

Developmental Changes in 4- and 8-month-old Infants' Attention to Infant-Directed Speech that Differs in Segmental Duration

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Abstract

In these experiments, we either attenuated (i.e., decreased) or augmented (i.e., increased) voiced segmental durations in normal infant-directed speech (IDS). We then tested groups of 4- and 8-month-old infants in a serial attention protocol with either Normal-IDS vs. Fast-IDS, or Normal-IDS vs. Slow-IDS recordings. Two measures of attention were recorded: fixation of a visual target and heart rate activity. The results for the Normal-IDS v. Fast-IDS comparison showed that 4-month-olds looked significantly longer to Normal-IDS; older infants showed no difference in visual attention. Interestingly, both ages showed greater degrees of HR deceleration (sustained attention) to Normal-IDS. The results for the Normal-IDS v. Slow-IDS comparison showed equal visual attention across speech types, but increased sustained attention (HR deceleration) to Slow-IDS in the 4-month-olds. These data suggest that the temporal features of IDS affect infants' attention, with longer segmental durations (slower speech) increasing attention more in younger than older infants. Attending more to slower speech may reflect younger infants' increased interest in highly emotive speech, but may also act to increase certain aspects of language learning such as native phonemes.

1. Introduction

Developmental research has focused on infants' attention to speech typically directed to infants by adult caretakers (infant directed speech or IDS). Although IDS differs from adult-directed speech (ADS) in many ways, the primary empirical focus has been on pitch characteristics. However, IDS is also typically slower in temporal form, largely because many of its voiced segments are stretched over time. Little attention has been paid to this characteristic of IDS and its effect on infant attention.

Given infants' differential attention to IDS, efforts have focused on discovering the feature and/or features most responsible for its potency. For example, Fernald and Kuhl (1987) created pure-tone simulations of the fundamental frequency ('pitch'), amplitude, and duration of IDS and ADS, and tested whether these characteristics would differentially elicit attention to IDS. Separate groups of 4-month-olds showed a significant preference for IDS- compared to ADS-pitch analogs, but did not show preferences for either IDS or ADS amplitude and duration analogs. However, it is important to note that pitch was

temporally arranged over time according to the voicing/non-voicing patterns of the original utterances, leaving open the possibility that infants' preferences for the IDS pitch analogs were influenced by the temporal characteristics as well. Other studies from the IDS literature have found that pitch information alone is not always sufficient to account for infants' IDS preferences (Cooper & Aslin, 1994; Kitamura & Burnham, 1998). For example, when 1-month-olds were presented with low-pass filtered recordings of IDS and ADS (preserving pitch contours but eliminating lexical information), infants showed no significant preferences (Cooper & Aslin, 1994). Other acoustic factors in IDS appear to influence infants' attention.

Slower duration (especially vowel lengthening) is also characteristic of IDS, and caretakers most likely extend the duration of their utterances to infants as part of their desire to convey emotion in their voices (Kitamura & Burnham, 2003). Trainor et al. (2000) found that duration also distinguishes between love-comfort utterances in IDS and ADS. So it is reasonable to expect slower duration in IDS as caretakers seek to express emotion to infants, and also to help regulate infant state. However, it may not be the case that the acoustic modifications in IDS remain constant across the entire first postnatal year. Although IDS has been characterized as more emotionally charged than ADS (Burnham, Kitamura, & Vollmer-Conna, 2002), the emotional tone of IDS also appears to change qualitatively across infant age. One prediction, then, is that infants' attention to IDS is influenced by its perceived emotionality, which includes acoustic modifications that include but are not limited to pitch, and that slow duration is one potential correlate of this perceptual enhancement, augmenting infants' attention to IDS. A second prediction is that the ability of these collective correlates (e.g., pitch and duration) to influence attention may vary as a function of infants' age and experience throughout the first postnatal year (Fernald, 1992). Thus, it is expected that slowed IDS may have a larger impact on infants' attention at younger than older ages.

Other than Fernald and Kuhl's (1987) study, there have been no specific investigations into infants' attention to duration in speech. The primary purpose of this study was to compare responsiveness to normal, fast, and slow IDS across 4-, and 8-month-old infants, using both a behavioral and a psychophysiological index of attention. Heart rate (HR) change was measured as a second index of

attention because HR changes are reflective of parasympathetic nervous system regulation, and changes in HR activity should shed light on how infants' attention is being modulated and regulated in the context of the speech experience (Casey & Richards, 1992; Richards & Casey, 1991). If duration of IDS is a factor that promotes attention in infants, but its ability to do so is more prominent in younger compared to older infants, younger infants should look for longer periods of time and show more pronounced HR decelerations during slow IDS presentations compared to normal IDS presentations, and also compared to older infants. We specifically contrasted infants' behavioral and psychophysiological responses to slow IDS with those produced while listening to fast IDS in order to control for the possibility that in the former case, infants could simply be responding to speech that was unusual. That is, both fast and slow IDS samples are artificial in the sense that changes in segmental duration (either decreasing or increasing) would typically result in pitch changes. However, we were able to keep pitch characteristics constant in these recordings by only manipulating voiced segments of the utterances; this manipulation resulted in fast and slow IDS that were highly similar in pitch measurements to the normal IDS, making both of them novel. If infants' attention is controlled primarily via the novelty of events, then more attention should be seen to both fast and slow IDS utterances.

2. Method

2.1 Participants: Out of 80 infants, a total of 77 infants completed testing and provided complete sets of both behavioral and psychophysiological data. Thirty nine 4-month-olds completed the study, 20 males and 19 females; \bar{M} age = 126.85 days, \bar{SD} = 5.93. and 38 8-month-olds completed the study, 19 males, 21 females; \bar{M} age = 240.25 days, \bar{SD} = 7.06. Nineteen 4-month-olds and 18 8-month-olds were tested in the Normal-IDS/Fast-IDS condition; 20 4-month-olds and 20 8-month-olds were tested in the Normal-IDS/Slow-IDS condition.

2.2 Speech Samples. Speech recordings of 4 Normal-IDS (unaltered IDS), Fast-IDS (IDS that was half the duration of Normal-IDS) and Slow-IDS (IDS that was twice the duration of Normal-IDS) were created using *Digital Performer*, a waveform-editor program. The three speech types consisted of the same four sentences.

2.3 Procedure. Infants were seated on their parent's lap in the testing room. At the onset of the session, and between all subsequent trials, a flashing, red dot (7 1/2 inches in diameter, 60 flashes per minute) against a white background was presented on the monitor in order to attract the infant's attention toward the screen. Once the observer determined that the infant was visually attending the screen, the first trial began. The auditory and visual events (e.g., ID-normal speech and a bullseye) were presented continuously until the

observer judged the infant to look away from the display (for at least 1 second). The flashing dot reappeared and the next trial began when the infant looked at the display (e.g., ID-slow speech and a bullseye). HR was recorded continuously throughout the session, and later aligned with the looking data (via the event marker). Within each of the age groups, order of speech presentation was counterbalanced across participants. Interrater observer reliability was extremely high.

3. Results

3.1. Normal-IDS vs. Slow-IDS. Mean looking times were calculated by dividing the total time spent looking during each presentation by the number of trials presented (6 of each speech type). A 2 x 2 x 2 mixed ANOVA was conducted with order (Slow-IDS first, Normal-IDS first) and age (4 mo, 8 mo) as between subject factors and speech type (Slow-IDS, Normal-IDS) as the within-subject factor. This analysis did not reveal any significant main effects or interactions (see Figure 1), suggesting that attention to Slow-IDS and Normal-IDS did not vary for either age group.

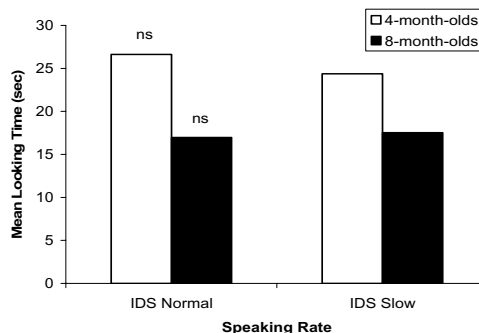


Figure 1: Mean looking time (sec) in 4- and 8-month-olds to Normal-IDS and Slow-IDS utterances. No significant differences were found for this measure of attention.

In contrast, HR was also analyzed in a mixed ANOVA with order and age as between subject factors, and speech type and epoch (epoch 1, epoch 2) as the within subject factors. The epoch sizes were chosen to yield data that were sensitive to transient changes in HR, and to span the first two phases of HR-defined attention that correspond to event orienting (0 – 3 sec) and sustained attention (3 – 6 sec; Richards & Casey, 1992). The results of this second ANOVA showed a significant age x speech type x epoch interaction; follow up t-tests revealed that (1) HR decreased significantly across epochs for both speech types in the 4-month-olds; but that (2) the degree of HR deceleration was greater for Slow-IDS than for Normal-IDS, again only for the 4-month-olds (see Figure 2).

3.2 Normal-IDS vs. Fast-IDS. Mean looking times were calculated by dividing the total time spent looking during each presentation by the number of trials presented (6 for each speech type). A 2 x 2 x 2

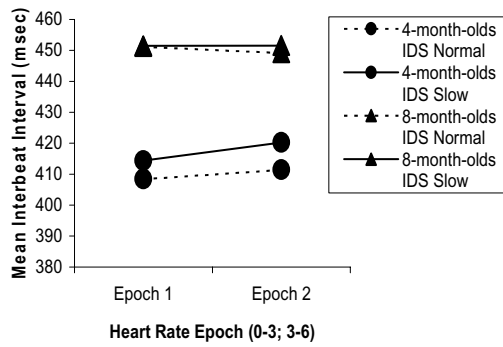


Figure 2: Changes in HR levels (higher values reflect decelerations) across epochs for 4- and 8-month-olds listening to normal- and Slow-IDS utterances;

4-month-olds:

Epoch 2 > Epoch 1 IDS Normal ($t(20)=2.11, p < .05$)
 Epoch 2 > Epoch 1 for IDS Slow ($t(20)=7.65, p < .001$)
 Epoch 1 (Slow) > Epoch 1 (Normal); ($t(20)=1.97, p < .06$)
 Epoch 2 (Slow) > Epoch 1 (Normal); ($t(20)=2.86, p < .02$)

mixed ANOVA was conducted with order (Fast-IDS first, Normal-IDS first) and age (4 mo, 8 mo) as between subject factors and speech type (Fast-IDS, Normal-IDS) as the within-subject factor. This analysis revealed a significant age x speech type interaction, with 4-month-olds looking significantly longer to Normal-IDS than to Fast-IDS (see Figure 3).

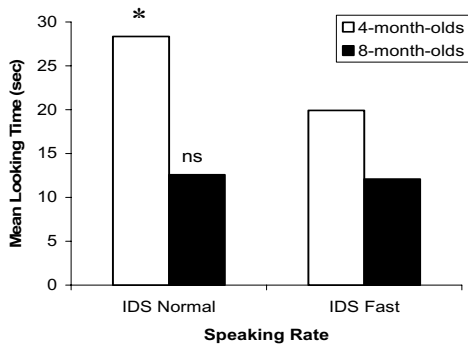


Figure 3: Mean looking time (sec) in 4- and 8-month-olds to Normal-IDS and Fast-IDS utterances. Only the 4-month-olds looked significantly longer to the Normal-IDS (* $p < .06$ ($t(18)=1.95$)).

The HR ANOVA again showed a significant age x speech type x epoch interaction; follow up t-tests revealed that (1) HR decreased significantly across epochs for both speech types in the 4-month-olds; but to a greater degree for the Normal-IDS; (2) HR decreased significantly across epochs for Normal-IDS in the 8-month-olds, but did not change for the Fast-IDS (see Figure 4).

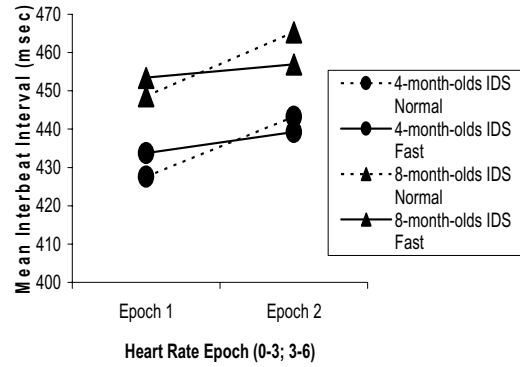


Figure 4: Changes in HR levels (higher values reflect decelerations) across epochs for 4- and 8-month-olds listening to normal- and Fast-IDS utterances;

4-month-olds:

Epoch 2 > Epoch 1 for IDS Normal ($t(18)=5.73, p < .001$)
 Epoch 2 > Epoch 1 for IDS Fast ($t(18)=2.18, p < .05$)

8-month-olds:

Epoch 2 > Epoch 1 for IDS Normal ($t(18)=6.31, p < .001$)

4. Discussion

The primary interest of this study was to examine developmental differences in infants' attention to the durational features of IDS (Normal-IDS, Fast-IDS, Slow-IDS), using both behavioral (looking time) and psychophysiological (heart rate) measures. The behavioral analyses revealed that neither group showed more attention (i.e., longer looking times) in the Slow-IDS vs. Normal-IDS comparison. In contrast to these behavioral outcomes, the 4-month-olds did show greater HR decelerations to Slow-IDS than to Normal-IDS within each epoch, suggesting greater orientation to the Slow-IDS. These infants also showed a greater degree of HR deceleration to Slow-IDS from epoch 1 to epoch 2, compared to Normal-IDS, suggesting that Slow-IDS produced more sustained attention. Neither measure of attention (looking or HR) differentiated the speech types in the 8-month-olds. For this age group, it seems clear that Slow-IDS did not promote more attention.

In terms of attention to Fast-IDS (when paired with Normal-IDS), a very different pattern emerged with the 4-month-olds showing significantly longer looking times to Normal-IDS. Moreover, this age group also showed significantly more HR deceleration from epoch 1 to epoch 2 for the Normal-IDS. Although the 8-month-olds did not show any differential behavioral attention to these two speech types, they did show greater HR deceleration from epoch 1 to epoch 2 for the Normal-IDS speech (sustained attention). Thus, the ability of segmental duration to alter attention depended on the age of infant, with slower IDS producing more attention in younger infants, and faster IDS producing less attention in both age groups. This latter point is important in that the ability of segmental duration to increase infants' attention can not be attributed simply to novelty (i.e., never hearing speech at such

exaggerated rates) because only in one case did attention increase (slow-IDS); in the other, attention actually decreased (fast-IDS).

Why should slowed speech increase younger infants' attention? As discussed earlier, some studies have suggested that infants are more responsive to the affect (specifically positive emotion) communicated in IDS rather than to the speech register itself (Kitamura & Burnham, 1998; Singh, Morgan, & Best, 2002; Trainor, Austin, & Desjardins, 2000) so it may be that slowed speech is perceived as being more positive in emotional tone (see Sherer, 1986; Trainor et al., 2000). Perhaps as infants grow older, the way in which they perceive emotion in speech becomes less dependent on exaggerated prosodic characteristics (such as exaggerated pitch width and slower duration). Thus, the 8-month-olds showed less attention to Slow-IDS because Normal-IDS is sufficient to communicate intent. Recently, Schmidt, Trainor, and Santesso (2003) found that cortical (EEG) activity increased in young infants as they listened to musical passages that were high in emotional tone, but that older infants (6-, 9-month-olds) showed no such increase, also suggesting that younger infants are more aroused by high emotional valence in prosody. The argument is not that 8-month-olds are immune to prosodic information in speech; to the contrary, several studies have demonstrated the importance of prosodic information for older infants' segmentation of speech and word-object learning (Jusczyk, Houston, & Newsome, 1999; Tincoff & Jusczyk, 1999). However, older infants may tune into linguistically-relevant prosody and pay less attention to other prosodic exaggerations that cue emotional intention.

Some interesting questions for future consideration are whether slowed speech segments can augment infants' preferences for utterances that have already been judged as high in emotional tone and/or utterances that have been judged as low in emotional tone. Also of interest is whether older infants (e.g., 8-month-olds) would prefer emotionally positive utterances in which "positive emotion" is conveyed prosodically (but not linguistically), linguistically (but not prosodically), or both.

5. Acknowledgements

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