449.543**	**243.910**	**208.561**	**34.724**	**2.003**	**10.141**
STD			35.659	166.261	36.525	165.726	21.903	1.533	5.152
			max:	**1585.000**		**1307.992**			
			min:		**149.000**	**56.621**			

Subject 3c - Cantonese						*8-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3c	8	1	272.072	329.707	191.865	137.842	19.794	2.102	7.275
3c	8	2	288.250	347.464	256.345	91.119	14.058	1.148	4.877
3c	8	3	318.197	390.168	191.278	198.890	57.312	2.881	18.012
3c	8	4	331.647	534.474	215.750	318.724	57.015	3.801	17.191
3c	8	5	354.534	447.427	198.373	249.054	88.859	6.694	25.064
3c	8	6	280.533	325.203	242.660	82.543	13.420	2.790	4.784
3c	8	7	316.441	389.560	238.949	150.611	19.108	2.349	6.039
3c	8	8	307.494	362.713	207.039	155.674	41.553	1.713	13.513
3c	8	9	267.621	332.447	197.668	134.779	20.320	1.556	7.593
3c	8	10	280.520	298.240	229.043	69.197	12.327	1.648	4.394
3c	8	11	294.983	343.761	226.449	117.312	37.383	2.989	12.673
3c	8	12	311.614	394.166	207.555	186.611	47.949	2.723	15.387
3c	8	13	291.948	319.081	198.098	120.983	35.307	3.051	12.093
3c	8	14	265.568	333.890	205.044	128.846	23.886	2.666	8.994
3c	8	15	332.166	370.645	242.072	128.573	45.907	8.907	13.821
3c	8	16	272.694	338.524	200.924	137.600	22.333	4.005	8.190
3c	8	17	275.250	319.489	202.758	116.731	30.490	4.174	11.077
3c	8	18	409.129	483.793	226.040	257.753	52.721	1.426	12.886
3c	8	19	296.042	328.407	208.464	119.943	30.401	1.554	10.214
3c	8	20	443.976	489.476	343.289	146.187	21.190	.683	4.773
3c	8	21	310.950	374.251	203.087	171.164	40.796	2.945	13.120
3c	8	22	324.592	383.142	234.907	148.235	48.110	1.165	14.822
3c	8	23	359.086	421.053	197.394	223.659	56.552	1.622	15.749
3c	8	24	344.183	374.532	279.486	95.046	21.379	.738	6.211
3c	8	25	247.698	391.236	195.503	195.733	34.175	13.539	13.797
3c	8	26	330.661	498.753	273.973	224.780	32.658	5.180	9.877
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**312.610**	**381.600**	**223.616**	**157.984**	**35.577**	**3.233**	**11.247**
STD			44.508	62.801	34.752	59.497	17.910	2.806	4.978
			max:	**534.474**		**318.724**			
			min:		**191.278**	**69.197**			

Subject 3c - Cantonese						*10-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3c	10	1	273.185	321.027	218.198	102.829	18.982	2.263	6.949
3c	10	2	297.468	391.389	225.378	166.011	46.829	2.861	15.743
3c	10	3	306.289	336.361	235.571	100.790	24.282	.952	7.928
3c	10	4	296.722	345.423	190.585	154.838	33.122	2.045	11.163
3c	10	5	304.026	334.448	246.366	88.082	16.124	.898	5.304
3c	10	6	331.844	471.698	284.576	187.122	24.190	1.560	7.290
3c	10	7	329.409	376.081	209.908	166.173	44.537	1.833	13.520
3c	10	8	299.131	376.790	231.803	144.987	38.081	1.389	12.731
3c	10	9	335.707	364.299	294.985	69.314	12.312	2.235	3.668
3c	10	10	279.020	342.583	239.349	103.234	16.593	1.199	5.947
3c	10	11	295.127	340.020	239.464	100.556	22.831	2.055	7.736
3c	10	12	329.366	426.439	213.721	212.718	57.388	1.543	17.422
3c	10	13	413.899	468.604	273.448	195.156	29.357	1.800	7.093
3c	10	14	300.956	343.171	233.046	110.125	22.344	1.307	7.424
3c	10	15	272.527	319.387	228.363	91.024	21.129	2.266	7.753
3c	10	16	325.479	397.298	224.467	172.831	41.099	1.810	12.627
3c	10	17	302.032	353.607	212.269	141.338	45.216	4.707	14.971
3c	10	18	437.074	602.410	335.345	267.065	65.837	3.943	15.063
3c	10	19	281.010	324.465	216.779	107.686	30.660	1.368	10.911
3c	10	20	350.355	617.284	211.015	406.269	97.200	4.987	27.743
3c	10	21	312.959	385.060	260.010	125.050	18.021	1.149	5.758
3c	10	22	300.645	372.717	199.760	172.957	59.486	1.765	19.786
3c	10	23	262.091	309.598	215.193	94.405	19.086	1.490	7.282
3c	10	24	289.918	342.466	234.577	107.889	15.266	.788	5.266
3c	10	25	327.616	410.678	247.709	162.969	42.061	1.615	12.839
3c	10	26	929.575	325.309	223.614	101.695	18.187	1.834	6.216
3c	10	27	304.088	331.126	285.551	45.575	9.653	1.765	3.174
3c	10	28	275.624	388.954	229.621	159.333	21.860	1.763	7.931
3c	10	29	297.165	359.324	230.097	129.227	26.050	2.034	8.766
3c	10	30	297.344	372.439	218.293	154.146	31.893	1.802	10.726
3c	10	31	345.736	453.721	246.124	207.597	40.847	1.454	11.814
3c	10	32	276.183	310.366	232.288	78.078	16.922	.991	6.127
3c	10	33	338.334	415.973	215.796	200.177	70.771	2.822	20.918
3c	10	34	318.545	378.358	217.391	160.967	46.180	2.194	14.497
3c	10	35	308.776	405.351	221.043	184.308	42.835	6.824	13.873
3c	10	36	276.539	357.782	207.641	150.141	33.844	3.768	12.239
3c	10	37	306.694	383.436	204.625	178.811	47.491	4.182	15.485
3c	10	38	304.748	402.576	226.757	175.819	38.722	3.685	12.706
3c	10	39	315.349	376.506	198.098	178.408	56.455	1.359	17.902
3c	10	40	306.047	358.423	228.571	129.852	29.891	2.013	9.767
3c	10	41	293.056	369.413	201.613	167.800	42.863	4.315	14.626
3c	10	42	619.892	717.000	240.442	476.558	265.423	3.499	42.818
3c	10	43	339.059	476.644	221.190	255.454	49.866	4.055	14.707
3c	10	44	319.839	415.110	272.405	142.705	30.930	1.004	9.671
3c	10	45	307.220	388.651	218.388	170.263	26.689	1.046	8.687
3c	10	46	259.300	363.636	198.491	165.145	22.041	3.055	8.500

Subject 3c - Cantonese						*10-months*			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**330.282**	**391.813**	**231.737**	**160.076**	**39.814**	**2.289**	**11.762**
STD			106.465	80.356	28.376	76.513	38.231	1.299	6.807
			max:	**717.000**		**476.558**			
			min:		**190.585**	**45.575**			
Subject 3c - Cantonese						*Overall Scores*			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**327.165**	417.265	235.969	**182.683**	**35.609**	**2.335**	**10.901**
STD			69.380	129.731	34.376	126.973	27.855	1.824	5.742
			max:	**1585.000**		**1307.990**			
			min:		**149.000**	**45.575**			

Subject 4c - Cantonese						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4c	6	1	367.044	409.333	328.407	80.926	13.881	1.172	3.782
4c	6	2	328.413	458.505	298.597	159.908	22.458	2.407	6.838
4c	6	3	322.538	365.230	302.024	63.206	12.016	1.045	3.725
4c	6	4	377.587	424.989	274.424	150.565	29.064	.720	7.697
4c	6	5	424.633	494.560	343.053	151.507	25.311	1.386	5.961
4c	6	6	357.802	496.032	284.091	211.941	41.546	2.672	11.611
4c	6	7	392.680	480.769	257.334	223.435	38.509	2.839	9.807
4c	6	8	380.088	432.900	194.742	238.158	70.114	1.881	18.447
4c	6	9	370.094	449.438	255.951	193.487	41.687	2.560	11.264
4c	6	10	343.309	383.117	198.965	184.152	47.813	3.832	13.927
4c	6	11	306.916	353.357	191.902	161.455	18.954	1.440	6.176
4c	6	12	346.476	367.918	312.891	55.027	14.049	1.369	4.055
4c	6	13	358.685	436.681	265.745	170.936	27.167	1.506	7.574
4c	6	14	330.740	539.084	191.755	347.329	103.807	23.614	31.386
4c	6	15	340.802	454.133	197.161	256.972	75.182	5.303	22.060
4c	6	16	326.226	359.159	201.898	157.261	38.630	1.070	11.841
4c	6	17	492.334	570.776	339.443	231.333	45.223	1.165	9.185
4c	6	18	316.847	412.031	263.852	148.179	31.889	1.926	10.065
4c	6	19	309.513	393.082	260.892	132.190	22.140	1.590	7.153
4c	6	20	384.555	415.110	297.708	117.402	22.101	1.520	5.747
4c	6	21	287.757	460.405	203.046	257.359	46.096	4.504	16.019
4c	6	22	286.662	390.320	198.020	192.300	42.181	2.978	14.714
4c	6	23	379.732	518.941	301.114	217.827	18.598	.756	4.898
4c	6	24	376.176	488.998	321.337	167.661	17.390	.965	4.623
4c	6	25	286.321	329.056	190.006	139.050	43.819	4.152	15.304
4c	6	26	380.361	433.839	277.162	156.677	18.519	.663	4.869
4c	6	27	357.774	450.045	325.309	124.736	14.820	.552	4.142
4c	6	28	352.699	386.847	327.547	59.300	7.603	.493	2.156
4c	6	29	383.465	459.559	290.444	169.115	22.522	.947	5.873
4c	6	30	400.400	457.457	317.058	140.399	28.586	.846	7.139
4c	6	31	314.980	423.370	191.865	231.505	45.767	2.252	14.530
4c	6	32	312.342	397.141	190.549	206.592	70.838	2.403	22.680
4c	6	33	297.465	350.140	190.186	159.954	40.661	1.141	13.669
4c	6	34	361.182	389.257	292.569	96.688	30.043	1.043	8.318
4c	6	35	379.367	489.716	313.873	175.843	25.451	.824	6.709
4c	6	36	393.411	488.998	341.997	147.001	15.494	1.012	3.938
4c	6	37	305.741	383.289	277.393	105.896	19.337	.753	6.324
4c	6	38	365.980	402.091	281.611	120.480	23.375	1.136	6.387
4c	6	39	344.072	379.507	247.280	132.227	29.992	.633	8.717
4c	6	40	329.877	475.511	260.960	214.551	22.088	1.358	6.694
4c	6	41	339.957	368.596	253.743	114.853	15.171	.645	4.463
4c	6	42	397.099	498.753	249.563	249.190	64.809	1.056	16.321
4c	6	43	353.870	420.521	204.708	215.813	46.845	2.904	13.238
4c	6	44	293.211	423.012	261.301	161.711	16.005	1.295	5.458
4c	6	45	302.586	430.478	191.755	238.723	44.838	5.838	14.818
4c	6	46	430.571	480.538	339.213	141.325	25.995	.771	6.037
4c	6	47	442.947	505.817	374.672	131.145	36.099	1.231	8.150

4c	**6**	48	429.545	514.668	272.405	242.263	46.817	.857	10.899
4c	**6**	49	351.243	525.762	302.939	222.823	22.916	3.160	6.524
4c	**6**	50	408.104	455.996	216.123	239.873	37.793	1.931	9.261
4c	**6**	51	379.322	431.034	209.336	221.698	80.991	3.074	21.351
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**356.892**	**437.370**	**264.234**	**173.136**	**34.569**	**2.219**	**9.853**
STD			44.363	54.974	52.989	58.744	19.821	3.298	5.913
			max:	**570.776**		**347.329**			
			min:		**190.006**	**55.027**			

Subject 4c - Cantonese						***8-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4c	**8**	1	274.065	366.166	221.582	144.584	24.338	3.946	8.881
4c	**8**	2	274.464	347.343	195.733	151.610	27.299	4.780	9.946
4c	**8**	3	415.004	471.921	264.340	207.581	47.557	5.833	11.459
4c	**8**	4	438.516	467.946	390.930	77.016	22.148	.880	5.051
4c	**8**	5	428.195	508.906	362.188	146.718	20.270	.820	4.734
4c	**8**	6	417.844	474.158	317.561	156.597	22.644	.937	5.419
4c	**8**	7	403.641	507.099	201.776	305.323	91.580	2.775	22.688
4c	**8**	8	333.080	380.518	263.435	117.083	17.953	1.683	5.390
4c	**8**	9	368.553	444.840	267.666	177.174	37.421	6.201	10.153
4c	**8**	10	314.553	368.460	239.636	128.824	22.089	1.199	7.022
4c	**8**	11	319.339	396.825	231.750	165.075	33.629	3.747	10.531
4c	**8**	12	354.960	459.982	191.351	268.631	91.731	7.632	25.843
4c	**8**	13	354.609	465.983	234.852	231.131	49.189	7.409	13.871
4c	**8**	14	321.464	361.011	201.005	160.006	38.038	2.281	11.833
4c	**8**	15	355.402	409.165	330.688	78.477	12.516	1.586	3.522
4c	**8**	16	288.565	333.444	190.913	142.531	33.937	2.578	11.761
4c	**8**	17	473.996	536.193	406.339	129.854	28.652	4.018	6.045
4c	**8**	18	376.431	411.862	223.364	188.498	53.303	1.959	14.160
4c	**8**	19	315.249	372.024	214.454	157.570	33.175	1.795	10.524
4c	**8**	20	319.206	407.498	197.472	210.026	49.383	3.883	15.470
4c	**8**	21	330.983	411.184	298.063	113.121	21.843	2.107	6.599
4c	**8**	22	424.552	453.515	306.843	146.672	24.038	.630	5.662
4c	**8**	23	368.062	436.300	199.561	236.739	54.444	1.425	14.792
4c	**8**	24	422.490	458.926	298.063	160.863	27.830	1.225	6.587
4c	**8**	25	347.705	441.501	317.158	124.343	18.190	1.645	5.232
4c	**8**	26	358.709	409.500	194.894	214.606	61.067	1.942	17.024
4c	**8**	27	360.729	381.534	312.598	68.936	17.750	.802	4.921
4c	**8**	28	404.801	434.216	282.725	151.491	18.922	.532	4.674
4c	**8**	29	383.026	435.920	273.149	162.771	35.466	.852	9.259
4c	**8**	30	311.084	365.097	190.694	174.403	57.204	3.886	18.389
4c	**8**	31	314.673	376.932	281.849	95.083	10.259	.990	3.260
4c	**8**	32	347.042	472.590	193.050	279.540	43.115	4.289	12.424
4c	**8**	33	454.798	514.139	367.918	146.221	29.199	1.075	6.420
4c	**8**	34	445.422	527.148	277.085	250.063	32.875	.647	7.381
4c	**8**	35	302.669	364.166	220.848	143.318	30.854	4.092	10.194
4c	**8**	36	407.576	436.110	340.368	95.742	21.642	1.323	5.310
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**364.763**	**428.059**	**263.942**	**164.117**	**35.043**	**2.595**	**9.790**
STD			53.240	54.063	62.650	56.981	19.048	1.955	5.343
			max:	**536.193**		**305.323**			
			min:		**190.694**	**68.936**			

Subject 4c - Cantonese						***10-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4c	**10**	1	351.531	449.843	302.206	147.637	31.083	2.122	8.842
4c	**10**	2	263.866	347.584	222.321	125.263	29.450	5.280	11.161
4c	**10**	3	379.029	415.455	230.734	184.721	43.045	.766	11.357
4c	**10**	4	268.051	371.058	208.551	162.507	21.677	2.127	8.087
4c	**10**	5	370.730	491.884	245.942	245.942	68.064	2.701	18.360
4c	**10**	6	299.483	405.844	208.638	197.206	45.830	1.594	15.303
4c	**10**	7	366.035	739.645	200.803	538.842	92.473	8.166	25.264
4c	**10**	8	372.373	471.921	216.920	255.001	52.961	.776	14.223
4c	**10**	9	279.500	341.413	190.585	150.828	45.023	2.886	16.109
4c	**10**	10	314.029	401.284	216.029	185.255	41.500	2.890	13.215
4c	**10**	11	311.514	455.373	196.812	258.561	46.130	4.952	14.808
4c	**10**	12	391.222	515.198	268.817	246.381	68.712	2.902	17.563
4c	**10**	13	414.835	527.704	269.469	258.235	42.720	3.035	10.278
4c	**10**	14	293.206	483.092	190.476	292.616	34.571	2.323	11.791
4c	**10**	15	413.816	535.619	218.531	317.088	76.775	3.391	18.553
4c	**10**	16	354.065	399.680	290.867	108.813	30.392	3.077	8.584
4c	**10**	17	339.028	465.983	277.162	188.821	30.842	2.973	9.097
4c	**10**	18	302.485	339.674	194.099	145.575	36.613	4.452	12.104
4c	**10**	19	304.705	373.972	215.239	158.733	40.272	4.560	13.217
4c	**10**	20	314.466	380.662	213.584	167.078	43.627	3.373	13.873
4c	**10**	21	279.402	406.504	246.792	159.712	20.762	3.095	7.431
4c	**10**	22	328.803	416.840	234.192	182.648	39.539	4.368	12.025
4c	**10**	23	407.286	444.642	271.297	173.345	41.275	.780	10.134
4c	**10**	24	318.651	438.596	214.777	223.819	31.714	2.058	9.953
4c	**10**	25	333.918	388.199	245.339	142.860	30.241	2.166	9.056
4c	**10**	26	315.600	372.024	233.809	138.215	23.567	1.851	7.468
4c	**10**	27	364.604	670.241	262.743	407.498	64.508	1.237	17.693
4c	**10**	28	316.415	356.761	216.263	140.498	32.283	1.735	10.203
4c	**10**	29	305.092	383.654	195.160	188.494	71.800	5.383	23.534
4c	**10**	30	375.856	415.800	305.437	110.363	22.742	.798	6.051
4c	**10**	31	366.068	419.111	216.216	202.895	33.804	2.176	9.234
4c	**10**	32	256.993	553.097	192.567	360.530	41.331	8.403	16.083
4c	**10**	33	243.010	265.252	196.117	69.135	15.370	1.906	6.325
4c	**10**	34	327.684	406.339	229.463	176.876	46.368	1.058	14.150
4c	**10**	35	289.599	471.698	213.356	258.342	24.864	3.253	8.586
4c	**10**	36	414.642	487.092	382.555	104.537	12.409	1.035	2.993
4c	**10**	37	324.682	395.257	197.122	198.135	65.194	7.371	20.079
4c	**10**	38	301.578	399.042	200.200	198.842	27.406	2.409	9.088
4c	**10**	39	380.164	442.087	330.688	111.399	19.516	1.296	5.133
4c	**10**	40	316.102	373.274	224.266	149.008	33.963	2.009	10.744
4c	**10**	41	294.414	366.838	203.376	163.462	37.113	3.226	12.606
4c	**10**	42	313.085	419.639	198.177	221.462	60.722	2.726	19.395
4c	**10**	43	322.895	404.694	201.086	203.608	44.967	2.057	13.926
4c	**10**	44	353.046	552.486	253.229	299.257	53.155	9.009	15.056
4c	**10**	45	320.048	521.376	190.042	331.334	53.155	8.497	22.618
4c	**10**	46	514.650	632.911	198.491	434.420	149.332	3.702	29.016
4c	**10**	47	316.597	463.607	224.972	238.635	51.862	22.205	16.381

4c	**10**	48	294.427	376.081	202.634	173.447	40.647	2.295	13.805
4c	**10**	49	338.335	569.801	232.612	337.189	57.358	11.785	16.953
4c	**10**	50	270.125	376.790	197.239	179.551	29.033	4.100	10.748
4c	**10**	51	350.943	451.467	287.109	164.358	23.622	2.993	6.731
4c	**10**	52	303.673	369.413	230.362	139.051	33.335	1.894	10.977
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**331.968**	**440.837**	**230.874**	**209.962**	**43.360**	**3.716**	**12.999**
STD			49.195	87.191	40.250	90.162	22.365	3.520	5.278
			max:	**739.645**		**538.842**			
			min:		**190.042**	**69.135**			
Subject 4c - Cantonese						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**349.607**	436.255	251.678	**184.577**	**37.980**	**2.876**	**11.014**
STD			50.231	68.350	53.592	74.017	20.897	3.152	5.708
			max:	**739.645**		**538.842**			
			min:		**190.006**	**55.027**			

Subject 5c - Cantonese						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5c	**6**	1	371.567	390.320	320.000	70.320	13.448	3.182	3.619
5c	**6**	2	333.161	368.732	289.519	79.213	20.343	1.414	6.106
5c	**6**	3	339.482	352.361	282.725	69.636	10.934	.975	3.221
5c	**6**	4	315.560	485.673	236.798	248.875	41.903	5.572	13.279
5c	**6**	5	369.217	433.088	282.247	150.841	30.791	1.813	8.339
5c	**6**	6	382.223	428.082	346.141	81.941	25.012	1.740	6.544
5c	**6**	7	373.046	437.063	340.483	96.580	12.093	1.618	3.242
5c	**6**	8	367.492	430.663	251.509	179.154	34.984	3.033	9.520
5c	**6**	9	357.075	382.409	301.568	80.841	24.852	.649	6.960
5c	**6**	10	346.235	489.476	212.540	276.936	40.713	5.400	11.759
5c	**6**	11	398.795	549.149	354.484	194.665	20.326	1.432	5.097
5c	**6**	12	399.855	444.642	373.274	71.368	13.055	1.156	3.265
5c	**6**	13	360.283	439.367	313.676	125.691	20.688	1.488	5.742
5c	**6**	14	331.841	365.230	293.255	71.975	16.433	1.221	4.952
5c	**6**	15	399.890	475.964	361.795	114.169	18.892	1.476	4.724
5c	**6**	16	422.601	464.900	295.770	169.130	38.410	1.119	9.089
5c	**6**	17	323.299	385.951	259.471	126.480	23.542	5.611	7.282
5c	**6**	18	413.161	467.508	311.915	155.593	40.580	2.343	9.822
5c	**6**	19	336.532	439.174	280.899	158.275	27.671	2.227	8.222
5c	**6**	20	364.948	554.017	224.266	329.751	50.239	3.652	13.766
5c	**6**	21	427.943	468.165	388.500	79.665	15.852	2.157	3.704
5c	**6**	22	371.738	447.227	283.046	164.181	22.318	2.895	6.004
5c	**6**	23	306.934	319.898	273.598	46.300	10.303	1.037	3.357
5c	**6**	24	326.858	364.166	291.375	72.791	13.405	1.129	4.101
5c	**6**	25	314.512	389.408	273.748	115.660	20.023	1.560	6.366
5c	**6**	26	361.763	405.680	335.458	70.222	10.779	.713	2.980
5c	**6**	27	349.730	409.836	325.627	84.209	13.952	.946	3.989
5c	**6**	28	351.414	385.802	299.940	85.862	18.602	1.129	5.294
5c	**6**	29	347.259	410.172	282.566	127.606	23.432	3.244	6.748
5c	**6**	30	376.299	412.712	348.432	64.280	11.963	.990	3.179
5c	**6**	31	379.092	440.141	306.843	133.298	30.453	1.290	8.033
5c	**6**	32	358.869	431.779	297.354	134.425	24.280	1.073	6.766
5c	**6**	33	329.246	366.032	291.630	74.402	17.623	1.890	5.352
5c	**6**	34	367.563	407.000	328.731	78.269	18.085	1.281	4.920
5c	**6**	35	371.357	412.371	320.513	91.858	20.294	1.192	5.465
5c	**6**	36	379.370	441.696	322.061	119.635	31.420	2.313	8.282
5c	**6**	37	335.945	390.320	203.915	186.405	43.925	6.354	13.075
5c	**6**	38	335.326	364.697	253.743	110.954	22.767	1.669	6.790
5c	**6**	39	343.574	369.413	295.159	74.254	16.355	1.508	4.760
5c	**6**	40	323.837	387.297	283.366	103.931	18.017	2.228	5.563
5c	**6**	41	315.446	364.830	254.065	110.765	19.259	2.423	6.105
5c	**6**	42	340.299	434.594	258.799	175.795	28.812	3.213	8.467
5c	**6**	43	315.074	370.782	253.550	117.232	16.858	2.456	5.350
5c	**6**	44	352.306	420.345	255.232	165.113	26.003	1.588	7.381
5c	**6**	45	339.397	380.228	299.043	81.185	12.170	1.556	3.586
5c	**6**	46	342.783	409.836	287.109	122.727	15.174	1.990	4.427
5c	**6**	47	346.038	397.456	301.659	95.797	19.569	1.635	5.655

5c	**6**	48	349.395	423.370	268.962	154.408	18.413	1.742	5.270
5c	**6**	49	321.154	380.228	192.271	187.957	66.789	3.379	20.797
5c	**6**	50	323.049	360.490	274.879	85.611	19.945	1.682	6.174
5c	**6**	51	327.523	381.534	268.962	112.572	14.708	.735	4.491
5c	**6**	52	334.549	465.333	302.115	163.218	13.061	.841	3.904
5c	**6**	53	322.520	351.494	218.055	133.439	30.406	1.334	9.428
5c	**6**	54	361.790	443.066	229.148	213.918	45.497	3.289	12.575
5c	**6**	55	315.269	462.321	225.023	237.298	41.473	5.987	13.155
5c	**6**	56	329.542	373.134	234.357	138.777	22.800	1.642	6.919
5c	**6**	57	328.664	348.189	280.112	68.077	14.034	.771	4.270
5c	**6**	58	335.903	412.031	277.932	134.099	23.504	1.875	6.997
5c	**6**	59	351.579	424.088	279.330	144.758	29.065	2.002	8.267
5c	**6**	60	355.016	416.146	293.858	122.288	19.302	1.711	5.437
5c	**6**	61	354.417	393.546	282.008	111.538	19.228	2.207	5.425
5c	**6**	62	339.602	398.089	249.128	148.961	22.648	2.248	6.669
5c	**6**	63	332.320	356.125	285.878	70.247	21.773	2.155	6.552
5c	**6**	64	357.232	386.698	306.373	80.325	17.671	2.654	4.947
5c	**6**	65	357.088	403.714	301.568	102.146	17.370	1.732	4.864
5c	**6**	66	383.511	467.508	339.905	127.603	19.581	2.233	5.106
5c	**6**	67	356.678	446.229	261.643	184.586	30.602	4.310	8.580
5c	**6**	68	368.220	395.883	294.811	101.072	18.048	.872	4.901
5c	**6**	69	308.405	343.879	253.421	90.458	23.343	1.854	7.569
5c	**6**	70	348.602	388.048	276.549	111.499	20.111	1.403	5.769
5c	**6**	71	334.047	395.413	301.205	94.208	14.928	1.522	4.482
5c	**6**	72	332.432	375.094	286.944	88.150	22.827	1.479	6.867
5c	**6**	73	351.116	397.772	289.352	108.420	22.724	1.807	6.472
5c	**6**	74	370.944	408.664	252.653	156.011	32.171	1.192	8.673
5c	**6**	75	373.472	450.450	272.777	177.673	32.492	2.084	8.700
5c	**6**	76	342.305	408.330	274.499	133.831	20.166	2.372	5.891
5c	**6**	77	376.215	447.227	194.590	252.637	60.505	4.104	16.082
5c	**6**	78	347.647	447.227	259.605	187.622	22.210	2.893	6.389
5c	**6**	79	343.923	384.320	260.146	124.174	19.896	1.750	5.785
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**351.270**	**411.662**	**283.993**	**127.669**	**23.847**	**2.107**	**6.806**
STD			25.787	43.393	39.083	53.639	10.936	1.243	3.148
			max:	**554.017**		**329.751**			
			min:		**192.271**	**46.300**			

Subject 5c - Cantonese						***8-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5c	**8**	1	374.540	411.523	338.295	73.228	12.982	1.036	3.466
5c	**8**	2	308.335	376.506	205.634	170.872	34.793	4.974	11.284
5c	**8**	3	380.015	442.674	346.981	95.693	11.651	1.139	3.066
5c	**8**	4	344.595	454.959	284.414	170.545	27.791	3.051	8.065
5c	**8**	5	325.538	346.981	276.319	70.662	12.843	2.060	3.945
5c	**8**	6	426.666	440.529	406.669	33.860	5.225	.477	1.225
5c	**8**	7	394.685	479.846	289.855	189.991	27.304	1.153	6.918
5c	**8**	8	342.463	453.104	214.823	238.281	44.649	2.853	13.038
5c	**8**	9	372.385	524.384	238.209	286.175	35.951	2.836	9.654
5c	**8**	10	377.687	491.400	191.608	299.792	79.122	2.596	20.949
5c	**8**	11	388.868	455.373	242.424	212.949	44.080	.881	11.335
5c	**8**	12	499.921	777.001	299.401	477.600	56.225	.779	11.247
5c	**8**	13	415.502	458.926	191.424	267.502	39.570	.643	9.524
5c	**8**	14	414.573	464.037	362.319	101.718	21.144	1.002	5.100
5c	**8**	15	517.323	639.795	355.366	284.429	46.652	.938	9.018
5c	**8**	16	508.496	569.801	323.729	246.072	58.976	.647	11.598
5c	**8**	17	332.719	380.952	195.427	185.525	60.615	3.688	18.218
5c	**8**	18	391.136	521.648	249.938	271.710	46.453	1.022	11.876
5c	**8**	19	351.535	379.507	311.042	68.465	17.208	.789	4.895
5c	**8**	20	472.037	615.764	354.862	260.902	48.900	1.661	10.359
5c	**8**	21	475.281	612.745	284.414	328.331	66.201	3.267	13.929
5c	**8**	22	459.857	619.195	252.207	366.988	51.988	.872	11.305
5c	**8**	23	359.828	468.384	272.702	195.682	24.111	2.170	6.701
5c	**8**	24	372.750	414.250	208.247	206.003	42.293	1.177	11.346
5c	**8**	25	444.967	597.000	271.887	325.113	52.329	1.732	11.760
5c	**8**	26	320.665	386.698	251.130	135.568	25.682	1.608	8.009
5c	**8**	27	350.544	372.995	294.985	78.010	16.375	1.345	4.671
5c	**8**	28	369.745	431.965	308.166	123.799	30.926	2.433	8.364
5c	**8**	29	346.025	400.481	319.693	80.788	18.954	2.910	5.477
5c	**8**	30	381.266	547.945	208.464	339.481	68.223	3.244	17.894
5c	**8**	31	362.948	402.253	322.269	79.984	12.763	1.962	3.516
5c	**8**	32	381.895	421.053	334.001	87.052	16.781	1.559	4.394
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**392.650**	**479.990**	**281.466**	**198.524**	**36.211**	**1.828**	**9.130**
STD			56.264	98.497	57.154	108.459	19.376	1.084	4.673
			max:	**777.001**		**477.600**			
			min:		**191.424**	**33.860**			

Subject 5c - Cantonese						***10-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5c	10	1	362.116	390.625	312.402	78.223	18.457	1.481	5.097
5c	10	2	316.099	349.528	285.878	63.650	11.750	1.542	3.717
5c	10	3	363.325	403.388	317.662	85.726	19.435	2.665	5.349
5c	10	4	326.938	354.484	300.030	54.454	11.568	1.663	3.538
5c	10	5	347.967	391.236	328.839	62.397	12.138	1.502	3.488
5c	10	6	376.819	460.829	326.904	133.925	20.056	2.066	5.323
5c	10	7	348.909	501.253	227.480	273.773	43.379	5.599	12.433
5c	10	8	317.799	372.995	271.076	101.919	14.625	1.487	4.602
5c	10	9	357.494	453.926	199.681	254.245	52.907	5.833	14.800
5c	10	10	303.149	414.594	264.690	149.904	24.872	1.855	8.204
5c	10	11	318.260	569.476	250.438	319.038	46.637	2.911	14.654
5c	10	12	311.648	383.289	234.467	148.822	22.776	1.889	7.308
5c	10	13	353.921	492.126	312.891	179.235	25.483	.908	7.200
5c	10	14	323.530	497.760	254.323	243.437	26.507	1.669	8.193
5c	10	15	340.696	367.107	248.385	118.722	24.030	2.227	7.053
5c	10	16	330.349	358.551	302.024	56.527	10.620	1.122	3.215
5c	10	17	302.702	472.813	232.180	240.633	33.720	7.435	11.140
5c	10	18	341.795	423.729	306.560	117.169	19.787	2.356	5.789
5c	10	19	287.129	429.369	206.569	222.800	24.887	1.480	8.668
5c	10	20	344.230	481.000	206.484	274.516	44.207	3.233	12.842
5c	10	21	347.382	502.260	289.268	212.992	19.732	1.487	5.680
5c	10	22	602.019	744.602	429.185	315.417	62.095	4.093	10.314
5c	10	23	310.261	365.364	246.184	119.180	30.442	1.313	9.812
5c	10	24	339.112	362.713	282.646	80.067	19.789	.860	5.836
5c	10	25	312.796	365.764	255.493	110.271	15.058	1.222	4.814
5c	10	26	312.222	350.754	266.170	84.584	16.193	.755	5.186
5c	10	27	324.673	416.146	277.778	138.368	14.668	1.913	4.518
5c	10	28	334.417	783.699	195.160	588.539	40.713	5.135	12.174
5c	10	29	344.254	399.202	276.702	122.500	27.217	1.495	7.906
5c	10	30	432.585	558.659	297.354	261.305	85.043	26.924	19.659
5c	10	31	347.321	395.101	267.594	127.507	24.765	1.306	7.130
5c	10	32	341.238	412.201	249.626	162.575	38.655	3.858	11.328
5c	10	33	298.503	388.954	260.349	128.605	16.763	1.740	5.616
5c	10	34	303.854	396.354	189.502	206.852	35.656	2.926	11.735
5c	10	35	308.956	342.583	232.883	109.700	17.053	1.382	5.519
5c	10	36	301.126	376.364	269.107	107.257	14.465	1.563	4.804
5c	10	37	315.566	342.114	293.341	48.773	9.571	1.428	3.033
5c	10	38	342.501	470.367	229.621	240.746	39.222	1.562	11.452
5c	10	39	413.206	461.894	361.402	100.492	23.972	1.100	5.801
5c	10	40	356.838	484.966	265.182	219.784	41.554	2.255	11.645
5c	10	41	332.662	479.157	190.114	289.043	50.833	4.004	15.281
5c	10	42	393.744	523.013	316.857	206.156	43.557	1.937	11.062
5c	10	43	306.201	336.474	254.065	82.409	12.951	1.272	4.230
5c	10	44	310.714	391.389	236.967	154.422	29.232	1.428	9.408
5c	10	45	305.226	332.447	231.321	101.126	12.852	1.487	4.211
5c	10	46	440.935	535.045	310.174	224.871	89.459	1.396	20.288
5c	10	47	566.478	706.714	332.889	373.825	69.667	3.252	12.298

5c	**10**	48	319.499	390.320	253.100	137.220	33.291	.988	10.420
5c	**10**	49	457.552	730.994	247.280	483.714	70.510	5.708	15.410
5c	**10**	50	715.420	916.590	365.497	551.093	184.344	2.858	25.767
5c	**10**	51	455.959	747.943	215.983	531.960	153.506	6.237	33.667
5c	**10**	52	428.995	660.939	199.203	461.736	102.011	6.305	23.779
5c	**10**	53	450.652	781.250	294.118	487.132	82.278	3.499	18.258
5c	**10**	54	354.631	397.298	278.087	119.211	35.812	1.139	10.099
5c	**10**	55	377.302	553.710	282.566	271.144	44.509	2.616	11.797
5c	**10**	56	327.748	347.343	269.833	77.510	16.200	1.143	4.943
5c	**10**	57	301.417	417.711	190.803	226.908	53.676	3.780	17.808
5c	**10**	58	282.970	388.500	214.546	173.954	23.853	2.663	8.430
5c	**10**	59	367.855	458.505	315.358	143.147	23.749	1.341	6.456
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**358.638**	**467.517**	**268.174**	**199.343**	**37.843**	**2.852**	**9.834**
STD			77.286	133.393	48.003	132.650	32.762	3.559	6.091
			max:	**916.590**		**588.539**			
			min:		**189.502**	**48.773**			
Subject 5c - Cantonese						***Overall Score***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**361.617**	443.909	278.027	**165.881**	**31.032**	**2.313**	**8.294**
STD			56.329	98.400	46.344	103.922	23.191	2.333	4.828
			max:	**916.590**		**588.539**			
			min:		**189.502**	**33.860**			

Subject 2e - Englis						***6-month***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
2e	**6**	1	286.544	319.285	274.123	45.162	5.395	.727	1.883
2e	**6**	2	277.901	402.253	219.635	182.618	37.621	11.228	13.538
2e	**6**	3	293.525	434.594	211.551	223.043	50.501	20.882	17.205
2e	**6**	4	333.445	394.322	257.202	137.120	30.995	3.464	9.295
2e	**6**	5	320.756	366.972	284.414	82.558	17.643	1.427	5.500
2e	**6**	6	299.318	341.763	242.895	98.868	22.673	.962	7.575
2e	**6**	7	302.600	381.825	234.852	146.973	41.500	2.080	13.715
2e	**6**	8	330.263	410.509	231.374	179.135	58.411	3.438	17.686
2e	**6**	9	286.548	426.803	190.114	236.689	69.167	24.416	24.138
2e	**6**	10	426.411	546.747	334.672	212.075	61.110	6.261	14.331
2e	**6**	11	345.962	457.247	250.376	206.871	21.590	2.723	6.241
2e	**6**	12	326.077	408.163	232.019	176.144	37.416	4.083	11.475
2e	**6**	13	333.114	440.141	237.925	202.216	40.841	4.502	12.260
2e	**6**	14	416.107	503.525	307.409	196.116	42.123	1.480	10.123
2e	**6**	15	331.749	422.119	243.724	178.395	27.595	4.046	8.318
2e	**6**	16	310.495	357.782	202.224	155.558	27.243	.962	8.774
2e	**6**	17	362.584	451.671	286.369	165.302	27.044	3.633	7.459
2e	**6**	18	504.158	769.231	337.496	431.735	127.642	8.157	25.318
2e	**6**	19	392.826	582.072	332.226	249.846	36.097	5.328	9.189
2e	**6**	20	359.198	501.002	244.918	256.084	48.358	10.061	13.463
2e	**6**	21	285.687	367.512	213.812	153.700	35.994	6.795	12.599
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**339.298**	442.168	255.682	**186.486**	**41.284**	**6.031**	**11.909**
STD			56.269	99.734	43.638	77.280	24.915	6.263	5.737
			max:	**769.231**		**431.735**			
			min:		**190.114**	**45.162**			

Subject 2e - Englis						8-months			
ID	Age	#	Avg. Fo	High Fo	Low Fo	Fo range	STD	Sppq	vFo
2e	8	1	273.352	306.279	218.341	87.938	21.639	1.589	7.916
2e	8	2	284.030	356.888	221.190	135.698	18.109	2.453	6.376
2e	8	3	267.085	302.663	197.044	105.619	27.044	4.082	10.126
2e	8	4	327.079	412.712	207.082	205.630	51.570	4.026	15.767
2e	8	5	443.331	460.829	397.456	63.373	12.964	.852	2.924
2e	8	6	298.938	315.756	247.219	68.537	15.999	2.113	5.352
2e	8	7	271.659	345.543	197.355	148.188	31.760	3.599	11.691
2e	8	8	480.481	636.943	251.383	385.560	112.487	2.482	23.411
2e	8	9	265.580	300.842	196.618	104.224	30.463	2.010	11.470
2e	8	10	282.512	486.855	211.685	275.170	31.372	5.020	11.105
2e	8	11	257.432	378.931	223.614	155.317	19.104	3.262	7.421
2e	8	12	412.549	463.607	264.901	198.706	58.790	1.695	14.250
2e	8	13	443.802	465.983	388.500	77.483	22.025	1.598	4.963
2e	8	14	276.361	452.284	216.029	236.255	36.803	3.987	13.317
2e	8	15	329.687	360.101	246.488	113.613	28.820	4.810	8.742
2e	8	16	368.483	404.694	232.721	171.973	39.992	1.886	10.853
2e	8	17	324.770	381.098	260.010	121.088	35.659	3.014	10.980
2e	8	18	291.105	424.628	214.777	209.851	24.726	2.033	8.494
2e	8	19	384.001	448.632	277.239	171.393	27.863	1.143	7.256
2e	8	20	353.629	485.437	262.674	222.763	63.620	3.324	17.990
2e	8	21	413.015	499.251	213.858	285.393	56.658	2.857	13.718
2e	8	22	299.802	351.494	228.885	122.609	22.102	2.039	7.372
2e	8	23	318.549	535.332	231.857	303.475	30.305	2.936	9.513
2e	8	24	504.541	627.746	210.217	417.529	117.529	9.287	23.294
2e	8	25	261.716	287.191	211.999	75.192	19.644	1.334	7.506
2e	8	26	295.311	349.284	238.322	110.962	20.377	1.738	6.900
2e	8	27	329.673	367.647	305.810	61.837	17.343	4.269	5.261
2e	8	28	321.088	560.852	226.040	334.812	32.831	3.394	10.225
2e	8	29	378.062	452.080	452.080	246.063	52.587	.987	13.910
2e	8	30	283.384	452.489	217.014	235.475	32.191	3.045	11.360
2e	8	31	508.028	884.173	318.979	565.194	135.153	4.412	26.603
2e	8	32	389.109	484.262	312.305	171.957	36.274	5.615	9.322
2e	8	33	327.023	457.666	252.016	205.650	36.297	3.382	11.099
2e	8	34	364.749	472.590	272.480	200.110	43.063	6.570	11.806
2e	8	35	282.607	315.956	231.589	84.367	18.934	4.025	6.700
2e	8	36	294.994	338.983	214.270	124.713	37.078	1.985	12.569
2e	8	37	301.789	368.460	208.160	160.300	36.678	3.846	12.153
2e	8	38	324.322	416.667	270.709	145.958	22.840	1.762	7.043
2e	8	39	275.643	384.911	198.334	186.577	30.035	4.756	10.896
2e	8	40	316.982	344.116	257.798	86.318	24.403	1.235	7.699
2e	8	41	294.902	330.797	195.046	135.751	27.507	2.975	9.328
2e	8	42	281.596	325.309	253.936	71.373	15.276	4.047	5.425
2e	8	43	283.158	376.932	221.092	155.840	31.218	6.314	11.025
2e	8	44	388.561	550.358	255.689	294.669	64.580	3.441	16.620
2e	8	45	310.779	585.138	244.260	340.878	37.967	8.559	12.217
2e	8	46	278.109	467.946	198.059	269.887	41.105	4.668	14.780
2e	8	47	424.209	504.286	289.855	214.431	68.694	3.459	16.193

2e	**8**	48	415.367	516.262	269.324	246.938	97.927	4.610	23.576
2e	**8**	49	356.201	466.636	252.525	214.111	63.058	3.705	17.703
2e	**8**	50	353.518	464.684	247.709	216.975	62.250	4.225	17.609
2e	**8**	51	370.071	392.465	318.471	73.994	15.318	1.438	4.139
2e	**8**	52	328.836	374.813	245.580	129.233	24.154	2.854	7.345
2e	**8**	53	300.634	364.964	237.982	126.982	31.720	6.727	10.551
2e	**8**	54	367.896	449.035	220.410	228.625	43.437	3.866	11.807
2e	**8**	55	313.367	371.609	249.875	121.734	24.552	4.193	7.835
2e	**8**	56	322.115	395.101	251.572	143.529	31.132	6.051	9.665
2e	**8**	57	277.118	339.213	197.785	141.428	23.017	2.749	8.306
2e	**8**	58	350.922	474.608	222.767	251.841	66.648	1.855	18.992
2e	**8**	59	340.069	413.223	267.380	145.843	25.459	4.334	7.486
2e	**8**	60	305.529	444.444	217.533	226.911	39.279	6.274	12.856
2e	**8**	61	323.069	424.628	229.832	194.796	36.096	7.807	11.173
2e	**8**	62	564.841	1002.004	285.063	716.941	199.503	7.139	35.320
2e	**8**	63	382.310	499.002	249.626	249.376	36.719	3.119	9.604
2e	**8**	64	328.207	500.000	233.918	266.082	36.763	5.387	11.201
2e	**8**	65	358.816	424.448	271.370	153.078	27.907	2.446	7.778
2e	**8**	66	317.551	497.512	197.044	300.468	59.286	10.348	18.670
2e	**8**	67	335.350	350.385	307.503	42.882	9.817	1.300	2.927
2e	**8**	68	468.129	632.911	322.269	310.642	61.459	4.185	13.129
2e	**8**	69	319.465	446.828	198.373	248.455	54.940	5.925	17.197
2e	**8**	70	360.523	390.930	301.205	89.725	24.583	3.008	6.819
2e	**8**	71	318.526	443.459	229.200	214.259	39.138	6.575	12.287
2e	**8**	72	461.419	545.256	376.364	168.892	36.685	3.165	7.950
2e	**8**	73	329.373	353.607	304.229	49.378	8.872	.859	2.694
2e	**8**	74	465.398	562.114	354.862	207.252	37.160	2.957	7.985
2e	**8**	75	313.544	422.297	228.102	194.195	40.273	11.842	12.844
2e	**8**	76	298.900	421.408	232.450	188.958	29.873	5.400	9.994
2e	**8**	77	339.673	564.334	236.686	327.648	50.233	5.831	14.789
2e	**8**	78	266.632	342.231	201.369	140.862	21.950	3.970	8.232
2e	**8**	79	275.746	326.797	220.361	106.436	20.770	1.452	7.532
2e	**8**	80	255.991	361.011	192.456	168.555	23.710	5.196	9.262
2e	**8**	81	490.995	613.121	327.439	285.682	85.877	2.486	17.490
2e	**8**	82	259.014	330.469	191.644	138.825	24.724	5.069	9.545
2e	**8**	83	316.151	341.647	273.523	68.124	10.878	1.492	3.441
2e	**8**	84	339.521	371.747	265.041	106.706	20.516	1.336	6.043
2e	**8**	85	365.455	496.278	317.058	179.220	31.046	2.620	8.495
2e	**8**	86	330.730	373.552	264.831	108.721	20.726	1.242	6.267
2e	**8**	87	299.950	452.284	204.584	247.700	44.707	4.420	14.905
2e	**8**	88	366.094	523.834	297.796	226.038	26.799	3.069	7.320
2e	**8**	89	371.898	396.825	323.311	73.514	18.025	3.100	4.847
2e	**8**	90	320.887	417.188	206.612	210.576	53.090	2.871	16.545
2e	**8**	91	381.400	558.036	210.615	347.421	66.601	5.528	17.462
2e	**8**	92	469.854	598.086	353.607	244.479	51.433	2.477	10.947
2e	**8**	93	317.676	375.235	255.624	119.611	29.063	2.480	9.149
2e	**8**	94	378.425	459.137	305.998	153.139	26.297	2.431	6.949
2e	**8**	95	396.720	482.160	225.175	256.985	50.395	3.410	12.703
2e	**8**	96	331.542	372.856	273.149	99.707	23.585	2.378	7.114
2e	**8**	97	297.713	330.251	240.964	89.287	20.570	3.161	6.909

2e	**8**	98	353.174	435.730	238.550	197.180	62.108	2.979	17.636
2e	**8**	99	337.386	396.983	244.081	152.902	37.066	3.159	10.986
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**342.397**	440.265	253.069	**189.682**	**39.663**	**3.681**	**11.121**
STD			63.979	110.413	49.906	104.266	27.658	2.051	5.356
			max:	**1002.004**		**716.941**			
			min:		**191.644**	**42.882**			

Subject 2e - Englis						*10-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
2e	10	1	441.476	522.193	296.824	225.369	90.543	1.227	20.509
2e	10	2	431.844	558.347	283.447	274.900	60.711	1.060	14.058
2e	10	3	455.109	572.410	258.532	313.878	60.802	3.989	13.360
2e	10	4	285.818	318.979	191.571	127.408	26.756	1.904	9.361
2e	10	5	471.781	581.734	199.800	381.934	108.800	3.040	23.062
2e	10	6	403.919	546.448	195.771	350.677	99.506	4.660	24.635
2e	10	7	449.818	497.512	301.659	195.853	34.124	.843	7.586
2e	10	8	712.456	985.222	354.484	630.738	182.205	7.456	25.574
2e	10	9	410.139	536.193	215.378	320.815	107.741	8.263	26.269
2e	10	10	420.533	548.246	287.439	260.807	70.831	4.547	16.847
2e	10	11	327.845	515.996	226.244	289.752	27.816	2.536	8.484
2e	10	12	334.726	435.730	229.779	205.951	39.633	1.056	11.840
2e	10	13	373.772	547.345	307.314	240.031	37.987	3.325	10.163
2e	10	14	258.082	289.101	227.015	62.086	17.264	2.477	6.690
2e	10	15	254.825	339.213	223.864	115.349	16.236	3.746	6.372
2e	10	16	359.300	424.268	259.605	164.663	40.109	2.151	11.163
2e	10	17	398.497	735.835	234.962	500.873	76.702	6.945	19.248
2e	10	18	282.524	416.146	236.911	179.235	27.268	3.031	9.652
2e	10	19	346.998	419.992	217.770	202.222	45.738	2.910	13.181
2e	10	20	283.518	451.060	203.998	247.062	31.902	4.588	11.252
2e	10	21	265.049	357.270	221.828	135.442	21.936	4.040	8.276
2e	10	22	323.651	482.393	272.554	209.839	42.302	3.869	13.070
2e	10	23	366.155	467.508	242.072	225.436	40.905	4.778	11.172
2e	10	24	388.176	420.698	254.065	166.633	26.230	1.542	6.757
2e	10	25	278.299	347.102	206.313	140.789	23.926	1.337	8.597
2e	10	26	442.836	529.381	229.253	300.128	91.553	2.234	20.674
2e	10	27	364.532	565.931	296.472	269.459	39.492	6.745	10.834
2e	10	28		1600.000	256.739	1343.261			
2e	10	29	361.860	482.160	252.781	229.379	56.851	2.483	15.711
2e	10	30	347.708	518.941	289.855	229.086	40.620	10.939	11.682
2e	10	31	382.212	427.533	227.635	199.898	43.536	1.050	11.390
2e	10	32	421.387	751.315	202.675	548.640	90.198	6.692	21.405
2e	10	33	277.105	411.353	202.388	208.965	27.737	5.685	10.010
2e	10	34	405.355	534.188	242.836	291.352	53.276	1.351	13.143
2e	10	35	487.477	532.198	249.314	282.884	68.235	2.210	13.998
2e	10	36	407.033	478.011	306.843	171.168	46.089	.970	11.323
2e	10	37	350.450	426.985	250.501	176.484	47.346	4.097	13.510
2e	10	38	374.516	460.193	249.563	210.630	46.292	3.371	12.361
2e	10	39	425.459	515.464	238.663	276.801	67.417	1.134	15.846
2e	10	40		1750.000	277.162	1472.838			
2e	10	41	365.557	565.611	214.316	351.295	71.710	9.238	19.617
2e	10	42	363.373	458.716	200.884	257.832	74.862	3.342	20.602
2e	10	43	352.375	410.341	252.525	157.816	22.984	2.644	6.523
2e	10	44	309.733	407.166	234.742	172.424	23.638	1.126	7.632
2e	10	45	323.279	487.329	233.645	253.684	31.895	3.627	9.866
2e	10	46	371.954	426.257	302.206	124.051	29.475	1.741	7.924
2e	10	47	534.313	1064.963	285.878	779.085	139.021	5.087	26.019

2e	**10**	48	296.051	333.778	235.682	98.096	17.273	3.375	5.834
2e	**10**	49	447.036	599.161	276.932	322.229	58.607	2.384	13.110
2e	**10**	50	466.419	1004.016	240.211	763.805	156.634	5.637	33.582
2e	**10**	51	477.764	819.672	239.464	580.208	66.400	3.597	13.898
2e	**10**	52	290.686	488.759	205.423	283.336	38.289	6.959	13.172
2e	**10**	53	340.491	458.505	249.377	209.128	36.664	4.148	10.768
2e	**10**	54	331.870	416.493	226.655	189.838	38.296	2.819	11.539
2e	**10**	55	433.987	551.876	258.665	293.211	45.111	3.809	10.395
2e	**10**	56	365.176	402.739	267.809	134.930	23.948	1.654	6.558
2e	**10**	57	494.671	761.035	237.361	523.674	117.565	6.536	23.766
2e	**10**	58	429.924	641.026	199.880	441.146	82.647	5.196	19.224
2e	**10**	59	324.839	478.011	190.949	287.062	66.009	4.168	20.320
2e	**10**	60	352.087	458.926	271.444	187.482	42.428	5.511	12.050
2e	**10**	61	313.924	335.796	260.892	74.904	17.888	.867	5.698
2e	**10**	62	473.555	686.342	201.816	484.526	126.238	4.634	26.657
2e	**10**	63	427.965	704.722	278.009	426.713	106.580	3.930	24.904
2e	**10**	64	498.421	585.480	242.601	342.879	96.446	.983	19.350
2e	**10**	65	416.684	501.505	226.552	274.953	65.430	1.074	15.703
2e	**10**	66	284.747	320.410	231.965	88.445	21.209	1.366	7.448
2e	**10**	67	308.902	359.971	211.372	148.599	36.739	3.417	11.894
2e	**10**	68	290.919	373.832	239.981	133.851	21.958	4.077	7.548
2e	**10**	69	323.317	585.823	194.288	391.535	36.764	4.180	11.371
2e	**10**	70	277.614	424.989	204.415	220.574	26.038	3.783	9.379
2e	**10**	71	381.328	469.484	190.367	279.117	81.235	1.131	21.303
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**377.409**	547.653	242.650	**305.002**	**56.472**	**3.570**	**14.097**
STD			79.250	246.216	34.594	239.560	35.474	2.167	6.322
			max:	**1750.000**		**1472.838**			
			min:		**190.367**	**62.086**			
Subject 2e - Englis						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**354.835**	480.393	249.483	**232.200**	**45.980**	**3.902**	**12.295**
STD			70.977	179.890	44.208	174.740	31.366	2.939	5.903
			max:	**1750.000**		**1472.800**			
			min:		**190.114**	**42.882**			

Subject 3e - English						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3e	6	1	338.532	406.009	276.014	129.995	25.299	2.502	7.473
3e	6	2	358.894	495.295	283.688	211.607	33.608	3.353	9.364
3e	6	3	333.183	384.468	260.552	123.916	26.631	1.878	7.993
3e	6	4	368.620	430.849	271.150	159.699	49.625	1.563	13.462
3e	6	5	345.845	407.664	295.770	111.894	26.530	1.941	7.671
3e	6	6	389.948	457.038	306.748	150.290	37.254	1.623	9.554
3e	6	7	397.280	464.037	304.321	159.716	47.182	.864	11.876
3e	6	8	425.640	581.734	344.471	237.263	57.984	3.762	13.623
3e	6	9	423.576	488.759	296.296	192.463	37.473	2.746	8.847
3e	6	10	466.210	514.668	337.952	176.716	33.875	.817	7.266
3e	6	11	341.664	389.105	300.210	88.895	16.503	4.702	4.830
3e	6	12	425.838	588.235	232.180	356.055	58.794	2.218	13.807
3e	6	13	429.452	532.481	251.762	280.719	70.762	2.341	16.477
3e	6	14	385.101	563.380	295.508	267.872	26.097	2.066	6.777
3e	6	15	405.390	459.770	327.439	132.331	30.673	2.066	7.566
3e	6	16	545.546	977.517	311.624	665.893	131.082	2.964	24.028
3e	6	17	446.001	637.349	347.464	289.885	51.005	1.527	11.436
3e	6	18	512.324	922.509	323.206	599.303	132.091	2.476	25.783
3e	6	19	425.722	587.889	213.265	374.624	65.648	3.666	15.420
3e	6	20	426.855	540.541	373.274	167.267	19.022	1.808	4.456
3e	6	21	423.633	679.810	258.799	421.011	96.011	3.418	22.664
3e	6	22	456.678	537.057	349.284	187.773	47.792	3.473	10.465
3e	6	23	427.701	531.632	331.455	200.177	37.972	1.551	8.878
3e	6	24	645.390	1010.101	225.124	784.977	319.491	3.019	49.503
3e	6	25	450.858	530.223	365.764	164.459	52.220	1.171	11.582
3e	6	26		1800.000	1480.000	320.000			
3e	6	27	436.364	484.731	324.781	159.950	40.814	1.582	9.353
3e	6	28	401.414	442.674	311.139	131.535	24.274	1.816	6.047
3e	6	29	385.662	437.637	329.381	108.256	30.892	1.229	8.010
3e	6	30	361.484	449.640	196.928	252.712	60.298	4.339	16.681
3e	6	31	368.696	478.011	244.918	233.093	42.542	2.214	11.538
3e	6	32	382.104	468.384	248.016	220.368	52.238	1.853	13.671
3e	6	33	326.790	410.509	192.493	218.016	49.826	2.711	15.247
3e	6	34	365.868	536.481	206.868	329.613	66.344	3.228	18.133
3e	6	35	324.727	386.548	266.028	120.520	28.759	1.583	8.857
3e	6	36	380.983	415.800	316.857	98.943	20.749	2.119	5.446
3e	6	37	420.205	484.496	284.981	199.515	48.084	2.098	11.443
3e	6	38	367.542	464.037	309.215	154.822	32.725	1.136	8.904
3e	6	39	408.274	509.944	331.565	178.379	45.906	1.612	11.244
3e	6	40	446.751	666.667	301.114	365.553	57.892	3.808	12.958
3e	6	41	376.024	615.006	305.530	309.476	33.487	3.248	8.906
3e	6	42	424.616	557.724	215.008	342.716	56.708	1.828	13.355
3e	6	43	345.831	563.380	196.850	366.530	43.354	2.063	12.536
3e	6	44	450.784	527.148	308.166	218.982	43.537	1.227	9.658
3e	6	45	364.990	454.752	262.605	192.147	49.044	3.362	13.437
3e	6	46	332.461	428.082	257.136	170.946	34.025	2.246	10.234
3e	6	47	416.048	482.393	308.452	173.941	45.607	1.895	10.962

3e	6	48	449.581	619.963	308.547	311.416	66.413	4.985	14.772
3e	6	49	385.043	442.478	306.279	136.199	32.243	2.040	8.374
3e	6	50	421.954	604.595	211.372	393.223	56.293	2.256	13.341
3e	6	51	460.042	554.939	275.406	279.533	31.783	1.307	6.909
3e	6	52	467.274	599.161	331.016	268.145	52.651	2.977	11.268
3e	6	53	410.922	477.327	338.409	138.918	33.090	1.432	8.053
3e	6	54	377.065	415.455	345.662	69.793	10.483	1.228	2.780
3e	6	55	425.693	593.472	283.206	310.266	53.212	3.585	12.500
3e	6	56	439.845	600.601	299.220	301.381	35.040	1.602	7.967
3e	6	57	458.100	623.830	330.907	292.923	47.229	1.612	10.310
3e	6	58	555.141	670.691	329.598	341.093	98.149	2.460	17.680
3e	6	59	450.865	531.915	326.904	205.011	45.743	1.300	10.146
3e	6	60	389.715	457.875	357.143	100.732	14.446	1.457	3.707
3e	6	61	412.167	597.015	290.613	306.402	56.100	4.257	13.611
3e	6	62	401.025	459.137	335.683	123.454	23.678	2.384	5.904
3e	6	63	445.912	495.050	317.360	177.690	46.638	1.588	10.459
3e	6	64	397.067	431.779	311.139	120.640	32.014	1.204	8.063
3e	6	65	425.221	584.795	276.319	308.476	57.110	3.234	13.431
3e	6	66	398.349	461.681	298.240	163.441	35.956	1.474	9.026
3e	6	67	675.206	914.913	337.382	577.531	188.189	2.086	27.871
3e	6	68	421.648	476.190	203.211	272.979	59.591	4.522	14.133
3e	6	69	409.225	482.625	257.202	225.423	48.353	1.849	11.816
3e	6	70		1316.000	342.583	973.417			
3e	6	71	411.793	593.472	245.640	347.832	51.949	3.379	12.615
3e	6	72	357.962	531.632	201.654	329.978	78.195	4.487	21.844
3e	6	73	454.170	536.193	226.912	309.281	51.924	2.390	11.433
3e	6	74	340.330	392.003	273.075	118.928	32.550	1.459	9.564
3e	6	75	503.882	900.090	320.000	580.090	125.443	2.759	24.895
3e	6	76	387.335	550.055	340.136	209.919	29.466	1.181	7.607
3e	6	77	419.678	479.846	350.018	129.828	28.173	1.403	6.713
3e	6	78	554.518	700.771	402.414	298.357	76.787	1.485	13.847
3e	6	79	414.244	439.754	380.228	59.526	14.171	1.729	3.421
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**418.240**	**566.044**	**309.302**	**256.742**	**52.608**	**2.309**	**11.967**
STD			63.290	210.483	141.836	158.445	42.125	.999	6.664
			max:	**1800.000**		**973.417**			
			min:		**192.493**	**59.526**			

Subject 3e - English						*8-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3e	8	1	4.843	459.137	293.772	165.365	44.366	2.024	10.959
3e	8	2	398.657	507.614	290.867	216.747	37.780	4.103	9.477
3e	8	3	539.058	583.000	322.685	260.315	112.324	6.228	20.837
3e	8	4	482.576	632.111	274.876	357.235	64.527	2.564	13.371
3e	8	5	502.032	663.570	286.123	377.447	60.448	1.913	12.041
3e	8	6	386.438	468.384	297.000	171.384	32.153	3.593	8.320
3e	8	7	429.955	515.996	362.713	153.283	35.736	2.857	8.312
3e	8	8	422.703	520.291	300.571	219.720	56.116	2.007	13.276
3e	8	9	334.391	424.268	209.952	214.316	80.803	7.186	24.164
3e	8	10	414.476	464.900	324.886	140.014	24.932	1.567	6.015
3e	8	11	414.828	461.255	314.070	147.185	34.551	1.918	8.329
3e	8	12	441.895	482.859	373.134	109.725	17.784	1.504	4.024
3e	8	13	435.265	497.018	299.670	197.348	51.409	1.416	11.811
3e	8	14	468.748	629.723	304.971	324.752	54.455	2.947	11.617
3e	8	15	400.343	466.853	202.061	264.792	53.510	2.507	13.366
3e	8	16	404.802	474.158	290.023	184.135	44.566	1.436	11.009
3e	8	17	380.556	447.828	321.958	125.870	26.632	2.950	6.998
3e	8	18	528.257	732.601	382.409	350.192	95.002	2.000	17.984
3e	8	19	440.349	594.530	297.265	297.265	64.096	5.670	14.556
3e	8	20	411.440	561.167	294.204	266.963	71.839	5.964	17.460
3e	8	21	357.386	569.476	310.849	258.627	23.321	2.618	6.525
3e	8	22	450.778	510.204	290.107	220.097	61.580	1.601	13.661
3e	8	23	367.794	408.330	301.568	106.762	17.959	2.102	4.883
3e	8	24	410.227	510.204	271.813	238.391	53.214	2.786	12.972
3e	8	25	440.626	599.520	274.725	324.795	77.307	3.064	17.545
3e	8	26	386.227	476.872	302.755	174.117	39.135	1.719	10.133
3e	8	27	448.123	556.174	314.169	242.005	37.881	1.210	8.453
3e	8	28	397.862	474.834	320.616	154.218	20.785	2.326	5.224
3e	8	29	432.822	500.250	326.904	173.346	37.040	2.399	8.558
3e	8	30	436.419	607.165	328.407	278.758	40.410	2.587	9.259
3e	8	31	423.766	547.645	303.306	244.339	41.759	2.190	9.854
3e	8	32	397.361	451.671	281.770	169.901	50.370	2.057	12.676
3e	8	33	360.066	390.168	247.402	142.766	32.595	1.890	9.052
3e	8	34	370.172	428.633	290.613	138.020	29.004	2.522	7.835
3e	8	35	396.179	469.925	335.121	134.804	26.642	3.900	6.725
3e	8	36	438.252	554.017	210.970	343.047	59.003	1.835	13.463
3e	8	37	470.468	538.213	366.569	171.644	43.620	3.269	9.272
3e	8	38	431.400	525.210	299.043	226.167	49.889	1.482	11.564
3e	8	39	398.438	485.201	244.377	240.824	34.835	3.434	8.743
3e	8	40	412.002	592.417	300.300	292.117	55.132	3.675	13.382
3e	8	41	352.477	405.515	287.687	117.828	21.663	1.951	6.146
3e	8	42	417.424	583.771	280.034	303.737	58.734	2.411	14.071
3e	8	43	405.846	485.437	287.356	198.081	41.668	2.610	10.267
3e	8	44	405.517	449.236	297.000	152.236	40.204	1.406	9.914
3e	8	45	369.665	430.478	317.259	113.219	19.649	1.658	5.315
3e	8	46	421.110	489.956	296.033	193.923	34.855	1.493	8.277
3e	8	47	331.594	384.320	284.252	100.068	17.558	1.220	5.295

3e	**8**	48	399.491	488.759	284.172	204.587	50.981	2.167	12.761
3e	**8**	49	432.114	554.324	260.281	294.043	39.772	2.083	9.204
3e	**8**	50	406.164	520.291	240.269	280.022	46.543	3.204	11.459
3e	**8**	51	420.176	515.996	341.064	174.932	48.637	1.221	11.575
3e	**8**	52	457.173	534.474	321.647	212.827	53.222	1.465	11.641
3e	**8**	53	404.131	443.066	300.210	142.856	30.757	.804	7.611
3e	**8**	54	412.972	495.295	243.605	251.690	70.159	2.191	16.989
3e	**8**	55	441.423	520.562	283.126	237.436	59.757	1.992	13.537
3e	**8**	56	451.611	530.223	271.297	258.926	72.966	3.413	16.157
3e	**8**	57	381.607	461.894	225.989	235.905	60.472	5.892	15.847
3e	**8**	58	408.013	449.035	339.559	109.476	17.860	1.722	4.377
3e	**8**	59	405.527	497.512	285.714	211.798	39.154	1.867	9.655
3e	**8**	60	390.301	462.321	306.091	156.230	33.618	1.288	8.613
3e	**8**	61	468.519	618.429	333.111	285.318	56.107	4.010	11.975
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**410.669**	**509.906**	**295.907**	**213.999**	**46.047**	**2.575**	**10.892**
STD			66.380	69.168	36.717	70.703	19.253	1.334	4.066
			max:	**732.601**		**377.447**			
			min:		**202.061**	**100.068**			

Subject 3e - English						*10-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
3e	10	1	355.258	479.157	318.573	160.584	23.262	3.808	6.548
3e	10	2	307.489	389.105	193.798	195.307	41.091	1.615	13.363
3e	10	3	397.821	482.859	298.240	184.619	46.832	3.616	11.772
3e	10	4	353.926	475.285	198.886	276.399	51.200	3.735	14.466
3e	10	5	318.565	432.900	206.782	226.118	41.797	1.929	13.120
3e	10	6	366.786	468.165	258.198	209.967	29.043	2.766	7.918
3e	10	7	420.059	546.150	263.505	282.645	87.546	1.521	20.841
3e	10	8	392.082	500.000	258.398	241.602	59.380	2.979	15.145
3e	10	9	412.231	502.513	298.775	203.738	56.604	3.811	13.731
3e	10	10	323.495	448.029	222.222	225.807	43.165	4.224	13.343
3e	10	11	341.293	379.651	287.109	92.542	19.099	3.674	5.596
3e	10	12	367.793	421.408	289.519	131.889	36.555	2.782	9.939
3e	10	13	348.805	537.346	195.274	342.072	60.712	5.103	17.406
3e	10	14	370.724	451.875	279.955	171.920	33.205	2.584	8.957
3e	10	15	439.169	547.645	278.940	268.705	58.781	3.382	13.385
3e	10	16	374.019	443.262	287.356	155.906	26.178	3.152	6.999
3e	10	17	383.613	536.193	221.337	314.856	57.941	2.245	15.104
3e	10	18	380.886	443.853	236.911	206.942	49.191	3.052	12.915
3e	10	19	366.753	514.668	303.122	211.546	34.756	3.224	9.477
3e	10	20	376.502	411.862	285.307	126.555	32.850	2.225	8.725
3e	10	21	336.038	431.593	274.424	157.169	20.053	2.201	5.967
3e	10	22	369.380	436.681	249.563	187.118	46.438	3.198	12.572
3e	10	23	417.061	544.366	317.561	226.805	52.101	3.228	12.492
3e	10	24	377.296	481.928	268.889	213.039	47.792	3.061	12.667
3e	10	25	381.348	505.561	192.938	312.623	96.107	2.927	25.202
3e	10	26	411.183	526.316	236.183	290.133	102.903	1.473	25.026
3e	10	27	386.707	552.792	256.937	295.855	53.157	3.589	13.746
3e	10	28	439.296	588.928	350.631	238.297	36.643	3.033	8.341
3e	10	29	344.363	734.754	231.000	503.754	66.398	4.354	19.282
3e	10	30	349.202	469.032	259.605	209.427	30.797	2.502	8.819
3e	10	31	400.719	512.821	306.654	206.167	65.555	1.611	16.359
3e	10	32	326.093	383.583	261.849	121.734	27.793	2.228	8.523
3e	10	33	390.132	440.141	344.353	95.788	18.932	2.622	4.853
3e	10	34	359.509	432.713	283.366	149.347	32.059	2.777	8.917
3e	10	35	375.837	488.043	292.312	195.731	51.922	1.957	13.815
3e	10	36	461.721	573.066	302.572	270.494	76.029	1.637	16.466
3e	10	37	360.022	455.996	276.091	179.905	46.422	1.829	12.894
3e	10	38	345.551	443.066	287.274	155.792	38.321	2.349	11.090
3e	10	39	368.546	459.982	270.416	189.566	24.728	2.066	6.710
3e	10	40	324.398	415.800	192.160	223.640	39.478	1.975	12.169
3e	10	41	378.465	491.884	302.939	188.945	30.638	2.566	8.095
3e	10	42	364.475	444.840	288.600	156.240	35.944	1.967	9.862
3e	10	43	333.604	408.497	285.063	123.434	21.314	1.605	6.389
3e	10	44	343.953	514.668	225.378	289.290	54.380	2.947	15.810
3e	10	45	433.392	607.533	307.125	300.408	78.808	4.122	18.184
3e	10	46	344.435	438.212	267.809	170.403	28.157	2.441	8.175
3e	10	47	354.834	431.593	284.091	147.502	30.933	2.737	8.718

3e	**10**	48	382.664	489.716	281.057	208.659	41.405	4.021	10.820
3e	**10**	49	381.359	495.786	262.950	232.836	51.829	5.702	13.591
3e	**10**	50	377.622	478.927	279.096	199.831	57.512	2.420	15.230
3e	**10**	51	388.654	463.392	302.847	160.545	36.062	2.372	9.279
3e	**10**	52	421.090	515.730	318.167	197.563	34.325	2.560	8.152
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**373.581**	**482.113**	**270.041**	**212.072**	**45.464**	**2.837**	**12.057**
STD			33.392	63.125	38.352	71.304	19.060	.920	4.555
			max:	**734.754**		**503.754**			
			min:		**192.160**	**92.542**			
Subject 3e - English						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**403.587**	525.477	294.413	**231.064**	**48.550**	**2.539**	**11.647**
STD			60.513	148.085	96.364	116.808	30.669	1.114	5.383
			max:	**1800.000**		**973.417**			
			min:		**192.160**	**59.526**			

Subject 4e - English						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4e	**6**	1	358.488	411.692	239.234	172.458	55.286	1.121	15.422
4e	**6**	2	312.788	367.377	255.754	111.623	20.209	2.971	6.461
4e	**6**	3	374.976	431.406	241.255	190.151	37.855	3.492	10.095
4e	**6**	4	296.864	333.222	243.784	89.438	19.600	1.551	6.602
4e	**6**	5	313.882	409.333	238.493	170.840	21.334	1.296	6.797
4e	**6**	6	284.083	334.001	221.976	112.025	35.143	5.255	12.371
4e	**6**	7	308.530	445.038	281.057	163.981	19.761	1.044	6.405
4e	**6**	8	288.096	332.668	240.848	91.820	22.203	1.363	7.707
4e	**6**	9	293.578	367.377	204.040	163.337	36.825	.875	12.543
4e	**6**	10	360.754	440.917	240.616	200.301	57.658	2.471	15.983
4e	**6**	11	362.358	433.839	279.408	154.431	39.722	5.959	10.137
4e	**6**	12	311.312	399.361	222.866	176.495	26.953	1.717	8.658
4e	**6**	13	367.191	933.707	190.042	743.665	75.855	5.369	20.658
4e	**6**	14	324.264	381.534	198.768	182.766	44.287	2.275	13.658
4e	**6**	15	385.793	407.000	330.797	76.203	14.618	.922	3.789
4e	**6**	16	319.592	352.983	252.845	100.138	20.358	1.252	6.370
4e	**6**	17	312.488	362.845	271.003	91.842	21.858	1.680	6.987
4e	**6**	18	342.401	371.609	208.117	163.492	28.921	.896	8.446
4e	**6**	19	321.523	334.113	294.377	39.736	8.727	.739	2.714
4e	**6**	20	347.040	388.954	285.633	103.321	22.701	.977	6.541
4e	**6**	21	353.201	421.941	267.165	154.776	43.517	1.503	12.321
4e	**6**	22	302.566	413.907	230.787	183.120	19.267	1.339	6.368
4e	**6**	23	355.166	391.236	297.974	93.262	21.548	2.150	6.067
4e	**6**	24	325.608	396.197	273.973	122.224	21.861	1.565	6.714
4e	**6**	25	387.724	423.729	346.021	77.708	20.083	.806	5.180
4e	**6**	26	324.012	410.846	210.748	200.098	30.680	.880	9.469
4e	**6**	27	314.173	355.619	234.687	120.932	31.816	1.165	10.127
4e	**6**	28	281.664	299.491	217.061	82.430	15.954	1.002	5.664
4e	**6**	29	297.658	329.272	235.294	93.978	10.459	.779	3.514
4e	**6**	30	328.050	366.838	280.978	85.860	23.653	2.019	7.210
4e	**6**	31	285.524	413.565	199.283	214.282	39.887	3.574	13.970
4e	**6**	32	314.939	355.366	215.750	139.616	43.312	.658	13.753
4e	**6**	33	331.392	384.025	267.237	116.788	30.775	.658	9.287
4e	**6**	34	359.391	408.497	301.568	106.929	26.467	1.073	7.364
4e	**6**	35	298.813	387.147	255.428	131.719	25.384	2.171	8.495
4e	**6**	36	302.080	379.507	257.533	121.974	12.189	1.579	4.035
4e	**6**	37	309.453	365.497	262.123	103.374	14.833	1.408	4.793
4e	**6**	38	294.748	333.778	202.963	130.815	27.757	1.516	9.417
4e	**6**	39	295.739	326.584	244.200	82.384	24.575	.533	8.310
4e	**6**	40	305.220	358.295	237.079	121.216	40.406	.856	13.238
4e	**6**	41	312.872	363.976	214.915	149.061	25.733	.819	8.225
4e	**6**	42	292.412	328.299	199.283	129.016	30.955	1.181	10.586
4e	**6**	43	389.402	584.112	288.684	295.428	52.840	4.455	13.570
4e	**6**	44	308.283	489.716	115.875	373.841	97.688	5.031	31.688

Subject 4e - English				***6-months***			
	Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages	**324.002**	**398.328**	**245.398**	**152.929**	**30.943**	**1.862**	**9.493**
STD	30.228	96.365	41.125	108.754	17.075	1.408	5.093
	max:	**933.707**		**743.665**			
	min:		**115.875**	**39.736**			

Subject 4e - English						***8-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4e	8	1	389.314	411.184	360.620	50.564	12.416	3.430	3.189
4e	8	2	480.901	516.796	378.931	137.865	32.407	4.883	6.739
4e	8	3	428.884	521.376	346.861	174.515	27.538	1.465	6.421
4e	8	4	320.943	367.377	256.213	111.164	36.748	6.986	11.450
4e	8	5	356.379	403.388	218.914	184.474	47.888	2.084	13.438
4e	8	6	340.932	402.901	247.525	155.376	22.834	1.705	6.698
4e	8	7	317.029	437.445	219.587	217.858	41.847	6.406	13.200
4e	8	8	355.461	397.614	307.314	90.300	18.830	1.908	5.297
4e	8	9	318.142	395.257	256.345	138.912	20.484	2.531	6.439
4e	8	10	286.635	371.333	237.756	133.577	20.872	3.156	7.282
4e	8	11	320.557	403.877	276.702	127.175	17.925	1.727	5.592
4e	8	12	357.198	417.885	303.859	114.026	22.063	3.074	6.177
4e	8	13	314.946	341.064	264.901	76.163	21.290	1.668	6.760
4e	8	14	335.873	436.491	270.197	166.294	16.608	1.142	4.945
4e	8	15	662.707	875.657	493.583	382.074	98.749	14.302	14.901
4e	8	16	33.329	357.015	281.057	75.958	19.372	3.431	5.847
4e	8	17	402.936	460.617	308.737	151.880	39.853	5.475	9.891
4e	8	18	417.013	465.116	313.381	151.735	33.341	3.283	7.995
4e	8	19	319.693	430.108	255.624	174.484	23.919	3.835	7.482
4e	8	20	349.736	388.048	298.864	89.184	29.333	.630	8.387
4e	8	21	310.372	340.020	285.225	54.795	9.518	.732	3.067
4e	8	22	295.165	326.797	262.123	64.674	15.609	.912	5.288
4e	8	23	276.413	313.087	240.732	72.355	14.627	1.063	5.292
4e	8	24	287.260	301.659	264.201	37.458	8.762	.672	3.050
4e	8	25	309.336	370.096	241.196	128.900	25.744	3.719	8.322
4e	8	26	347.214	430.478	287.936	142.542	22.003	1.591	6.337
4e	8	27	297.876	345.304	248.077	97.227	24.203	1.875	8.125
4e	8	28	348.241	649.773	231.214	418.559	74.777	3.942	21.473
4e	8	29	360.309	453.926	319.795	134.131	37.570	1.510	10.427
4e	8	30	317.733	356.633	261.780	94.853	14.691	1.591	4.624
4e	8	31	582.199	885.740	454.133	431.607	70.599	2.225	12.126
4e	8	32	452.163	712.251	300.120	412.131	117.545	2.958	25.996
4e	8	33	327.558	467.946	228.990	238.956	30.117	3.424	9.194
4e	8	34	309.687	345.185	273.000	72.185	14.152	1.463	4.570
4e	8	35	334.517	398.089	233.536	164.553	35.056	5.325	10.480
4e	8	36	346.098	417.885	244.678	173.207	27.923	1.568	8.068
4e	8	37	343.270	495.540	254.388	241.152	54.834	5.440	15.974
4e	8	38	292.217	325.521	269.614	55.907	18.560	.920	6.351
4e	8	39	276.806	333.444	246.471	86.973	14.033	3.699	5.069
4e	8	40	299.718	344.116	259.471	84.645	9.630	1.000	3.213
4e	8	41	302.253	327.654	258.598	69.056	9.787	.565	3.238
4e	8	42	311.698	361.664	250.000	111.664	9.402	.720	3.016
4e	8	43	316.747	377.501	268.745	108.756	12.527	1.114	3.955
4e	8	44	304.157	349.650	249.626	100.024	9.545	.782	3.138
4e	8	45	367.853	390.016	322.477	67.539	14.801	.973	4.024
4e	8	46	365.474	803.859	235.905	567.954	114.219	10.908	31.252
4e	8	47	380.974	469.925	299.043	170.882	25.985	.894	6.821

4e	**8**	48	345.490	416.840	252.334	164.506	32.251	2.065	9.335
4e	**8**	49	337.597	434.783	292.483	142.300	17.727	.749	5.251
4e	**8**	50	378.014	450.248	314.169	136.079	30.964	1.297	8.191
4e	**8**	51	388.074	475.059	341.763	133.296	17.487	1.011	4.506
4e	**8**	52	304.136	411.184	215.983	195.201	25.923	2.181	8.523
4e	**8**	53	300.489	352.485	229.253	123.232	14.235	1.681	4.737
4e	**8**	54	311.217	367.782	253.036	114.746	22.593	1.036	7.260
4e	**8**	55	305.550	412.371	193.536	218.835	47.672	2.452	15.602
4e	**8**	56	318.559	424.088	275.330	148.758	20.272	1.648	6.364
4e	**8**	57	355.381	452.694	263.852	188.842	35.283	3.120	9.928
4e	**8**	58	410.124	462.321	305.530	156.791	43.105	1.560	10.510
4e	**8**	59	336.654	385.356	251.889	133.467	32.898	1.720	9.772
4e	**8**	60	303.199	365.764	283.930	81.834	13.329	.582	4.396
4e	**8**	61	457.839	506.842	372.717	134.125	26.477	.986	5.783
4e	**8**	62	312.481	381.243	213.538	167.705	19.982	1.781	6.395
4e	**8**	63	482.150	786.164	344.471	441.693	68.795	4.245	14.268
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**346.331**	**437.770**	**279.236**	**158.534**	**30.310**	**2.584**	**8.277**
STD			79.684	127.414	53.363	105.199	23.209	2.394	5.258
			max:	**885.740**		**567.954**			
			min:		**193.536**	**37.458**			

Subject 4e - English						*10-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
4e	10	1	373.868	496.771	335.570	161.201	26.822	.911	7.174
4e	10	2	484.072	604.230	302.572	301.658	74.712	2.764	15.434
4e	10	3	535.983	835.422	334.896	500.526	156.075	4.116	29.119
4e	10	4	442.848	519.751	408.664	111.087	26.664	2.052	6.021
4e	10	5	760.384	951.475	619.195	332.280	83.608	2.848	10.996
4e	10	6	517.140	700.280	392.311	307.969	83.796	5.053	16.204
4e	10	7	401.096	529.661	330.469	199.192	45.825	1.117	11.425
4e	10	8	513.575	662.691	403.877	258.814	77.156	.992	15.023
4e	10	9	508.541	613.874	420.521	193.353	52.235	1.918	10.272
4e	10	10	584.807	839.631	405.186	434.445	137.854	17.269	23.573
4e	10	11	513.713	723.066	370.645	352.421	111.392	2.179	21.684
4e	10	12	823.662	1052.632	448.229	604.403	232.619	5.433	28.242
4e	10	13	288.028	384.911	232.829	152.082	20.188	3.451	7.009
4e	10	14	441.623	566.572	373.134	193.438	36.351	.987	8.231
4e	10	15	418.154	558.036	361.925	196.111	38.369	1.974	9.176
4e	10	16	469.376	621.118	352.983	268.135	51.981	5.449	11.075
4e	10	17	370.532	436.681	289.603	147.078	33.933	3.344	9.158
4e	10	18	360.858	422.297	275.786	146.511	30.071	1.267	8.333
4e	10	19	295.207	365.364	198.965	166.399	46.023	2.834	15.590
4e	10	20	397.901	517.598	287.604	229.994	37.496	3.347	9.424
4e	10	21	363.396	456.204	281.294	174.910	32.075	2.792	8.827
4e	10	22	506.417	764.526	342.936	421.590	110.712	4.285	21.862
4e	10	23	560.822	739.098	415.455	323.643	109.940	7.754	19.603
4e	10	24	409.066	477.099	326.797	150.302	43.923	1.359	10.737
4e	10	25	381.444	612.745	273.224	339.521	51.909	5.769	13.609
4e	10	26	339.749	363.108	317.864	45.244	6.647	.842	1.957
4e	10	27	397.388	492.611	338.524	154.087	26.229	3.490	6.600
4e	10	28	324.214	379.219	264.410	114.809	24.974	2.907	7.703
4e	10	29	311.344	459.770	206.868	252.902	55.559	7.092	17.845
4e	10	30	376.180	467.508	261.028	206.480	40.231	2.336	10.695
4e	10	31	354.012	544.959	276.243	268.716	19.262	1.075	5.441
4e	10	32	526.341	825.764	244.858	580.906	124.149	2.849	23.587
4e	10	33	361.425	521.105	203.749	317.356	67.946	3.746	18.800
4e	10	34	508.432	606.796	409.668	197.128	33.397	1.329	6.569
4e	10	35	426.790	530.786	326.052	204.734	41.626	.737	9.753
4e	10	36	378.148	543.478	197.668	345.810	90.458	2.942	23.921
4e	10	37	363.248	464.037	284.576	179.461	51.017	8.679	14.045
4e	10	38	263.844	292.227	236.407	55.820	11.867	1.436	4.498
4e	10	39	261.951	486.145	203.791	282.354	28.301	2.887	10.804
4e	10	40	349.792	414.594	254.130	160.464	50.545	2.550	14.450
4e	10	41	271.472	322.789	214.777	108.012	29.229	3.398	10.767
4e	10	42	490.543	678.887	387.297	291.590	76.607	5.237	15.617
4e	10	43	526.813	648.929	467.290	181.639	34.180	3.938	6.488
4e	10	44	292.624	333.444	251.319	82.125	15.801	1.494	5.400
4e	10	45	289.067	311.333	224.618	86.715	27.461	2.353	9.500
4e	10	46	329.543	419.815	302.115	117.700	20.807	1.350	6.319
4e	10	47	348.736	405.844	242.542	163.302	50.143	1.995	14.379

4e	**10**	48	563.713	858.369	340.368	518.001	172.152	4.739	30.539
4e	**10**	49	828.296	1050.420	332.779	717.641	263.247	3.223	31.782
4e	**10**	50	450.425	601.323	313.480	287.843	54.414	3.045	12.081
4e	**10**	51	358.750	481.464	308.642	172.822	33.218	3.887	9.259
4e	**10**	52	357.428	445.038	259.808	185.230	50.046	3.431	14.002
4e	**10**	53	355.608	389.257	319.081	70.176	16.753	1.474	4.711
4e	**10**	54	296.728	366.972	258.665	108.307	19.827	1.982	6.682
4e	**10**	55	482.766	848.896	300.120	548.776	94.384	6.053	19.551
4e	**10**	56	401.270	439.947	325.521	114.426	25.318	2.412	6.309
4e	**10**	57	412.146	457.247	353.482	103.765	22.951	.858	5.569
4e	**10**	58	407.241	591.366	287.356	304.010	56.753	19.619	13.936
4e	**10**	59	402.247	582.072	238.436	343.636	118.508	1.823	29.461
4e	**10**	60	338.186	439.754	247.586	192.168	62.632	2.348	18.520
4e	**10**	61	401.455	526.870	234.632	292.238	62.112	3.019	15.472
4e	**10**	62	393.389	451.467	313.480	137.987	33.782	1.313	8.587
4e	**10**	63	337.519	392.157	286.615	105.542	24.364	2.155	7.220
4e	**10**	64	427.873	488.998	361.925	127.073	31.084	1.359	7.265
4e	**10**	65	319.866	403.551	250.689	152.862	42.022	1.927	13.137
4e	**10**	66	292.050	336.700	237.192	99.508	19.425	3.039	6.651
4e	**10**	67	338.862	400.962	255.493	145.469	37.872	1.174	11.176
4e	**10**	68	368.195	438.212	246.427	191.785	57.685	1.721	15.667
4e	**10**	69	333.003	408.330	265.182	143.148	43.176	1.117	12.966
4e	**10**	70	290.618	378.501	201.532	176.969	26.369	.864	9.073
4e	**10**	71	274.499	334.336	237.643	96.693	24.425	.526	8.898
4e	**10**	72	280.161	373.972	210.349	163.623	27.545	.733	9.832
4e	**10**	73	270.476	288.600	203.169	85.431	13.617	.816	5.035
4e	**10**	74	307.397	329.815	252.589	77.226	19.205	1.078	6.247
4e	**10**	75	310.616	349.162	253.229	95.933	29.490	.796	9.494
4e	**10**	76	538.467	668.896	371.471	297.425	100.208	3.952	18.610
4e	**10**	77	504.625	644.745	424.628	220.117	57.838	1.487	11.462
4e	**10**	78	608.545	760.456	364.830	395.626	142.786	3.267	23.464
4e	**10**	79	466.359	678.426	367.647	310.779	47.305	1.717	10.143
4e	**10**	80	496.195	616.523	432.900	183.623	26.712	2.017	5.383
4e	**10**	81	463.295	625.000	310.463	314.537	81.930	3.682	17.684
4e	**10**	82	598.897	946.970	370.233	576.737	188.004	6.539	31.392
4e	**10**	83	460.363	637.755	306.185	331.570	61.907	1.523	13.447
4e	**10**	84	477.163	615.006	397.614	217.392	58.080	4.824	12.172
4e	**10**	85	732.676	935.454	400.320	535.134	166.912	3.820	22.781
4e	**10**	86	295.184	331.345	249.750	81.595	22.549	.801	7.639
4e	**10**	87	316.286	514.668	224.871	289.797	67.228	4.461	21.255
4e	**10**	88	254.401	269.179	205.297	63.882	12.045	.523	4.735
4e	**10**	89	272.003	306.560	218.245	88.315	15.101	.614	5.552
4e	**10**	90	259.779	307.409	194.932	112.477	13.737	.913	5.288
4e	**10**	91	256.497	297.530	223.864	73.666	11.966	1.077	4.665
4e	**10**	92	270.883	380.952	248.447	132.505	13.110	1.485	4.840
4e	**10**	93	272.813	438.212	219.539	218.673	19.615	2.547	7.190
4e	**10**	94	340.983	369.549	260.688	108.861	26.243	.596	7.696
4e	**10**	95	273.917	351.989	253.229	98.760	11.921	.651	4.352
4e	**10**	96	582.024	803.859	354.862	448.997	136.776	2.636	23.500
4e	**10**	97	510.166	675.219	325.309	349.910	77.895	4.232	15.269

4e	**10**	98	329.097	434.594	239.981	194.613	40.338	2.213	12.257
4e	**10**	99	602.347	938.967	384.615	554.352	130.163	3.525	21.609
4e	**10**	100	560.601	734.754	384.911	349.843	92.383	2.601	16.479
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**411.585**	**537.027**	**303.308**	**233.719**	**57.833**	**2.942**	**12.709**
STD			123.450	185.336	75.990	142.945	48.537	2.795	7.012
			max:	**1052.632**		**717.641**			
			min:		**194.932**	**45.244**			
Subject 4e - English						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**373.109**	477.336	283.672	**193.664**	**43.741**	**2.604**	**10.677**
STD			104.302	163.932	67.017	130.882	39.265	2.463	6.437
			max:	**1052.630**		**743.665**			
			min:		**115.875**	**37.458**			

Subject 5e - English						***6-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5e	6	1	456.553	570.125	319.489	250.636	44.129	2.755	9.666
5e	6	2	454.976	634.115	358.551	275.564	43.931	2.099	9.656
5e	6	3	390.497	415.282	366.703	48.579	11.550	1.129	2.958
5e	6	4	344.507	395.413	297.619	97.794	26.203	1.740	7.606
5e	6	5	472.637	527.704	383.583	144.121	40.478	1.871	8.564
5e	6	6	294.928	369.276	241.138	128.138	25.935	3.873	8.794
5e	6	7	684.612	1012.146	265.675	746.471	375.419	3.720	54.837
5e	6	8	639.275	982.318	271.297	711.021	199.251	3.500	31.168
5e	6	9	616.445	779.423	439.947	339.476	118.322	1.053	19.194
5e	6	10	365.794	506.329	265.252	241.077	47.374	3.272	12.951
5e	6	11	369.878	435.350	205.677	229.673	41.613	1.950	11.250
5e	6	12	312.339	371.747	267.788	103.959	18.925	6.723	6.059
5e	6	13	304.494	375.799	194.288	181.511	37.263	5.792	12.238
5e	6	14	401.188	572.410	201.979	370.431	50.403	.931	12.563
5e	6	15	342.276	383.289	313.087	70.202	15.043	1.753	4.395
5e	6	16	301.714	339.098	246.427	92.671	21.398	1.024	7.092
5e	6	17	378.833	440.141	270.856	169.285	39.529	2.193	10.439
5e	6	18	273.521	350.508	243.902	106.606	15.628	3.675	5.714
5e	6	19	419.275	707.714	223.964	483.750	112.934	5.027	26.936
5e	6	20	312.472	357.015	279.642	77.373	15.368	1.762	4.918
5e	6	21	286.265	331.236	234.852	96.384	16.391	2.347	5.726
5e	6	22	547.337	707.214	350.385	356.829	71.920	4.107	13.140
5e	6	23	395.669	498.008	339.905	158.103	22.571	2.703	5.704
5e	6	24	329.242	381.971	280.112	101.859	16.985	2.347	5.159
5e	6	25	314.200	424.088	240.154	183.934	25.076	2.478	7.981
5e	6	26	439.720	494.560	389.105	105.455	19.345	.852	4.399
5e	6	27	390.303	430.849	338.181	92.668	17.061	1.235	4.371
5e	6	28	401.111	509.944	326.584	183.360	37.638	4.033	9.383
5e	6	29	372.048	478.469	315.557	162.912	26.293	1.210	7.067
5e	6	30	384.860	437.637	257.931	179.706	23.679	2.586	6.153
5e	6	31	307.484	333.890	242.307	91.583	26.180	1.889	8.514
5e	6	32	393.888	474.383	203.500	270.883	91.801	4.918	23.306
5e	6	33	287.212	439.754	206.996	232.758	40.493	2.415	14.099
5e	6	34	399.626	462.963	320.513	142.450	24.906	2.115	6.232
5e	6	35	672.499	801.282	472.813	328.469	91.394	4.405	13.590
5e	6	36	378.026	422.654	200.884	221.770	62.656	1.437	16.574
5e	6	37	375.940	442.282	303.122	139.160	22.749	2.120	6.051
5e	6	38	412.556	478.927	345.066	133.861	28.155	1.020	6.825
5e	6	39	364.332	451.467	311.139	140.328	29.655	2.863	8.140
5e	6	40	397.953	499.002	239.406	259.596	40.994	3.199	10.301
5e	6	41	355.881	394.322	319.285	75.037	19.590	1.097	5.505
5e	6	42	352.004	381.098	293.083	88.015	20.449	3.224	5.809
5e	6	43	307.671	414.422	274.198	140.224	22.223	4.897	7.223
5e	6	44	413.851	524.109	326.371	197.738	25.225	3.031	6.095
5e	6	45	487.828	527.983	379.507	148.476	22.001	1.110	4.510
5e	6	46	295.359	343.053	198.689	144.364	24.421	1.436	8.268
5e	6	47	285.866	404.040	242.131	161.909	22.108	3.209	7.734

5e	**6**	48	307.888	394.633	257.998	136.635	21.752	3.739	7.065
5e	**6**	49	369.392	467.508	227.946	239.562	59.610	10.987	16.137
5e	**6**	50	356.141	491.884	206.058	285.826	71.467	6.337	20.067
5e	**6**	51	366.416	515.996	195.274	320.722	78.394	8.194	21.395
5e	**6**	52	341.391	494.071	299.401	194.670	22.870	4.873	6.699
5e	**6**	53	489.578	686.342	311.526	374.816	96.351	2.680	19.680
5e	**6**	54	330.833	351.989	274.725	77.264	18.642	.808	5.635
5e	**6**	55	418.936	570.776	305.810	264.966	36.201	3.338	8.641
5e	**6**	56	310.266	523.560	214.638	308.922	66.796	5.825	21.529
5e	**6**	57	393.537	489.476	316.056	173.420	26.118	.827	6.637
5e	**6**	58	302.136	336.134	255.297	80.837	18.932	2.156	6.266
5e	**6**	59	419.481	451.060	358.295	92.765	12.265	1.556	2.924
5e	**6**	60	307.377	430.478	240.154	190.324	23.238	3.553	7.560
5e	**6**	61	405.236	456.204	338.524	117.680	30.701	2.662	7.576
5e	**6**	62	296.257	320.821	260.620	60.201	14.971	3.241	5.053
5e	**6**	63	441.615	796.813	213.538	583.275	107.496	5.643	24.341
5e	**6**	64	342.972	436.872	206.612	230.260	65.364	1.068	19.058
5e	**6**	65	369.645	442.478	273.373	169.105	26.155	1.121	7.076
5e	**6**	66	390.783	457.875	347.947	109.928	20.005	1.504	5.119
5e	**6**	67	357.598	430.663	283.206	147.457	29.694	1.877	8.304
5e	**6**	68	386.096	460.405	193.686	266.719	42.501	.659	11.008
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**385.125**	**485.601**	**282.196**	**203.405**	**45.326**	**2.894**	**10.774**
STD			88.016	141.367	61.720	137.736	51.921	1.910	8.192
			max:	**1012.146**		**746.471**			
			min:		**193.686**	**48.579**			

Subject 5e - English						***8-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5e	**8**	1	307.054	412.371	250.313	162.058	22.741	3.496	7.406
5e	**8**	2	321.183	379.363	280.505	98.858	18.601	3.085	5.791
5e	**8**	3	293.169	320.821	235.905	84.916	14.909	2.121	5.085
5e	**8**	4	405.242	526.870	256.213	270.657	70.722	1.578	17.452
5e	**8**	5	357.036	559.910	224.921	334.989	46.244	1.679	12.952
5e	**8**	6	328.540	356.379	300.842	55.537	9.286	1.679	2.826
5e	**8**	7	334.870	367.782	305.717	62.065	13.248	1.862	3.956
5e	**8**	8	317.536	410.004	284.250	125.754	20.132	2.332	6.340
5e	**8**	9	308.367	506.329	191.314	315.015	41.518	5.673	13.464
5e	**8**	10	371.502	482.160	308.261	173.899	30.205	1.244	8.131
5e	**8**	11	342.613	414.938	272.331	142.607	21.810	1.814	6.366
5e	**8**	12	334.067	393.236	281.373	111.863	27.207	1.314	8.144
5e	**8**	13	396.334	441.891	338.181	103.710	27.375	1.253	6.907
5e	**8**	14	336.020	432.713	196.618	236.095	54.474	7.029	16.211
5e	**8**	15	351.725	462.963	233.754	229.209	48.750	4.658	13.860
5e	**8**	16	324.750	361.272	262.881	98.391	27.266	1.359	8.396
5e	**8**	17	308.608	342.936	264.831	78.105	15.781	1.080	5.114
5e	**8**	18	591.208	1057.082	283.366	773.716	180.052	4.743	30.455
5e	**8**	19	321.349	524.109	259.673	264.436	21.452	2.698	6.676
5e	**8**	20	317.793	407.997	204.457	203.540	27.458	2.242	8.640
5e	**8**	21	357.456	395.570	283.607	111.963	27.780	.857	7.772
5e	**8**	22	332.872	359.195	291.375	67.820	13.814	.815	4.150
5e	**8**	23	380.314	453.515	292.826	160.689	43.167	1.382	11.350
5e	**8**	24	276.671	316.656	259.202	57.454	13.612	1.347	4.920
5e	**8**	25	309.547	339.674	257.400	82.274	14.058	1.388	4.542
5e	**8**	26	301.290	352.609	266.241	86.368	23.235	1.641	7.714
5e	**8**	27	340.243	394.322	291.971	102.351	20.427	1.422	6.004
5e	**8**	28	317.535	354.484	279.252	75.232	16.059	1.546	5.057
5e	**8**	29	410.678	488.520	321.750	166.770	31.754	1.519	7.732
5e	**8**	30	329.284	388.802	210.084	178.718	38.973	2.105	11.836
5e	**8**	31	351.825	444.247	294.118	150.129	26.651	1.639	7.575
5e	**8**	32	393.003	495.295	237.982	257.313	88.099	1.660	22.417
5e	**8**	33	353.947	409.165	294.031	115.134	19.380	2.370	5.491
5e	**8**	34	326.050	379.651	260.892	118.759	24.818	1.800	7.612
5e	**8**	35	332.933	366.166	195.925	170.241	45.995	1.283	13.815
5e	**8**	36	330.465	372.856	228.258	144.598	21.920	1.496	6.633
5e	**8**	37	337.208	378.931	200.040	178.891	45.749	2.921	13.567
5e	**8**	38	455.626	616.143	341.880	274.263	57.160	2.139	12.545
5e	**8**	39	404.745	439.560	346.981	92.579	13.335	.673	3.295
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**348.991**	**433.500**	**266.398**	**167.102**	**33.980**	**2.127**	**9.185**
STD			54.119	122.954	40.838	124.369	29.460	1.345	5.544
			max:	**1057.082**		**773.716**			
			min:		**191.314**	**55.537**			

Subject 5e - English						***10-months***			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
5e	10	1	389.682	553.403	303.122	250.281	55.904	1.083	14.346
5e	10	2	368.811	443.459	306.654	136.805	32.146	2.003	8.716
5e	10	3	461.978	605.327	327.225	278.102	54.434	1.768	11.783
5e	10	4	473.963	612.370	370.233	242.137	43.854	1.487	9.253
5e	10	5	442.456	520.021	377.358	142.663	15.309	.854	3.460
5e	10	6	346.471	528.541	265.534	263.007	42.893	1.046	12.380
5e	10	7	427.108	522.193	333.222	188.971	27.809	2.234	6.511
5e	10	8	399.793	466.418	343.525	122.893	31.363	.848	7.845
5e	10	9	323.170	419.815	200.924	218.891	42.247	2.651	13.073
5e	10	10	308.573	372.578	262.398	110.180	15.335	.806	4.970
5e	10	11	411.850	483.559	256.937	226.622	68.456	1.685	16.621
5e	10	12	377.102	435.350	287.191	148.159	38.409	1.578	10.185
5e	10	13	356.237	435.161	311.042	124.119	23.001	2.861	6.457
5e	10	14	283.387	424.989	211.999	212.990	24.507	3.640	8.648
5e	10	15	260.119	386.997	196.580	190.417	25.546	3.770	9.821
5e	10	16	294.150	312.500	191.351	121.149	19.289	.769	6.558
5e	10	17	287.192	321.647	261.917	59.730	13.308	.990	4.634
5e	10	18	311.717	382.995	206.868	176.127	43.098	1.784	13.826
5e	10	19	328.865	531.915	243.013	288.902	41.029	3.954	12.476
5e	10	20	313.073	348.797	282.167	66.630	16.273	.819	5.198
5e	10	21	320.016	335.683	300.752	34.931	8.425	.889	2.633
5e	10	22	284.287	307.031	242.601	64.430	13.871	1.178	4.879
5e	10	23	405.249	584.112	296.912	287.200	53.792	2.592	13.274
5e	10	24	257.378	326.371	189.970	136.401	33.157	3.027	12.883
5e	10	25	345.740	380.807	233.863	146.944	42.580	2.728	12.316
5e	10	26	393.218	544.959	251.826	293.133	61.690	3.255	15.688
5e	10	27	305.139	404.204	189.897	214.307	35.548	3.603	11.650
5e	10	28	300.452	332.336	245.519	86.817	15.793	1.433	5.257
5e	10	29	290.995	321.440	198.926	122.514	43.565	2.869	14.971
5e	10	30	278.810	314.663	200.562	114.101	30.729	3.744	11.022
5e	10	31	614.022	710.227	380.518	329.709	107.798	2.130	17.556
5e	10	32	283.765	381.388	196.618	184.770	25.581	3.193	9.015
5e	10	33	263.211	305.530	197.239	108.291	28.855	2.006	10.963
5e	10	34	340.603	466.418	195.618	270.800	92.260	5.520	27.087
5e	10	35	300.989	348.554	277.778	70.776	9.308	1.131	3.092
5e	10	36	275.890	296.472	233.590	62.882	10.422	1.495	3.778
5e	10	37	266.671	298.063	238.152	59.911	11.154	1.391	4.183
5e	10	38	349.076	364.830	332.226	32.604	6.771	.969	1.940
5e	10	39	261.335	293.427	239.292	54.135	11.548	1.713	4.419
5e	10	40	311.524	354.610	239.406	115.204	36.399	2.164	11.684
5e	10	41	291.421	345.423	233.100	112.323	18.886	1.403	6.481
5e	10	42	307.017	444.642	193.087	251.555	44.842	2.263	14.606
5e	10	43	304.825	382.555	232.829	149.726	27.384	1.872	8.982
5e	10	44	349.926	396.040	323.625	72.415	13.122	1.252	3.750
5e	10	45	321.683	355.872	287.936	67.936	10.338	2.193	3.214
5e	10	46	401.693	491.159	350.140	141.019	21.042	.599	5.238
5e	10	47	349.568	421.408	232.721	188.687	27.458	2.678	7.855

5e	**10**	48	318.712	337.952	286.615	51.337	10.754	1.305	3.374
5e	**10**	49	297.265	338.295	202.429	135.866	26.976	2.622	9.075
5e	**10**	50	283.571	313.578	211.999	101.579	22.497	1.775	7.933
5e	**10**	51	328.677	410.509	206.356	204.153	33.941	2.441	10.327
5e	**10**	52	359.398	417.014	292.056	124.958	30.711	2.372	8.545
5e	**10**	53	383.400	531.915	270.636	261.279	51.790	3.331	13.508
5e	**10**	54	370.748	399.840	332.668	67.172	16.157	1.194	4.358
5e	**10**	55	299.356	383.583	248.262	135.321	19.691	1.223	6.578
5e	**10**	56	315.813	362.976	278.087	84.889	13.093	1.362	4.146
5e	**10**	57	342.945	418.760	292.312	126.448	33.956	2.301	9.901
5e	**10**	58	307.578	383.289	241.371	141.918	19.007	1.988	6.179
5e	**10**	59	401.327	522.739	341.530	181.209	29.353	2.353	7.314
5e	**10**	60	363.602	384.615	327.332	57.283	16.916	1.296	4.652
5e	**10**	61	379.041	391.236	354.862	36.374	7.969	.500	2.102
5e	**10**	62	408.009	436.491	348.189	88.302	19.812	1.253	4.856
5e	**10**	63	407.289	442.478	353.938	88.540	16.630	1.074	4.083
5e	**10**	64	414.050	437.828	318.167	119.661	24.875	1.505	6.008
5e	**10**	65	390.133	511.509	272.628	238.881	53.781	4.764	13.785
5e	**10**	66	286.857	327.761	196.812	130.949	39.890	7.524	13.906
5e	**10**	67	330.039	349.895	265.182	84.713	14.758	1.077	4.472
5e	**10**	68	383.937	573.066	212.179	360.887	106.236	4.958	27.670
5e	**10**	69	416.999	596.659	286.041	310.618	72.178	4.883	17.309
5e	**10**	70	410.015	509.165	323.834	185.331	40.845	2.342	9.962
5e	**10**	71	325.456	357.015	249.938	107.077	29.720	1.937	9.132
5e	**10**	72	327.334	412.541	208.030	204.511	66.909	4.254	20.440
5e	**10**	73	284.780	336.247	204.960	131.287	19.594	3.335	6.880
5e	**10**	74	521.533	680.272	335.345	344.927	109.347	2.274	20.966
5e	**10**	75	605.375	793.021	254.777	538.244	224.683	5.041	37.115
5e	**10**	76	323.440	378.931	211.506	167.425	58.352	2.066	18.041
5e	**10**	77	475.325	623.830	222.965	400.865	161.993	6.149	34.080
5e	**10**	78	349.513	399.840	227.221	172.619	33.264	1.640	9.517
5e	**10**	79	310.219	399.361	195.886	203.475	64.733	3.792	20.867
5e	**10**	80	339.890	383.995	312.012	71.983	8.423	.741	2.478
5e	**10**	81	313.184	338.295	244.858	93.437	10.810	1.124	3.452
5e	**10**	82	388.621	434.594	342.231	92.363	25.255	.765	6.499
5e	**10**	83	386.778	453.515	313.873	139.642	13.734	1.328	3.551
5e	**10**	84	399.445	455.581	311.139	144.442	40.302	2.608	10.090
5e	**10**	85	355.491	523.286	328.407	194.879	15.606	.828	4.390
5e	**10**	86	396.927	441.306	350.631	90.675	15.898	1.794	4.005
5e	**10**	87	394.896	456.413	301.932	154.481	29.976	2.545	7.591
5e	**10**	88	410.007	446.229	385.060	61.169	13.271	.865	3.237
5e	**10**	89	356.477	458.295	226.603	231.692	63.306	4.090	17.759
5e	**10**	90	395.614	564.016	234.082	329.934	72.304	5.757	18.276
5e	**10**	91	409.857	527.148	366.166	160.982	35.109	1.057	8.566
5e	**10**	92	387.476	568.828	335.909	232.919	36.298	2.153	9.368
5e	**10**	93	419.715	584.795	278.164	306.631	77.908	6.001	18.562
5e	**10**	94	295.861	350.877	212.269	138.608	26.919	3.262	9.099
5e	**10**	95	351.887	405.680	219.539	186.141	29.543	1.528	8.396
5e	**10**	96	334.844	396.668	269.978	126.690	43.488	2.383	12.988
5e	**10**	97	333.788	517.866	262.812	255.054	43.071	2.295	12.904

5e	**10**	98	313.049	339.328	256.410	82.918	15.544	2.108	4.965
5e	**10**	99	378.536	407.498	235.571	171.927	51.702	1.674	13.658
5e	**10**	##	317.438	369.959	259.067	110.892	26.408	3.108	8.319
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**353.417**	**432.026**	**268.948**	**163.079**	**37.018**	**2.299**	**10.004**
STD			65.189	99.025	54.507	90.553	31.846	1.396	6.519
			max:	**793.021**		**538.244**			
			min:		**189.897**	**32.604**			
Subject 5e - English						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**362.999**	449.903	272.819	**177.084**	**39.175**	**2.462**	**10.103**
STD			73.113	120.946	54.941	115.356	39.295	1.598	6.945
			max:	**1057.080**		**773.716**			
			min:		**189.897**	**32.604**			

Subject 6e - Englis						*6-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
6e	6	1	372.883	501.253	289.184	212.069	41.830	1.644	11.218
6e	6	2	343.880	391.696	296.296	95.400	15.061	1.030	4.380
6e	6	3	344.880	506.842	249.296	257.546	26.233	1.984	7.609
6e	6	4	345.109	434.405	291.800	142.605	30.641	2.116	8.879
6e	6	5	315.886	368.053	194.326	173.727	33.373	5.093	10.565
6e	6	6	426.701	482.859	345.066	137.793	27.917	1.825	6.543
6e	6	7	359.954	467.727	196.967	270.760	55.662	.975	15.464
6e	6	8	283.951	371.333	196.117	175.216	43.121	3.966	15.186
6e	6	9	305.461	408.497	195.810	212.687	79.917	27.684	26.163
6e	6	10	316.669	369.004	228.728	140.276	32.858	1.056	10.366
6e	6	11	331.787	369.686	290.613	79.073	17.038	3.032	5.135
6e	6	12	313.786	348.432	247.525	100.907	20.510	2.488	6.536
6e	6	13	301.353	330.579	273.299	57.280	14.637	2.214	4.857
6e	6	14	356.354	423.191	304.507	118.684	17.290	2.360	4.852
6e	6	15	365.954	438.789	280.820	157.969	35.308	2.337	9.648
6e	6	16	386.950	453.515	244.439	209.076	46.384	2.374	11.987
6e	6	17	382.754	584.112	279.174	304.938	31.822	2.234	8.314
6e	6	18	316.490	371.471	189.861	181.610	43.435	3.291	13.724
6e	6	19	328.913	429.738	254.518	175.220	19.798	1.843	6.019
6e	6	20	333.333	403.388	268.097	135.291	23.844	3.068	7.153
6e	6	21	327.932	382.263	220.946	161.317	26.343	1.168	8.033
6e	6	22	359.977	427.533	270.563	156.970	25.595	1.712	7.110
6e	6	23	330.515	446.229	241.779	204.450	21.761	2.101	6.584
6e	6	24	354.623	384.468	297.708	86.760	23.877	1.036	6.733
6e	6	25	343.227	388.954	248.077	140.877	37.381	2.613	10.891
6e	6	26	365.739	392.311	302.297	90.014	23.191	.914	6.341
6e	6	27	405.976	454.545	250.501	204.044	62.457	5.499	15.384
6e	6	28	411.173	464.468	281.611	182.857	39.020	4.141	9.490
6e	6	29	403.346	591.366	296.033	295.333	34.115	3.536	8.458
6e	6	30	353.384	381.098	270.197	110.901	21.809	1.443	6.172
6e	6	31	357.220	404.531	291.206	113.325	26.959	4.642	7.547
6e	6	32	328.807	587.889	293.083	294.806	24.223	1.598	7.367
6e	6	33	391.443	550.661	265.887	284.774	55.310	2.554	14.130
6e	6	34	387.022	442.870	303.122	139.748	36.184	2.078	9.349
6e	6	35	425.329	503.525	307.409	196.116	33.645	3.162	7.910
6e	6	36	343.376	431.593	235.682	195.911	34.103	3.591	9.932
6e	6	37	338.715	370.096	237.417	132.679	28.714	1.892	8.477
6e	6	38	370.718	423.729	256.279	167.450	31.859	2.408	8.594
6e	6	39	302.481	339.213	202.511	136.702	34.570	2.765	11.429
6e	6	40	417.307	745.712	194.250	551.462	84.676	5.163	20.291
6e	6	41	681.884	964.320	472.144	492.176	172.377	1.335	25.279
6e	6	42	554.624	983.284	200.884	782.400	198.439	8.028	35.779
6e	6	43	335.761	395.570	275.710	119.860	32.271	1.817	9.611
6e	6	44	427.579	526.593	357.398	169.195	27.423	.953	6.414
6e	6	45	393.114	424.268	331.126	93.142	24.319	2.422	6.186
6e	6	46	339.640	367.242	290.867	76.375	14.880	1.933	4.381
6e	6	47	367.223	406.174	254.065	152.109	33.574	2.190	9.143

6e	**6**	48	348.155	422.476	257.798	164.678	26.924	1.890	7.733
6e	**6**	49	304.927	378.644	204.499	174.145	22.500	1.213	7.379
6e	**6**	50	286.889	345.423	246.063	99.360	13.290	1.227	4.633
6e	**6**	51	314.826	327.225	231.214	96.011	16.521	.853	5.248
6e	**6**	52	342.943	569.476	308.642	260.834	22.639	1.264	6.601
6e	**6**	53	593.960	1066.098	327.976	738.122	155.575	2.951	26.193
6e	**6**	54	815.269	1009.082	378.788	630.294	137.906	2.593	16.915
6e	**6**	55	416.824	558.347	189.897	368.450	71.621	3.981	17.183
6e	**6**	56		1660.000	408.000	1252.000			
6e	**6**	57	343.320	378.501	317.662	60.839	13.725	1.088	3.998
6e	**6**	58	553.937	925.926	335.121	590.805	151.570	3.779	27.362
6e	**6**	59	376.667	523.013	268.673	254.340	61.933	1.424	16.442
6e	**6**	60	457.594	539.665	346.861	192.804	39.061	.695	8.536
6e	**6**	61	425.423	536.481	322.789	213.692	29.070	1.437	6.833
6e	**6**	62	361.827	512.033	214.684	297.349	44.902	4.164	12.410
6e	**6**	63	368.441	512.558	206.740	305.818	40.637	1.161	11.030
6e	**6**	64	432.557	631.313	206.016	425.297	66.430	3.249	15.357
6e	**6**	65	379.651	510.986	196.580	314.406	84.475	7.183	22.251
6e	**6**	66	439.884	614.628	33.111	581.517	32.734	1.148	7.441
6e	**6**	67	385.564	495.786	267.308	228.478	39.525	.704	10.251
6e	**6**	68	308.763	375.799	190.006	185.793	29.305	1.027	9.491
6e	**6**	69	356.121	394.633	312.695	81.938	22.197	.879	6.233
6e	**6**	70	365.338	392.465	215.100	177.365	36.662	.818	10.035
6e	**6**	71	374.674	394.011	334.896	59.115	10.092	.502	2.693
6e	**6**	72	364.451	398.724	260.146	138.578	31.673	1.015	8.690
6e	**6**	73	302.595	345.423	214.408	131.015	24.362	.755	8.051
6e	**6**	74	346.783	442.087	204.165	237.922	59.545	2.430	17.171
6e	**6**	75	345.596	466.636	207.211	259.425	32.203	2.037	9.318
6e	**6**	76	354.234	478.240	289.519	188.721	19.850	1.566	5.604
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**377.579**	**497.905**	**263.971**	**233.934**	**42.702**	**2.645**	**10.569**
STD			84.222	207.718	61.394	192.343	36.608	3.272	6.199
			max:	**1660.000**		**1252.000**			
			min:		**33.111**	**57.280**			

Subject 6e - Englis						*8-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
6e	8	1	402.573	703.730	289.603	414.127	75.768	2.329	18.821
6e	8	2	393.966	434.594	318.979	115.615	29.684	1.565	7.535
6e	8	3	385.945	440.335	299.401	140.934	33.577	1.621	8.700
6e	8	4	437.612	520.021	319.081	200.940	42.732	3.072	9.765
6e	8	5	411.475	654.450	200.803	453.647	77.825	6.517	18.914
6e	8	6	371.069	434.783	294.898	139.885	26.089	2.268	7.031
6e	8	7	329.728	458.295	253.357	204.938	31.023	4.473	9.409
6e	8	8	385.716	417.711	319.693	98.018	13.787	1.514	3.574
6e	8	9	396.808	486.145	199.283	286.862	95.661	5.057	24.108
6e	8	10	307.201	393.082	203.211	189.871	42.000	6.399	13.672
6e	8	11	338.182	520.291	290.867	229.424	29.617	2.476	8.758
6e	8	12	351.438	403.714	219.154	184.560	49.024	3.139	13.949
6e	8	13	636.875	896.861	399.202	497.659	132.122	3.544	20.745
6e	8	14	349.768	542.888	276.625	266.263	32.195	4.983	9.205
6e	8	15	470.286	672.495	368.596	303.899	41.265	5.158	8.774
6e	8	16	359.453	458.926	275.786	183.140	25.469	2.456	7.085
6e	8	17	382.844	410.509	312.989	97.520	20.672	1.044	5.400
6e	8	18	366.261	430.663	262.055	168.608	43.264	4.353	11.812
6e	8	19	324.598	366.838	280.191	86.647	19.992	1.145	6.159
6e	8	20	337.343	400.481	292.227	108.254	26.011	1.456	7.711
6e	8	21	328.482	356.379	244.798	111.581	24.779	1.890	7.543
6e	8	22	377.535	462.749	287.356	175.393	53.480	10.136	14.166
6e	8	23	459.346	650.195	294.377	355.818	49.004	3.391	10.668
6e	8	24	339.569	429.185	268.962	160.223	25.160	3.885	7.409
6e	8	25	378.754	498.504	217.533	280.971	45.041	3.325	11.892
6e	8	26	373.656	409.333	308.261	101.072	28.732	1.464	7.689
6e	8	27	325.531	356.888	290.444	66.444	12.129	1.994	3.726
6e	8	28	425.906	613.121	343.761	269.360	30.399	2.842	7.138
6e	8	29	392.363	445.633	300.300	145.333	26.450	1.969	6.741
6e	8	30	381.581	417.188	336.814	80.374	19.114	2.944	5.009
6e	8	31	339.995	385.208	234.742	150.466	38.063	6.340	11.195
6e	8	32	316.289	354.108	252.016	102.092	23.190	2.896	7.332
6e	8	33	338.694	397.456	293.600	103.856	25.691	1.680	7.585
6e	8	34	348.787	394.945	270.051	124.894	23.396	1.460	6.708
6e	8	35	429.625	509.424	382.117	127.307	23.791	.959	5.538
6e	8	36	325.622	371.195	299.312	71.883	11.663	1.048	3.582
6e	8	37	314.258	351.247	260.824	90.423	17.967	2.438	5.717
6e	8	38	327.856	346.620	250.376	96.244	15.758	.704	4.806
6e	8	39	736.666	823.723	533.618	290.105	48.786	1.356	6.623
6e	8	40	321.339	347.343	285.633	61.710	12.742	1.456	3.965
6e	8	41	313.747	340.136	287.191	52.945	9.079	1.216	2.894
6e	8	42	634.749	787.402	454.959	332.443	77.697	2.547	12.241
6e	8	43	371.326	448.229	304.878	143.351	17.564	1.054	4.730
6e	8	44	319.687	399.840	251.699	148.141	18.703	.911	5.850
6e	8	45	328.347	386.100	277.546	108.554	15.539	1.884	4.733
6e	8	46	320.983	346.741	269.179	77.562	18.225	1.895	5.678
6e	8	47	333.172	372.995	292.141	80.854	16.977	.935	5.096

6e	**8**	48	361.621	457.247	315.457	141.790	21.792	2.505	6.026
6e	**8**	49	343.002	392.157	229.779	162.378	23.310	2.003	6.799
6e	**8**	50	675.034	982.318	408.163	574.155	117.453	3.349	17.400
6e	**8**	51	440.881	467.727	354.359	113.368	13.831	.849	3.137
6e	**8**	52	374.385	387.898	288.351	99.547	10.931	.775	2.920
6e	**8**	53	327.807	357.654	301.114	56.540	11.840	2.012	3.612
6e	**8**	54	333.262	372.995	288.101	84.894	25.015	.962	7.506
6e	**8**	55	663.987	816.993	489.956	327.037	110.040	2.965	16.573
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**390.236**	**477.885**	**298.978**	**178.908**	**35.475**	**2.629**	**8.570**
STD			97.879	150.885	65.088	117.073	27.491	1.809	4.801
			max:	**982.318**		**574.155**			
			min:		**199.283**	**52.945**			

Subject 6e - Englis						*10-months*			
ID	**Age**	**#**	**Avg. Fo**	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
6e	10	1	383.371	562.114	274.348	287.766	56.900	13.700	14.840
6e	10	2	479.817	717.875	190.913	526.962	181.000	3.980	37.724
6e	10	3	292.188	444.444	233.155	211.289	41.993	12.673	14.372
6e	10	4	341.989	499.750	253.743	246.007	49.959	9.845	14.608
6e	10	5	342.195	488.520	244.320	244.200	55.499	4.484	16.219
6e	10	6	365.722	473.485	283.447	190.038	37.504	2.744	10.255
6e	10	7	305.358	349.895	269.397	80.498	17.072	3.164	5.591
6e	10	8	343.479	526.316	257.798	268.518	33.700	1.903	9.811
6e	10	9	312.173	452.694	230.894	221.800	36.383	3.848	11.655
6e	10	10	285.004	369.004	202.470	166.534	29.879	2.656	10.484
6e	10	11	296.137	454.339	220.799	233.540	47.768	13.379	16.300
6e	10	12	307.056	419.111	195.008	224.103	58.927	17.523	19.191
6e	10	13	300.733	437.637	233.372	204.265	42.936	5.834	14.277
6e	10	14	403.200	594.177	235.849	358.328	59.751	3.151	14.819
6e	10	15	334.665	515.996	219.877	296.119	49.982	4.934	14.935
6e	10	16	395.402	579.039	298.418	280.621	45.997	2.859	11.633
6e	10	17	363.362	429.923	267.523	162.400	38.663	3.287	10.640
6e	10	18	338.563	464.535	292.398	172.137	22.605	.961	6.677
6e	10	19	347.094	415.800	266.241	149.559	20.897	.909	6.020
6e	10	20	308.829	455.789	225.428	230.361	45.035	9.811	14.583
6e	10	21	334.052	416.667	244.320	172.347	28.308	3.554	8.474
6e	10	22	373.250	444.444	312.989	131.455	35.061	2.595	9.393
6e	10	23	480.880	568.182	361.272	206.910	46.723	3.121	9.716
6e	10	24	397.221	473.934	311.915	162.019	31.182	1.225	7.850
6e	10	25	435.946	561.798	312.012	249.786	49.095	4.549	11.262
6e	10	26	428.171	491.642	324.359	167.283	32.475	1.971	7.585
6e	10	27	280.350	365.097	241.255	123.842	18.058	3.717	6.441
6e	10	28	372.818	407.498	327.761	79.737	12.699	.821	3.406
6e	10	29	405.724	449.640	313.381	136.259	42.559	3.000	10.490
6e	10	30	505.222	640.205	366.435	273.770	42.464	3.133	8.405
6e	10	31	433.855	582.072	345.543	236.529	35.350	2.932	8.148
6e	10	32	352.556	469.043	288.434	180.609	28.328	1.828	8.035
6e	10	33	414.497	521.648	293.686	227.962	52.593	2.980	12.689
6e	10	34	414.775	509.165	279.642	229.523	57.750	3.684	13.923
6e	10	35	457.604	594.177	332.557	261.620	49.152	5.071	10.741
6e	10	36	253.492	372.578	193.836	178.742	23.704	5.237	9.351
6e	10	37	357.286	563.063	194.137	368.926	63.561	8.962	17.790
6e	10	38	416.000	569.801	281.690	288.111	40.295	4.401	9.686
6e	10	39	417.850	554.939	299.222	255.717	39.821	3.907	9.530
6e	10	40	400.461	553.097	328.515	224.582	30.296	3.556	7.565
6e	10	41	471.045	523.835	408.998	114.837	17.897	1.410	3.799
6e	10	42	488.392	565.291	375.516	189.775	38.221	4.356	7.826
6e	10	43	310.111	451.671	237.925	213.746	39.281	12.616	12.667
6e	10	44	397.948	513.084	234.742	278.342	70.611	9.592	17.744
6e	10	45	337.226	395.413	266.951	128.462	27.587	2.664	8.181
6e	10	46	303.723	337.610	268.312	69.298	15.004	3.124	4.940
6e	10	47	393.813	554.324	297.796	256.528	31.177	2.883	7.917

6e	10	48	424.371	514.403	331.455	182.948	41.817	2.507	9.854
6e	10	49	308.882	396.983	194.401	202.582	60.411	6.430	19.558
6e	10	50	309.980	354.988	246.670	108.318	24.530	2.049	7.913
6e	10	51	368.790	529.101	283.447	245.654	36.249	5.117	9.829
6e	10	52	373.572	476.644	274.801	201.843	26.262	2.386	7.030
6e	10	53	440.861	544.662	360.360	184.302	32.614	2.078	7.398
6e	10	54	403.241	646.831	292.141	354.690	70.847	6.534	17.569
6e	10	55	412.091	514.933	331.345	183.588	27.639	4.037	6.564
6e	10	56	375.782	432.339	308.833	123.506	27.309	1.328	7.267
6e	10	57	300.688	348.189	268.528	79.661	14.810	2.788	4.926
6e	10	58	388.358	597.015	279.642	317.373	64.673	7.112	16.653
6e	10	59	303.054	362.319	262.881	99.438	17.684	3.550	5.835
6e	10	60	433.178	533.049	308.166	224.883	38.261	1.921	8.833
6e	10	61	406.852	477.555	347.826	129.729	19.534	2.084	4.801
6e	10	62	320.016	360.231	279.877	80.354	19.860	2.000	6.206
6e	10	63	339.764	429.553	242.189	187.364	45.096	1.710	13.273
6e	10	64	374.575	527.426	254.259	273.167	70.491	19.549	18.819
6e	10	65	366.024	411.523	324.992	86.531	12.893	1.280	3.523
6e	10	66	306.932	403.551	208.030	195.521	30.140	5.925	9.820
6e	10	67	343.774	367.377	316.957	50.420	9.532	1.783	2.773
6e	10	68	325.578	453.309	257.400	195.909	29.330	.950	4.387
6e	10	69	388.570	523.286	265.887	257.399	36.165	3.640	9.307
6e	10	70	297.625	409.500	208.899	200.601	41.715	8.051	14.016
6e	10	71	369.180	480.538	305.157	175.381	27.706	1.868	7.505
6e	10	72	354.202	402.253	290.276	111.977	49.615	.661	12.097
6e	10	73	410.132	545.256	255.167	290.089	49.615	.661	12.097
6e	10	74	424.724	579.374	300.842	278.532	29.766	3.335	7.008
6e	10	75	340.371	441.501	237.197	204.304	31.804	3.726	9.344
6e	10	76	334.004	384.911	254.647	130.264	31.411	4.010	9.400
6e	10	77	351.829	465.766	190.730	275.036	56.108	8.257	15.947
6e	10	78	364.762	481.696	235.239	246.457	37.918	2.216	10.395
6e	10	79	383.020	482.625	351.370	131.255	22.375	1.666	5.842
6e	10	80	416.233	549.451	354.108	195.343	31.629	4.697	7.599
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**369.270**	**481.606**	**277.029**	**204.577**	**39.219**	**4.431**	**10.520**
STD			54.631	79.749	49.222	79.272	21.700	3.740	5.107
			max:	**717.875**		**526.962**			
			min:		**190.730**	**50.420**			
Subject 6e - Englis						***Overall Scores***			
			Avg. Fo	**High Fo**	**Low Fo**	**Fo range**	**STD**	**Sppq**	**vFo**
averages			**377.729**	486.507	278.047	**208.460**	**39.482**	**3.321**	**10.027**
STD			78.635	154.052	59.446	139.895	29.253	3.269	5.493
			max:	**1660.000**		**1252.000**			
			min:		**33.111**	**50.420**			