

**Non-Linguistic Influences on Infants' Nonnative Phoneme Perception:
Exaggerated Prosody and Visual Speech Information Improve Discrimination**

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(ABSTRACT)

Research indicates that infants lose the capacity to perceive distinctions in nonnative sounds as they become sensitive to the speech sounds of their native language (i.e., by 10- to 12-months of age). However, investigations into the decline in nonnative phonetic perception have neglected to examine the role of non-linguistic information. Exaggerated prosodic intonation and facial input are prominent in the infants' language-learning environment, and both have been shown to ease the task of speech perception. The current investigation was designed to examine the impact of infant-directed (ID) speech and facial input on infants' ability to discriminate phonemes that do not contrast in their native language. Specifically, 11-month-old infants were tested for discrimination of both a native phoneme contrast and a nonnative phoneme contrast across four conditions, including an auditory manipulation (ID speech vs. AD speech) and a visual manipulation (Face vs. Geometric Form). The results indicated that infants could discriminate the native phonemes across any of the four conditions. Furthermore, the infants could discriminate the nonnative phonemes if they had enhanced auditory and visual information available to them (i.e., if they were presented in ID speech with a synchronous facial display), and if the nonnative discrimination task was the infants' first test session. These results suggest that infants do not lose the capacity to discriminate nonnative phonemes by the end of the first postnatal year, but that they rely on certain language-relevant and non-linguistic sources of information to discriminate nonnative sounds.

Dedication

Dad and Mom, this is for you...
After all, we really did it together.

Dad, thank you for teaching me to love to read.
I don't think I would have been able to read for four years straight if it hadn't been
for our early adventures in Big Pines Forest or with Frog, Toad or Cousin Bernard.
And Mama, thank you for always telling me exactly what to say.
I owe the verbal skills to our conversations every single night.

Thank you both for cheering me on, and for teaching me
that I can do anything in this whole world.
Thank you also for reminding me how short life is,
and how important it is to spend some days just looking at clouds or collecting rocks.

Thank you for making us your top priority always,
even when it meant sacrificing things for yourselves.
Thank you for being there not matter what, but more importantly, for being happy to be there.

I love you more than anything else in this world.

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Chapter 1. INTRODUCTION & LITERATURE REVIEW

Infants from all parts of the world learn to perceive and produce their native language at approximately the same time, and without explicit instruction (McNeil, 1970; Shatz, 1991). This is remarkable considering that the languages of the world vary tremendously in terms of phonology, semantics and grammar—with the structure of some languages being significantly more complex than others. Although variability exists between languages, experience for each infant *within* their own language environment is highly ordered. In other words, all infants are immersed in a rich and social native language context (Vygotsky, 1986). As a result, they begin to attend to specific information available in the surround, to organize the native language input, and to extract invariances from it. Thus, the development of speech perception in infants seems to be well characterized by an ecological view of perception.

According to ecological theory, every level of organismic function is intimately construed within its context. The way that organisms come to operate in their surround is through perception, which is based on the direct pickup of plentiful, complex, valid information (J.J. Gibson, 1986). Perceptual development depends upon perceptual learning, the progressive specification of the information in the world through experience. Thus, organisms must come to discover regularities by differentiating persistent from changing aspects of the environment (E.J. Gibson, 1969, 1991). Perception also involves the filtering out of unnecessary noise so as to encounter only that information that specifies the structure of relevant events and objects. For instance, in language development, directed attention toward the array of speech information leads to the formation of perceptual biases which delimit what must be processed and make the relevant information for native language perception more prominent (Werker, 1991, 1994). That is, in the course of learning how to perceive speech, infants become both attuned to the sounds present in their native language and insensitive to the sounds not present in their native language (Aslin & Smith, 1988; Werker & Tees, 1984).

The attunement to native language sounds occurs in a context abundant with both non-linguistic and linguistic information. Two prominent nonlinguistic sources of language-relevant information are exaggerated prosodic intonation and visual (e.g., facial) input. Impressive bodies

of research have indicated that each of these nonlinguistic sources ease the task of speech perception, thereby serving an important language function (e.g., Karzon, 1985; Kuhl et al., 1997; Massaro, 1987; Summerfield, 1987). Given that language development naturally occurs in a context with both exaggerated prosody and visual input, their contribution to the native language tuning process needs to be explored. The pick-up of nonlinguistic information may be critical to the process of learning native language sounds. However, past research on infants' perception of native and non-native speech sounds has neglected the role of non-linguistic information. The present investigation has been designed as a first step toward understanding how non-linguistic influences affect infants' discrimination of native and non-native speech sounds.

1.1 Categorical and Cross-Language Speech Perception

In order to acquire their native language, infants must organize the continuous stream of speech into discrete perceptual entities that can be mapped onto meaning (Best, 1994). This is quite a task considering that the acoustical form of every utterance varies tremendously across and within individual speakers, rates of speech and contexts. Infants organize speech input by perceiving speech sounds categorically. That is, they perceive slightly different sounds that correspond to a single phoneme as equivalent (part of a single category) but perceive other similarly distinct sounds as different phonemes (belonging to two separate categories) (Kuhl et al., 1991). This was empirically demonstrated in a classic study by Eimas and his colleagues, in which 1- and 4-month-olds exhibited superior discrimination of phonetic contrasts which were from two different perceptual categories, and failed to discriminate phonetic contrasts within the same category (Eimas, Siqueland, Jusczyk & Vigorito, 1971). Notably for the language learner, sounds that are from different perceptual categories tend to signal a difference in meaning (such as in the sounds /r/ and /l/ in /rock/ and /lock/).

Young infants' ability to categorize speech sounds is manifest in their capacity to discriminate any phonetic comparison, whether or not it is contrasted phonologically in their native language. This was first reported in a study by Streeter (1976), in which young Kikuyu-learning infants exhibited discrimination of an English voiced/voiceless phonemic distinction that does not exist in the Kikuyu language. Since then, a corpus of research has shown that

infants under 6-months of age do not need specific language experience to discriminate any phoneme comparison on which they have been tested (e.g., Aslin, Pisoni, Hennessy & Perey, 1981; Best, McRoberts & Sithole, 1988; Eimas, 1975; Lasky, Syrdal-Lasky & Klein, 1975; Trehub, 1976; Werker, Gilbert, Humphrey & Tees, 1981; Werker & LaLonde, 1988; Werker & Tees, 1984). This universal sensitivity is a precursor to learning the phonetic properties (including articulatory and/or acoustic information) that define the phonological organization of one's own native language (Aslin, Jusczyk & Pisoni, 1996).

Interestingly, adults have considerable difficulty with categorizing and discriminating phoneme contrasts that are not present in their native language (Lively, Logan & Pisoni, 1993; Logan, Lively & Pisoni, 1991; Pisoni, Lively & Logan, 1994; Tees & Werker, 1984). For instance, although the consonants /r/ and /l/ are contrasted allophonically in English, they are not contrasted in many Asian languages (Tees & Werker, 1984). As a result, monolingual adult speakers of such languages as Japanese, Thai and Korean have problems perceiving the difference between these English sounds (Sheldon & Strange, 1982). In the same way, adult speakers of English have trouble distinguishing between the retroflex /ʈa/ sound and the dental /t̪a/ sound in Hindi (Werker, Gilbert, Humphrey & Tees, 1981; Werker & Tees, 1984); and the stridency contrast /za/ versus /ra/ in Czech (Trehub, 1976). Adults can achieve a rudimentary ability to perceive certain nonnative phoneme contrasts with enough training, but they rarely reach the accuracy level of infants (Werker et al., 1981).

1.2 The Decline in Nonnative Phoneme Perception

Werker and her colleagues discovered that children also have difficulty perceiving nonnative phoneme contrasts (Tees & Werker, 1984), and began examining infancy for changes in this perceptual capacity. From a series of seminal experiments Werker and Tees (1984) reported that a profound change in ease of phoneme discrimination occurred by the latter half of the first postnatal year. In their longitudinal study, infants were tested for their ability to distinguish between two phonemes sounding almost alike but from different “perceptual categories”. The stimuli were from three languages: English, Hindi, and Nthlakapmx. At the age of 6- to 8-months, all of the English-reared infants were able to discriminate the three contrasts. By 8- to 10-months, only a small percentage of the infants could discriminate the

nonnative contrasts, and by 10- to 12-months, none of the infants tested could discriminate between the phonemes that were not contrasted in their native language (Werker & Tees, 1984). Thus, it appeared that specific language experience within the first year of postnatal life facilitated a reorganization in perceptual capabilities, which was evident by approximately 10- to 12-months of age. This reorganization manifested itself in infants' declining abilities to discriminate sounds not represented in their native language. Apparently, as infants experience the structured milieu of their native language, their perceptual systems become influenced by the sound categories and sound patterns appropriate to their native language (Aslin et al., 1996; Tees & Werker, 1984). That is, infants perceptually delimit the available input by attending to those sounds that exist in their native language and tuning out the sounds that do not. This finding has been replicated in several laboratories using various procedures, with naturally produced as well as synthetic speech tokens, and in several languages (see Best, 1994, 1995 and Werker, 1991, 1994 for reviews). Because phonemes are used contrastively in all languages, the emergence of word meaning at approximately the same age (i.e., 10- to 12-months) should come as no surprise (Werker & LaLonde, 1988). Indeed, this phenomenon is understood to reflect the perceptual biasing which is required for the acquisition of a native language.

It seems that the decline in nonnative phoneme processing is a critical step in the infant's language-learning process. And yet, we know little about the factors in the ambient language environment that are involved in this tuning process. If the decline in nonnative speech perception is part of the foundation of native phonology acquisition, researchers need to understand how the available information in the native language context may affect it. Again, speech perception develops out of a transaction between an exploratory organism, and a rich, social, multimodal context (E.J. Gibson, 1987). Both exaggerated prosodic information and visual information are prominent features of the infant's typical experience with their native language, and they both afford information for language specifics. However, neither the impact of exaggerated prosody, nor the impact of visual language information has ever been examined within the native language perceptual tuning process.

1.3 Prosodic Exaggeration Enhances Language Information

Across cultures, languages, modalities and species, infants are addressed differently than adults (Biben, Symmes & Bernhards, 1989; Fernald & Simon, 1984; Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies & Fukui, 1989; Grieser & Kuhl, 1988; Masataka, 1992; Rabain-Jamin & Sabeau-Jouannet, 1997). The speech directed to infants is prosodically exaggerated—tending to be higher pitched and more melodic, with elongated vowels, expanded pitch contours, increased rhythmicity, repetitious words and simplified content (Cooper, Abraham, Berman & Staska, 1997; Fernald, 1985; Fernald & Kuhl, 1987; Papousek, Papousek & Bornstein, 1985; Werker & McLeod, 1989). This specialized speech register, known as infant-directed (ID) speech, has been documented in adults of both sexes (Jacobson, Boersma, Fields & Olson, 1983), parents as well as nonparents (Gleason, 1975), and children (Sachs, 1977). Furthermore, infants exhibit enhanced attention to ID speech over adult directed (AD) speech across the entire first year of life (Cooper & Aslin, 1990; Cooper et al., 1997; Fernald, 1985; Glenn & Cunningham, 1983; Pegg, Werker & McLeod, 1992; Werker & McLeod, 1989). Because ID speech is so prominent in the environment of the infant listener, its value for infant functioning has been repeatedly examined. Among other possible roles (including the modulation of arousal and the direction of attention), ID speech has been found to enhance the perception of information available in faces and other linguistically relevant input.

For example, Kaplan and his colleagues used a conditioned attention paradigm to assess whether ID speech would more readily promote the processing of facial information over AD speech. To do so, these researchers paired ID or AD speech with a visual presentation of a smiling face, and then presented the infants with a novel checkerboard pattern to assess summation (i.e., if the infants formed an association between the speech type and the face, they would look longer at a presentation of the speech paired with a novel visual stimulus than at the novel visual stimulus alone). The data revealed that the attentional responses elicited by ID speech were greater than those elicited by AD speech, as ID speech and the face stimulus were associated more quickly and strongly. In fact, the AD speech elicited no conditioning at all. Thus, it seems that ID speech can function to prime infants for the processing of facial information (Kaplan, Jung, Ryther & Zarlengo-Strouse, 1996).

Data suggest that the exaggerated prosody of ID speech can also facilitate speech perception, by specifying phonetic information for the infant. In one experiment Kuhl and her colleagues discovered that the acoustically extreme vowel sounds characteristic of ID speech across languages actually expand the vowel triangle, thereby making the distinctions between phonemes more prominent (Kuhl, Andruski, Chistovich, Chistovich, Kozhevnikova, Ryskina, Stolyarova, Sundberg & Lacerda, 1997). Desjardins and Trainor (1999) discovered that the large pitch contours of ID speech could aid infants in discriminating between vowel sounds, as they facilitate the extraction of formant-frequency information (which specifies critical information about individual vowels). In a series of experiments by Karzon (1985), 1- and 4-month-old infants only discriminated embedded phoneme contrasts (i.e., /ra/ and /la/ in the nonsense words [*malana*] and [*marana*]), if the embedded phonemes were accentuated by ID speech. The infants could not make the discrimination if the words were spoken in AD speech or if another syllable was accentuated with ID speech. Karzon concluded that prosodic characteristics play an important role in speech perception by drawing attention to sound differences that need to be deciphered.

ID speech can also aid infants in the task of parsing an ongoing stream of speech, by highlighting syntactic units within a sentence. For instance, Hirsh-Pasek and her colleagues found that 7- to 10-month-old infants used prosodic markers to identify the clausal units of paragraphs (Hirsh-Pasek, Kelmer Nelson, Jusczyk, Wright Cassidy, Druss, & Kennedy, 1987). That is, they preferred ID speech paragraphs with pauses inserted at the clause boundaries (as they are normally) to ID speech paragraphs with pauses inserted in spots not coincidental with the clauses. In a follow-up study, Kelmer Nelson, Hirsh-Pasek, Jusczyk and Wright Cassidy (1989) discovered that 7- to 10-month-olds only exhibited preferential attention to the “correct” paragraphs when they were spoken in ID speech. In another investigation by Jusczyk, Hirsh-Pasek, Kelmer Nelson, Kennedy, Woodward and Piwoz (1992) 9-month-old infants attended longer to ID speech sentences interrupted at the appropriate phrase boundary, over sentences interrupted within a phrase. This pattern of results was observed in five groups of infants and with two sets of stimuli. The pattern was also observed when the speech samples were low-pass filtered to eliminate linguistic content (Jusczyk et al., 1992). In these experiments, the

exaggerated prosody of ID speech acted as a bracket, dividing the stream of speech into those meaningful units that are required for the acquisition of a grammar.

Even late in the first postnatal year, when infants have begun to attune to the linguistic properties of their native language, their attention is still guided by the information in prosodically exaggerated speech. In a recent study from our laboratory, Ostroff and Cooper (1999) examined the attention of 10-month-old infants to ID speech in a native versus a nonnative language. The infants exhibited a preference for native ID speech, and did so even when the utterances had matching prosodic envelopes (i.e., when the ID speech recordings were identical nursery rhymes in each language). This pattern of results indicated that the infants were in fact processing linguistic level information. In a subsequent study, 10-month-olds were given a choice to attend to native linguistic content with diminished prosody (i.e., AD native speech) or non-native linguistic content with exaggerated prosody (i.e., ID foreign speech). In this case, the infants exhibited more attention toward ID speech. In other words, the prosody of ID speech appears to remain an informative perceptual event even when infants have begun to ‘tune out’ linguistic information that does not exist in their native language. However, the role of ID speech has never been directly examined in the context of the decline in nonnative phoneme perception.

1.4 Language Information Available in the Visual Modality

Although language perception is typically thought of as an auditory function, visual information is an integral part of the speech signal. Charles Darwin noted, “The force of language is much aided in the expressive movements of the face...” (1872, p. 354). Actions of the face can reinforce, intensify, weaken or even contradict the message in linguistic communication, and are considered to be responsible for much of the signal that makes up speech (Locke, 1993). For instance, speech can be perceived under extremely impoverished listening conditions if the face of the talker is in full view (Grant, Ardell, Kuhl & Sparks, 1985). In one experiment, speech presented against a background of interfering prose was transcribed much more accurately when the perceiver could view the speaker’s face. Interestingly, the subjects in this study claimed that test sentences “sounded clearer” when they were presented bimodally (Summerfield, 1979). The sight of a person producing speech also contributes to its

perception by hearing impaired individuals. Watching the oral movements of a talker has been compared to about a 20dB boost in the auditory signal (Sumbly & Pollack, 1954).

It seems that the visual and auditory information about speech integrates directly (in the Gibsonian sense), devoid of the influence of learned associations. This was demonstrated in an experiment by Green and Kuhl (1991), in which they examined adults' reaction times to classify auditory-visual syllables along the voicing dimension (which varies only in the auditory domain) and along the place of articulation dimension (which varies only in the visual domain). When classifying the auditory stimuli according to voicing, variation in place of articulation (i.e., a visual feature) produced an increase in classification times, even though vision does not contribute information about voicing. Likewise, when classifying visual stimuli according to place of articulation, variation in voicing (i.e., an auditory feature) resulted in increased classification times. The authors reasoned that the observed “interference” effect indicated an integration of information from the two modalities prior to phonetic feature assignment (i.e., that the two were never treated as separate). Thus, what people report “hearing” is really a unified percept derived from both auditory and visual sources (Meltzoff & Kuhl, 1994).

In fact, it is impossible for normal hearing listeners *not to attend* to visual information for speech when it is available (Massaro & Cohen 1983). This was most remarkably demonstrated in a study by McGurk and MacDonald (1976) in which adults were presented with auditory information (/ba/) concurrently with conflicting visual information (/ga/). When asked to report what sound they perceived, 95% of the adults reported “hearing” /da/, a fused syllable from the two. Called the McGurk Effect, the strength of this finding is impressive as demonstrated by Green, Kuhl, Meltzoff and Stevens (1991). These authors created an obvious discrepancy between the gender of the talker and the gender of the face presented. In particular, the face that subjects saw was a masculine, thick-necked man saying the phoneme /ga/ paired with the voice of an extremely feminine, high-pitched voice saying /ba/, and vice versa. Although subjects reported that it was strange to hear a high-pitched voice come out of a large man's face, the number of auditory-visual blends was not significantly different from that in the matched gender case. That is, subjects did not report seeing and hearing different phonetic sounds—they reported hearing the blended sound /da/.

The McGurk effect has been replicated across several manipulations: including when subjects are explicitly told of the dubbing procedure or asked to attend to information from only one modality (Massaro, 1987); when the visual stimuli (i.e., the faces) are rotated or inverted (Jordan & Bevan, 1997; Massaro & Cohen, 1996); and when the auditory stimuli are asynchronous with the visual stimuli, lagging by up to 180 milliseconds (Munhall, Gribble, Sacco & Ward, 1996). McGurk Effect-like blends are also commonly perceived when audio recordings of real words are dubbed onto faces saying different words. For example, when the acoustical word /mail/ was dubbed onto a video of a face saying /deal/, many subjects reported hearing the word /nail/ (Dekle, Fowler & Funnell, 1992).

In an interesting study by Werker, Frost and McGurk (1992), the McGurk Effect was reexamined within the context of the decline in nonnative phoneme perception. These researchers were interested in discovering whether specific linguistic experience affects the perception of visual speech information, as it does auditory. They presented French- and English-speaking adults with the visual stimuli /ba/, /va/, /da/, /za/, /ga/ and /ɔa/ (all of which, except /ɔa/, exist in both languages) paired with the auditory phoneme /ba/. Results indicated no differences between the French- and English-speakers in auditory-alone and visual-alone control trials. When the audio-visual stimuli were presented, however, there were profound and consistent differences between the groups. Specifically, there was an inverse relationship between proficiency in English and the proportion of visual capture during the /ɔa/-visual paired with /ba/-auditory trials (i.e., the only visual phoneme tested that does not exist in French). In other words, the perception of visual speech information was affected by specific language experience in much the same way as infant perceptual attunement to native language phonemes. The French speakers were more compelled to utilize visual information as part of their perception when the available signal was nonexistent in their native language. Perhaps in the same vein, infants who have perceptually tuned to their native language could utilize visual information to help them perceive nonnative sounds. Thus, an important point arises for the present investigation. Namely, when auditory perception becomes difficult, perceivers tend to rely more heavily on visual input. Because the decline in nonnative phoneme perception has never been observed in a bimodal context, we have no way of knowing whether infants would begin to more actively utilize visual cues as the auditory information became imperceptible (i.e.,

after about 10- to 12-months of age). In other words, to fully understand the perceptual tuning to native language sounds, it is necessary to further explore infant use of visual information for language.

1.5 The Importance of Visual Information for Infant Speech Perception

According to E.J. Gibson (1969), infants' perceptual systems are equipped from the start to pick up multimodal information. Several lines of research have supported this claim, revealing that infants are sensitive to correspondences in audio and visual information, and that such multimodal sources of stimulation may aid in perceptual learning. For example, Lewkowicz (1988, 1992, 1996) has conducted a number of experiments on infant discrimination of changes in multimodal displays—in the auditory dimension, the visual dimension, or both. Although these studies have produced mixed results with regard to sensory dominance, they have repeatedly shown that infants can discriminate bimodal (i.e., audio and visual) changes in stimulation with greater ease and months earlier than they can discriminate changes to audio or visual information alone. Bahrick and her colleagues have also demonstrated the facility with which infants integrate sensory information from different modalities. In particular, these researchers reported that infants are sensitive to a number of temporal parameters that unite vision and audition—including synchrony of audio-visual objects hitting surfaces (Bahrick, 1983); and the composition of moving objects (whether they are comprised of a single large element or many smaller elements) (Bahrick, 1987, 1988).

Young infants exhibit distinct sensitivities to facial and vocal correspondence. For example, infants are bothered by audio-visual asynchronies in speech. In one experiment, they were more than twice as likely to turn away from a video screen when the speaker's articulatory movements were out of sync than when they were in perfect time (Dodd, 1979). Infants also exhibited distress when presented with their mother's voice displaced from her face (Aronson & Rosenbloom, 1971). Walker-Andrews (1982, 1986) has reported that by 7-months of age, infants can match the facial and vocal aspects of an emotional display, by selectively attending to one of two adjacent faces which corresponds to the emotional tone of a single soundtrack. Apparently the faces and voices are perceived as a unified multimodal event with unique communicative affordances for the infant (Walker-Andrews, 1997). By the same token, Kuhl

and Meltzoff (1982, 1984) showed that 4-month-old infants attend significantly longer to one of two adjacent faces that matches a single vowel sound. The capacity to match vowel sounds with corresponding facial configurations appears to be robust, in that it has been repeated with various vowels and sound combinations (MacKain et al., 1983; Walton & Bower, 1993). In one study, 4 ½-month-olds could match intermodal speech information in both native and foreign phonetic units (Walton & Bower, 1993). Furthermore, the ability to match sounds with faces presenting the same vowel is specific to linguistic information, as infants have shown no ability to match pure tones of various frequencies, or to match three-tone non-speech analogs with the appropriate visual stimuli (Kuhl et al., 1991).

The McGurk Effect seems to occur in infancy as readily as it does in adulthood. In one experiment, Rosenblum, Schmuckler and Johnson (1997) presented 5-month-old infants with matched and mismatched audio-visual stimuli in an infant-controlled habituation procedure. In particular, infants were habituated to a presentation of audio /va/-visual /va/ and then tested for dishabituation to either audio /ba/-visual /va/ or audio /va/-visual /ba/ stimuli. The infants recovered their looking times when there was a switch in the visual stimulus, but not when there was a switch in the auditory stimulus, indicating that they perceived a McGurk-type visual influence. Subsequent study revealed that this result was not due to a greater inherent interest in the audio /va/-visual /ba/ stimulus; and was also not due to an inability to discriminate the two auditory phonemes (i.e., they could discriminate the phonemes /ba/ and /va/ without problem when they were presented with a static image of a face). Burnham and his colleagues found similar results with 4 ½-month olds. Using a habituation model, they observed that both the auditory stimuli and the visual stimuli elicited novelty responses when presented in isolation, subsequent to habituation to the auditory-visual presentation (Burnham & Dodd, 1996; Burnham, 1992). Apparently visual information *can and does* provide important cues to infants during the ontogeny of native language speech perception. How infants use such cues, however, has been relatively unexplored. In short, a full understanding of the integration of auditory and visual speech information—how the integration develops and how it might be affected by specific linguistic experience—is absolutely essential for a comprehensive model of speech perception (Burnham, 1998).

1.6 Importance of the Present Investigation

Much research has been conducted on the perceptual tuning to native phoneme contrasts, and this perceptual reorganization is thought to be an important part of acquiring one's native language (Werker, Lloyd, Pegg & Polka, 1996). Generally speaking, it is agreed in the perception literature that organisms utilize multiple sources of information to achieve perceptual recognition (Massaro et al., 1993). More specifically, within ecological theory of perception, it is believed that perceivers directly pick up all information in the stimulus array with meaning for them (Aslin & Smith, 1988; J.J. Gibson, 1986; E.J. Gibson, 1969, 1987, 1991). Nevertheless, the decline in nonnative phoneme perception has never been examined within the context that it typically occurs (i.e., with exaggerated prosodic information and audio-visual information available). Instead, studies of nonnative phoneme discrimination have traditionally been carried out using a man's monotone voice as the auditory stimulus, paired with a language-irrelevant visual display (e.g., a geometric shape or a blinking light) (Best et al., 1988; Best et al. 1995; Tees & Werker, 1984; Trehub, 1976; Werker & LaLonde, 1988; Werker & Tees, 1984). Thus, the question arises as to the validity of these data. Perhaps existing evidence for a decline in discrimination of nonnative phonemes is constrained by the types of stimulus materials that have been used.

Often in investigations of perceptual competency, slightly changing the stimuli or the context leads to pronounced changes in results, forcing researchers to reconsider their conclusions. For instance, in the ID speech literature, it was considered ubiquitous that young infants prefer ID speech to AD speech (Cooper & Aslin, 1990; Cooper et al., 1997; Fernald, 1985; Glenn & Cunningham, 1983; Pegg, Werker & McLeod, 1992; Werker & McLeod, 1989). However, subsequent study revealed that in the context of a familiar voice (i.e., the voice of the mother), the preference for ID over AD speech in 1-month-olds desists (Cooper, Abraham, Berman & Staska, 1997). Given greater postnatal exposure to auditory stimulation (i.e., by 4-months of age) the infants in this study did come to prefer maternal ID speech to maternal AD speech. Manipulating the context of the speech presentation led to a more complete picture of the development of preferential attention to ID speech.

Research in the audio-visual perception literature has also indicated that careful analysis of the context is necessary before conclusions about infant capabilities can be reached. For instance, Walker-Andrews and Lennon (1991) found that 5-month old infants could discriminate between happy, angry and sad vocal expressions when paired with a visual stimulus of a face. However, the 5-month-olds could not make any of the same discriminations when the voices were paired with a checkerboard visual stimulus. Again, it seems that dynamic, multimodal and contextually rich situations are needed in order to accurately assess infants' perceptual competencies (Walker-Andrews, 1997). The importance of examining multiple contextual factors when exploring infant responsivity cannot be overstated.

The current investigation was designed to examine the impact of typically present information (i.e., ID speech and facial input) on infants' ability to discriminate phonemes that do not contrast in their native language. The fact that speech perception always occurs in context, and the fact that exaggerated prosody and visual information are both tied to the perception of language, made it critical to examine the impact that each could have on the perception (or lack thereof) of nonnative sounds. Also, knowing that prosodic and visual information come to be most important when the auditory input is difficult to discern or is imperceptible (e.g., Karzon, 1984; Werker, Frost & McGurk, 1992), further implied a role for these types of information in the native language tuning process. This line of inquiry is critical to our understanding of the language acquisition process in general and the development of native language speech perception in particular.

In this experiment, 11-month-old infants were tested for discrimination of both a nonnative phoneme contrast and a native (control) phoneme contrast in one of four contexts: (1) in ID speech, paired with a synchronous facial display of a female speaker uttering the phonemes (ID-F), (2) in AD speech, paired with a synchronous facial display of a female speaker uttering the phonemes (AD-F), (3) in ID speech, paired with a visual display of a geometric form (ID-G), and (4) in AD speech, paired with a visual display of a geometric form (AD-G).

It was predicted that the 11-month-old infants would discriminate the control phonemes regardless of Auditory Condition (ID speech vs. AD speech) or Visual Condition (face vs.

geometric form). Furthermore, it was predicted that the 11-month-old infants who had enhanced auditory and/or visual information available to them would discriminate the nonnative phonemes, as both ID speech and facial information can provide cues for discriminating otherwise imperceptible auditory signals. However, it was predicted that infants would not discriminate the non-native phonetic change when they did not have enhanced auditory or visual information available to them (i.e., the AD-G context).

Chapter 2. METHOD

2.1 Participants

Parents and infants were located by public record birth announcements, invited to participate first by letter (see Appendix A), and subsequently by phone. Infants from American English, monolingual homes were scheduled to come into the lab for testing at a time of convenience. On the day of testing, parents were contacted by phone to confirm the appointment. As an incentive for participation, parents were paid \$10.00 for their visit to the laboratory.¹ Each parent also received a souvenir certificate and Polaroid photo of their infant.

Fifty-one healthy, full-term, 11-month-old infants (35 males and 16 females) made up the final sample (M age = 45.97 weeks, SD = 1.62 weeks). Forty-nine of the infants successfully completed both the English and the Hindi test sessions, whereas 2 infants successfully completed the English test session only. An additional 3 infants were tested, but failed to complete the task, either due to fussiness (2) or to equipment failure (1). Prenatal and postnatal health and monolinguality were confirmed by parental report at the time of testing. The demographics of the final sample was as follows: 98% were white/Caucasian, while 2% were African American; 96% were from married homes, while 4% were from single parent homes; 82% were delivered vaginally; 55% were exclusively breast fed, while 33% had been both breast and bottle fed; and 39% were first-born. The average age of the infants' mothers was M = 31.25 years, SD = 4.17

¹ The money used for payment of parents was funded by two grants awarded to the experimenter: The Virginia Tech Graduate Research Development Program Grant and the American Psychological Association Dissertation Research Award.

years; the average combined formal education level of the parents was $M = 4.7$ years post high school, $SD = 2.43$ years; the average combined annual household income of the parents was $M = 59,690$ dollars; $SD = 35,442$ dollars.

2.2 Auditory Stimuli

The phonemes for the present experiment consisted of one English and one Hindi contrast. Both contrasts were those originally used by Werker and her colleagues (e.g., Werker & Tees, 1984). Specifically, the control contrast was the bilabial /ba/ versus the alveolar /da/ and the Hindi contrast was the retroflex /ta/ versus the dental /ṭa/. Speech samples for the present experiment were obtained by making audio-visual recordings of an American woman speaking English and an Asian woman speaking Hindi.² The women listened to and mimicked Werker's original recordings of the relevant language contrasts, and repeated each phoneme contrast multiple times.

The phonemes considered for the test stimuli were selected based on appropriateness as sound exemplars and on similarity to Werker's original stimuli (judged by independent English and Hindi native speaking coders). Chosen phoneme instances in each language were then analyzed acoustically and matched with the most similar phonemes from the other language. Independent samples t -tests revealed no significant differences in the mean pitch, duration and pitch variability of the AD English phonemes, AD Hindi phonemes, ID English phonemes or ID Hindi phonemes. On the other hand, an independent samples t -test revealed significant differences in the mean pitch $t(30) = 9.13$, $p < .001$, duration $t(30) = 9.09$, $p < .001$, and pitch variability $t(30) = 7.48$, $p < .001$ of the ID speech and AD speech phonemes overall, in keeping with defined differences between ID and AD speech in the literature (e.g., Cooper, Abraham, Berman &

² The English and Hindi phonemes were originally recorded from a single bilingual woman who spoke English without any recognizable accent. However, native Hindi-speaking coders determined that her Hindi speech was accented. Thus, it became apparent that the phonemes should be recorded from separate women, each of whom had learned the language of interest as their primary language.

Staska, 1997; Fernald, 1985; Papousek, Papousek & Bornstein, 1985; Werker & McLeod, 1989). Four instances of each English and each Hindi phoneme comprised the final stimulus set.

2.3 Visual Stimuli

The visual stimuli were created by synchronously matching dynamic video images of the women's faces with their voices (for the face condition), and by pairing a computer-generated display of colored concentric circles with their voices (for the geometric form condition). In both conditions, the audio-visual clips for each language were edited and pieced together into a single movie file using Adobe Premier 5.0 video editing software for the IBM PC 300 PL.

2.4 Apparatus

Infants were placed on a parent's lap facing a black plywood (80 cm x 60 cm) stimulus display, with floor length fabric extending 24 inches from the left and right to create a 3-sided enclosure. A 15 inch computer monitor was positioned behind an opening in the plywood panel, offset 7.6 centimeters to the right of midline and approximately 30 centimeters away from the infant. A small speaker (Jamo compact 60) was located below the television screen, also positioned behind an opening in the plywood panel. A video camcorder (Panasonic AG-180) was located behind the plywood panel, its lens positioned within a 3.5 centimeter radius hole, 2 centimeters to the left of midline. The camcorder recorded infant responses and provided a view of the infant to the observer. The observer watched the video signal of the infant on a 16.7 centimeter by 14 centimeter black-and-white television monitor (Magnavox RX4030-WA02).

The observer controlled the presentation of the audio-visual stimuli and recorded looking times by pressing the spacebar on a Power Macintosh computer. The computer ran an infant-controlled habituation-dishabituation procedure executed by a *Macromedia Director* software application. This program coordinated the presentation of the stimulus events and recorded trial length. The audio output of the computer was sent through an amplifier (Harman Kardon PM635) and presented through the panel speaker at 60-65dB (B scale) as determined by a sound-level monitor (Radio Shack, catalog #33-2050).

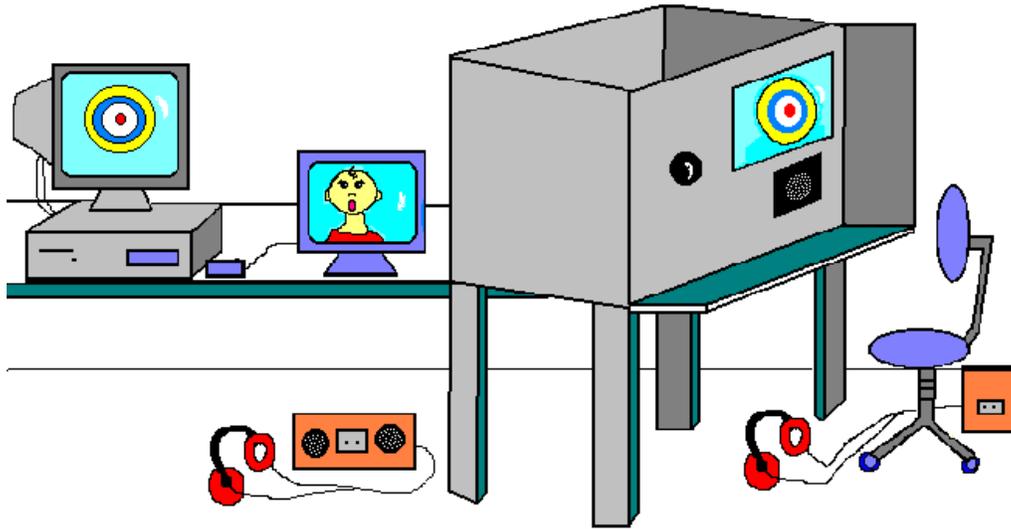


Figure 2.1. Schematic of the infant-controlled habituation protocol at the Infant Speech Perception Lab of Virginia Polytechnic Institute and State University.

2.5 Procedure

The infant-controlled visual habituation technique for assessing auditory discrimination developed by Horowitz (1975) and subsequently used by Best and her colleagues (1988, 1995) was employed in the present investigation. As an example of this procedure, in the ID speech-face condition (ID-F), each infant was habituated to the female face uttering an ID speech sound token in Hindi (e.g., the retroflex sound /ta/), and subsequently tested for discrimination of the same face uttering a second Hindi sound token (e.g., the dental sound /t̪a/). After completing the first discrimination task, each infant took a short break, and then began the second discrimination task (e.g., the discrimination of the native phonemes /ba/ versus /da/). Order of language presentation and order of phoneme presentation were randomized across infants.

All infants were tested at the Infant Speech Perception Lab of Virginia Polytechnic Institute and State University. Upon arrival, parents were asked to fill out an Informed Consent Form and a Family Information Sheet (see Appendices B & C). When the infant was believed to be alert and calm, he or she was brought into the testing room, placed onto the parent's lap in front of the 3-sided enclosure, and the lights were dimmed. Both the parent holding the infant and the observer were deafened to the sounds being presented to the infant by wearing headphones playing continuous vocal music. Infant fixations were viewed via video camcorder for real-time coding by the observer. The observer began each session by pushing the spacebar of the Power Macintosh computer, which activated a blinking red dot on a white background on the infant monitor. This served to draw the infant's attention to the visual display. When the infant was judged to be looking at the screen (as determined by corneal reflection on the eyes) the observer pressed the spacebar a second time. This activated the audio-visual display. The audio-visual display of the first phoneme remained present until the observer judged that the infant had looked away for more than 1-second. Upon infant visual disengagement, the observer pressed the spacebar again, and the trial was terminated (i.e., the presence of the audio-visual display ceased). The red dot began flashing again, and the sequence was repeated.

Habituation to the audio-visual presentation was operationally defined as a drop in fixation duration to less than half of the mean of the first two trials. After this habituation criterion was met, each infant received two no-change post-habituation trials (called 'lag' trials) to allow for the assessment of possible spontaneous recovery effects. Because infant visual attention often fluctuates between long and short looking times, changes in visual attention may not be due to a change in the stimuli. The inclusion of the post-habituation lag trials allowed for the assessment of spontaneous attention shifts (see Bertenthal, Haith & Campos, 1983). Following the lag trials, the audio and video presentations switched to the contrasting phoneme display. The test phase consisted of two trials.

The habituation criterion was calculated and updated on a trial-by-trial basis by a computer algorithm that was programmed into an application for the *Macromedia Director* software package. It was intended that the algorithm switch to the second (test) stimulus when infant attention across two consecutive trials had dropped to below half of the average of the

initial two trials. However, after all the data had been collected, we realized that the algorithm was written such that the habituation criterion was met by a single trial. That is, the stimulus presentation switched after a drop in attention on a single trial, rather than a drop in attention across two consecutive trials. Because the habituation criterion was based upon one trial (rather than two), it could be argued that individual habituation levels had not stabilized. Fortunately, we did have data from two additional post-criterion trials (i.e., lag trials) for each infant. We decided to include the lag trial data in the analyses for half of the infant sample, so that the pretest index would be a more accurate gauge of habituation. Thus, for half the infants the pretest phase consisted of the trial at criterion (50% of the initial two trials). For the other half, the pretest phase consisted of the second lag trial (which was immediately before the change, but not associated with the criterion).

Chapter 3. RESULTS

3.1 English (Control) Sessions

Preliminary Analyses

To reiterate, the pretest (familiarization) phase for half of the infants was contingent upon a drop in attention below 50% of the mean of the first two trials. For the other half of the infants, the pretest phase consisted of the second lag trial. An independent samples t -test was carried out to compare the two. Results indicated no significant difference between lag pretest trials ($M = 5.73$ sec, $SD = 2.33$ sec) and criterion-related pretest trials ($M = 4.95$ sec, $SD = 2.09$ sec), $t(49) = 1.27$, $p > .05$.

Three variables were included in this experiment primarily for control purposes: Order of Language Presentation, Order of Phoneme Presentation and Gender. To test the impact of these variables on infant phoneme discrimination, a preliminary mixed analysis of variance (ANOVA) was carried out. Specifically, Trial (pretest phase attention vs. test phase attention) was the within subjects factor, Order of Language Presentation (English first vs. English second), Order of Phoneme Presentation (/ba/ or /da/ first) and Gender (male vs. female) were the between subjects factors. The results indicated no significant main or interaction effects for these between-subjects variables. More specifically, there was no effect of Language Order, $F(1, 43)$

= .44, $p > .05$, Phoneme Order, $F(1,43) = .50$, $p > .05$, or Gender, $F(1,43) = .50$, $p > .05$.

Because these variables did not seem to impact infant attention in the discrimination procedure, we collapsed across them for the remainder of the English analyses.

Analysis of Discrimination

For the analysis of discrimination performance, fixation times in the pretest phase were compared with the fixation times in the test phase (i.e., when the phoneme was changed). These data were entered into a mixed ANOVA, with Trial (pretest phase attention vs. test phase attention) as the within subjects factor; Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects factors. The results indicated a main effect of Trial. Specifically, test phase fixation ($M = 6.67$ sec; $SD = 4.00$ sec) was significantly longer than pretest fixation ($M = 5.33$ sec; $SD = 2.22$ sec), $F(1,47) = 7.52$, $p < .01$. There was also a significant main effect of Visual Type. That is, infant attention to Face visual stimuli ($M = 6.94$ sec; $SD = 2.63$ sec) was greater than infant attention to Geometric Form stimuli ($M = 5.17$ sec; $SD = 2.60$ sec), $F(1,47) = 5.73$, $p < .05$. There were no other significant main effects and no significant interaction effects, suggesting that the infants discriminated the English phonemes in both auditory and both visual contexts.

In terms of individual infant performance, 31 out of the 51 infants exhibited an increase in fixation when the phoneme was changed. This was significant according to the binomial distribution, $p < .05$ (1-tailed). Within the auditory and visual contexts, the number of infants who exhibited an increase in attention at the test trial were as follows: 9 out of 14 in the AD-G condition, 7 out of 12 in the AD-F condition, 6 out of 13 in the ID-G condition, and 9 out of 12 in the ID-F condition.

Next, infant attention was examined during the initial (baseline) trials upon which the habituation criterion was established. An ANOVA with Average Fixation as the within subjects variable; Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects variables indicated a significant main effect for Visual Type. That is, infants who were presented with a Face exhibited greater attention in the initial trials ($M = 16.67$ sec, $SD = 8.95$ sec) than infants who were presented with a Geometric Form ($M = 12.07$ sec, SD

= 5.15 sec), $F(1, 47) = 4.98, p < .04$. There was no significant difference in baseline means among infants who were presented with ID speech ($M = 14.68$ sec, $SD = 7.01$ sec) versus AD speech ($M = 13.81$ sec, $SD = 8.04$ sec), $F(1, 47) = .157, p > .05$. There was also no significant Speech Type x Visual Type interaction, $F(1,47) = .06, p > .05$. A second ANOVA was carried out to examine the number of trials to habituation in each of the conditions. Trials to habituation was the within subjects variable, Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) were the between subjects variables. There was no significant main effect of Speech Type, $F(1,47) = .86, p > .05$, and no significant main effect of Visual Type, $F(1,47) = .05, p > .05$. There was also no significant Speech Type x Visual Type interaction, $F(1,47) = .17, p > .05$. The average number of trials to habituation in each of the conditions was as follows: AD-G condition ($M = 8$ trials, $SD = 4.76$ trials), AD-F condition ($M = 8.75$ trials, $SD = 5.58$ trials), ID-G condition ($M = 7.38$ trials, $SD = 2.5$ trials), and ID-F condition ($M = 7.17$ trials, $SD = 3.38$ trials).

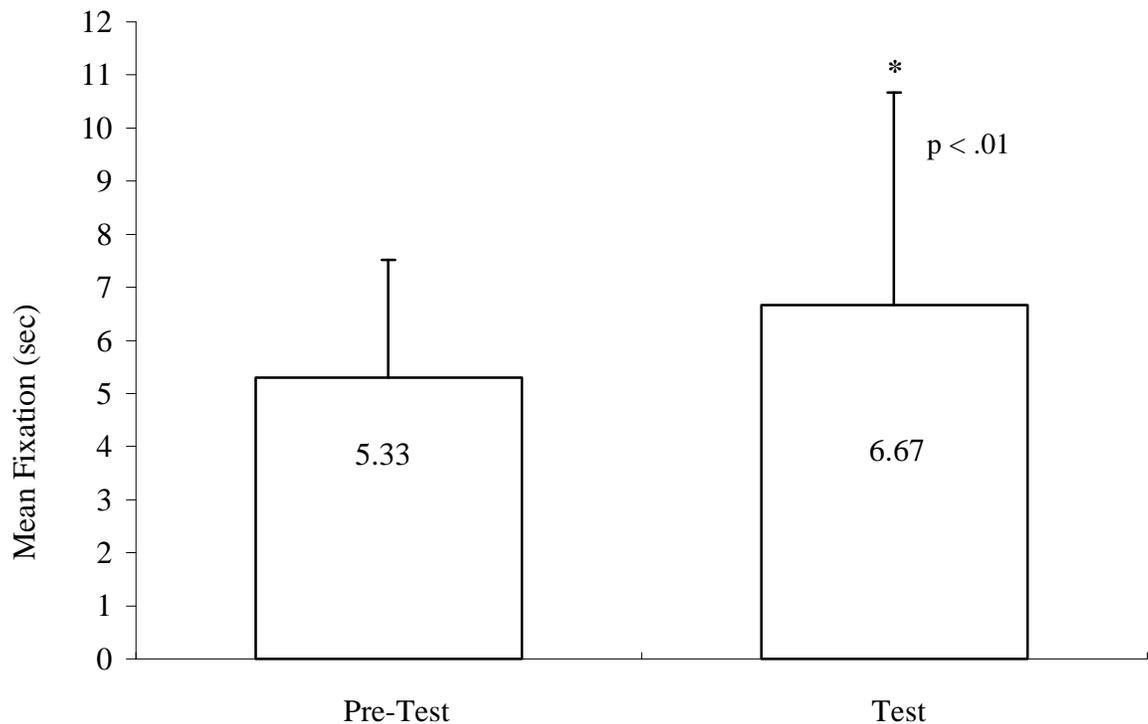


Figure 3.1. Discrimination of the English phonemes: Mean infant fixation during the test phase compared with mean infant fixation during the pre-test phase. (Note. * $p < .01$).

Finally, the two test phase trials were examined for maintenance of dishabituation. A mixed ANOVA was carried out, with Trial (test 1 vs. test 2) as the within subjects factor; Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects factors. The results indicated no significant main or interaction effects. That is, there was no difference in attention between the first ($M = 6.94$ sec; $SD = 4.71$ sec) and second ($M = 6.39$ sec; $SD = 5.16$ sec) test phase trials, $F(1, 47) = .53$, $p > .05$. In other words, the dishabituation effect was maintained across the two test trials in each of the conditions.

3.2 Hindi Sessions

Preliminary Analyses

Again, for the Hindi data an independent samples t -test was carried out to compare the lag pretest trials and the criterion-related pretest trials. Results indicated no significant difference between the lag trials ($M = 5.72$ sec, $SD = 3.40$ sec) and the pretest trials ($M = 5.53$ sec, $SD = 3.08$ sec), $t(47) = -.21$, $p > .05$.

Next, to assess any potential impact of Order of Language Presentation, Order of Phoneme Presentation and Gender on infant phoneme discrimination, a preliminary mixed ANOVA was carried out. Trial (pretest phase vs. test phase) was the within subjects factor, Order of Language Presentation (Hindi first vs. Hindi second), Order of Phoneme Presentation (/ta/ or /tɑ/ first) and Gender (male vs. female) were the between subjects factors. The results indicated no significant main effects for any of these between-subjects variables: no effect of Language Order, $F(1, 41) = 3.57$, $p > .05$, Phoneme Order, $F(1,41) = .26$, $p > .05$, or Gender, $F(1,41) = 1.46$, $p > .05$. However, there was a significant Trial x Language Order interaction, $F(1,41) = 3.86$, $p = .05$. Thus, we collapsed across Phoneme Order and Gender, and left Language Order in the model.

Analysis of Discrimination

For the analysis of discrimination performance, the Hindi data were entered into a mixed ANOVA, with Trial (pretest phase attention vs. test phase attention) as the within subjects factor; Order of Language Presentation (Hindi first vs. Hindi second), Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects factors. The results indicated a significant main effect of Trial, $F(1,41) = 16.76$, $p < .001$; a significant main effect of Visual Type, $F(1,41) = 4.2$, $p < .05$; and a significant main effect of Language Order, $F(1,41) = 6.77$, $p < .02$. There was also a significant Trial x Language Order interaction, $F(1,41) = 6.72$, $p < .02$; and a significant Trial x Speech Type x Visual Type interaction, $F(1,41) = 4.41$, $p < .05$.

Simple main effects analyses of the Trial x Language Order interaction indicated a significant increase in mean fixations between pretest ($M = 6.29$ sec; $SD = 3.96$ sec) and test trials ($M = 11.64$ sec; $SD = 9.55$ sec) when Hindi was presented first, $t(23) = -3.53$, $p < .01$; but no significant fixation increase between the pretest ($M = 5.00$ sec; $SD = 2.17$ sec) and test trials ($M = 6.20$ sec; $SD = 2.59$ sec) when Hindi was presented second, $t(24) = -1.88$, $p > .05$.

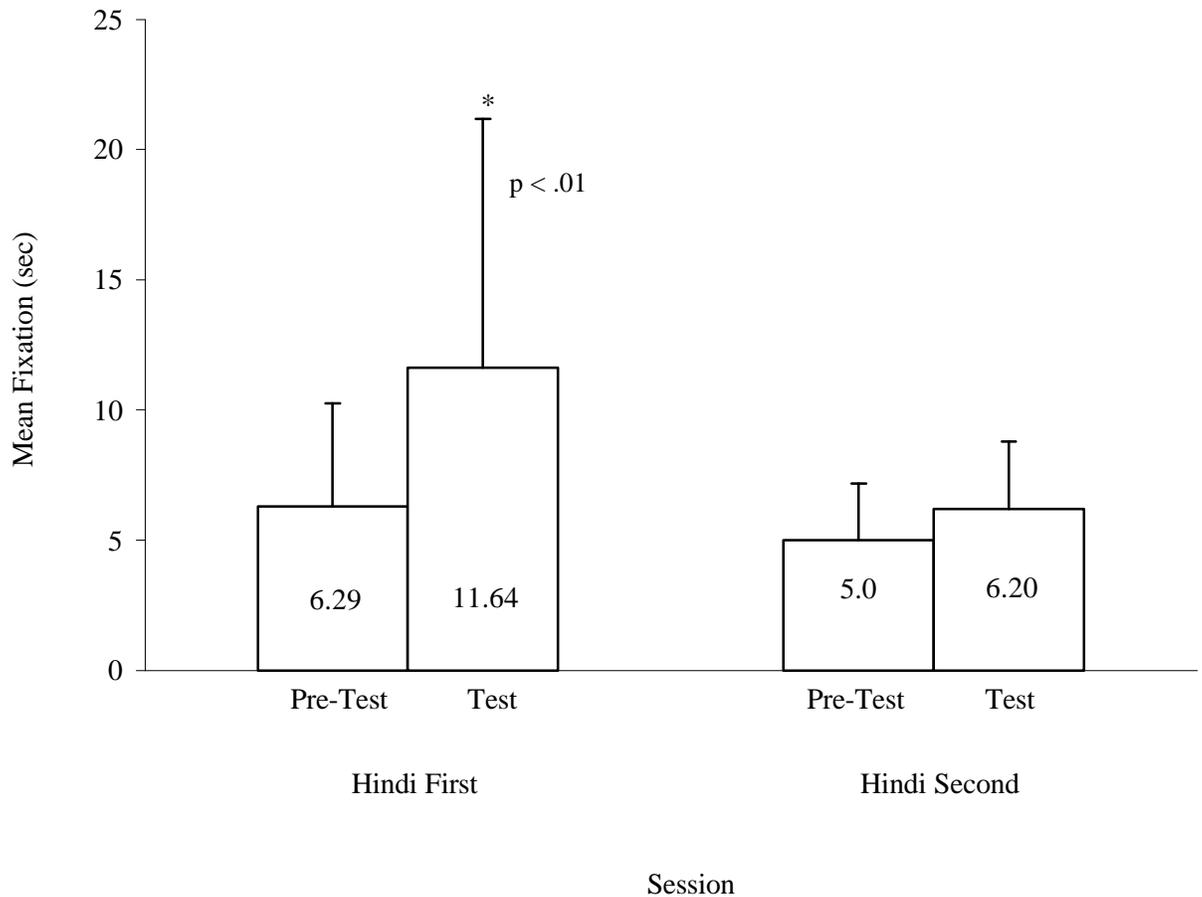


Figure 3.2. Discrimination of the Hindi Phonemes: Mean infant fixation during the test phase compared with mean infant fixation during the pre-test phase, as a function of order of language presentation. (Note. * $p < .01$).

Simple main effects analyses of the Trial x Speech Type x Visual Type interaction revealed that the infants who were presented with ID speech and a Face displayed a significant pretest to test increase in fixation. That is, they exhibited significantly longer fixation times on the test trials ($M = 13.18$ sec; $SD = 9.86$ sec) than on the pretest trials ($M = 6.72$ sec; $SD = 3.49$ sec), $t(11) = -2.97$, $p < .05$. Infants in the other audio/visual conditions did not exhibit a significant increase between the pretest and test phases (i.e., the difference between pretest and test fixation durations was not significant in the ID-G condition, $t(11) = -1.51$, $p > .05$; in the AD-F condition, $t(11) = -.97$, $p > .05$; or in the AD-G condition, $t(12) = -1.92$, $p > .05$).

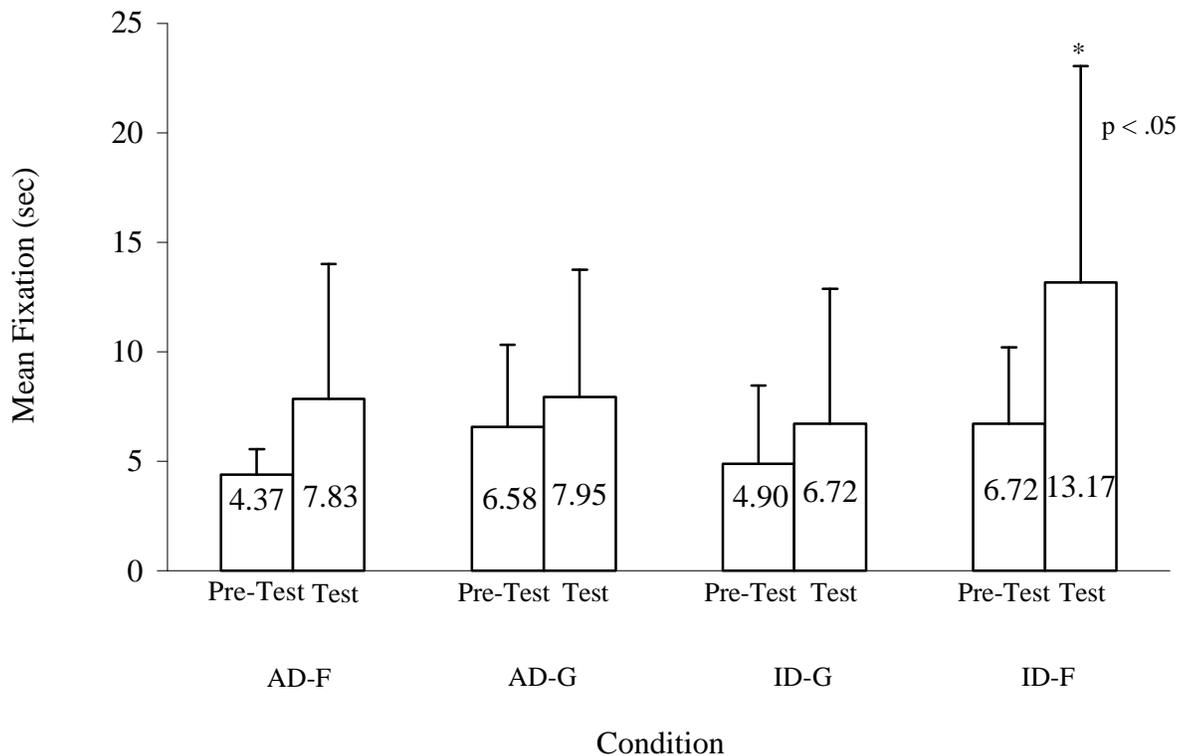


Figure 3.3. Discrimination of the Hindi Phonemes: Mean infant fixation during the test phase compared with mean infant fixation during the pre-test phase, as a function of audio-visual condition. (Note. F = Face; G = Geometric Form; ID = Infant-Directed Speech; AD = Adult-Directed Speech; * $p < .05$).

In terms of individual infant performance, 33 out of the 49 infants exhibited an increase in fixation when the stimulus was changed. This was significant according to the binomial distribution, $p < .01$ (2-tailed). Within the auditory and visual contexts, the number of infants who exhibited an increase in attention at the test trial were as follows: 8 out of 13 in the AD-G condition, 7 out of 12 in the AD-F condition, 8 out of 12 in the ID-G condition, and 10 out of 12 in the ID-F condition.

Next, infant attention during the initial (baseline) trials was examined. An ANOVA with Average Fixation as the within subjects variable; Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects variables indicated no

significant main or interaction effects. That is, infants who were presented with a Face did not exhibit significantly greater attention in the initial criterion trials ($\underline{M} = 19.15$ sec, $\underline{SD} = 17.8$ sec) than infants who were presented with a Geometric Form ($\underline{M} = 12.34$ sec, $\underline{SD} = 8.34$ sec), $\underline{F}(1, 45) = 2.89$, $p > .05$. In addition, there was no significant difference in baseline means among infants who were presented with ID speech ($\underline{M} = 16.92$ sec, $\underline{SD} = 14.32$ sec) versus AD speech ($\underline{M} = 14.57$ sec, $\underline{SD} = 14.08$ sec), $\underline{F}(1, 45) = .344$, $p > .05$. A second ANOVA was carried out to examine the number of trials to habituation in each of the conditions. Trials to habituation was the within subjects variable, Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) were the between subjects variables. There was no significant main effect of Speech Type, $\underline{F}(1, 45) = .20$, $p > .05$, and no significant main effect of Visual Type, $\underline{F}(1, 45) = 1.08$, $p > .05$. There was also no significant Speech Type x Visual Type interaction, $\underline{F}(1, 45) = .90$, $p > .05$. The average number of trials to habituation in each of the conditions was as follows: AD-G condition ($\underline{M} = 10$ trials, $\underline{SD} = 8.83$ trials), AD-F condition ($\underline{M} = 6.33$ trials, $\underline{SD} = 1.23$ trials), ID-G condition ($\underline{M} = 9.08$ trials, $\underline{SD} = 7.18$ trials), and ID-F condition ($\underline{M} = 8.91$ trials, $\underline{SD} = 5.65$ trials).

Finally, the two test phase trials were examined for the maintenance of dishabituation. A mixed ANOVA was carried out, with Trial (test 1 vs. test 2) as the within subjects factor; Speech Type (ID speech vs. AD speech) and Visual Type (Face vs. Geometric Form) as the between subjects factors. The results indicated no significant main or interaction effects. That is, there was no difference in attention between the first ($\underline{M} = 9.03$ sec; $\underline{SD} = 8.12$ sec) and second ($\underline{M} = 8.67$ sec; $\underline{SD} = 8.46$ sec) test phase trials, $\underline{F}(1, 45) = .12$, $p > .05$. The dishabituation effect was maintained across the two test trials in each of the conditions.

3.3 Post Hoc Analyses

Adult Phoneme Discrimination

As a means of comparison with both the infant data and past research on nonnative phoneme perception, adults were also tested for their ability to discriminate the native and nonnative phonemes: spoken in either AD speech ($\underline{N} = 22$) or ID speech ($\underline{N} = 19$). Adult participants were volunteers from undergraduate Psychology courses at Virginia Polytechnic Institute and State University. They were brought into a testing room in groups of four, seated at

a table, and presented with auditory stimuli via tape player. On each trial participants were presented with four instances of the same sound followed by a comparison sound, which was either a different instance of the same phoneme, or a different phoneme. They were instructed to mark on a coding sheet whether the comparison sound was the same sound or a different sound as compared to the four that they had just heard. The four familiarization phonemes were the exemplars used in the infant discrimination procedure. The single comparison sound was randomly chosen from the eight exemplars (four of each phoneme) used in the infant discrimination procedure.

The adult data was analyzed by mixed ANOVA, with Speech Type (ID speech vs. AD speech) as the between subjects factor and Language (English vs. Hindi) as the within subjects factor. The results indicated a significant main effect for Language, with percent of correctly discriminated English phonemes ($\underline{M} = 94\%$, $\underline{SD} = 17\%$) significantly greater than percent of correctly discriminated Hindi phonemes ($\underline{M} = 50\%$, $\underline{SD} = 15\%$), $\underline{F}(1, 85) = 163.14$, $p < .0001$. That is, the adults were able to discriminate the English sounds and unable to discriminate the Hindi sounds above the level that could be expected by chance. There were no other significant main or interaction effects.

Chapter 4. DISCUSSION

The loss in ability to discriminate nonnative phonemes by the end of the first postnatal year is thought to be an important part of infants' language development. However, past research on this phenomenon has failed to address the influence of non-linguistic, language-relevant information on infants' ability to differentiate between nonnative sounds (e.g., Best, McRoberts & Sithole, 1988; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Polka & Werker, 1994; Streeter, 1976; Trehub, 1976; Werker, Gilbert, Humphrey & Tees, 1981; Werker & LaLonde, 1988; Werker & Tees, 1984). The purpose of the present study was to reexamine the decline in infant nonnative phoneme sensitivity with the addition of enhanced non-linguistic information. Eleven-month-old infants were tested for discrimination of both a native and a nonnative phoneme contrast across four conditions, including an auditory manipulation (ID speech vs. AD speech) and a visual manipulation (Face vs. Geometric Form). In the native-

language discrimination task it was predicted that infants would discriminate across each of the four conditions, whereas in the nonnative-language discrimination task it was predicted that infants would discriminate the phonemes when they were presented in the context of enhanced auditory and/or visual information (i.e., the ID-F, ID-G and AD-F conditions).

The pattern of results in the native-language discrimination task indicated that the infants discriminated the English phonemes regardless of audio-visual condition. This is consistent with our hypothesis, and with a host of research literature showing that infants discriminate native-language phonemes from early infancy throughout the first postnatal year (e.g., Aslin et al., 1981; Best, McRoberts & Sithole, 1988; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Eimas et al., 1971; Polka & Werker, 1994; Werker, Gilbert, Humphrey & Tees, 1981; Werker & LaLonde, 1988; Werker & Tees, 1984). Furthermore, across the English discrimination task infants fixated longer when they were presented with a face as opposed to a geometric form. This was shown in their attention during the initial baseline trials as well as their attention during the habituation/dishabituation trials.

It is no surprise that infants would display greater attention to a meaningful visual stimulus over a non-socially relevant form. Indeed, infants prefer face-like over non-face-like visual stimuli from birth (Morton & Johnson, 1991). Although attention to faces may begin as a preference for visual features that are perceptible to infants (i.e., large, high-contrast features that are symmetric in arrangement), by late in the first postnatal year facial preference is more likely due to social relevance and/or experience (Banks, 1985; Dannemiller & Stephens, 1988). In fact, older infants exhibit greater attention to faces over geometric forms, regardless of variations in brightness, pattern symmetry and number of pattern elements (Fantz, 1961).

Whereas the order of language presentation made no difference in the English discrimination task, results of the nonnative-language discrimination task revealed a significant Trial by Language Order interaction. That is, infants discriminated the nonnative phonemes only when they were presented with the Hindi task as the first of their two test sessions. A look at previous studies of infant phoneme discrimination revealed that order of language presentation has not typically been counterbalanced (e.g., Lalonde & Werker, 1995; Polka & Werker, 1994;

Werker & Lalonde, 1988; Werker & Tees, 1984). In most of the studies by Werker and her colleagues infants were tested for discrimination of the English phoneme contrast first, and eliminated from the study if they failed to reach the criterion of correct responses (i.e., failed to discriminate the English phonemes). From this type of design it is impossible to discern whether the infants failed to discriminate nonnative phonemes because they could not perceive the difference between them, or because they were fatigued. In one study (Werker & Tees, 1984) infants were required to exhibit discrimination of English phonemes both before and after the nonnative task in order to be included in the study. Although the issue of fatigue was controlled by this design, potential carry-over effects and/or interference effects were not.

Best and her colleagues (e.g., Best, McRoberts & Sithole, 1988; Best et al., 1995) did counterbalance the order of language presentation in their infant-controlled visual habituation procedure. The results of these studies indicated no significant differences in discrimination performance with respect to language order. Nevertheless, infants exhibited significantly longer fixations to English when it was presented first, and significantly lower fixations for both English and Zulu when they were presented second (Best, McRoberts & Sithole, 1988). This suggests that participation in the first task had some effect on the infants' ability to attend in the second task. If the second session was Hindi (the harder discrimination to make), the infants would not have exhibited the ability to discriminate nonnative phonemes. The results of the present study suggest that either fatigue or interference effects could have impacted the infants' ability to distinguish between nonnative phonemes. Future discrimination research with infants of this age should be designed with such effects in mind.

The results of the present nonnative-language discrimination task also revealed a significant Trial by Audio by Visual interaction. In other words, discrimination of the Hindi phonemes depended on the specific audio/visual condition. A closer look at the data showed that infants only discriminated the Hindi phonemes when they were presented with both ID speech and a face (i.e., in the ID-F condition). This partially supported our hypothesis that enhanced information would aid infants in the task of discriminating nonnative phonemes. But rather than discriminating across each of the enhanced conditions as expected, the infants discriminated the nonnative sounds only when they were presented with both enhanced auditory *and* enhanced

visual information. A first step toward understanding the combined influence of ID speech and facial information in this task was to examine the information that each may have afforded infants alone.

4.1 Potential Influences of ID speech

There are two types of information which exaggerated speech may have afforded the infants in the present discrimination task. First, ID speech may have made subtle differences in the phonemes more obvious. Second, ID speech may have helped the infants to attend to, process, learn and remember the available linguistic information. As for the former, research indicates that ID speech expands the vowel triangle, making the distinctions between phonemes more prominent (Kuhl et al., 1997). In addition, the augmented pitch contours in ID speech help infants to extract formant-frequency information (which specifies information about vowels) (Desjardins & Trainor, 1999). Finally, ID speech makes phoneme differences more apparent. Recall the study by Karzon (1985) in which infants could only discriminate between the word-embedded phonemes /ra/ and /la/ if they were exaggerated with ID speech. In the present experiment, the women we recorded seemed to naturally enhance differences in the phonemes when asked to say them as they would to an infant.

Research evidence suggests that ID speech aids in the processing, learning and remembering of language-relevant information. For example, Jusczyk and Aslin (1995) discovered that ID speech helped 7½-month-old infants detect and remember familiar sound patterns. Moreover, Fernald, McRoberts and Herrera (cited in Werker, Lloyd, Pegg & Polka, 1996) discovered that 15-month-old infants could only pair objects with the appropriate word labels when the labels were presented in ID speech. In another study, Gerken and McIntosh (1993) presented 2-year-olds with words preceded by either appropriate or inappropriate functional morphemes, and instructed them to point to the picture that the words represented. The children were not successful at this task (i.e., they responded at chance levels) when the words were presented in a lower-pitched, monotone voice. They were highly successful when the words were presented in a high-pitched voice with wide pitch excursions. Another recent series of studies has indicated that adults can more easily learn foreign language words when they are presented in ID speech. More specifically, Michnick and her colleagues familiarized

English-speaking adults with a series of sentences that described slides of common objects. The sentences were spoken in Chinese, in either AD or ID speech. During a test phase, only the adults who had heard ID speech utterances exhibited any evidence of learning the target words (Michnick & Alioto, 1995).

Within the current investigation, ID speech may have made the differences in the sounds more apparent by elongating and exaggerating phonetic information. Furthermore, ID speech may have eased the task of phoneme discrimination by eliciting infant attention. ID speech may also have aided infants in learning and remembering the initial phoneme, thereby facilitating discrimination of the test phoneme. While it is possible that all of these processes were involved, future research should address the specific ways in which ID speech helps infants with phoneme perception. One possibility would be to manipulate the features of ID speech phonemes for maximal discriminability. Perhaps if the vowels were even more lengthened and the pitch variability more exaggerated, infants would discriminate nonnative phonemes without the presence of a face.

4.2 Potential Influences of Facial Information

Faces may also have eased the task of nonnative phoneme discrimination in the present experiment. The presence of a synchronously moving face may have increased infant attention to the available information in general, or may have provided specific place of articulation information. As for the former, the face is a powerful feature of the infants' caretaking context. Adults exaggerate their facial expressions when addressing infants in the same way that they exaggerate their speech (Werker & McLeod, 1989). For example, the women who provided the audio-visual stimuli for the present experiment automatically raised their eyebrows and smiled when asked to say the phonemes as if they were speaking to an infant.

In fact, faces do guide infant attention throughout the first postnatal year. Infants exhibit a consistent preference for faces over scrambled features or forms (Fantz, 1961; Morton & Johnson, 1991). Infants also imitate a variety of facial gestures from birth, including mouth opening, lip protrusion and tongue protrusion (e.g., Abravanel & Sigafos, 1984; Field, Woodson, Greenberg & Cohen, 1982; Meltzoff & Moore, 1977). To do so necessitates focused

attention to the specific configurations of the imitated face. Furthermore, infants become highly upset and avert their gaze when an interactive face suddenly becomes still, even if the face is televised (e.g., Gusella, Muir & Tronick, 1988; Tronick, Als, Adamson, Wise & Brazelton, 1978). The same response is not observed when an interactive non-face object ceases to respond (Ellsworth, Muir & Hains, 1993). In general, the prominence of facial information in the caretaking environment is coupled with infant sensitivity to facial signals. If the presence of a face increased infant attention in the present task, the pickup of subtle information (e.g., slight phonetic differences) would be more likely. Future research needs to address the impact that the presence of a face itself has on perception. One possibility is to pair the phonemes with a dynamic face that is not saying the sounds (i.e., just smiling and nodding). If faces helped infants in the present task by simply increasing attention, the presence of a face itself should aid in nonnative phoneme discrimination.

Alternatively, the presence of a face in the current task may have provided infants with specific place of articulation information. The place of articulation of a speech sound refers to the location of the mouth where the primary constriction of airflow occurs in production (Jakobson, Fant & Halle, 1969; Kuhl & Meltzoff, 1988). It is possible that infants were able to discriminate native and nonnative phonemes in the face conditions based upon visible place of articulation information alone. Each of the phonemes used in the present experiment had different places of articulation: the English sound /ba/ is bilabial (i.e., the constriction of airflow is between the two lips), the English sound /da/ is alveolar (i.e., the restriction of airflow occurs as the tongue tip touches the ridge of the gums behind the upper front teeth), the Hindi sound /ta/ is retroflex (i.e., airflow is restricted as the tip of the tongue is raised and bent slightly backward toward the hard palate), and the Hindi sound /ṭa/ is dental (i.e., it is articulated by pressing the tip of the tongue directly behind the front teeth) (Jakobson, Fant & Halle, 1969). Whereas bilabial and alveolar sounds have marked visual differences in place of articulation, retroflex and dental sounds both occur inside of the mouth, and are very similar visually (Jakobson, Fant & Halle, 1969). The English contrast /ba/ versus /da/ was chosen to provide a systematic replication of previous phoneme discrimination work (e.g., Best, McRoberts & Sithole, 1988; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Lalonde & Werker, 1995; Werker & Lalonde,

1988; Werker & Tees, 1984). But previous research in this domain has never included facial information.

If future studies are to examine the impact of place of articulation, infants should be presented with phonemes having similar places of articulation across the two languages. For example, the English phonemes /da/ and /ta/ are both articulated within the mouth. A very different pattern of results may emerge with such visibly indistinguishable places of articulation. On the other hand, if differences in place of articulation were maximized across phonemes, it may be the case that infants could discriminate nonnative phonemes without the addition of ID speech.

Importantly, if infants in the present study discriminated the nonnative phonemes based upon place of articulation information alone, we would expect them to discriminate the Hindi phonemes across both face conditions (i.e., ID-F and AD-F). Instead, infants only discriminated the nonnative sounds when facial information was coupled with ID speech. ID speech may enhance language-relevant facial information by exaggerating place of articulation cues. Again, future research is needed for a better understanding of how faces and ID speech function to increase infant attention in general. In addition, we need to understand the specific linguistic information infants can perceive as a result of exaggerated audio-visual input. One way to tease apart the influences of place of articulation and ID speech is to present the infants with a visual-only discrimination task. Infants could be habituated to silent faces producing ID speech or AD speech versions of the first phoneme, and tested for recovery of attention upon the presentation of the second visual phoneme.

4.3 Potential Influences of Multimodal (Audio-Visual) Information

To reiterate, infants in the present study were able to discriminate nonnative phonemes, but only when they were presented in the context of *both* ID speech and a dynamic, synchronous face. The fact that the audio-visual phonemes were presented at the same spatial location and in temporal synchrony with one another may have played a role in their discriminability by infants. According to Bahrick, Lickliter and their colleagues, information that is redundant across modalities provides unique affordances for infants. Specifically, repetitive or ‘amodal’

information is more easily detected, learned and remembered by infants than information which is only available to one sense modality (Bahrick & Pickens, 1994; Bahrick & Lickliter, 2000). As an example, Bahrick (1988) familiarized 3-month-old infants with a film of marbles colliding against a surface, which was paired with either a congruent or an incongruent audio soundtrack. The infants in the congruent and incongruent conditions received the same amount of exposure to the auditory and visual stimuli. However, only the group who experienced redundant information across modalities (in this case temporal synchrony) exhibited evidence of learning in a subsequent matching task. In a more recent set of experiments, 5-month-old infants who were habituated to complex audio-visual rhythmic patterns exhibited robust dishabituation to novel rhythmic configurations. Discrimination did not occur for groups of infants who were habituated to an auditory or visual rhythm alone, or for groups of infants who were habituated to asynchronized audio-visual rhythmic patterns (Bahrick & Lickliter, 2000).

Gogate, Walker-Andrews and Bahrick (in press) have proposed that intersensory redundancy can also account for such language-relevant processes as the learning of word-object relations. They have reasoned that infants' general sensitivity to bimodal events over the first postnatal year enables them to detect similar relations in more arbitrarily linked patterns of audio and visual simulation, including the relation of words to objects. Research evidence supports this hypothesis. Across laboratories and procedures infants exhibited the detection of arbitrary relations between syllables and moving objects, but only when the timing of the vocalizations coincided with the movements of the object in temporal synchrony (Gogate, under review; cited in Gogate et al., in press; Werker, Cohen, Lloyd, Casasola & Stager, 1998).

In the present experiment, the visual configurations of the mouth were redundant with the structure and activity of the voice in two conditions (AD-F and ID-F). However, only the ID-F condition provided infants with redundant language information as it is typically experienced: exaggerated in both its auditory and visual features. Adult interaction with infants is multimodal and exaggerated by nature. Caregivers often provide auditory, visual, tactile, and olfactory information to their infants within a single interaction (Gogate et al., in press). For example, mothers create concurrent and synchronous visual stimulation when they are using word labels, by moving or pointing to target objects (Masur, 1997; Zukow-Goldring, 1997). Within the

mother-infant communicative context, ID speech is naturally accompanied by exaggerated facial cues including raised eyebrows, smiles, and the enlargement of corresponding mouth movements. Such general communicative exaggeration has been termed “multimodal motherese” (Gogate, et al., in press). In fact, infants exhibit attentional and affective preferences for exaggerated audio/visual infant-directed communication (Werker & McLeod, 1989). Perhaps in the present task, the discriminability of nonnative phonemes was enhanced by exaggerated and redundant information across the auditory and visual modalities.

Future research is necessary to understand the influence of redundant audio-visual information above and beyond the influences of the face and ID speech. One possibility is to present the infants with the same discrimination task in the context of exaggerated, multimodal information (ID speech and a face), but without redundancy. For example, the phoneme soundtrack and corresponding facial display could be made asynchronous or could emanate from different spatial locations. If redundancy across sensory modalities was a critical feature in the present task, we would not expect discrimination of nonnative sounds in this case.

4.4 Summary

The results of the present investigation indicate that infants do not necessarily lose their ability to discriminate nonnative phonemes by the end of the first postnatal year. Specifically, 11-month-old infants exhibited the ability to discriminate Hindi phonemes when they were presented in the context of enhanced, non-linguistic auditory and visual information. The infants’ ability to discriminate nonnative phonemes in the present experiment may have been influenced by heightened attention in general (as a result of seeing a face and/or hearing ID speech and/or the synchrony of the two), or by the fact that the specific linguistic differences in the phonemes were made more apparent (as a result of elongated sounds in ID speech and/or visible cues in place of articulation and/or redundant information). Notably, these perceptual influences are readily available in the language-learning context of most infants. Although it is likely that they were operating together, future research is needed to determine the unique impact of both auditory and visual influences, and the specific conditions under which infants perceive native as well as nonnative phonemes.

Chapter 5. REFERENCES

Abravanel, E. & Sigafos, A.D. (1984). Exploring the presence of imitation during early infancy. Child Development, *55*, 381-392.

Aronson, E. & Rosenblum, S. (1971). Space perception in early infancy: Perception within a common auditory-visual space. Science, *172*, 1161-1163.

Aslin, R.N., Jusczyk, P.W., & Pisoni, D.B. (1996). Speech and auditory processing during infancy: Constraints on and precursors to language. In W. Damon (Ed.), Handbook of child psychology (5th ed.). Volume 2: Cognition, Perception & Language (D. Kuhn & R. Siegler, Eds.). New York: Wiley.

Aslin, R.N., Pisoni, D.B., Hennessy, B.L., & Perey, A.J. (1981). Discrimination of voice onset time by human infants: New findings and implications for the effects of early experience. Child Development, *52*, 1135-1145.

Aslin, R.N. & Smith, L.B. (1988). Perceptual development. Annual Review of Psychology, *39*, 435-473.

Bahrick, L.E. (1983). Infants' perception of substance and temporal synchrony in multimodal events. Infant Behavior and Development, *6*, 429-451.

Bahrick, L.E. (1987). Infants' intermodal perception of two levels of temporal structure in natural events. Infant Behavior and Development, *10*, 387-416.

Bahrick, L.E. (1988). Intermodal learning in infancy: Learning on the basis of two kinds of invariant relations in audible and visible events. Child Development, *59*, 197-209.

Bahrick, L.E. & Pickens, J.N. (1994). Amodal relations: The basis for intermodal perception and learning in infancy. In D.J. Lewkowicz & R. Lickliter (Eds.), The development of intersensory perception: Comparative perspectives (pp. 205-233). Hillsdale, NJ: Erlbaum.

Bahrick, L.E. & Lickliter, R. (2000). Intersensory redundancy guides attentional selectivity and perceptual learning in infancy. Developmental Psychology, *36* (2), 190-201.

Banks, M.S. (1985). How should we characterize visual stimuli? In G. Gottlieb and N.A. Krasnegor (Eds.), Measurement of audition and vision in the first year of postnatal life (pp. 31-51). Norwood, NJ: Ablex.

Bertenthal, B.I., Haith, M.M. & Campos, J.J. (1983). The partial-lag design: A method for controlling spontaneous regression in the infant-control habituation paradigm. Infant Behavior and Development, *6*, 331-338.

Best, C.T. (1994). A direct realist view of cross-language speech perception. In W. Strange (Ed.), Speech perception and linguistic experience: Theoretical and methodological issues in cross-language speech research. Timonium, MD: York Press.

Best, C.T. (1995). Learning to perceive the sound patterns of English. In C. Rovee-Collier & L. Lipsett (Eds.), Advances in Infancy Research. Norwood, NJ: Ablex.

Best, C.T., McRoberts, G.W., LaFleur, R., & Silver-Isenstadt, J. (1995). Divergent developmental patterns for infants' perception of two nonnative consonant contrasts. Infant Behavior and Development, 18, 339-350.

Best, C.T., McRoberts, G.W., & Sithole, N.M. (1988). Examination of perceptual reorganization for nonnative speech contrasts: Zulu click discrimination by English-speaking adults and infants. Journal of Experimental Psychology: Human Perception and Performance, 14 (3), 345-360.

Biben, M., Symmes, D., & Bernhards, D. (1989). Contour variables in vocal communication between squirrel monkey mothers and infants. Developmental Psychobiology, 22 (6), 617-631.

Burnham, D. (1992). Processing audio-visual speech in infancy and across phonologies. International Journal of Psychology, 27, 59.

Burnham, D. (1998). Language specificity in the development of auditory-visual speech perception (pp. 27-60). In R. Campbell & B. Dodd (Eds.), Hearing by eye II: Advances in the psychology of speechreading and auditory-visual speech. Hove, England: Erlbaum UK.

Burnham, D. & Dodd, B. (1996). Auditory-visual speech perception as a direct process: The McGurk Effect in infants and across languages. In D. Stork & M. Hennecke (Eds.), Speechreading by humans and machines. Berlin: Springer-Verlag.

Cooper, R.P., Abraham, J., Berman, S., & Staska, M. (1997). The development of infants' preferences for motherese. Infant Behavior and Development, 20 (4), 477-488.

Cooper, R.P. & Aslin, R.N. (1990). Preference for infant-directed speech in the first month after birth. Child Development, 61, 1584-1595.

Dannemiller, J.L. & Stephens, B.R. (1988). A critical test for infant pattern preference models. Developmental Psychology, 59, 210-216.

Darwin, C. (1872). The expression of emotions in man and the animals. London: Murray.

Dekle, D.J., Fowler, C.A. & Funnell (1992). Audiovisual integration in perception of real words. Perception & Psychophysics, *51*, 355-362.

DesJardins, R.N., & Trainor, L.J. (1999). The influence of fundamental frequency on vowel discrimination in infants. Poster presented at the Society for Research in Child Development Biennial Meeting, Albuquerque, NM, April.

Dodd, B. (1979). Lip reading in infants: Attention to speech presented in- and out-of-synchrony. Cognitive Psychology, *11*, 478-484.

Eimas, P.D. (1975). Developmental studies in speech perception. In L.B. Cohen and P. Salapatek (Eds.), Infant perception: From sensation to perception (vol. 2). New York: Academic Press.

Eimas, P.D., Siqueland, E.R., Jusczyk, P.W., & Vigorito, J. (1971). Speech perception in infants. Science, *171*, 303-306.

Ellsworth, C.P., Muir, D.W. & Hains, S.M.J. (1993). Social competence and person-object differentiation: An analysis of the still-face effect. Developmental Psychology, *29* (1), 63-73.

Fantz, R.L. (1961). The origin of form perception. Scientific American, *204*, 66-72.

Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. Infant Behavior and Development, *8*, 181-195.

Fernald, A. & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. Infant Behavior and Development, *10*, 279-293.

Fernald, A. & Simon, T. (1984). Expanded intonation contours in mother's speech to newborns. Developmental Psychology, *20* (1), 104-113.

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson Bardies, B. & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. Journal of Child Language, *16*, 477-501.

Field, T.M., Woodson, R., Greenberg, R. & Cohen, D. (1982). Discrimination and imitation of facial expressions by neonates. Science, *218*, 79-181.

Gerken, L.A. & McIntosh, B.J. (1993). Interplay of function morphemes and prosody in early language. Developmental Psychology, *29* (3), 448-457.

Gibson, E.J. (1969). Principles of perceptual learning and development. New York: Appleton-Century-Crofts.

- Gibson, E.J. (1991). An odyssey in learning and perception. Cambridge, MA: MIT Press.
- Gibson, E.J. (1987). Introductory essay: What does infant perception tell us about theories of perception? Journal of Experimental Psychology: Human Perception and Performance, 13 (4), 515-523.
- Gibson, J.J. (1986). The ecological approach to visual perception. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Gleason, J.B. (1975). Fathers and other strangers: Men's speech to young children. In D.P. Dato (Ed.), Developmental Psycholinguistics: Theory and applications (pp. 289-297). Washington DC: Georgetown University Press.
- Glenn, S.M. & Cunningham, C.C. (1983). What do babies listen to most? A developmental study of auditory preferences in non-handicapped infants and infants with Down's syndrome. Developmental Psychology, 19, 332-337.
- Gogate, L.J., Walker-Andrews, A.S. & Bahrick, L.E. (in press). The intersensory origins of word comprehension: An ecological-dynamic systems view. Developmental Science.
- Grant, K.W., Ardell, L.A.H., Kuhl, P.K. & Sparks, D.W. (1985). The contribution of fundamental frequency, amplitude envelope and voicing duration cues to speechreading in normal-hearing subjects. Journal of the Acoustical Society of America, 77, 671-677.
- Green, K. P. & Kuhl, P.K. (1991). Integral processing of visual place and auditory voicing information during phonetic perception. Journal of Experimental Psychology: Human Perception and Performance, 17, 278-288.
- Green, K. P., Kuhl, P.K., Meltzoff, A.N. & Stevens, E.B. (1991). Integrating speech information across talkers, gender and sensory modality: Female faces and male voices in the McGurk Effect. Perception and Psychophysics, 50, 524-536.
- Grieser, D.L. & Kuhl, P.K. (1988). Maternal speech to infants in a tonal language: Support for universal prosodic features in motherese. Developmental Psychology, 24, 14-20.
- Gusella, J.L., Muir, D.W. & Tronick, E.Z. (1988). The effect of manipulating maternal behavior during an interaction on 3- and 6-month-olds' affect and attention. Child Development, 59, 1111-1124.
- Hirsh-Pasek, K., Kelmer Nelson, D.G., Jusczyk, P.W., Wright Cassidy, K., Druss, B., & Kennedy, L. (1987). Clauses are perceptual units for young infant. Cognition, 26, 269-286.

Horowitz, F.D. (1975). Visual attention, auditory stimulation, and language discrimination in infants. Monographs of the Society for Research in Child Development, 39, 5-6, Serial No. 158.

Jacobson, J.L., Boersma, D.C., Fields, R.B. & Olson, K.L. (1983). Paralinguistic features of adult speech to infants and small children. Child Development, 54, 436-442.

Jakobson, R., Fant, C.G.M. & Halle, M. (1969). Preliminaries to speech analysis: The distinctive features and their correlates. Cambridge, MA: MIT Press.

Jordan, T.R. & Bevan, K. (1997). Seeing and hearing rotated faces: Influences of facial orientation on visual and audiovisual speech recognition. Journal of Experimental Psychology: Human Perception and Performance, 23, 388-403.

Jusczyk, P.W. & Aslin, R.N. (1995). Infants' detection of the sound patterns of words in fluent speech. Cognitive Psychology, 29, 1-23.

Jusczyk, P.W., Hirsh-Pasek, K., Kelmer Nelson, D.G., Kennedy, L.J., Woodward, A., & Piwoz, J. (1992). Perception of acoustic correlates of major phrasal units by young infants. Cognitive Psychology, 24, 252-293.

Kaplan, P.S., Jung, P.C., Ryther, J.S. & Zarlengo-Strouse, P. (1996). Infant-directed versus adult-directed speech as signals for faces. Developmental Psychology, 32, 880-891.

Karzon, R.G. (1985). Discrimination of polysyllabic sequences by one- to four-month-old infants. Journal of Experimental Child Psychology, 39, 326-342.

Kelmer Nelson, D.G., Hirsh-Pasek, K., Jusczyk, P.W., & Wright Cassidy, K. (1989). How the prosodic cues in motherese might assist language learning. Journal of Child Language, 16, 55-68.

Kuhl, P.K., Andruski, J.E., Chistovich, I.A., Chistovich, L.A., Kozhevnikova, E.V., Ryskina, V.L., Stolyarova, E.I., Sundberg, U., & Lacerda, F. (1997). Cross-language analysis of phonetic units in language addressed to infants. Science, 277, 684-686.

Kuhl, P.K. & Meltzoff, A.N. (1982). The bimodal perception of speech in infancy. Science, 218, 1138-1141.

Kuhl, P.K. & Meltzoff, A.N. (1984). The intermodal representation of speech in infants. Infant Behavior and Development, 7, 361-381.

Kuhl, P.K. & Meltzoff, A.N. (1988). Speech as an intermodal object of perception. In A. Yonas (Ed.), Perceptual development in infancy: The Minnesota symposia on child psychology, Vol. 20, (pp. 235-266). Hillsdale, NJ: Lawrence Erlbaum.

Kuhl, P.K., Williams, K.A., Lacerda, F., Stevens, K.N., & Lindblom, B. (1991). Linguistic experience alters phonetic perception in infants by 6 months of age. Science, *255*, 606-608.

Lalonde, C.E. & Werker, J.F. (1995). Cognitive influences on cross-language speech perception in infancy. Infant Behavior and Development, *18*, 459-475.

Lasky, R.E., Syrdal-Lasky, A., & Klein, R.E. (1975). VOT discrimination by four to six and a half month old infants from Spanish environments. Journal of Experimental Child Psychology, *20*, 215-225.

Lewkowicz, D.J. (1988). Sensory dominance in infants, 1: Six-month-old infants' response to auditory-visual compounds. Developmental Psychology, *24*, 155-171.

Lewkowicz, D.J. (1992). Infants' responsiveness to the auditory and visual attributes of a sounding/moving stimulus. Perception & Psychophysics, *52*, 519-528.

Lewkowicz, D.J. (1996). Infants' response to the audible and visible properties of the human face, I: Role of lexical/syntactic content, temporal synchrony, gender and manner of speech. Developmental Psychology, *32*, 347-366.

Lively, S., Logan, J.S., & Pisoni, D.B. (1993). Training Japanese listeners to identify English /r/ and /l/. II: The role of phonetic environment and talker variability in learning new perceptual categories. Journal of the Acoustical Society of America, *94*, 1242-1255.

Locke, J.L. (1993). Learning to speak. Journal of Phonetics, *21*, 141-146.

Logan, J.S., Lively, S.E., & Pisoni, D.B. (1991). Training Japanese listeners to identify English /r/ and /l/: A first report. Journal of the Acoustical Society of America, *89*, 874-886.

MacKain, K.S., Studdert-Kennedy, M., Spieker, S. & Stern, D. (1983). Infant intermodal speech perception is a left hemisphere function. Science, *219*, 1347-1349.

Masataka, N. (1992). Motherese in a signed language. Infant Behavior and Development, *15*, 453-460.

Massaro, D.W. (1987). Speech perception by ear and eye: A paradigm for psychological inquiry. Hillsdale, NJ: Erlbaum.

Massaro, D.W. & Cohen, M.M. (1983). Evaluation and integration of visual and auditory information in speech perception. Journal of Experimental Psychology: Human Perception and Performance, *9*, 753-771.

Massaro, D.W. & Cohen, M.M. (1996). Perceiving speech from inverted faces. Perception & Psychophysics, *58*, 1047-1065.

Massaro, D.W., Cohen, M.M., Gesi, A., Heredia, R. & Tsuzaki, M. (1993). Bimodal speech perception: An examination across languages. Journal of Phonetics, *21*, 445-478.

Masur, E.F. (1997). Maternal labeling of novel and familiar objects: Implications for children's development of lexical constraints. Journal of Child Language, *24*, 427-439.

McGurk, H. & MacDonald, J. (1976). Hearing lips and seeing voices. Nature, *264*, 746-748.

McNeil, D. (1970). The development of language. In P. Mussen (Ed.), Carmichael's manual of child psychology (Vol. 1, pp. 1061-1161). New York: Wiley.

Meltzoff, A.N. & Kuhl, P.K. (1994). Faces and speech: Intermodal processing of biologically relevant signals in infants and adults. In D.J. Lewkowicz & R. Lickliter (Eds.), The development of intersensory perception: Comparative perspectives. Hillsdale, NJ: Erlbaum.

Meltzoff, A.N. & Moore, M.K. (1977). Imitation of facial and manual gestures by human neonates. Science, *198*, 75-78.

Michnick, R. & Alioto, A. (1995). Infant-directed speech facilitates lexical learning in adults hearing Chinese: Implications for language acquisition. Journal of Child Language, *22* (3), 703-726.

Morton, J. & Johnson, M.H. (1991). CONSPEC and CONLEARN: A two process theory of infant face recognition. Psychological Review, *98* (2), 164-181.

Munhall, K.G., Gribble, P., Sacco, L. & Ward, M. (1996). Temporal constraints on the McGurk effect. Perception & Psychophysics, *58*, 351-362.

Ostroff, W.L. & Cooper, R.P. (in preparation). Infant-directed speech within the context of declining nonnative phoneme perception: Implications for perceptual tuning to native language characteristics.

Papousek, M., Papousek, H., & Bornstein, M. (1985). The naturalistic vocal environment of young infants: The significance of homogeneity and variability in parental speech. In T.M. Field & N. Fox (Eds.), Social perception in infants. Norwood, NJ: Ablex.

Pegg, J.E., Werker, J.F. & McLeod, P.J. (1992). Preference for infant-directed over adult-directed speech: Evidence from 7-week old infants. Infant Behavior and Development, 15, 325-345.

Pisoni, D.B., Lively, S.E., & Logan, J.S. (1994). Perceptual learning of nonnative speech contrasts: Implications for theories of speech perception. In J.C. Goodman & H.C. Nusbaum (Eds.), The development of speech perception: The transition from speech sounds to spoken words. Cambridge, MA: MIT Press.

Polka, L. & Werker, J.F. (1994). Developmental changes in perception of nonnative vowel contrasts. Journal of Experimental Psychology: Human Perception and Performance, 20 (2), 421-435.

Rabain-Jamin, J. & Sabeau-Jouannet, E. (1997). Maternal speech to 4-month-old infants in two cultures: Wolof and French. International Journal Behavioral Development, 20, 425-451.

Rosenblum, L.D., Schmuckler, M.A. & Johnson, J.A. (1997). The McGurk effect in infants. Perception and Psychophysics, 59, 347-357.

Sachs, J. (1977). The adaptive significance of linguistic input to prelinguistic infants. In C.E. Snow & C.A. Ferguson (Eds.), Talking to Children (pp. 51-61). Cambridge, UK: Cambridge University Press.

Shatz, M. (1991). Using cross-cultural research to inform us about the role of language development: Comparisons of Japanese, Korean and English, and of German, American English and British English. In M.H. Bornstein (Ed.), Cultural approaches to parenting. Hillsdale, NJ: Erlbaum.

Sheldon, and Strange (1982). The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception. Applied Psycholinguistics, 3, 243-261.

Streeter, L.A. (1976). Language perception of 2-month old infants shows effects of both innate mechanisms and experience. Nature, 259, 39-41.

Sumby, W.H. & Pollack, I. (1954). Visual contribution to speech intelligibility in noise. Journal of the Acoustical Society of America, 26, 212-215.

Summerfield, Q. (1979). Use of visual information for phonetic perception. Phonetica, 36, 314-331.

Summerfield, Q. (1987). Some preliminaries to a comprehensive account of audio-visual speech perception. In B. Dodd & R. Campbell (Eds.), Hearing by eye: The psychology of lip-reading (pp. 3-51). Hillsdale, NJ: Erlbaum.

Tees, R.C., & Werker, J.F. (1984). Perceptual flexibility: Maintenance of recovery of the ability to discriminate nonnative speech sounds. Canadian Journal of Psychology, *38*, 579-590.

Trehub, S.E. (1976). The discrimination of foreign speech contrasts by infants and adults. Child Development, *47*, 466-472.

Tronick, E.Z., Als, H., Adamson, L., Wise, S. & Brazelton, T.B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. Journal of the American Academy of Child Psychiatry, *17*, 1-13.

Vygotsky, L. (1986). Myshlenie i rech' [Thought and language] (A. Kozulin trans.). Cambridge, MA: MIT Press. (Original work published 1934).

Walker, A.S. (1982). Intermodal perception of expressive behaviors by human infants. Journal of Experimental Child Psychology, *33*, 514-535.

Walker-Andrews, A.S. (1986). Intermodal perception of expressive behaviors: Relation of eye and voice? Developmental Psychology, *22*, 373-377.

Walker-Andrews, A.S. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. Psychological Bulletin, *121* (3), 437-456.

Walker-Andrews, A.S. & Lennon (1991). Infants' discrimination of vocal expressions: Contributions of auditory and visual information. Infant Behavior and Development, *14*, 131-142.

Walton, G.E. & Bower, T.G.R. (1993). Amodal representation of speech in infants. Infant Behavior and Development, *16*, 233-243.

Werker, J.F. (1991). The ontogeny of speech perception. In I.G. Mattingly & M. Studdert-Kennedy (Eds.), Speech perception and modularity. Hillsdale, NJ: Erlbaum.

Werker, J.F. (1994). Cross-language speech perception: Development change does not involve loss. In J.C. Goodman & H.C. Nusbaum (Eds.), The development of speech perception: The transition from speech sounds to spoken words. Cambridge, MA: MIT Press.

Werker, J.F., Cohen, L.B., Lloyd, V.L., Casasola, M. & Stager, C.L. (1998). Acquisition of word-object associations by 14-month-old infants. Developmental Psychology, *34* (6), 1289-1309.

Werker, J.F., Frost, P.E. & McGurk, H. (1992). La langue et les levres: Cross-language influences on bimodal speech perception. Canadian Journal of Psychology, *46* (4), 551-568.

Werker, J.F., Gilbert, J.H.V., Humphrey, K., & Tees, R.C. (1981). Developmental aspects of cross-language speech perception. Child Development, *52*, 349-355.

Werker, J.F., & LaLonde, C.E. (1988). Cross-language speech perception: Initial capabilities and developmental change. Developmental Psychology, *24* (5), 672-683.

Werker, J.F., Lloyd, V.L., Pegg, J.E., & Polka, L. (1996). Putting the baby in the bootstraps: Toward a more complete understanding of the role of input in infant speech processing. In J.L. Morgan & K. Demuth (Eds.), Signal to syntax. Hillsdale, NJ: Erlbaum.

Werker, J.F. & McLeod, P.J. (1989). Infant preference for both male and female infant-directed talk: A developmental study of attentional and affective responsiveness. Canadian Journal of Psychology, *43* (2), 230-246.

Werker, J.F., & Tees, R.C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. Infant Behavior and Development, *7*, 47-63.

Zukow-Goldring, P. (1997). A social ecological realist approach to the emergence of the lexicon: Educating attention to amodal invariants in gesture and speech. In C. Dent-Read & P. Zukow-Goldring (Eds.), Evolving explanations of development: Ecological approaches to organism-environment systems (pp. 199-252). Washington, DC: American Psychological Association.

Appendix A

Infant Speech Study Program
Department of Psychology
Virginia Tech

Dear Parent(s):

Soon after infants are born, they can recognize many different sounds and voices. For instance, we now know that newborn babies prefer to listen to their native language to a foreign language! All during the first year of life, infants hear sounds in their environment that may help them learn to understand speech. In the Department of Psychology at Virginia Tech, we are interested in how babies actually use the cues in their environment to learn to talk.

You and your baby are invited to participate in our latest project! Currently, we are investigating the particular speech sounds that infants pay attention to. To do this, we play recorded sounds for the infants in various languages, and observe what they are most interested in. Your participation would involve just one visit to the Infant Speech Study Program (located next to Bogen's restaurant in Blacksburg; a map is enclosed for your convenience) when your baby is between 10½ and 11 months old so that we can observe your infant's responsiveness to sounds in different languages.

The test only lasts about 15 minutes, but we like to schedule a half hour appointment, to give you and your baby time to get settled without feeling rushed. We schedule this appointment at a time that is most convenient for your (and your baby's) schedule. If you have older children, you are welcome to bring them along. We have a waiting room right next to the observation room with lots of toys, and we offer free baby-sitting for your convenience.

If you would like to schedule an appointment for your infant or to find out more about our program, please feel free to call the Infant Speech Perception Center at 231-3972 or to call Dr. Robin Cooper at 231-5938. We hope to see you and your baby soon!

Sincerely,

Wendy L. Ostroff

**VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
INFORMED CONSENT FORM**

TITLE: Non-Linguistic Influences on Infants' Nonnative Phoneme Perception: Do Exaggerated Prosody and Visual Speech Information Improve Discrimination?

PRINCIPAL INVESTIGATORS: Robin Panneton Cooper, Ph.D. & Wendy L. Ostroff, M.S.

I. Purpose of the Research Project

The purpose of this project is to investigate 10- to 11-month-old infants' perception of speech sounds in both a native and a nonnative language.

II. Procedure

Your infant will go through two test sessions, lasting about 5 minutes each, provided that he/she is awake, alert and quiet. You will hold your baby in your lap, facing a computer screen. When your infant looks at the screen, a display of either colored concentric circles or a woman's face will appear, and a speaker located below the screen will present a recording of a woman speaking. Your infant can control how long he/she gets to see and hear this presentation, by how long he/she looks at the computer screen. In one test session the voice will be in English, and in the other test session the voice will be in Hindi.

The sound levels of the voices played to your infant are no louder than the sounds present in the typical home environment (i.e., 70 dB). If your infant cries or falls asleep during either session, testing will stop. Your infant will be videotaped during the sessions so that we can examine their facial expressions in response to the types of sounds they hear. However, these tapes will remain confidential in our lab, and will be erased after 2 years. There are no apparent risks to you or your baby resulting from participating in this study.

III. Benefits of this Project

Your baby's participation in this project benefits the field of infant speech perception. Specifically, this study will further our knowledge of the cues in the environment which help infants learn language.

IV. Extent of Anonymity and Confidentiality

All of the information gathered in this study will be kept confidential and the results will not be released without your consent. The information your baby provides will be identified by a number only (no names). Your informed consent will be kept separate from your infant's information. The results of this study may be presented at scientific meetings, and/or published in a scientific journal. If you would like, you will be sent a summary of this work when the project is completed.

V. Freedom to Withdraw

You have the right to terminate your involvement in this project at any time and for any reason, if you so choose.

VI. Approval of Research

This project has been approved by the Human Subjects Committee of the Department of Psychology and the Institutional Review Board of Virginia Tech.

VII. Subject's Permission

I have read and understand the informed consent and conditions of this project. I have been given an opportunity to ask further questions about the procedure, and I understand that I have the right to end this session for any reason if I so choose. If I have any questions regarding this research and its conduct, I should contact one of the persons named below. Given these procedures and conditions, I give my permission to Dr. Robin Panneton Cooper and her graduate student to test my infant.

Signature of Parent

Date

Dr. Robin Panneton Cooper, Principal Investigator
Wendy L. Ostroff, Graduate Investigator

231-5938
961-1457

Appendix C

Family Information Sheet

(All information is strictly confidential)

Mother's Age: _____

Mother's Occupation: _____

Father's Occupation: _____

Mother's Education (in years): _____

Father's Education (in years): _____

Estimated Family Income: _____

Race: White/Caucasian African American Hispanic Asian Native American Other

Marital Status: Married Separated Divorced Single

For your most recent pregnancy, please note the following:

Method of Delivery: Vaginal Caesarean

Method of Feeding: Breast Bottle

Estimated Gestational Age at Birth (in weeks): _____

Please list the gender and age of your older children (if any):

1. _____

2. _____

3. _____

4. _____

May 2000

CURRICULUM VITAE

Wendy L. Ostroff

Personal Information

E-mail: wostroff@vt.edu

Current Address: 721 Hutcheson Drive
Blacksburg, VA 24060

Phone: (540) 961-1457

Academic Employment

Assistant Professor

Interdisciplinary Liberal Arts: Cognitive Science/Developmental Psychology
Hutchins School of Liberal Studies, Sonoma State University: Rohnert Park, CA
(beginning August 2000).

Educational History

Bachelor of Arts degree in Psychology, Magna cum Laude
University of Connecticut: Storrs, CT
(May 1996).

Masters of Science degree in Psychological Science: Developmental Concentration
Virginia Polytechnic Institute and State University: Blacksburg, VA
(October 1998).

Doctor of Philosophy degree in Psychological Science: Developmental Concentration
Virginia Polytechnic Institute and State University: Blacksburg, VA
(May 2000).

Research Activity

Undergraduate Research - University of Connecticut Infancy Lab

Supervisor: Gwen Gustafson, Ph.D.

- **Senior Thesis:**
Adult Perception of Infant Communication

Graduate Research - Infant Speech Perception Program of Virginia Tech

Graduate Mentor: Robin Panneton Cooper, Ph.D.

- **First Year Project:**
The Importance of Rate for Infant-Directed Communication

Graduate Research - Infant Speech Perception Program of Virginia Tech

Graduate Mentor: Robin Panneton Cooper, Ph.D.

- **Thesis - Master of Science Degree: Defended October 7, 1998**
The Perceptual Draw of Prosody: Infant-Directed Speech within the Context of Declining Non-Native Phoneme Perception
- **Dissertation - Doctor of Philosophy Degree: Defended May 9, 2000**
Non-Linguistic Influences on Infants' Nonnative Phoneme Perception: Exaggerated Prosody and Visual Speech Information Improve Discrimination

Manuscripts In Progress

Ostroff, W.L., & Cooper, R.P. (in preparation). Infant-Directed Speech within the Context of Increased Sensitivity to Native Language Features.

Cooper, J.S., Cooper, R.P., Ostroff, W.L. & Aslin, R.N. (in preparation). The ability of speaking rate to influence young infants' preferences for infant-directed speech.

Conference Activity

- **10th Biennial International Conference of Infant Studies** - Providence, RI: April 1996.
-Presented Poster:

Irwin, J.R., Green, J.A., Gustafson, G.E., & Ostroff, W.L. (1996).
The role of the face in perception of infant sounds: A first look.

-Published Abstract:

Infant Behavior and Development, 19, 523.
- **11th Biennial International Conference on Infant Studies** - Atlanta, GA: April 1998.
-Presented Poster:

Cooper, J.S., Ostroff, W.L. & Cooper, R.P. (1998).
The role of rate in directing attention to infant-directed speech: A replication.

-Published Abstract:

Infant Behavior and Development, 21, 356.

- **14th Annual Virginia Tech Research Symposium** - Blacksburg, VA: April 1998.
-Presented Poster:

Cooper, J.S., Ostroff, W.L. & Cooper, R.P. (1998).
The role of rate in directing attention to infant-directed speech: A replication.
- **10th Annual APS Convention** - Washington, DC: May 1998.
-Presented Poster:

Ostroff, W.L. & Cooper, J.S. (1998).
Temporal characteristics influence infant attention to infant-directed speech.
- **15th Annual Virginia Tech Research Symposium** - Blacksburg, VA: April 1999.
-Presented Poster:

Ostroff, W.L. & Cooper, R.P. (1999).
The perceptual draw of prosody: Infant-directed speech within the context of declining nonnative phoneme perception.
- **Biennial Meeting: Society For Research in Child Development** – Albuquerque, NM: April 1999.
-Presented Poster:

Ostroff, W.L. & Cooper, R.P. (1999).
The perceptual draw of prosody: Infant-directed speech within the context of declining nonnative phoneme perception.
- **XIIth Biennial International Conference on Infant Studies** – Brighton, UK: July 2000.
-Submitted Paper:

Cooper, R.P., Ostroff, W.L., Cooper, J.S. & Ward, C. (2000).
The usefulness of looking time as a measure of infants' speech preferences throughout the first postnatal year.

-Submitted Poster:

Ostroff, W.L. & Cooper, R.P. (2000).
The role of linguistic information in directing infant attention to native-language infant-directed speech.

Awards and Grants

American Psychological Association (APA) Dissertation Research Award

-Awarded \$1000.00 for Doctoral Dissertation research (December 1999) by the Science Directorate of the American Psychological Association.

Graduate Research Development Project Grants

-Awarded \$300.00 for Master's Thesis research (January 1998) and \$500.00 for Doctoral Dissertation research (August 1999) by the Graduate Student Assembly of Virginia Polytechnic Institute and State University.

Travel Awards

-Awarded \$275.00 for conference travel expenses (January 1998) and \$300.00 for conference travel expenses (January 1999) by the Travel Fund Committee of the Graduate Student Assembly of Virginia Polytechnic Institute and State University.

14th Annual Virginia Tech Research Symposium Award

-Awarded \$75.00 for excellence in the division of Social Science Research (April 1998).

Developmental Science Society

-Awarded \$1000.00 in graduate student organization small grant (March 1999).

15th Annual Virginia Tech Research Symposium Award

-Awarded \$75.00 for excellence in the division of Social Science Research (April 1999).

Teaching Experience

PSYC 2004: Introductory Psychology Recitation (Fall 1996; Spring 1997)

PSYC 2034: Developmental Psychology (Summer 1999; Fall 1999)

PSYC 2094: Principles of Psychological Research (Spring 2000)

Academic Advisory Experience

Department of Psychology Undergraduate Information Center

-Full time advisor (Fall 1997 - Summer 1999)

Responsible for academic advising, career counseling and transfer student support.
Coordinator of Freshman Orientation and Spring Commencement.

-Aid to Undergraduate Information Center (Fall 1999 - Spring 2000)

Responsible for advisor training, departmental organization and structuring of new courses.

Academic Activities

Developmental Science Society

-President and cofounder of graduate student organization and discussion forum.

Psychological Sciences Area - Graduate Student Liaison

-Liaison between Psychological Sciences graduate students and Area Director, Dr. Crawford.

Professional Organization Membership

American Psychological Association: Graduate Student Affiliate

APA Division 7: Developmental Psychology

International Society on Infant Studies

American Psychological Society

Graduate Level Course Work

Biological Bases of Behavior

Prenatal Development

Curriculum and Program Planning

Principles of Learning

Cognitive Development

Psychophysiology

Cognitive Psychology

Research Methods

Developmental Psychobiology

Social Development

Developmental Psychology

Statistics for Social Science Research I

Personality Processes

Statistics for Social Science Research II

Other Experience

- Volunteer
Norwich Psychiatric Hospital (Fall 1992 - Spring 1995): Norwich, CT.
- Study Abroad
Universita Karlova (Fall 1995): Prague, Czech Republic.