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# Chapter 1

## Introduction & Literature Review

One of the primary goals in the study of perceptual development is the discovery of features that guide attention. This is a challenging task in infancy given the rapid changes that take place in early sensory development. In spite of this empirical challenge, we know a lot about the effective features of the visual world that appear to guide infant attention (Haith, 1981). For example, young infants are sensitive to the amount of visual contrast within a given spatial array whereas older infants are more affected by patterned visual information, independent of visual contrast. Comparatively, we know little about the effective information which guides infants' attention to auditory events, especially speech (but see Trehub & Trainor, 1990). Although there are modality-specific features that need to be explored in order to understand infant perceptual functioning, there will also be certain perceptual features that are relevant to more than one sensory system (Lewkowicz & Lickliter, 1994). One such cross-modal perceptual feature is the rate at which information is presented over time.

The role that rate plays in infant attention to visual stimulation has been well researched. Generally speaking, infants attend more to visual displays that are presented at faster as opposed to slower rates (see Lewkowicz, 1989, for a review). Interestingly, few studies exist on the role that temporal characteristics play in infant attention to auditory events. This is surprising considering that much research has focused on auditory development in infants. One auditory event that has received attention in recent years is infant-directed (ID) speech. It has been found that across the first postnatal year, infants prefer to listen to ID speech as opposed to adult-directed (AD) speech (see Cooper, 1997, for a review). Because ID speech differs from AD speech in a variety of its perceptual features, it is not immediately clear what feature(s) primarily drive infant attention. The purpose of this study was to investigate the role that rate plays in infant attention to and preference for ID speech. A selective summary of the literature on infant attention to visual events that differ in rate will be presented, followed by an analogous discussion of the role of rate in determining auditory preferences.

### How does rate affect visual perception in infants?

Infants prefer visual events that are presented at faster as opposed to slower rates (Lewkowicz, 1989). Using concurrently available visual displays, Lewkowicz (1985) presented 6-month-olds with check patterns flashing at 2, 4, or 8 Hz, finding maximal attention at 8 Hz. Similarly, Balaban and Dannemiller (1992) found that 12-week-old infants

looked more at checkerboard and bulls-eye patterns when they flashed at 5 Hz as opposed to when they flashed at 1 Hz. It should be noted, at least from the results of these two studies, that the infants appeared to pay maximal attention to the highest *relative* frequency (i.e., either 5 or 8 Hz) rather than some *absolute* frequency.

Overall, it seems that infants across a variety of ages prefer visual stimuli presented at faster rather than slower rates of presentation. This general statement needs to be qualified by other studies that have found an upper limit on infant preference for faster rates of presentation. For example, Karmel, Lester, McCarville, Brown, and Hoffman (1977) presented checkerboard displays to 3-month-old infants at frequencies ranging from 1 to 20 Hz. They found that infants showed maximum preference for the check patterns presented at frequencies between 4 and 6 Hz. This suggests that a quadratic relationship (i.e., an inverted-U shaped distribution) may exist between infant attention and rate of visual presentation. It seems, therefore, that there is a range of temporal frequencies within which infants show maximum attention, with decreased attention to visual frequencies outside this effective 'window'.

#### How does rate affect auditory perception in infants?

Unlike the visual studies above, little research exists on human infant's preferences for rates of auditory stimulation. However, information on rate in auditory stimulation does exist for non-human species. Working with avian species, Gottlieb and others have shown that the rate of the species-typical assembly call is important in facilitating species-specific recognition in mallard ducklings. For example, Gottlieb (as discussed in his 1985 chapter) found that ducklings preferred maternal assembly calls with frequencies of 3.7 to 4.2 notes-per-second over calls at 2.3, 2.8, and 4.7 notes-per-second. Moreover, Gottlieb (1980) found that duckling embryos must have experienced the species-typical maternal call at 4.0 notes-per-second to facilitate responsiveness after hatching. Frequencies of 2.1 and 5.8 notes-per-second did not effectively induce preferences for the maternal call after hatching. Similarly, a study by Gaioni and Evans (1984) found that synthetic, maternal alarm calls differing by more than two or four standard deviations from the most effective rate elicited significantly less vocal inhibition in ducklings. This finding was replicated by Evans (1993) who found that ducklings were reliably less responsive to artificial calls that differed in rate from the species-typical mean by more than two standard deviations.

These studies on ducklings' attention to assembly and alarm calls indicate that the quadratic relationship that Karmel et al. (1977) discovered in human infants' preferences

for visual rate may also hold true for auditory perception, at least in terms of avian- species' performance. Unfortunately, few studies have explored the effect of auditory rate on attention in human infants. The need for further research into this realm is heightened by the findings of Lewkowicz (1988) who showed that when 6-month-old infants were presented with auditory and visual stimuli concurrently, they encoded only the temporal aspects of the auditory stimulation. Therefore, the temporal characteristics of auditory stimuli seem to be more perceptually salient than those of visual stimuli in early human infancy.<sup>1</sup>

#### Which auditory events are good candidates for infant attention?

Infant-directed (ID) speech is an auditory event that is readily available in most infants' environments (Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies, & Fukui, 1989). ID speech contains higher or exaggerated vocal pitch, greater pitch variability, shorter utterances, longer pauses between utterances, slower tempo/rate, increased phrase repetition, and increased amplitude as compared to AD speech (Fernald & Mazzie 1991; Fernald & Simon, 1984; Jacobson, Boersma, Fields, & Olson, 1983; Masataka, 1992; 1996; Papousek, Papousek, & Symmes, 1991). These vocal changes have been observed in males and females (Fernald et al., 1989; Jacobson et al., 1983) as well as parents and non-parents (Jacobson et al., 1983). ID speech has also been found to be a robust phenomenon cross-culturally in such languages as British-English, French, Italian, German, Mandarin Chinese, and Japanese (Fernald & Simon, 1984; Fernald et al., 1989; Papousek et al., 1991; Shute & Wheldall, 1989).<sup>2</sup> Furthermore, prosodic alterations analogous to pitch, tempo, and amplitude have been observed in sign language (Masataka, 1992; 1996).

Generally speaking, ID speech elicits more attention than AD speech in infants ranging in age from newborn to 18 months (Cooper, Abraham, Berman, & Staska, 1997; Cooper & Aslin, 1990; 1994; Fernald, 1985; Glenn & Cunningham, 1983; Kaplan, Goldstein, Huckleby, Owren, and Cooper, 1995; Pegg, Werker, & McLeod, 1992; Werker & McLeod, 1989). Given infants' differential attention to ID speech, efforts have been focused on discovering the feature and/or features most responsible for its potency. For example, Fernald and Kuhl

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<sup>1</sup>Lewkowicz (1996) obtained somewhat differing results. Using faces and voices, he obtained results that did not support the notion that infants attend to the temporal characteristics of auditory stimulation at 4-, 6-, and 8-months.

<sup>2</sup>A few studies have found cultures in which these prosodic modifications are not made. For example, Ratner and Pye (1984) found that the Quiche Mayans do not raise their pitch when addressing their infants.

(1987) created analogs that simulated the fundamental frequency ('pitch'), amplitude, and duration of ID and AD speech. These authors were testing to see if these characteristics would elicit selective attention to ID speech. In an experimental sequence, different groups of 4-month-old infants were given the opportunity to listen to the following: (1) ID and AD pitch analogs (with amplitude held constant), (2) ID and AD amplitude analogs (with duration and pitch held constant), and (3) ID and AD duration analogs (with pitch and amplitude held constant). Infants showed a significant preference for the ID pitch analogs, but did not prefer either the amplitude or duration analogs. Fernald and Kuhl interpreted these results as evidence for the primacy of pitch in directing infants' attention to ID speech. However, it is important to note that the pitch analogs also contained the temporal (i.e. duration) characteristics of both ID and AD speech. Thus, it is possible that infants' preferences for the pitch analogs were in part influenced by the temporal characteristics as well.

Because the 4-month-olds in Fernald and Kuhl's (1987) study preferred pitch analogs modeled after ID speech over those modeled after AD speech, the pitch contour has been of primary interest to researchers interested in infant speech perception. In a model of how ID speech influences infant perception throughout the first postnatal year, Fernald (1992) postulated that the pitch contour initially serves the unconditioned, biological function of arousing infant attention and modulating state. As the infant ages, pitch contours continue to serve this function, but also begin to regulate infants' emotional experiences and focus their attention in linguistically-meaningful ways as they listen to speech. The findings of other researchers, however, do not fully support the primacy of pitch contours in infants' speech perception.

For example, Columbo and Horowitz (1986) presented 4-month-olds with 1-second bell shaped tone sweeps designed to simulate the pitch ranges of ID and AD speech. Using a preference procedure, these authors found no significant differences in infants' attention to the ID and AD tone sweeps. In a follow-up experiment, however, Columbo and Horowitz did find that 4-month-olds could discriminate these contrasts. Although the results of Colombo and Horowitz do not support those of Fernald and Kuhl (1987), the lack of preference for the ID tone sweeps may have been due to the artificial nature of these sounds (e.g., they were pure-tones that were not patterned after any aspect of natural speech). A recent study from our laboratory attempted a more accurate replication of the Fernald and Kuhl study.

Four-month-olds were given the opportunity to listen to both ID and AD pitch analogs that were generated in a highly similar method to that used in Fernald and Kuhl (1987).

Infants could control how long they listened to either the ID or AD pitch recordings by focusing their attention on a visual display. It was predicted that infants would look longer on those trials that produced the ID pitch analogs. However, no significant differences in looking times were found as a function of analog type (McCartney & Cooper, 1998).

A series of experiments examining the influence of ID and AD speech on infant arousal obtained similar results to those of McCartney and Cooper (1998). Kaplan et al. (1995) used a procedure in which infants were presented with a checkerboard display for eight fixed-trials. On the ninth trial infants received either ID or AD speech in compound with the checkerboard. On trials 10, 11, and 12, infants again received only the checkerboard. The primary dependent measure was the amount of visual attention to the checkerboard as a function of trial number. Kaplan et al. found that infants showed visual habituation over the first eight trials (i.e., their looking decreased), and showed significant recovery of attention on Trial 9, regardless of speech type. However, only those infants who heard ID speech on Trial 9 continued to visually attend to the checkerboard on subsequent trials (i.e., they exhibited what is referred to as Thompson-Spencer dishabituation). This increased attention on post-compound trials is taken as an indication of heightened arousal.

Kaplan et al. (1995) repeated this experiment with another group of 4-month-olds using pitch analogs of ID and AD speech similar to those used in McCartney & Cooper (1998). In this case, no elevation in infants' looking times was found on the post-compound trials. That is, the pitch contours alone were not sufficient to increase infant arousal. Subsequently, Kaplan, Goldstein, Huckeby, and Cooper (1995) replicated this lack of arousal in 4-month-olds as they listened to configurations of ID analogs in which the number of harmonics were systematically controlled. Basically, these authors found that only recordings that contained the pitch as well as a full complement of harmonics effectively increased infant arousal. From these studies, it appears that pitch may be necessary but not sufficient in regulating infant attention to ID speech (see also Cooper & Aslin, 1994, for similar results with 1-month-old infants).

Karzon (1985) also demonstrated that elevated pitch might not be enough to elicit selective attention in infants. One- and 4-month-old infants were presented with the words "marana" and "malana" to determine if they could discriminate the syllabic change (i.e., ra vs. la). It was found that if the words were presented with the prosodic modifications of elevated pitch, increased amplitude, and slower rate/tempo the infants could discriminate the change. The infants could not, however, discriminate the change when the words were

presented in AD speech. Moreover, infants could not discriminate the syllabic change if elevated pitch was the only prosodic modification. Therefore, the stimuli containing the pitch-only aspects of ID speech were not as effective as those stimuli that also contained the amplitude and temporal characteristics of ID speech.

Taken together, these studies suggest that the ability of ID speech to regulate and modulate infant attention is the result of some constellation of perceptual features. Although it is clear that pitch is one of these features, it is less clear which other features aid this process. There is reason to suspect that temporal features may play a significant role in directing and/or maintaining infant attention to ID speech. As previously noted, the pitch analogs used by Fernald and Kuhl (1987) also contained the duration aspects of their respective speech types. In Columbo and Horowitz (1986), however, all tone sweeps were equivalent in their duration. Therefore, if the temporal characteristics of ID speech are separated from the pitch aspects, pitch may not be enough to elicit the attentional effects related to ID speech. Karzon's (1985) findings tend to support this idea. When the fundamental frequency was separated from the other ID aspects of the speech samples - duration being one of them - infants were not able to discriminate the syllabic change. Hence, the temporal aspects of the speech seemed to play a significant role.

A recent study from our laboratory supports the idea that speaking rate can influence infants' preferences for ID speech (Cooper & Cooper, 1997). In the first experiment, 1-month-old infants were tested with two computer-generated ID speech recordings; one was at the normal rate of ID speech, and the other was presented at double the rate of normal ID speech (i.e., fast ID speech). Importantly, the pitch contours were equivalent across the two speaking rates. We found that infants preferred the speech that was at the normal rate. In a second experiment, a different group of 1-month-olds was tested with the ID-fast recording and an AD recording whose rate was unaltered. In this case, the rates of the two recordings were essentially identical, but the pitch characteristics were different. Interestingly, we found that the 1-month-olds preferred the ID-fast recordings. Thus, when rate was held relatively constant, infant attention was more influenced by pitch information, even though the actual rate of the ID-fast speech was not the preferred rate in the previous experiment. Conversely, when the pitch characteristics of the different speech types were held relatively constant, infant attention was influenced by the rate information.

#### What Factors May Affect Preference for Rate?

The research discussed thus far establishes that rate is



an important factor in early perceptual development. The studies on the visual modality have shown that infants attend to faster relative frequencies with attention decreasing if the stimulation frequencies exceed certain levels. The neural and physiological pathways that govern these rate preferences, however, have not been well established. Haith (1981) suggested that infants (especially newborns) are organized to keep the neural pathways of the visual system firing at a high level. Additionally, he highlights the idea that infants tend to focus their gaze near the edges of stimuli, where visual contrast is often highest. In order to facilitate maximal firing of cortical receptors, infants may position and re-position their eyes so that these edges cross the fovea, where concentration of cortical receptors is highest.

In addition to studies which have found that infants prefer certain contour densities over others (e.g., Karmel, 1969), it has also been found that factors such as luminance levels can affect infant preferences for visual displays. For example, McCarville and Karmel (1976) found that infants preferred visual displays with middling levels of contour density. That is, they found an inverted U-shaped relationship between contour density and infant attention, similar to the relationship between visual frequency of flashing displays and attention that was discussed earlier. Additionally, this relationship between contour density and attention existed only at moderate and higher luminance levels.

Such interactions between ambient factors and stimulus values in visual events have also been demonstrated with flashing visual displays such as those used by Lewkowicz (1985) and Balaban and Dannemiller (1992). For example, Gardner and Karmel (1984) found that infants' visual attention to flashing displays was dependent upon their arousal level. More specifically, these researchers tested neonates' preferences for visual displays flashed at different rates before and after the infants had been fed. When infants were tested before they had been fed, they preferred slower relative frequencies of stimulation. In contrast, when these same infants were tested post-feeding, they looked more to visual displays flashed at faster relative frequencies. The basis for this model of arousal-modulated attention is research which shows that infant heart-rate (HR) is higher at times close to when they are normally fed, with decreases in HR noted after infants have been fed (e.g., Gardner & Turkewitz, 1982; Harper, Hoppenbrouwers, Bannett, Hodgman, Stermann, & McGinty, 1977). Similar results have been obtained under these conditions using 1-month-olds (Gardner & Karmel, 1995), as well as with preterm infants using both flashing displays and contour density (Gardner & Turkewitz, 1982).

These studies help to illustrate the ideas of Haith (1981) that there is an optimal level of stimulation that infants seek to maintain. Even though Haith (1981) concentrated his efforts on the visual modality, researchers such as Maurer (1993) have applied similar ideas to research that spans modalities. More specifically, she feels that the optimal level of stimulation that infants seek to maintain is a function of incoming stimulation from all modalities. The research discussed above on arousal-modulated attention lends credence to these ideas by showing that internal physiological factors such as HR and feeding status can affect infant preferences for visual rates of stimulation.

Even though these researchers have given much thought to the existence of an optimal level of stimulation, the origins of this level has not been significantly addressed. Haith (1981) briefly discusses this issue by suggesting that infants arrive organized to seek out stimuli which help maintain this optimal level of stimulation. However, when this organization occurs in prenatal development and how it is possibly affected by experience has gone unexplained. The research of Gottlieb (1980, 1985) and others using avian species provides some insight into how preferences for auditory rate may be affected and facilitated by early experience. As previously mentioned, research in this area stresses that early experience with species typical rates of auditory stimulation (e.g., 3.7 notes-per-second) facilitates the development of processes such as preference for the maternal assembly call (Gottlieb, as discussed in his 1985 chapter).

The findings of Cooper and Cooper (1997) support the idea that experience may affect preference for rate in the auditory modality in human infants. As already discussed, these researchers found that infants preferred ID speech at the rate they would normally encounter in their caretaking environment over ID speech at a rate twice as fast (i.e., the rate of AD speech). Considering work with avian species, this preference could have been a result of the infants' experiences with normal rates of ID speech. Part of the intention of the present study was to further investigate the degree to which infants' preferences for rate of speaking are affected by early experience with ID speech.

#### Purpose of the present study

In general, this experiment was designed to further our understanding of the role that rate plays in influencing infants' preferences for ID speech. More specifically, interest focused on whether there was a delimited *range* of rates (i.e., a 'perceptual window') within which infants are responsive to ID speech, but outside of which infants' attention to ID speech is diminished.

Six- to eight-week-old infants were tested in an auditory preference procedure with recordings of ID-normal and ID-slow speech. The ID-slow speech samples were created with the help of a computer algorithm which decreased the rate of normal ID speech by 50%. Importantly, the pitch characteristics of the ID-normal and ID-slow speech recordings were relatively equivalent. It was hypothesized that the infants would prefer the speech that was at the normal rate they would encounter in their caretaking environments. This hypothesis was made because of the artificial nature of the ID-slow speech samples (i.e., it is unlikely that infants' would have encountered speech at this rate). Coupled with the results from our earlier experiments (Cooper & Cooper, 1997), the results from this thesis help to determine whether limits on the 'perceptual window' for effective rates exist in determining young infants' attention to speech.

## Chapter 2

### Methods

#### Participants

The final sample was composed of 20 six- to eight-week-old infants (13 males, 7 females;  $M$  age = 53.15 days,  $SD$  = 4.89) with predominantly white (17 white, 1 Asian, 1 Middle Eastern, 1 American Indian), middle-class and college educated parents. An additional 17 infants (9 males, 8 females) were tested but failed to complete the procedure due to excessive crying (8), sleeping (6), or other reasons (2 because of computer difficulties, 1 because the coder could not reliably judge the infant's eye movements). Birth announcements from hospitals in the New River Valley were obtained and the parents of infants were initially contacted by letter (see Appendix A) and then by phone. All infants were awake and alert at the time of testing and in good health as reported by their parent(s).

#### Speech Recordings

ID speech samples were created using *Digital Performer*, a waveform-editor program for the Power Macintosh. Using a fairly sophisticated algorithm, this program can change the rate of speech by manipulating steady-state portions of digitized utterances. For example, in most speech, but particularly in ID speech (Kuhl, Andruski, Chistovich, Chistovich, Lozhevnikova, Ryskina, Stolyarova, Sundberg, & Lacerda, 1997), the period of the vowel tends to be relatively long and stable with regard to pitch and amplitude. By mathematically examining such periods, an algorithm can essentially decrease speaking rate by duplicating portions of the vowel space. This results in longer utterances (compared to the originals) without affecting their pitch characteristics. As mentioned earlier, the two recordings generated for this experiment were ID-normal (unaltered ID speech) and ID-slow (ID speech that has been slowed to 50% of the rate of normal ID speech, see Table 1).

#### Apparatus

Infants were placed in an infant seat facing the front panel of a three-sided (80 cm x 80 cm 60 cm) black plywood enclosure. A 27.5 cm by 21 cm television monitor was positioned behind an opening in the front panel of the enclosure offset 7.6 cm to the right of midline, approximately 50 cm away from the infant. A small speaker (Jamo compact 60) was located directly below the television screen. A video camcorder (Panasonic model AG-180) was also behind the front panel with its lens positioned behind a hole (3.5 cm radius) in the front panel. The camcorder recorded the infants' responses and provided a view of each infant to

an observer watching a 16.7 cm by 14 cm black-and-white television monitor (Magnavox, Model RX4030-WA02).

The observer controlled the presentations of the visual display, the speech recordings, and also recorded looking times via a hand-held microswitch attached to a Power Macintosh computer. Attached to this computer was also a custom-built control board which regulated access to two channels of a cassette recorder (Tascam Porta 05) and the output of a VCR (Sanyo VHS, Model VHR-5214). The audio output

Table 1: Acoustical Analyses of Utterances Used in Testing

Utterance	Duration	Mean Pitch	Pitch Variability(SD)
Good Morning (Slow)	2.619 s.	235 Hz.	84 Hz.
Good Morning (Normal)	1.320 s.	255 Hz.	95 Hz.
How are you today (Slow)	2.579 s.	252 Hz.	87 Hz.
How are you today (Normal)	1.320 s.	272 Hz.	99 Hz.
What are you doing (Slow)	2.639 s.	228 Hz.	72 Hz.
What are you doing (Normal)	1.280 s.	235 Hz.	85 Hz.
Let's go for a walk (Slow)	3.079 s.	228 Hz.	89 Hz.
Let's go for a walk (Normal)	1.520 s.	239 Hz.	89 Hz.

was sent through an amplifier (Harmon-Kardon, Model PM635) and presented through the panel speaker at 70-75 dB SPL (A-scale; measured at the infant's head) as determined by a sound-level monitor (Radio Shack, Cat. No. 33-2050).

#### Procedure

All testing for this study was conducted at the Infant Speech Study Program of Virginia Tech. Upon arriving at the laboratory, the parent(s) were asked to fill out a consent form (see Appendix B) plus infant temperament and demographic questionnaires (see Appendices C and D). After the infant was assessed by the experimenter and parent(s) to be in an awake and calm state, the infant was placed in the infant seat facing the 3-sided enclosure and the overhead lights were dimmed. The parent(s) were seated behind the observer and able to watch the session on the same monitor as the observer.

The observer was deafened by continuous, loud vocal music (delivered over headphones). This observer controlled

the presentation of the visual stimuli (colored circles) and the two speech types using a computer program running the infant-controlled preference procedure developed by Cooper and Aslin (1990). The observer pressed the microswitch once to prime the computer system and begin the session, and again to turn on the baby's monitor for the first trial. After visual fixation to the display had been determined by corneal reflection and general orientation of the infant's head, the observer pressed the microswitch again to begin presentation of the speech recording. When the infant looked away from the screen for more than one second, the observer pressed the switch again and the trial ended (i.e., visual display and speech went off). The same procedure was repeated for eight trials, with speech-type alternating between trials. The particular speech recording which the infant heard first (i.e., ID-normal, ID-slow) was randomly assigned, and counterbalanced across infants.

## Chapter 3

### Results

Mean looking times were calculated for each speech type. The criterion for a successful session was at least eight consecutive trials with no interruptions. A 2 x 2 mixed analysis of variance (ANOVA) was then performed using mean looking time as the dependent variable with order of presentation (ID-normal first, ID-slow first) as the between subjects variable and speech type (ID-normal, ID-slow) as the within subjects variable. It was found that infants looked significantly longer to the display,  $F(1, 18) = 5.65$ ,  $p < .05$ , when it was paired with the ID-slow speech ( $M = 53.11$ ,  $SD = 50.86$ ) than when it was paired with the ID-normal speech ( $M = 27.43$ ,  $SD = 15.09$ ). Neither order of presentation,  $F(1, 18) = 1.761$ ,  $p > .05$ , nor the interaction between order and speech type  $F(1, 18) = 3.014$ ,  $p > .05$  were found to be statistically significant. Seventeen of the 20 infants tested showed longer average looking times to the ID-slow speech ( $p < .01$ , two-tailed binomial; see Table 2).

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Table 2: Mean Looking Times of Each Subject (n = 20)

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Subject	ID-slow	ID-normal
1	10.71	9.47
2	13.00	12.42
3	13.86	17.98
4	15.96	11.03
5	17.74	31.67
6	20.82	15.18
7	21.48	67.21
8	25.71	14.47
9	27.87	21.50
10	39.71	27.31
11	46.18	27.40
12	48.62	40.06
13	58.66	30.89
14	62.15	31.40
15	66.95	17.31
16	69.94	30.27
17	80.89	32.03
18	85.42	30.75
19	101.28	60.29
20	235.25	19.99
	<b><math>M = 53.11</math></b>	<b><math>M = 27.43</math></b>
	<b><math>SD = 50.86</math></b>	<b><math>SD = 15.09</math></b>

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Even though the difference in mean looking times was significant, the standard deviations, especially for the ID-slow speech, were large. One source of this variance was that some infants looked unusually long on the first trial when looking produced ID-slow speech. In order to explore this facet of the data, average looking times on the first trial as a function of speech type were compared. However, these were not found to be significantly different despite a large discrepancy between the mean looking times for ID-slow ( $\bar{M} = 93.89$ ,  $\underline{SD} = 113.88$ ) and ID-normal speech ( $\bar{M} = 62.06$ ,  $\underline{SD} = 59.39$ ;  $t(18) = .78$ ,  $p > .05$ ). In addition, a second ANOVA with the first trial removed confirmed the original finding of a significant preference,  $F(1,18) = 5.93$ ,  $p < .05$ , for ID-slow ( $\bar{M} = 45.34$ ,  $\underline{SD} = 42.72$ ) over ID-normal ( $\bar{M} = 23.47$ ,  $\underline{SD} = 12.23$ ) speech. Because the difference between mean looking times for subject 20 was so large, a third ANOVA was performed which included all first trials, but did not include that subject's data. The results of this analysis reified the original finding of a significant preference,  $F(1,17) = 8.29$ ,  $p < .05$ , for ID-slow ( $\bar{M} = 43.53$ ,  $\underline{SD} = 28.21$ ) over ID-normal ( $\bar{M} = 27.82$ ,  $\underline{SD} = 15.40$ ) speech.



## Chapter 4

### Discussion & Conclusions

The present study showed that six-to eight-week old infants preferred to listen to speech at a substantially slower rate than they would normally encounter in their caretaking environment. Such a finding has many implications, the most important of which may deal with the ideas earlier explicated on inherent levels of stimulation that infant's seek to maintain and the effect of experiential factors on preferences for rates of stimulation.

The preference for ID-slow speech seems at first to be contradictory to the ideas of Haith (1981) that infants seek to maintain a relatively high level of cortical stimulation. Haith felt that infants are inherently motivated to seek out visual stimuli that maximize cortical firing. Therefore, infants will seek out visual stimuli that help them maintain this high level of stimulation. As previously stated, the findings of Lewkowicz (1985) and others that infants prefer higher relative rates of visual stimulation (e.g, flashing rates, contour density) support this idea. However, the results of the present study are not consistent with Haith's (1981) ideas when extended into the auditory modality. That is, infants in the present study preferred rates of stimulation that would assumingly elicit less cortical activation, as opposed to levels of activation elicited by faster stimulation. Furthermore, if infants sought to maintain a high rate of cortical activity through auditory stimulation, then it would be expected that infants prefer to listen to ID speech at faster rates. However, as Cooper and Cooper (1997) showed, this was not the case.

Similar to the ideas of Haith (1981), Maurer (1993) suggested that infants have an optimal level of stimulation they seek to maintain. However, unlike Haith, Maurer felt this value was affected by stimulation from all sensory modalities. Thus, stimulation from other modalities can affect infant preferences for visual and auditory rate. The example has already been offered of Gardner and Karmel's (1984) work investigating how infant preferences for visual rates of stimulation are affect by HR at time of testing. Similarly, Lewkowicz and Turkewitz (1981) found that exposing newborns to auditory tones prior to visual preference test trials affected their looking. In that study, infants were either not given any pre-trial stimulation, or they were presented with a 2 or 8 Hz auditory tone. There was an inverse relationship found between amount of pre-trial stimulation and attention to displays flashed at faster frequencies, such that the more pre-trial stimulation the infants received, the more they looked to the displays flashed at slow frequencies.

Studies such as Gardner and Karmel (1984) and Lewkowicz and Turkewitz (1981) highlight the possibility that, under normal circumstances, infants may actually prefer faster rates of speaking. However, there may have been factors in the present study inherent to the testing situation that affected infants' speech preferences. Factors such as the luminance level and/or complexity of the visual display may have increased infant cortical activity or arousal to levels such that showing increased attention to the ID-normal speech would have raised their stimulation level to a degree outside their optimal range. Therefore, infants may have looked more to the slower speech because it did not provide a level of stimulation that caused them to exceed their optimal value (was the less stimulating choice). However, the mechanism(s) by which such levels of optimal stimulation are established remains unclear. Hopefully, future research into infant perceptual development can address this confluence of internal and external stimulation as it affects infant visual and auditory rate preferences. Such research can contribute to this understanding through systematic manipulation of factors such as luminance level and complexity of the visual stimulus, in order to determine whether such factors influence infant attention.

In addition, future research also needs to attend more to the physiological processes that may be affecting infant attention. Inclusion of factors such as HR can aid our understanding of how different aspects of the stimuli presented affect infant arousal levels, and subsequent preferences for visual and auditory rates of stimulation. Indeed, it may be that slower rates serve to calm infants and put them in an optimally receptive state to attend to and process incoming stimuli. Conversely, it may be that slower speech serves to put infants in a somewhat lethargic state where they *seem* to be attending to incoming stimuli, but may not be fully processing the events. Both of these are possible given the high overall means and large variability in looking times for this sample<sup>3</sup>.

It is also important to relate the current findings to the research on how experience affects preferences for auditory rates in avian species (e.g., Gottlieb, 1980; Gaioni and Evans, 1984). The hypothesis that infants would prefer the normal rate of stimulation was not only based on the idea that infants prefer middling rates of stimulation (Maurer, 1993), but also that they prefer what they normally hear in their caretaking environment (i.e., experience would affect

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<sup>3</sup> The mean looking times for this study are quite large in comparison to other studies such as Cooper and Cooper (1997) where the mean looking times were 22.3 s. for ID-normal and 18.0 s. for ID-fast. Cooper and Aslin (1990) did, however, obtain looking times closer to those observed in the present study (33.6 s. for ID-speech and 21.4 s. for AD-speech).

their preferences). The research discussed by Gottlieb (1980) and others shows that the perceptual window of effective rates is affected by experience. It may be that 6- to 8-week-old infants have not had sufficient experience to form a window of delimited rates to which they show maximal attention. However, the research by Cooper and Cooper (1997), indicates that parameters for such a window exist early in development (i.e., 1-month old infants show decreased attention to faster rates of speaking). It may be that experience affects the bandwidth of the perceptual window such that with increased experience with normal rates of ID speech, the window of effective frequencies becomes more delimited. Testing older infants who would have had more experience with normal rates of ID speech may help to better understand the experiential nature of these preferences for rate.

In general, the results of this experiment do not necessarily refute the idea of a delimited window of rates to which infants show maximal attention. It may also be that this window does exist at 6- to 8-weeks of age, but the slower speech presented in this experiment failed to exceed that window. To investigate this possibility further, future research also needs to concentrate on better parsing the boundaries where decreases in attention may begin. That is, if the rate of the speech was slowed even more, infants may begin to show decreased attention.

Overall, the current experiment reinforces the fact that rate is an important construct in determining infant attention ID speech. Along with pitch, these two constructs may be the keys to the attentional draw of ID speech. Another avenue for future research is to determine which, if either, of these two parameters carries a heavier perceptual weight in directing infant attention. It may be, as suggested by Bergeson and Trehub (1998), that pitch is the prosodic feature which elicits infant attention to ID speech. However, the ability of pitch to hold infant attention once it has been elicited has not been examined. It may be that pitch is the factor that elicits infant attention to ID speech, but the rate characteristics are what hold the attention once it has been elicited.

Altogether, the results of the current study were surprising given the findings of research on human infant preferences for visual rate and avian infants' preferences for auditory rate. Even though the ideas of Haith (1981) are effective in explaining the results of studies on vision (i.e., infants prefer faster relative rates), his ideas do not immediately lend explanation to current findings on human infant preferences for rate in ID speech. Similarly, the experiential model that Gottlieb (1980, 1985) and others invoke to explain avian infants' preferences for rate of auditory stimulation also does not immediately help explain

the current results. Probably the most influential ideas come from theorists such as Maurer (1993) who have suggested that infants seek to maintain a certain level of global arousal/stimulation (i.e., from all sensory modalities). Therefore, stimulation from the visual modality may affect attention to auditory stimuli and vice-versa. As with the field of infant perceptual development in general, this possibility has been investigated with regard to attention to visual events, with the research supporting these ideas (e.g., Lewkowicz & Turkewitz, 1981). Altogether, how rate affects infants' preferences for not only ID speech but all auditory events remains an open area for further exploration. In conclusion, the current study not only helps fill a missing piece of a vast puzzle, but highlights the importance of other pieces in this puzzle to our understanding of infant perceptual development.

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## Appendix A

### Letter Sent to the Parents

#### **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 babies only a few days old would rather listen to their own mother's voice than to the voice of another woman. Even though babies this age are not yet talking on their own, we believe that they are listening to the speech of their parents and other people around them. In the Department of Psychology at Virginia Tech, we are working with young infants to see what other kinds of speech sounds babies recognize in the first months after birth. This information is very important for our understanding of how infants learn language.

Currently, we are investigating infants' attraction to various types of speech patterns. You and your baby are invited to participate in our latest project. Your participation would involve one visit to the Infant Speech Study Program (located next to Bogen's restaurant - a map is attached for your convenience) when your baby is between 4 and 8 weeks old so that we can observe your infant to see how responsive your baby is to different voices. This test lasts for approximately 15 minutes, but we schedule a full hour appointment at a time that is most conducive to your (and your baby's) schedule. If you have older children and would like to bring them along, we offer baby-sitting for your convenience. We have a waiting room with toys for your older child(ren) that is located next to our observation room.

If you would like to schedule an appointment for your infant or find out more about our work, please call us at either 231-3972 or 231-5938. We hope to see you and your baby soon!

Sincerely,

Robin Panneton Cooper, Ph.D.  
Associate Professor  
[rpscooper@vt.edu](mailto:rpscooper@vt.edu)

Jamie S. Cooper, M.A.  
Graduate Researcher  
[puff@vt.edu](mailto:puff@vt.edu)

## Appendix B

### Informed Consent Form

#### **Virginia Polytechnic Institute and State University Informed Consent for Participants of Investigative Projects**

Title of project: One-month-old Infants' Perception of Speaking Rate

Principle Investigators:

Dr. Robin Panneton Cooper

Jamie S. Cooper (graduate researcher)

Purpose of Research Project

You and your infant are invited to participate in our study investigating 1-month-old infants' perception of speaking rate.

Procedure

Your infant will be tested for approximately 15 minutes, provided that he/she is awake, alert, and quiet. Your baby will be placed in an infant seat and will watch a video screen onto which colored circles will appear. When your infant looks at this screen, a loudspeaker will present a recording of a female voice, speaking a sentence. Your infant can control the amount of time he/she gets to listen to this voice by how long they look at the circles. On some trials, the female will be speaking at a normal rate, and on other trials she will be speaking at a slower rate. If your infant prefers one rate over the other, we expect to see longer looking to the circles on particular trials.

The sound level of the voices played to your infant is no louder than the sounds present in the typical home environment (i.e., @ 65 dB). If your infant cries or falls asleep, testing will stop. Also, each infant will be videotaped during his/her session (these tapes will be stored in our lab, and erased after five years). There are no apparent risks to your baby or to yourself resulting from participation in this study.

Benefits of this project

Your baby's participation in this study benefits the field of infant speech perception. Specifically, this study will further our understanding of the development of young infants' perception of the pitch and temporal characteristics of the normal speech they hear everyday.

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 parental consent. The information your baby provides will be identified by subject 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 study when the project is completed.

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.

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.

Subjects' 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 this procedure and I understand 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. Cooper, her graduate students, and their co-workers to test my infant.

Dr. Robin Panneton Cooper, Principal Investigator	231-5938
Jamie S. Cooper, Graduate Researcher	552-3895
Dr. R. J. Harvey, Chair, Human Subjects Committee	231-7030
Dr. Thomas Hurd, Chair, Institutional Review Board	231-9359

\_\_\_\_\_  
Signature of Parent

\_\_\_\_\_  
Date



Appendix D

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):  
\_\_\_\_\_

How long has it been since the baby last ate?  
\_\_\_\_\_

How long has it been since the baby last slept/napped?  
\_\_\_\_\_

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

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

## Vita

Jamie S. Cooper

### **PERSONAL INFORMATION**

Born: August 19, 1974

SS#:

Business Address: Department of Psychology  
Virginia Polytechnic Institute & State  
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### **EDUCATION**

B.S. Tennessee Technological University, 1995  
Major field: Psychology

M.A. Tennessee Technological University, 1996  
Major field: Educational Psychology  
Thesis: Psychosocial development in  
college students: Gender, age, class  
standing, and other differences.

Ph.D. Virginia Polytechnic Institute & State  
University, candidate  
Major field: Psychological Science  
(Developmental)

## **EMPLOYMENT**

08/97 - Present Student Services Advisor, Undergraduate  
Information Center; Virginia Tech:  
Department of Psychology

06/97 - 08/97 Data Entry Technician; Virginia Tech Center  
for Research on Health Behavior

08/96 - 05/97 Graduate Teaching Assistant; Virginia Tech:  
Department of Psychology

05/96 - 07/96 G.E.D. Data Entry Specialist; Tennessee  
Technological University: Counseling Center

01/96 - 05/96 Graduate Assistant; Tennessee Technological  
University: Counseling Center

02/95 - 01/96 Teacher/Counselor; Youth Villages -  
FAMILIES

06/94 - 05/95 Intern; Youth Villages - FAMILIES

## **PROFESSIONAL AFFILIATIONS**

International Society for Infant Study (Student Member)

International Society for Developmental Psychobiology  
(Student Member)

American Psychological Society (Graduate Student Affiliate)

American Psychological Association (Graduate Student  
Affiliate)

APA Division 2 [Society for the Teaching of Psychology]  
(Graduate Student Affiliate)

APA Division 6 [Behavioral Neuroscience and Comparative  
Psychology] (Graduate Student Affiliate)

APA Division 7 [Developmental Psychology] (Graduate Student  
Affiliate)

## **CONFERENCES & SYMPOSIA ATTENDED**

29<sup>th</sup> Carnegie Symposium on Cognition: Pittsburgh, PA. October 1998.

Tenth Annual Convention of the American Psychological Society: Washington, D.C. May 1998.

Eleventh Biennial International Conference on Infant Studies: Atlanta, Georgia. April 1998.

Thirtieth Annual Meeting of the International Society for Developmental Psychobiology: New Orleans, Louisiana. October 1997.

1997 Biennial Meeting of the Society for Research in Child Development: Washington D.C. April 1997.

Third Annual Meeting of the Middle Tennessee Psychological Association: Nashville, Tennessee. May 1996.

Twenty-third Annual Meeting of the Southeastern Psychological Association: Norfolk, Virginia. April 1996.

Twenty-second Annual Meeting of the Southeastern Psychological Association: Savannah, Georgia. March 1995.

Twenty-first Annual Meeting of the Southeastern Psychological Association: New Orleans, Louisiana. March 1994.

## **PAPER PRESENTATIONS**

Cooper, J. S. & Cooper, R. P. (1997, October) Rate affects infants' preferences for speech. Paper presented at the Thirtieth Annual Meeting of the International Society for Developmental Psychobiology: New Orleans, Louisiana.

Cooper, J. S. & Zagumny, M. J. (1996, April) Condom use by college students: A comparison of two versions of the Health Belief Model. Paper presented at the Third Annual Meeting of the Middle Tennessee Psychological Association: Nashville, Tennessee.



## **POSTER PRESENTATIONS**

Ostroff, W. L. & Cooper, J. S. (1998, May) Temporal characteristics influence infant attention to infant-directed speech. Poster presented at the Tenth Annual Convention of the American Psychological Society: Washington, D.C. May 1998

Cooper, J. S. & Ostroff, W. L. (1998, April) The role of rate in directing attention to infant-directed speech: A replication. Poster presented at the Eleventh Biennial International Conference on Infant Studies: Atlanta, Georgia.

Cooper, J. S. & Zagumny, M. J. (1995, March) Predicting level of concern and low risk occupational AIDS behaviors in a sample of emergency medical service students, Poster presented at 1995 Southeastern Psychological Association Convention: Savannah, Georgia.

## **PUBLICATIONS & ARTICLES IN PREPARATION**

Cooper, R. P., Cooper, J. S., & Aslin, R. (in preparation). Young Infants Differentially Attend to Infant-Directed Speech Depending on Rate of Presentation.

Cooper, J. S., & Zagumny, M. J. (1994). Predicting risk-reducing occupational AIDS behaviors in a sample of emergency medical personnel. Perceptual and Motor Skills, 79, 1566.

## **AWARDS**

Travel Award from Carnegie Mellon University to attend the 29<sup>th</sup> Carnegie Symposium on Cognition, October 1998.

3<sup>rd</sup> Place, Humanities and Social Sciences Division; 14th Annual Virginia Tech Research Symposium, April 1998.

Travel Award from the Graduate Student Assembly of Virginia Tech, April 1998

"Above and Beyond" Award, June 1995, Youth Villages - FAMILIES

"Most Outstanding Psychology Student" Award, May 1994, Tennessee Technological University

## **SERVICE**

1997 - Present      President & Co-founder, Developmental Science Society of Virginia Tech

1997 - Present      Psychological Sciences Representative, Graduate Student Assembly: Virginia Tech

- 1995 - 1996 Student Representative, Psychological Review Committee: Tennessee Technological University
- 1995 - 1996 Coordinator, Student Wellness Awareness Team: Tennessee Technological University
- 1994 - 1996 President (1994 - 1995), Vice - President (1995 - 1996), Psi Chi National Honor Society: Tennessee Technological University Chapter
- 1994 - 1996 Member, Phi Kappa Phi National Honor Society: Tennessee Technological University Chapter
- 1994 - 1996 Vice - President (1994-1995), Psychology Club: Tennessee Technological University