

FOUR-MONTH-OLDS DO NOT PREFER BUT CAN DISCRIMINATE INFANT
DIRECTED AND ADULT DIRECTED PITCH CONTOURS

by

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COMPARING INFANT DIRECTED AND ADULT DIRECTED PITCH CONTOURS:
INFANTS' ATTENTION TO ADULT SPEECH

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(Abstract)

The purpose of the present study was to investigate the role of pitch contours in directing infant attention to adult speech. Several studies have shown that infants from a few days old to 9 months of age prefer infant-directed (ID) over adult-directed (AD) speech. Moreover, 4-month-olds have been shown to prefer pitch contours that simulate ID speech, suggesting that the exaggerated pitch contours are necessary for infant attention. The current study investigated this attentional preference utilizing ID and AD pitch contours in a fixation-based preference procedure. Results from the first experiment failed to show a similar preference for the ID pitch contours. Because a lack of preference could have been due to a failure to discriminate, a habituation study was also conducted. The results from the second experiment showed that 4-month-olds can discriminate the ID and AD pitch contours. From these results, it is argued that the pitch contour may be but one of many possible prosodic characteristics that attract infant attention and this attention may occur only within a language context. It is suggested that future studies investigate ID speech using a more context-dependent procedure, where natural or more complete speech samples are utilized.

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One of the most widely recognized characteristics of the infant/caretaker interaction is that adults speak differently to infants than they do to other adults. Specifically, adults simplify their vocabulary and exaggerate the prosodic features of their speech to infants. “Prosodic” refers to the acoustic features of speech that give it a musical quality (e.g., absolute pitch, pitch variability, tempo). Fernald (1984; 1992) argued that the exaggerated prosodic features of infant-directed (ID) speech makes it a highly salient auditory event for infants, serving three possible functions during early postnatal development: (1) ID speech may have features that differentially elicit and maintain infant attention, (2) ID speech may enhance opportunities for adults and infants to exchange emotional displays during social interactions, and (3) ID speech may make certain important features of language apparent to infants. The relationship between ID speech and its developmental function(s) would be more clear if we understood which features of ID speech regulated infant attention. For example, some recent studies have shown that the actual acoustic ‘shape’ of pitch contours in ID speech (i.e., the changes in fundamental frequency or F_0 over an utterance) is correlated with particular infant-caretaker contexts (Papousek, Papousek, & Symmes, 1991), and that adult listeners are quite accurate in assigning ID pitch contours to their appropriate contextual categories (Fernald, 1989). Such findings imply that the pitch contours of ID speech are important to our understanding of its developmental function. Because ID speech differs from AD speech along many dimensions, it is certainly possible that there are other characteristics of ID speech (in addition to pitch) which influence infant perception. The goal of this study was to examine some of the prosodic aspects of ID speech in relation to the development of infants’ attentional preferences.

ID speech contains many prosodic variations not present in AD speech. Speech directed toward infants has been shown, via acoustic analyses, to typically contain higher overall pitch, wider pitch excursions, broader pitch range, increased rhythmicity, slower tempo, shorter utterance durations, and increased amplitude as compared to AD speech (Berman, 1989; Fernald & Simon, 1984; Fernald et al., 1989; Grieser & Kuhl, 1988; Stern

et al., 1983). Jacobsen, Boersma, Fields, and Olson (1983) found that both males and females exaggerated the prosodic features of their speech when speaking to infants. These authors also found that nonparents, who had little prior experience with infants, modified their speech the same way parents did. Moreover, ID speech occurs in such diverse languages as German (Fernald & Simon, 1984), Mandarin (Grieser & Kuhl, 1988), Italian, French, Japanese, and both British and American English (Fernald et al., 1989; Shute & Wheldall, 1989). It appears that ID speech is utilized by both genders, across diverse cultures, as a pattern of speech that naturally occurs in the infant-caretaker context.

In a study on intonation and communicative intent, Fernald (1989) examined maternal speech to adults and infants in five interactional contexts. Adult subjects (40 parents and 40 nonparents) were asked to identify the communicative intent of the speaker using only prosodic information, given a 5-alternative forced choice. The maternal speech was low-pass filtered at 400 Hz making the speech semantically unintelligible but preserving the frequency contour (Fo) and certain prosodic features (e.g., temporal structure, intensity). The five common categories of communicative intent in ID speech selected were: approval, prohibition, comfort, attention-bid, and game initiation. Adult subjects were able to use the intonation to identify the speaker's intent with significantly higher accuracy in ID speech than AD speech. These results suggest that the intonational patterns of ID speech may serve a communicative function for the infant and caregiver in various contexts. It seems that parents use different speech patterns in different contexts to communicate with their infants.

The context-dependency of ID pitch contours occurs in cultures other than our own (Papousek, Papousek, & Symmes, 1991). Both American and Chinese mothers used similar frequency contours to convey the same kinds of meanings in various contexts. For example, the mothers communicated approval or disapproval by using similar intonational patterns. The authors concluded that the frequency contours in parental ID speech may

represent cross-linguistic universals which may function as guiding messages.

Importantly, ID speech appears to regulate infant attention.

One study that looked at infants' responsiveness to ID speech was conducted with 4-month-olds (Fernald, 1985). In this study, infants were presented with ID and AD utterances from four different female speakers, all of whom were unfamiliar to the infants. Fernald used an operant head turning procedure in which infants learned that a head turn to one side produced ID speech whereas a head turn to the other side produced AD speech. The results of this study showed that infants turned their heads significantly more often in the direction that produced ID speech, suggesting that ID speech differentially elicited infant attention.

Werker and McLeod (1989) investigated ID speech preferences in a sample of infants from a broader age range. Their procedure involved showing 4 to 5.5 and 7.5 to 9-month-olds successive, fixed-duration trials of video recordings of male and female adults reciting identical scripts in ID and AD speech. The primary dependent variable was the amount of time spent looking at the monitor depending on speech type and speaker gender. Compared to Fernald's (1985) study, Werker and McLeod's procedure addressed whether ID speech can differentially maintain infant attention. The results showed that infants in both age groups looked longer when ID speech was available, independent of speaker gender.

Using a younger sample of infants, Cooper and Aslin (1990) investigated whether ID speech preferences are present from birth. In their procedure, infants turned on recordings of either ID or AD speech whenever they fixated a black-and-white checkerboard. The recording continued until the infant looked away. Cooper and Aslin found that both 1-month-olds and newborns looked significantly longer when looking produced ID speech.

Similar results with 7-week-olds were found in a recent study by Pegg, Werker, and McLeod (1992). Infants showed an attentional preference for ID over AD speech (both

male and female) using an infant-controlled habituation procedure. In their procedure, 7-week-old infants were randomly presented one speech type (ID or AD) during the habituation phase (preshift). After the infant reached the habituation criterion, the speech type was changed to the opposite speech type (ID or AD). The authors found that in addition to discriminating the contours the infants also showed significantly longer looking times on the initial trials when they heard either male and or female ID speech.

It is reasonable to conclude from this literature that preference for ID speech is a robust and stable finding in infants across the first postnatal year. However, the dynamics of the infant-caretaker relationship have largely been ignored in this area of research. For example, in recent studies involving infant attention for maternal speech, there was no preference for maternal ID over maternal AD speech in 1-month-olds (Cooper, Abraham, Berman & Staska, 1997) although a second group of 1-month-olds who were unfamiliar with the female speaker did prefer the ID speech. Moreover, in a similar study involving 4-month-olds, a significant preference for maternal ID over maternal AD was found. These results suggest that infants' attention to caretaker speech patterns is not uniform across ages. Cooper et al. (1997) hypothesized that infants learn to prefer maternal ID over maternal AD as a result of experience. That is, over the first several postnatal months, infants typically encounter maternal ID speech in many contexts. Caregiver speech patterns become part of the complex, dynamic relationship between infant and parent. It is possible that the infant's attention to the prosodic features of ID speech (e.g., pitch contours) changes as this dynamic unfolds. However, little research has been conducted on infants' changing perceptions of speech in the caretaking context.

Interestingly, Stern, Spieker, Barnett, and McKain (1983) found that this infant-parent dynamic changes with infant development, from birth to 24-months. In their longitudinal study mothers were audio-taped when addressing their infants as newborns and then at 4, 12 and 24 months of age. They found that the greatest modification in parent speech occurred at the time when the infants were 4-months-old. Stern et al. (1983)

suggest that the context of the interaction may be responsible for the difference in speech modifications. When the infant is a newborn, the parent's role is to prevent the baby from crying and to keep him/her at an even level of stimulation. At 4 months of age, the infant-parent interaction is more face-to-face oriented, with the adult trying to keep the infant in a happy mood. The more a parent exaggerates his or her speech, the more the infant may become engaged. Once the child gets as old as 12 and 24 months, the parent evolves into an instructor who leads the infant toward various aspects of the environment. The nature of the interactive context changes over time, due to changes in both the infant and caregiver. Pitch contours occurring in caretakers speech become dependent on the context as the interaction goals change with development.

We can assume, then, that in order for the characteristics of caretakers' speech to be effective the infant must also be sensitive to the context. Papousek et al. (1990) found that 4-month-olds varied their looking times depending on the pitch contour presented. In one study, these authors examined infants' visual responsiveness to rising-falling contours used by adults in "approving" and "disapproving" contexts. The infants preferred rising (approving) over falling (disapproving) contours independent of speaker gender, suggesting that contour patterns differentially affect infant attention. Sullivan and Horowitz (1983) performed a similar study on pitch contours with 2-month-olds. In their study, the infants received six familiarization trials during which two visual slides were presented (one on the right and the other on the left), comparing male and female pitch contours and synthetic rising and falling pitch contours. Each pitch contour was paired with the same visual slide. The infants looked significantly more often to the side associated with the naturally produced rising contour (approval). The authors suggested that the rising pitch contour seemed to be a more effective auditory stimulus for eliciting and maintaining infant attention.

Recently, Fernald (1993) examined 5-month-old infants responsiveness to vocal expressions in ID speech in several different languages. The infants smiled more to

approval contours and showed more negative affect in response to prohibitive contours (only for ID but not AD speech). These results suggest that infants' behavior in response to approval pitch contours may reinforce parents' further use of similar contours. It is this ongoing interaction between parent and child that makes the frequency contours context-dependent. The speech that works at one age changes across development and to stay effective the caretaker must be sensitive to this dynamic flux.

The research discussed thus far implicates the pitch contour as a *meaningful* feature of speech directed to infants. That is, pitch contours differentially occur in caretakers' speech, depending on the context, and infants seem sensitive to this context-specificity. However, it is important to recognize that a multitude of prosody characteristics (not only the fundamental frequency) vary in ID speech. It should be noted that speech is a complex waveform which can be broken down into a series of sine waves with specific frequencies with a theorem created by Fourier (Moore 1977). The fundamental component is the lowest sine wave in speech, and it is said to form the "foundation" for the other components (harmonics). The harmonics are multiples of the fundamental component (The n th harmonic has a frequency which is n times that of the fundamental). ID speech has a richer harmonic structure, and is more rhythmic than AD speech. One way to compare the various prosodic characteristics is to investigate them each individually. Along these lines, Fernald and Kuhl (1987) investigated infants' preferences for three prosodic characteristics in a series of experiments. Initially, Fernald and Kuhl acoustically analyzed ID and AD speech samples, in order to isolate three major prosodic features. They then manufactured pure tones that simulated the pitch contours, amplitude patterns, and duration patterns of the speech. For their first experiment Fernald and Kuhl examined infants' preferences for ID and AD pitch contours. Therefore, in the first experiment, 4-month-old infants could listen to frequency-modulated pure tones (with amplitude held constant). In the second experiment, 4-month-olds heard synthesized amplitude-modulated stimuli (with frequency held constant). In the third experiment both frequency and amplitude were held constant, while duration was

allowed to vary. Using the operant head-turning procedure discussed earlier, Fernald and Kuhl found that 4-month-olds preferred the pitch contours of ID over AD, but showed no preferences for the amplitude or durational patterns. Fernald and Kuhl concluded that the pitch contour characteristics of ID speech may be critical acoustic determinants of infant preference for ID speech.

In contrast, Colombo and Horowitz (1986) failed to find preferences for frequency-modulated pure tones (simulating the degree of modulation seen in ID speech) over less modulated tones (including a monotone) in 4-month-olds. Importantly, these authors did find that 4-month-olds could discriminate each of these tone contrasts. These results contradict those obtained by Fernald and Kuhl (1987), where infants preferred the highly modulated ID pitch contours. However, the difference in outcomes across these two studies could be attributable to the fact that Colombo and Horowitz used synthesized stimuli that were not based on actual speech samples, resulting in stimuli that may have sounded unnatural. Because Fernald and Kuhl (1987) used natural speech samples, their resulting synthesized pitch contours captured potentially important speech characteristics such as temporal patterns (i.e., pauses) which are produced by periods of voiced and non-voiced consonants. The patterning of real speech includes the pauses and breaks where one phrase or sentence begins and another begins, unlike the modulated pure tones used by Colombo and Horowitz (1986).

In another set of studies, Colombo (1985) looked at the effects of varying the spectral complexity of tones on infant attention. Colombo presented four different tones to the infants: (1) fundamental alone, (2) the fundamental plus the next 6 harmonics, (3) the fundamental plus the next 12 harmonics, and (4) the fundamental plus the next 18 harmonics. The infants' attention generally increased with increased spectral complexity, (i.e., more harmonics), with 4 month-olds showing the longest fixation times for the most complex auditory stimuli (F₀ plus the next 18 harmonics). Colombo suggested that the increased spectral complexity may cause a net increase in the neural activity along the

auditory pathway. Therefore, the effects of ID speech may rely more on spectral structure than frequency contour. Again, these findings do not support those of Fernald and Kuhl (1987).

This difference in findings between Colombo (1985) and Fernald and Kuhl (1987) may be attributable to differences in research designs. Fernald and Kuhl utilized a head turning procedure whereas Colombo simply looked at length of visual fixation. Therefore, Cooper and Aslin (1994) performed a set of studies that more directly replicated those conducted by Fernald and Kuhl (1987). The infants were tested via a fixation-based preference procedure with a variety of speech related stimuli. For the first two experiments, ID and AD utterances were low-pass filtered to remove the higher frequency pitch characteristics. Cooper and Aslin (1994) found that 1-month-olds showed no preference for ID speech over AD speech when both had been filtered in a manner that preserved their lower frequency prosodic features but eliminated all frequency information above 400 Hz. In a second experiment, Cooper and Aslin checked to see if the lack of preference was due to an inability of the infants to discriminate the filtered speech samples. However, the results showed that the infants were able to differentiate them. These authors concluded that the lower-frequency prosodic information was not sufficient to account for the ID speech preference in 1-month-old infants. There is one possible explanation for the contradiction between Fernald and Kuhl's research and Cooper and Aslin's research. The filtering manipulation used in Cooper and Aslin's experiments may have affected the speech samples differently. ID speech is higher and more variable in pitch and contains wider pitch ranges, so when the speech samples are filtered there may be more information lost in the ID speech. Cooper and Aslin (1994) conducted another experiment to check if this explanation seemed plausible. They tested 1-month-olds' preferences for the isolated pitch contours of either ID or AD speech. The stimuli in this experiment resembled those in the Fernald and Kuhl (1987) study in that the synthetic tones (frequency contours) that were generated followed the frequency patterns of real speech. Cooper and Aslin found that there was no

preference exhibited for ID over AD pitch contours in 1-month-olds. They concluded that 1-month-olds may not be as sensitive as 4-month-olds to the isolated prosodic contours of ID speech. They also noted that ID speech may be better at gaining the attention of infants than AD speech, rather than maintaining attention.

Research by Kaplan, Goldstein, Huckleby, Owren and Cooper (1995a) also failed to support Fernald and Kuhl's research. This research utilized a habituation paradigm, based on Thompson-Spencer dishabituation. Thompson-Spencer dishabituation refers to the renewed response to a familiarized stimulus when it is retested after the introduction of a novel stimulus (Kaplan, Werner, & Rudy, 1990; Thompson & Glanzman, 1976). In this procedure one stimulus is presented several times (a checkerboard pattern), then the checkerboard is compounded with a novel stimulus (ID or AD speech). The renewed responsiveness in Thompson-Spencer dishabituation occurs after the novel stimulus is removed (Thompson & Spence, 1966). Therefore, the increase in looking times must be mediated by some lingering consequence of the novel stimulus. Renewed responsiveness is thought to be mediated by an increase in the infant's state of arousal which is elicited by the novel stimulus. In these studies, dishabituation of visual attention by ID and AD speech was investigated using 4-month-olds.

The infants received 12 10-s presentations of a checkerboard pattern with a speech segment compounded only on the ninth trial. Recovery of visual attention was observed on the compound trial in response to both ID and AD speech, but ID speech alone dishabituated visual attention during the following pattern-alone retest. That is, the ID speech produced a Thompson-Spencer dishabituation effect. When the infants were presented with synthetic analogs of the ID and AD speech segment's pitch contours, both elicited equivalent increases in attention on the compound trial, but neither stimulus elicited Thompson-Spencer dishabituation. This suggests that neither the ID nor AD pitch contours sufficiently increased the infant's state of arousal enough to be exhibited after the compound trials. In a follow up experiment, Kaplan et al. (1995b) studied the effects of both contour modulation

and the number of harmonics on infants' responses to ID speech. Four computer-based synthetic stimuli were modeled on ID speech; a Fo only stimulus, a Fo plus H1 (the first harmonic), the Fo plus H1-H5 (the first five harmonics), and harmonics-only condition (H1-H5). All four of these synthetic stimuli were frequency modulated, but they varied in their spectral composition and linguistic intelligibility. None of the four stimuli elicited Thompson-Spencer dishabituation. The results suggest that frequency modulation in a speech segment's low-frequency components cannot fully account for the dishabituation elicited by ID speech. Although the full-spectral ID speech elicited Thompson-Spencer dishabituation, none of the manipulated ID speech did.

In sum, only one study has shown that 4-month-old infants prefer ID over AD speech due to the isolated frequency contours (Fernald & Kuhl, 1987). Colombo and Horowitz (1986) failed to show any infant preference for modulated stimuli over pure tones. Cooper and Aslin (1994) found that 1-month-olds did not prefer either filtered ID over filtered AD speech or ID over AD pitch contours. Kaplan et al. (1995b) showed no Thompson-Spencer dishabituation to manipulated ID speech, but dishabituation did occur with normal ID samples. The results of these previous studies suggest that ID speech may attract infant attention due to its richness on several acoustic dimensions; harmonic structure, frequency modulation, level of maximum frequency.

The conflicting results on the role of frequency modulation in mediating the effects of ID speech on infant attention show the need for further research to assess the effects of frequency modulation and other relevant stimulus characteristics. Cooper and Aslin (1994) suggested that pitch contour modulation combined with the presence of higher-frequency harmonic components and temporal discontinuities (i.e., periods of no voicing) draw infant attentional preferences. Colombo (1985) suggested that the increased spectral complexity of ID speech (more harmonics) somehow increased the stimulation of the infant's auditory pathway. The frequency modulation in ID speech is only part of a complex dynamic in the communicative interaction between infant and caregiver. The rich experiential history of the

infant with ID speech is multifaceted and contextually bound. More research on features of ID speech is required before any characteristic can be named *critical*.

The purpose of the present experiment was to provide a systematic replication of Fernald and Kuhl's (1987) research. Four month-olds were given the opportunity to hear recordings of an isolated pitch contour (a sine wave) of AD speech and an isolated pitch contour of ID speech. Infants were tested in an infant-controlled preference procedure, similar to the one used by Cooper and Aslin (1994), in which the infant is only given one stimulus choice at a time. It was expected that the infants would show preferences for the pitch contour resembling ID speech. "Preference" was operationally defined as significantly longer mean looking times to the visual stimulus when looking was associated with a particular speech recording.

Experiment 1: Preference for ID vs. AD Fo Contours in 4-Month-Olds

Method

Subjects

Twenty-four 4-month-old infants comprised the final sample ($M = 131.4$ days, $SD = 6.6$; fourteen females and ten males). An additional five infants failed to complete testing due to excessive crying or fussiness. The parents of these infants were recruited for participation through the birth announcements in Roanoke Times and World News. Upon receipt of the birth announcements, the parents were sent a letter describing the study. A few days after the letter was mailed the parents were contacted by phone to see if the parents were interested in participating. Demographic information from the 24 infants was obtained via a questionnaire given on the day of the testing. The questionnaire requested parent ages, race, education levels, net yearly income, and occupations.

Pitch Stimuli

Four ID and four AD sentences used in Cooper and Aslin (1990) were used in the present study. These recordings were made of a adult female saying the sentences, "Good morning. How are you today? What are you doing? Let's go for a walk." as she would to

her infant and to another adult. Pitch analyses of these recordings showed that the fundamental frequency, frequency range, and frequency variability of the ID sentences were significantly higher than those of the AD sentences (see Table 1). These four ID and four AD sentences were initially digitized and then analyzed using the Pitch Edit program from Micro Speech Lab software on a personal IBM computer. Individual pitch contours were also visually inspected using a computer graphics program which provided the opportunity to count individual pitch pulses per 25-ms analysis frames. This visual analysis made it possible to resolve discrepant pitch values between the two techniques (e.g., whenever the Pitch Edit program derived a F_0 value that was a multiple of the previous value, suggesting that the algorithm mistook the first harmonic as the fundamental frequency). After successive F_0 values were derived and validated for each individual sentence, these values were fed into a tone-generator program (with silence inserted whenever a period of no-voicing occurred), resulting in both ID and AD sine-wave (ID- F_0 and AD- F_0) analogs (with amplitude held constant at 68 dB across each utterance). These contours were then recorded onto separate channels of a 20 second loop tape.

Insert Table 1 Here

Apparatus

In the laboratory, the parent was seated in a chair facing a black wooden 3-sided enclosure (80-cm (length) X 80-cm (width) X 60-cm (height)). To the parent's left and rear was a white wall, and to his/her right was a black covering (piece of cardboard). This covering was in place to restrict the infant's peripheral view. Each infant was held on their parent's lap facing the front wooden panel. Separating the parent and the infant from the front panel was a 40-cm X 80-cm wooden shelf painted black and covered with a white foam pad. This shelf provided the infant with support and a safe place to touch. Inside the

enclosure was a custom-built interface, an Emerson VCR-875 videocassette player/recorder, a 13 in Mitsubishi (model #cs1347R) color television monitor, a Realistic (model 40 2054/8 ohms) loudspeaker, and a Panasonic VHS camcorder (model AG 170).

Infants were able to view the screen of the television monitor through a cut-out in the wall of the front panel. The screen was approximately 35 cm from the infant's face. A video tape of concentric colored circles was played on the VCR and was presented via the television monitor to the infant. The loudspeaker was located behind a cut-out in the front panel directly above the television monitor, over which the auditory recordings were presented.

An observer used a small 5 in JVC (model #TM 22U) color television monitor to observe each infant during testing (this monitor was connected to the camcorder which broadcast the infant's face). A small red light was in front of the observer (attached to bottom of the monitor) to indicate when the infants' visual display was on. The observer had access to a Power Mac 6500 computer, which controlled the presentation of both the visual and audio stimuli, time between stimulus presentations, and stored the length of infant visual fixations.

Procedure

Each of the infants was seated on either their mother's or father's lap in front of the three-sided enclosure. The parent wore headphones over which continuous vocal music was played to mask the speech stimuli being presented to the infant. Once the infant was judged to be happy and alert by the experimenter, the procedure was started. During testing, the room lights were turned off, allowing the observer to judge looks based on the reflection of light from the television off the infant's eyes. The observer recorded the duration of each infant's look to the circles by depressing a button connected to the computer. This observer wore headphones and listened to uninterrupted music at a level that masked all extraneous sounds. A second experimenter stood next to the apparatus and was responsible for maintaining infant temperament and overall comfort of parent and child.

When the observer judged that the infant was looking toward the circles, he or she depressed a key that activated channel 1 (or 2) of the tape recorder. The recording associated with that channel was played continuously through the loudspeaker until the observer judged that the infant had looked away from the circles. As soon as the key was depressed signaling the end of a look, the recording and the circles were shut off. After a brief time interval the observer pressed the key turning on the circles again. Once the infant looked at the television the procedure was repeated for the second channel. The ID and AD contour were presented on alternate trials, depending on which stimulus was presented first. To control for any bias resulting from order of presentation, half of the infants received the ID contours first and half received the AD contours first. Each session ended when the subject completed a minimum of 10 trials (out of a possible 12 trials).

Previous researchers have shown that infants often exhibit a significant difference in looking time when just the first look is analyzed (Berman, 1989; Cooper & Aslin, 1990; Pegg et al., 1992). For example, Cooper and Aslin (1990) found that 1-month-olds and newborns looked longer on the first trial when they heard female ID speech (compared to AD speech). Berman (1989) found a similar effect in 1-month-olds when maternal AD speech was compared to maternal ID speech. Pegg et al. (1992) found that infants who heard ID speech during the first trials of an habituation procedure looked longer on those trials (i.e., had greater mean looking times when compared to the average looking time on the first trials for both groups). In addition, this same pattern was found for speaker gender, with infants who heard female speakers first looking longer (on average) than the infants who heard the male speaker first. Based on this previous work, an additional control was implemented for the first trials of the sessions as a function of whether the infants heard the ID and AD contours or no auditory stimuli. For half of the infants, the first two trials consisted of only the circles with no speech contour (visual alone). This was done to control for the amount of attention being captured by the visual display alone. It is possible that the long looks on the first and second trials were due to the novelty of the

visual stimulation. The first two trials for the infants receiving only the visual stimuli (pretrial group) were compared to those of the infants receiving both the auditory and visual stimuli (no pretrial group).

Results and Discussion

The first analysis compared the looking times for the pretrial group and the no pretrial group. Specifically, the looking time on the first pretrial was compared to the first trial for the no pretrial group. This test showed no significant difference in looking times, (\underline{M} (visual alone) = 6.51, \underline{SD} = 4.06, \underline{M} (visual and contour) = 7.03, \underline{SD} = 4.54), $t(22) = -.30$, $p > .05$).

Thus infants failed show any differential responding to the compound stimulus (the circles and the contours) compared to the visual alone. It appears that the addition of the pitch contours did not add or subtract to the looking times, at least on the initial trials. The first trial may have simply been a warm-up period for the infants, where all the surrounding features *capture* their attention.

To determine whether the infants looked longer at the visual display during either the presentation of the ID-Fo or the AD-Fo, mean looking times to both contour types were calculated by dividing the sum of time spent looking during the presentation of each contour type by their respective number of trials. A mixed 2 X 2 repeated measures analysis of variance (ANOVA) was computed on the infants' mean looking times, with order [ID-Fo first, AD-Fo first] as the between-subjects factor and contour type [ID-Fo, AD-Fo] as the within-subjects factor. The results showed no significant main effect for order, $\underline{F}(1, 22) = .32$, contour type, $\underline{F}(1, 22) = .34$, or the order X contour type interaction, $\underline{F}(1, 22) = .54$, all p values $> .05$. Mean looking times for contour type were \underline{M} (ID) = 8.52 sec, \underline{SD} = 3.64 and \underline{M} (AD) = 9.0 sec, \underline{SD} = 3.07. An additional analysis was done on the first trials as a function of contour type (ID-Fo first v. AD-Fo first). However, this test also showed no significant difference in looking times, (\underline{M} (ID first) = 10.07, \underline{SD} = 8.40, \underline{M} (AD first) =

7.66, $SD = 4.30$), $t(22) = .908$, $p > .05$. Neither pitch contour type sufficiently drew the 4-month-olds attention on based simply on the first presentation.

The results of experiment 1 contradict the findings of Fernald and Kuhl (1987), in which 4-month-olds showed a significant preference for ID pitch contours. This difference is surprising due to the similar age range of infants and the similarity of the procedure utilized. One explanation for the difference in findings could be due to the auditory stimuli heard by the infants in these two studies. However, Cooper and Aslin (1994) performed a pitch analysis of the ID and AD recordings and found that the fundamental frequency, frequency range, and frequency variability of the ID sentences were significantly higher than the AD sentences. This means that the ID contours were based on a speech sample that accurately resembled the prosodic characteristics typically found in ID speech. The difference in findings is therefore not due to nonprototypical speech contours in experiment 1. Another explanation for the conflicting results may rest on infants' lack of discrimination of the ID and AD contours. That is, the infants failed to show an attentional preference for the ID contours because they were not sufficiently different from the AD contours. The ID and AD contours may sound indistinguishable to the 4-month-old due to the absent auditory information present in full speech. However, this explanation seems highly unlikely due to the findings of other researchers (Cooper & Aslin, 1994; Pegg et al., 1992) where younger infants showed similar discriminative abilities. Nonetheless, to rule out this explanation a second experiment was conducted to see if 4-month-old infants could discriminate the ID and AD contours.

Experiment 2: Discrimination of ID-Fo vs. AD Fo Contours in 4-Month-Olds

The purpose of the second experiment was to investigate whether or not 4-month-olds could discriminate the ID and AD frequency contours used in experiment 1. Given the previous research (Cooper & Aslin, 1994; Fernald & Kuhl, 1987) it was predicted that the infants would discriminate the two frequency contours. A variant of the visual fixation procedure from Experiment 1 was used in which infants listened to the same contours on

repeated trials by visually fixating the visual display until their looking time decreased to some prespecified level (i.e., habituation occurred). After habituation infants were given the opportunity to listen to novel contours. Discrimination was inferred if the change from the familiar to the novel contours was accompanied by increased looking to the visual display.

Subjects

Twenty-two healthy 4-month-old infants comprised the final sample ($M = 131.4$ days, $SD = 8.9$; 8 females and 13 males). An additional 5 infants failed to complete testing due to excessive crying or sleeping. As in the previous experiment, infants were recruited through local birth announcements and contacting parents by letter and telephone.

Pitch Stimuli

The same ID and AD contours from Experiment 1 were used in this experiment. All speech stimuli were presented to the infants at approximately 63-65 dB SPL (B scale).

Apparatus and Procedure

The apparatus used in the previous experiment was also used in Experiment 2. The procedure was also the same except that instead of hearing two different contour recordings on alternate trials, the infant heard the same contour recording on successive trials. The mean looking time to the checkerboard on the first three trials was computed and stored by the computer for later reference. This mean looking time was then compared to the average of every three consecutive trials. When this "running" average dropped to 50% or less of the mean of the first three trials, the habituation criterion was met. For 11 of the 22 infants, their looks to the checkerboard on the next four trials after habituation activated the other channel of the tape recording (either the ID or the AD contours). The session ended after these four postcriterion trials had been completed. For the other 11 infants, two additional trials (hereafter called *lag* trials) were administered after the criterion had been met but before the change in contour was presented. This partial-lag design controlled for the possibility of spontaneous recovery in looking times during habituation (Bertenthal, Haith, & Campos, 1983). For example, infants often exhibit attention patterns in which long looks are

followed by short looks or vice versa. Thus, increased looking after habituation (i.e., recovery of attention) may be unrelated to the stimulus change per se. If this were so, infants should look longer on the lag trials even though the auditory stimulus has not yet changed. Additionally, to control for any bias due to the order of speech presentation, 11 of the 22 infants heard the ID-Fo contours first (eight subjects had two lag trials), and the other 11 infants heard the AD-Fo contours first (three subjects had two lag trials).

Results and Discussion

To test for discrimination infants' mean looking times on the last two precriterion trials (which were lag trials for 11 of the infants) were compared to their mean looking times across the first four postcriterion trials in a mixed ANOVA with order (ID-Fo contour first vs. AD-Fo contour first) and lag trials (zero lag trials vs. two lag trials) as the between-subjects factor and test trials (precriterion vs. postcriterion) as the within-subjects factor. The results of this analysis showed a main effect of test trials, $F(1, 20) = 4.45, p < .05$, indicating that the mean looking time across the four postcriterion trials ($M = 7.71$ sec, $SD = 4.1$) was significantly longer than the mean looking time on the last two criterion trials ($M = 6.37$ sec, $SD = 4.89$). There were no other significant main or interaction effects. The mean looking times across infants on the first three trials of the session (baseline), the last two criterion trials (collapsed across the lag variable: pre 1 and 2), and the first four postcriterion trials (post 1-4) are presented in Figure 1.

Insert Figure 1 Here

A second analysis was conducted to compare the mean looking of the last two precriterion trials to the mean looking time of last three postcriterion trials (i.e., minus the first postcriterion trial). By looking at individual subjects' data, it appeared that the infants did not always increase their attention on the first change trial. This secondary analysis showed a more robust effect for test trials ($F(1, 20) = 9.61, p < .01$).

Additional analyses were performed to compare the amount of trials needed to reach criterion and the duration of the first look based on contour type (ID-Fo first or AD-Fo first). Although the infants did not prefer the ID-Fo contour in experiment 1, they may have taken more trials to reach criterion or longer initial looks in this second experiment. If the ID-Fo contours were *attractive*, infants hearing it first could take more trials to reach habituation and show long first looks. The trials to criterion were calculated for the infants receiving the ID-Fo contours first and the AD-Fo contours first, the results showed no significant difference in the number of trials needed to reach criterion (ID first; $\underline{M} = 9.27$, $\underline{SD} = 4.67$; AD first; $\underline{M} = 8.91$, $\underline{SD} = 2.66$, $t(20) = .224$, $p > .05$, two-tailed). Interestingly, an analysis of the first look showed a significant difference in the two groups dependent on which contour type was presented first; ID first, $\underline{M} = 13.40$, $\underline{SD} = 5.09$, AD first, $\underline{M} = 21.59$, $\underline{SD} = 10.42$, ($t(20) = -2.34$, $p, .05$, two-tailed). However, this effect disappeared when two extremely long lookers were removed from the analysis (AD first group).

The results of Experiment 2 showed that 4-month-olds lack of preference for the ID-Fo contours in experiment 1 was not due to their failure to discriminate the ID and AD contours. The infants exhibited a significant recovery of their visual fixation (attention) when the second novel contour was presented. In addition, the lack of any significant main effect for “lag” trials suggests that the recovery of attention was not due to simple regression. If the infants had spontaneously recovered their attention after reaching a low level of attention, there would have been a similar recovery during the lag trials. However, the infants receiving the two additional lag trials showed no recovery of visual attention until after the novel contour had been presented.

General Discussion

Overall, the implication of the results presented here is that infants' preferences seen for ID speech cannot be explained solely by the information contained in pitch contours. The 4-month-olds in experiment 1 showed no preference for the ID contours despite being

able to accurately differentiate them from the AD contours (experiment 2). These results add to those found by other researchers, all of which failed to replicate the findings of Fernald and Kuhl (1987) (Colombo & Horowitz, 1986; Cooper & Aslin, 1994; Kaplan et al., 1995b). In all of these studies involving ID and AD contours, only Fernald and Kuhl found a preference for ID contours. Thus, non-significant findings have been found for infants' preference for frequency contours resembling ID speech in a variety of methodological preparations.

The finding that infants could discriminate the contours supports past research (Clarkson & Clifton, 1985; Cooper & Aslin, 1994; Mehler et al., 1988; Papousek et al., 1990; Sullivan & Horowitz, 1983). Mehler et al. (1988) showed that 4-day-olds could discriminate native and nonnative language even when the speech was filtered so that only the low-frequency information was available. Sullivan and Horowitz (1983) found that 2-month-olds preferred a rising intonation contour of "BA" over a falling contour. Similarly, Papousek et al. (1990) showed that 4-month-olds looked significantly longer to a rising melodic contour when compared to a falling contour. When added together these results suggest that infants as young as 2-months have the ability to discriminate different contour patterns.

This study extends the findings of Cooper and Aslin's third experiment (1994). In these studies neither 1-month-olds nor 4-month-olds showed a preference for the ID pitch contours. Cooper and Aslin suggested that young infants, between one and four month of age, may be in the process of learning to categorize and extract certain prosodic information from the speech of others. The more experience the infants have with the prosodic features of ID speech the better they may become at recognizing the pitch contour information. The infants may learn to be sensitive to certain prosodic aspects in the speech directed towards them. However, the results of Experiment 1 show that four-month-olds have still not become sensitive to contour shape alone. That is, the infants failed to show a preference for ID speech based only on contour shape. There appears to be other important features in ID

speech that help to draw infants attention in addition to pitch contours. When infants attend to ID speech they are in a particular context, where the speech contains many prosodic characteristics that may help to maintain their attention. At no time is the infant hearing ID speech that is manipulated to accentuate one prosodic feature. Therefore, the lack of preference seen in experiment 1 may simply be due to what's missing from the normal ID speech which may include aspects of the language environment (e.g., face and movement). Infants hear speech in an environment which includes visual information, especially at this young age. The vocal interactions are often face-to-face with the caregiver holding the infant as they communicate with them. Infants may require this additional input from the visual modality to correctly recognize specific acoustic features. When the ID speech has been manipulated and presented in a modified language environment (e.g., experimental room), the infant is placed in a highly unfamiliar context lacking features contained in actual language environments.

Infants may need more than just the pitch contour present in ID speech to guide their attention (e.g., spectral structure, tempo or amplitude). In their fourth experiment, Cooper and Aslin (1994) showed that 1-month-old infants preferred full spectral ID speech over low-pass filtered ID speech. Low-pass filtering allows the experimenter to eliminate acoustic information above a certain cut-off point. The infants looked longer on the trials with the ID speech containing all of the prosodic information, even though both of the ID stimuli contained similar fundamental frequency contours. Thus, full ID speech contains some other characteristics that draw infant attention.

Overall, it appears that infants are more responsive to ID speech when more spectral information is added to the frequency contour (Colombo, 1985; Cooper & Aslin, 1994; Kaplan & Owren, 1994; Kaplan et al., 1995b). Colombo (1985) found the greatest level of attention with the stimuli containing the most spectral information (contour plus the next 18 harmonics). Kaplan et al. (1995b) found the highest level of dishabituation to the stimulus containing the contour plus the first harmonic, when compared to the stimuli containing the

frequency contour alone or the harmonics alone. There appears to be some attention captured by the added harmonics and the contour, with the highest level of responding being to both. Infants are most "captured" by the ID stimulus when it contains more spectral information. Full ID speech has both greater overall spectral information (amount) and greater stimulus complexity. After months of being part of a language environment, ID speech becomes increasingly complex for the four-month-old infant. The cumulative experience with ID speech has made it a *meaningful* stimuli, for it is often paired with many positive events (e.g., mother, food, warmth, etc.). ID speech may be an acoustic cue for all the positive experiences during the early period of postnatal development.

Kaplan et al. (1995b) suggested that the differences in observed responding seen in Cooper and Aslin (1994) and Fernald and Kuhl (1987) may have been due to the methodological differences. Cooper and Aslin (1994) relied on visual fixation as a measure of infant attention, whereas Fernald and Kuhl (1987) measured which direction the infants turned their head depending on the training order (e.g., left ID-right AD). The latter procedure requires that subjects only look in the direction of the stimuli whereas the first procedure involves directing and maintaining a visual gaze (Cooper & Aslin 1994). If the ID contour is to be the "critical acoustic determinant" of ID speech preferences, it should maintain this ability over time (Fernald & Kuhl, 1987, p. 285). Therefore, the visual fixation procedure, which allows extremely long looks, should enable the infant to exhibit a preference for the ID contour. Yet, in two different studies 1- and 4-month-olds have failed to show any differential looking based on the contour information alone. Simple procedural differences cannot account for why infants fail to show some preference for the ID contour, there must be some other prosodic feature in ID speech that helps to explain infants' preference for ID speech.

The studies presented here utilized the same methodology as Cooper and Aslin (1994) with infants maintaining their visual attention in order to hear either the ID or AD contour. However, there was a difference in findings between the recent study using 4-

month-olds and Cooper and Aslin's (1994) study. Cooper and Aslin showed different levels of responding based on the order of presentation. However, the difference was evident only in the first trial. Infants hearing the ID contour first looked significantly longer than those infants hearing the AD contour first (ID first trial, $M = 63.5$ sec, $SE = 15.6$; AD first trials, $M = 25.7$ sec, $SE = 7.5$). When the first trials were removed in the analysis of variance, the effect of order disappeared. Cooper and Aslin suggested that the difference observed in the first trials may have been due to the initial arousing effects of the ID contours. However, the arousal does not last into later trials after the infant has had a chance to hear both contours. There was no significant difference in the looking times to ID and AD contour after the infant had heard both contours.

In contrast, in experiment 1 there was no effect due to order of presentation, the infants exhibited no initial "arousal" response when hearing the ID contour first. It appears that 4-month-old infants are less "captured" than the 1-month-olds by the ID frequency contour. The additional analysis on the pretrials also showed no significant difference between the initial trials that included ID or AD contours and the trials that did not (visual alone). The infants showed equal attention patterns regardless of whether or not the contour was present, at least on the initial two trials. It is possible that after several more months of experience with ID speech that the infants are less aroused by the contour alone and may need more stimulation. The 1-month-old infant may not have accumulated enough listening time to ID speech to realize exactly what differentiates it from AD speech. The frequency contour alone may be enough, at least on the first trial, to draw their attention more than the AD contour. However, by four months of age the infant has had enough experience listening to ID speech to realize that an isolated contour is not the same full spectral speech. The contours may sound somewhat incomplete to the four month infant, lacking enough of the necessary ingredients required to get their attention.

The isolated frequency contours may have appeared unnatural or foreign to the four-month-old (Kaplan et al., 1995b; Cooper & Aslin, 1994). It is unlikely to imagine a 4-

month-old hearing ID and AD contours outside the lab setting. Infants normally *hear* and *see* adults speaking either AD speech or ID speech, both of which contain rich acoustic information. Some researchers have shown that infants can differentiate tonal complexes containing different ranges of harmonics according to their fundamental frequencies (contours) (Clarkson & Clifton 1985). The added spectral information carried in the harmonics allows the infants to group the sounds according to the contour pattern. More recently, Clarkson, Martin and Michiek (1996) found that 7-month-olds' performance in a pitch perception task deteriorated as the number of harmonics in a tonal complex decreased. The highest level of performance occurred when the tones contained six harmonics. These authors suggested that infants' perception of pitch may rely on the additional spectral information provided by the harmonic complexes. This research implies that for the infant to perceive the ID contour as attractive as full ID speech, additional harmonic complexes would have to be added. This may be especially true for infants younger than those tested by Clarkson et al. (1996) because younger infants have less accumulated experience with speech and contour shapes.

Lastly, a general comment should be made in terms of practical significance, effect size and power in this area of research investigating ID contours. The power of a test varies as a function of significance criterion (alpha level), the reliability of the sample results, and the predicted effect size. Cohen's (1969) power tables involving the comparison of group means provide an estimate of the power of experiment one (.10), given the prediction of a small effect (preference) for the ID contours. This value represents the power of the test times 100, or the percentage of tests carried out under the given conditions that would have resulted in the acceptance of the null hypothesis. This means that given the current experimental conditions (i.e., 24 subjects and the expectation of a small effect size) out of every 100 tests conducted only 10 would show a significant effect for the ID contours. In addition, if a strong effect had been predicted and found the overall power ratio would have increased dramatically for the current study (.77). However, given the conflicting results

concerning ID contours, a strong effect size was not not predicted a priori. Past studies involving ID contours have predominantly (except for Fernald & Kuhl 1987) failed to show even a small effect size.

There are several implications from this discussion of the limited power and small effect size in the field of infant speech perception. The first implication involves possible remedies for the low power that is seen in some of the current work. One way the power could be increased is by simply increasing the overall sample sizes. However, this is not be the most practical solution (given obvious time limitations). Another possible solution would involve altering the stringent alpha levels used in most statistical analysis ($p < .05$). This would allow researchers to increase the overall power of their tests by decreasing the normal cutoff value. By changing the significance criterion researchers would be more likely find the small effect for ID contours that is predicted given the past research.

The second implication of this discussion of power and effect size concerns the direction of future research. Researchers should seek to uncover some other aspects present in this ID language environment that help mediate infants' preference for ID speech (e.g., spectral information). If these other aspects are identified stronger effect sizes could be predicted even when using the normal significance level ($p < .05$).

Overall, it appears that the contention of Fernald and Kuhl (1987) that the pitch contour is critical acoustic determinant, may have been premature. Several studies failing to show any preferential attention in infants based on contour information alone attest to this (Colombo, 1985; Cooper & Aslin, 1994; Kaplan et al., 1995b). Perhaps there is another study that can more directly compare the perceptual similarities between ID contours and ID speech. If the infant was forced to compare the ID contour and full ID speech directly, we may get a better assessment as to how much perceptual information ID contours actually contains. If greater spectral complexity draws infant attention the infant should show preferential looking for full ID speech. However, if the contour alone contains sufficient

acoustic information no difference in looking time should be found for both ID contours and full ID speech contain identical contour information.

The difference in findings concerning the ID contours may also relate to the pattern of research seen in infant speech perception research labs. Often times researchers are placing the child in situations where only two artificial sounds are presented or where two stimuli differ only on one acoustic dimension (e.g., contour pattern). In actuality, infants are rarely given the opportunity to choose between only two events and their natural auditory stimuli are often vastly different from the sounds presented in the experimental environment. When we limit infants to two choices we are bound to find some conflicting results supporting one theory or another. However, it is highly unlikely that infants rank and order the features of the ID speech along a continuum of "criticalness". Each feature in ID speech serves some function, whether it carries the main focus of infant attention or not. To remove ID speech from the context within which it is used prevents us from being able to explain it fully. The infant never hears ID contours in isolation without other necessary prosodic and linguistic features, all of which may play a part in why an infant prefers ID speech.

Table 1

Pitch and duration characteristics of the Infant-Directed (ID) and Adult-Directed (AD)

Utterances

<u>Prosodic Features</u>	<u>Utterances</u>			
	<u>“Good morning.”</u>	<u>“How are you today?”</u>	<u>“What are you doing?”</u>	<u>“Let’s go for a walk.”</u>
Average Fo (Hertz):				
ID.....	377	281	341	265
AD.....	251	251	299	237
Fo Range (Hertz):				
ID.....	188-656	163-645	160-649	159-685
AD.....	210-354	167-400	161-372	181-302
Duration (seconds):				
ID.....	1.29	1.33	1.37	1.63
AD.....	.65	.74	.70	.94
Pause Length (seconds):				
ID.....68	.91	.98
AD.....52	.73	.62

Figure 1

Design of Experiment One

ORDER	EXTRA TRIALS	CONTOUR TYPE	
		ID CONTOUR	AD CONTOUR
ID FIRST	PRETRIALS		
	NO PRETRIALS		
AD FIRST	PRETRIALS		
	NO PRETRIALS		

Figure 2

Mean looking times (in seconds) across ID and AD contours (Experiment 1). Standard errors are also included. No significant difference was found between these means.

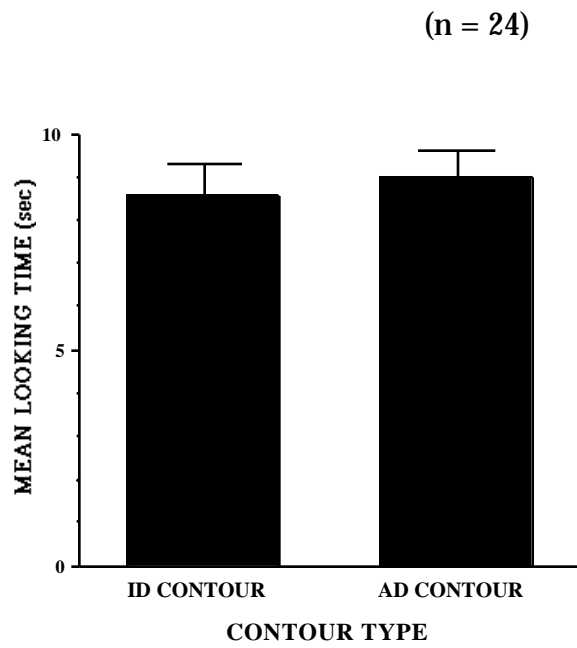


Figure 3

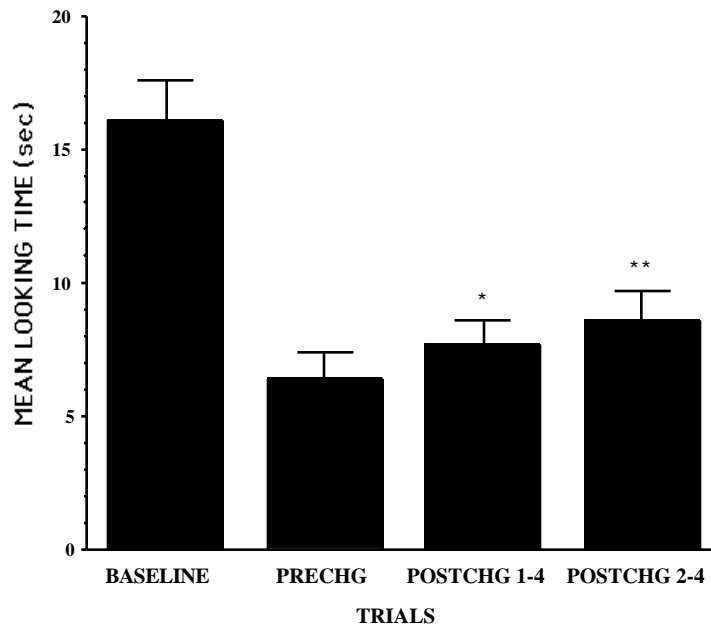
Design of Experiment Two

		TRIALS	
ORDER	EXTRA TRIALS	PRECHANGE TRIALS	POSTCHANGE TRIALS
ID FIRST	LAG		
	NO LAG		
AD FIRST	LAG		
	NO LAG		

Figure 4

Mean looking times (in seconds) during the first three habituation trials (baseline), the last two criterion trials (pre 1 and pre 2), the four postcriterion trials (post 1-post 4; Experiment 2) and the last three postcriterion trials (post2-post4, Experiment 2). Standard errors are also indicated.

(n =22)



* p < .05

**p < .01

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- 1996 Graduate Teaching Assistant, Virginia Tech Psychology Department. Spring 1996. Physiological Psychology. Contact Robert Lickliter, Department of Psychology, Virginia Tech, Blacksburg, VA 24061-0436.
- 1996 Instructor, Virginia Tech Psychology Department. Taught Developmental Psychology Lab classes. Contact Helen Crawford, Department of Psychology, Virginia Tech, Blacksburg, VA 24061-0436.
- Current Instructor, Virginia Tech Psychology Department. Taught Developmental Psychology Lab classes. Contact Helen Crawford, Department of Psychology, Virginia Tech, Blacksburg, VA 24061-0436.

Research Experience

- 1993 EEG differences in response to auditory stimuli in college aged subjects. Supervised by Dr. Barry Smith, University of Maryland at College Park.
- 1994 Lack of preference for the paternal voice in four-month-olds. Supervised by Dr. Robin P. Cooper, Virginia Tech, Blacksburg, VA 24061-0436.
- 1995 Infants' preference for their Mothers' AD Speech or Unfamiliar Female ID Speech. Supervised by Robin P. Cooper, Virginia Tech, Blacksburg, VA 24061-0436.
- 1996-present Thesis: 4-month-olds do not Prefer but can Discriminate Infant-Directed Contours from Adult-Directed Contours. Supervised by Robin P. Cooper, Virginia Tech, Blacksburg, VA 24061-0436.