A New Look at Infant Preference for Infant-Directed Speech

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***Abstract*— Infants' preference for infant-directed speech has been reliably demonstrated throughout the first year of life using looking time measures. Though widely used in developmental science, interpretations of looking time are often rich, making assumptions about underlying mental states. In addition to being driven by preference, infant visual fixations can be caused endogenously by other factors such as arousal. We present a new methodology for measuring infant preference – the conditioned place preference paradigm (CPP), a widely used tool in animal research – that allows researchers to disentangle arousal and preference. Using CPP, infants' preference for infant-directed speech was replicated, but only when the speech was paired with a video of a social partner. We propose a new hypothesis, that preference for infant-directed speech is driven by its strong social signal value.**

Keywords— Intrinsic Motivation, Exploration and Play; Reward and Value Systems

I. Introduction

Measuring looking time to a stimulus is a prominent methodology in infant research. The infant looking time paradigm was traditionally used to test simple visual discrimination (i.e., whether infants discriminate between different shapes [1]). More recently, however infant looking has been used to assess numerous cognitive abilities (e.g., object knowledge [2], understanding of causal relationships [3], and number discrimination [4]), language development [5,6], morality [7], and more. The nature of looking time paradigms varies – two competing stimuli can be presented simultaneously and time spent looking to each stimulus is measured (e.g., [6]) or infants can be habituated to one stimulus, then tested on whether they dishabituate to a second stimulus that varies from the first in a fundamental way (e.g., [8]). As if eyes are the windows to the soul, looking time is now often interpreted as a measure of "surprise"; if infants see something that goes against their world view, they will look at that stimulus longer (e.g., [2]). Several cautionary critiques of infant looking time studies have emerged – warning against rich interpretation, the reliance on a single paradigm, and the conflation of looking and attention [1, 9, 10].

Looking time is often confounded with other phenomena that could compromise the conclusions of many studies. Notably, arousal and reward can drive attention [11, 12, 13], suggesting that many studies describing a preference for one stimulus could simply be measuring how arousing that stimulus is (i.e. assessing an orienting response [14]). One frequently-reported finding of infant preference is that for infant-directed speech (IDS) over adult-directed speech (ADS). IDS is characterized by a higher pitch, wider pitch range, simplified lexicon, and slower rhythm and tempo, compared to ADS [15, 16]. Even individually, the unique characteristics of IDS, such as the isolated pitch contours, attract infant attention [17]. Attention to a visual stimulus presented concurrently with IDS or that triggers the presentation of IDS is found to be higher than attention to the ADS-paired stimulus, which is interpreted as a preference for IDS. While looking time studies show that IDS is a salient stimulus, they are unable to conclude that IDS is preferred, rather than arousing, because these measures do not separate differences in looking time due to preference or due to an orienting response.

Work by Kaplan [18, 19] has demonstrated robust effects of IDS in producing arousal-based increases in visual fixation. Studies using fixed-trial habituation demonstrated that IDS, but not ADS, caused increases in arousal that drove increased fixation to a visual stimulus presented concurrently with the speech as well as to visual stimuli presented afterwards [18, 19]. A likely explanation of these findings is that IDS, but not ADS, leads to sensitization, or heightened responsiveness, after repeated exposure in infants [18]. These findings emphasize the need for methodology that allows researchers to disentangle preference from arousal. Assessing the rewarding nature (i.e. preference) for a stimulus, while removing confounding effects of arousal from the dependent measure, is possible using a conditioned place preference paradigm (CPP).

CPP is often used in studies of nonhuman animals to assess the reward value of various stimuli, including pharmacological substances [20], copulation [21], song production [22], and social interactions [23]. The apparatus consists of two rooms that differ only in an environmental cue, such as wall color. In repeated conditioning trials, an appetitive and a neutral stimulus are each paired with one of the two rooms. After these exposures, a room preference test is conducted with the stimuli absent. The reward value of the appetitive stimulus is assessed by the preference that develops for the distinct context in which the subject experienced that stimulus. This association formation is akin to classic Pavlovian conditioning, in which a

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neutral context is repeatedly paired with a rewarding stimulus, until that context becomes rewarding itself. Rewarding stimuli have the capacity to elicit an approach response; thus increased time spent in one room relative to the other indicates a preference for the stimulus. Because the conditioning process eliminates the need to present the appetitive stimulus during the preference test, CPP provides a valid assessment of preference formation while controlling for the possible confound of arousal.

In the presented work, we used CPP to measure infant preference for IDS over ADS, in the absence of an arousing stimulus presentation. In most respects, our study was designed to be identical to a traditional looking time study. We collected speech from a mother telling a story in IDS and ADS, controlling for mean length of utterance. The speech was presented over speakers while infants explored one of two distinct contexts. Importantly, however, no speech was presented during the actual preference tests. We hypothesized that infants would still show a robust preference for IDS using the new CPP paradigm.

II. Experiment 1

A. Methods

The CPP paradigm was constructed by hanging colored curtains from the ceiling in a large playroom to form two 6ft x 6ft rooms (Figure 1). The rooms were nearly identical, distinguished only by the color of the walls (red or yellow) and the patterns on 16inx16in posters hung on the walls (bullseye or checkerboard). The division between the two rooms was indicated by a retractable dividing curtain hung between the two rooms and a black line sewn into the carpeted floor. Ceiling speakers were mounted in the center of each room.

The ADS and IDS stimuli consisted of 1-min audio clips of a mother, unknown to the participants, reading from the children's picture book *Good Dog, Carl* [24]. The IDS was spontaneously generated by the stimulus mother based on the pictures in the book, who subsequently provided the ADS stimuli by reading a transcription of her improvised IDS. IDS and ADS stimuli were thus matched for speech content. The audio was played from the overhead speakers.

Eighteen 11-month-old infants (range: 10.4-12.6 months; 9 girls) participated. Subjects were recruited from a college town in upstate New York and were predominantly from Caucasian, middle-class families. English was the primary language spoken at home for most infants (n=1 heard primarily Spanish). For their participation, caregivers received either an infant t-shirt or a bib. An additional 20 infants participated, but were excluded due to failure to crawl (n=4), crying or fussiness (n=15), or experimenter error (n=1).

Fig. 1. CPP contexts. The dividing curtain is shown pushed back, as it was during the baseline and test periods.

The experimental session consisted of three periods: a 2-min baseline period, four 1-min conditioning trials, and a 2-min test period. Caregivers were instructed to not speak to the infant and listened to music through sound-attenuating headphones throughout the study.

During the baseline period, the dividing curtain was pushed back to create an opening between the two rooms. The infant was placed on the dividing line and then allowed to freely explore the two rooms. The caregiver was seated on the dividing line. The baseline period provided a preliminary measure of infant preference for each room prior to stimuli exposure.

The dividing curtain was then drawn to create two separate rooms for the conditioning trials. During the first trial, the infant was seated in the caregiver's lap on the floor of either the red or yellow room. A 1-min clip of either ADS or IDS was presented to the infant. While the clip was playing, the infant could stay in the caregiver's lap or crawl freely around the room. Immediately following this first conditioning trial, the infant and caregiver were reseated in the second room, in which the infant was exposed to the other type of speech. A total of four conditioning trials were conducted in this manner, alternating between the IDS and ADS contexts, for a total exposure of two minutes each to IDS and ADS. All features of the conditioning trials and rooms were counterbalanced across participants.

The dividing curtain between the two rooms was once again pushed back and the baseline procedure was repeated for the test period. The 2-min test period allowed infants to crawl freely between the two contexts and demonstrate any place preference that might have developed during the conditioning trials.

B. Results

To determine infant preference, time spent in each room was measured. Infants spent more time in the IDS context at baseline, before the conditioning trials took place ($t(17) = -2.12$, $p = 0.049$, $d = 0.499$). None of the counterbalanced variables, i.e. the side of the IDS context, the side of the room on which infants started their conditioning trials, or which color was on which side, significantly covaried with preference at baseline ($ps > 0.340$). Since none of these factors were significant, they were not controlled for in subsequent analyses. To account for the unconditioned preferences at baseline, infant preference for each context was calculated as a function of baseline preference using difference scores (i.e., subtracting time in a room at baseline from time in the room at test), as is commonly done in studies employing CPP.

Infants did not significantly change the amount of time spent in the IDS context ($t(17) = -1.03$, $p = 0.320$, $d = 0.242$) or the ADS context from baseline to test ($t(17) = 1.88$, $p = 0.077$, $d = 0.443$); Figures 2, 3).

C. Discussion

We were unable to replicate the expected infant preference for IDS over ADS using CPP. Our results suggest that in typical looking time studies, infant looking may be driven by arousal, rather than preference. When we disentangled arousal by testing

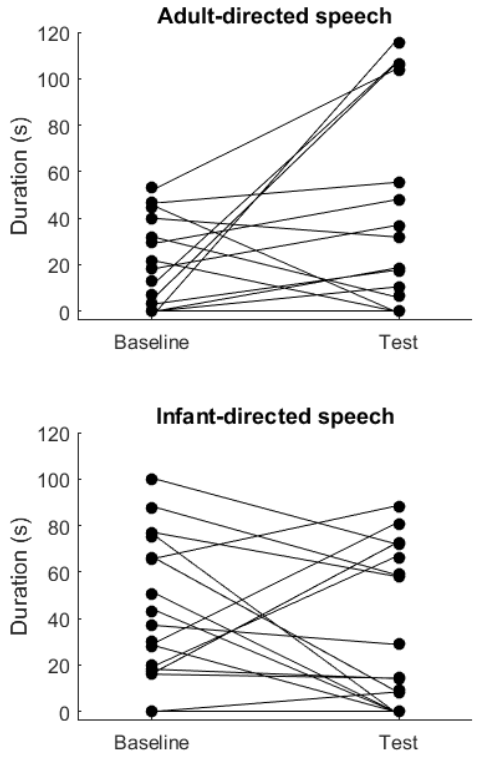

Fig. 2. Duration spent in the ADS (top) and IDS (bottom) context at baseline and test. Each point represents the data from one subject.

for preference in the absence of speech stimuli, infants did not demonstrate a preference for IDS.

Despite our efforts to match looking time procedures in many ways, there are notable differences inherent to the design of CPP that may contribute to this result. First, the novelty of the CPP environment may have distracted infants during the experiment. Second, locomoting to a room arguably requires more effort than shifting gaze to a stimulus and is dependent on the individual infant's motoric abilities. Infants may have preferred IDS, but were not sufficiently motivated to move into the room paired with IDS. Third, perhaps the isolated IDS and ADS stimuli we used were not "potent" enough. Infants may have needed longer exposure to the unimodal stimulus in order to form a demonstrable preference, or exposure to speech alone

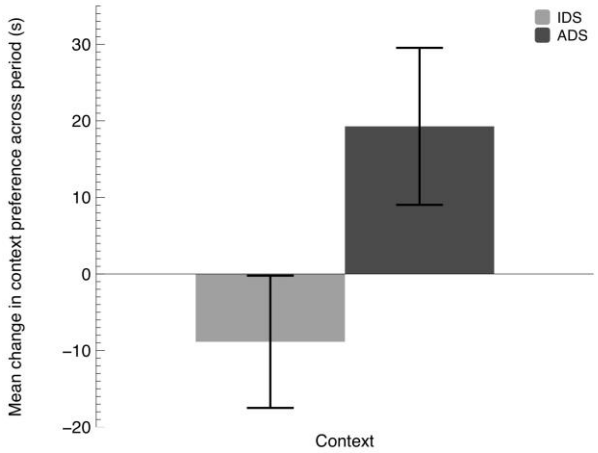

Fig. 3. Infants did not increase preference for the context associated with IDS.

was not sufficiently interesting (given the potentially distracting environment and effort required to move).

Only four infants, however, were excluded due to failure to crawl during the experiment – suggesting that the need to locomote did not affect our findings. Further, distractibility does not appear to play a significant role as the amount of time spent looking at the speech source (the ceiling) did not correlate with the change in amount of time spent in either the ADS or IDS context from baseline to test ($ps > 0.384$). The saliency of the stimuli, however, may have been an important factor.

Consider the natural context in which an infant hears IDS (and ADS). A person, typically in the infant's field of vision or otherwise proximal, accompanies the speech. By 11 months of age, the reward value of IDS may be associated with the social events that naturally co-occur with IDS. Thus, disembodied IDS may not be as rewarding to older infants, relative to the previously studied younger infants [17-19]. To test the hypothesis that speech alone was not sufficiently salient to elicit a preference, we developed multimodal stimuli that included a video of a social partner speaking IDS or ADS

III. EXPERIMENT 2

A. Methods

Eighteen 11-month-old infants (range: 10.2-11.7 months; 9 girls) participated. Subjects were recruited from a college town in upstate New York and were predominantly from Caucasian, middle-class families. English was the primary language spoken at home for all infants. For their participation, caregivers received either an infant t-shirt or a bib. 6 additional infants participated, but were excluded due to failure to crawl (n=2) and crying or fussiness (n=4). No infants from Experiment 1 were tested in Experiment 2.

Experiment 2 was conducted in a manner identical to Experiment 1, save for the addition of videos of a social partner during the conditioning trials. The audiovisual stimuli were presented via a 17-inch LCD monitor and speaker in each room. The curtains were tailored to ensure that only the screen of the monitor was visible, concealing the speakers and power cords from the infants. The monitors were mounted low enough for infants to easily see the screen from a crawling or sitting position (the center of the screen was 17in from the floor).

The multimodal IDS and ADS stimuli were produced as in the unimodal condition. The audio/video clips were of the same woman as in Exp 1. In both video clips, the woman wore a plain black t-shirt and was filmed in front of a blue-grey backdrop. She held the book in her lap and kept her eye gaze directed downward at the book (Figure 4).

Fig. 4. Still from the audiovisual speech stimuli.

B. Results

Infants spent more time in the IDS context than the ADS context during the conditioned preference test (t(17) = -2.692, p = 0.015). As in Experiment 1, difference scores were calculated to assess if infants changed the amount of time spent in each context from baseline to test. Infants significantly increased time spent in the IDS room from baseline to test ($t(17) = 2.13$, $p = 0.048$, $d = 0.502$) and significantly decreased time spent in the ADS room ($t(17) = -2.33$, $p = 0.032$, $d = 0.550$; Figures 5, 6). There was no baseline preference for either room ($p = 0.184$).

Previous studies (e.g. [25, 18]) have shown that infants orient more to the speech source during IDS. To assess the connection between looking to the speech source and preference, we tested whether infant visual attention to the source of the speech stimuli (the screen) during conditioning trials predicted changes in infants' preference. The change in the amount of time spent in the IDS room from baseline to test (the IDS difference score) was not significantly correlated with duration of looking to the speech source in either the IDS or ADS conditioning trials (*ps* > .188). Thus, infants' looking at the speech source did not predict their demonstrated IDS place preference.

C. Discussion

With the addition of a video of a social partner, we observed the predicted preference of IDS over ADS. It could be that a more salient stimulus was needed to circumvent the aforementioned issues (i.e., the context was too distracting or the preference not strong enough to promote locomotion). Additionally, adding videos to the stimuli may have increased infant arousal beyond that expected from IDS (and ADS),

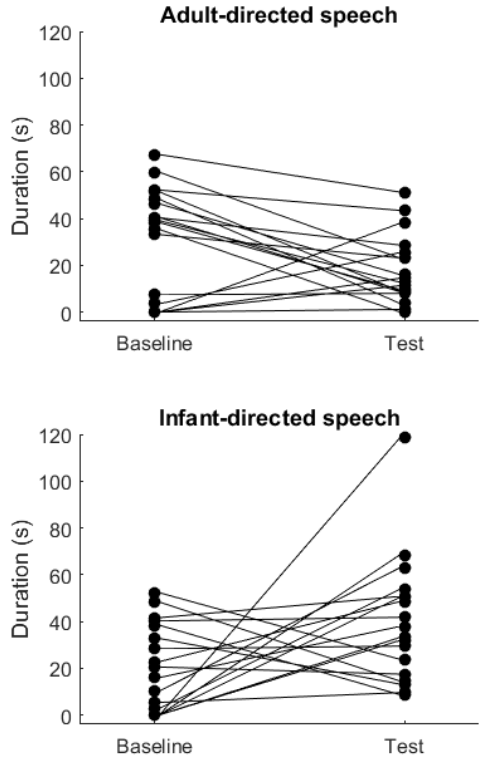

Fig. 5. Duration spent in the ADS (top) and IDS (bottom) context at baseline and test. Each point represents the data from one subject.

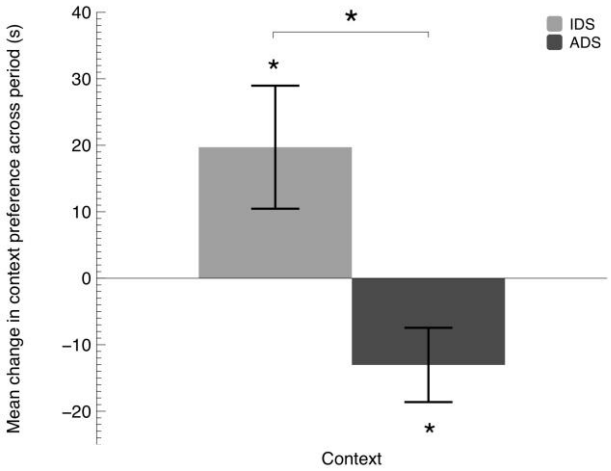

Fig. 6. Infants demonstrated a preference for the IDS context and an aversion for the ADS context.

contributing to the observed preference. Rosenblatt ([26], discussed in [27]), described how originally arbitrary cues (like IDS) can become a signal for a significant event (such as a social partner) through learning. Once the agent has learned the incentive, they become motivated to seek out the incentive, and the incentive can be used as an unconditioned rewarding stimulus in other contexts (like the current CPP experiment). Once a stimulus has become an incentive, it becomes arousing and can elicit orienting responses (as we have seen in studies testing for IDS preference [25]). While the added "presence" of a social partner, which is also an incentive, may have increased infant arousal, further facilitating the conditioning seen in Exp 2, the video was added for both the IDS and ADS stimuli. Nonetheless, we only observed an increase in the amount of time spent in the IDS context, indicating that the conditioned preference we observed was not solely due to the addition of the social partner. Thus, though arousal still played a role in the conditioning of infant's behavior, we were able to test for preference for IDS without the orienting response confound inherent in looking time studies.

Taken together, Exp 1 and 2 suggest that while arousal from the acoustic properties of IDS may drive the preferences for IDS typically seen in looking time studies with younger infants (e.g., [25]), it is not a satisfactory explanation for older infants. The difference between unimodal speech and multimodal speech is enough to make multimodal speech sufficiently rewarding to older infants to condition a context preference. Perhaps the unimodal presentation of speech removed IDS from its natural context of social interactions, changing the reward value normally inherent to IDS.

IV. General Discussion

We used conditioned place preference (CPP), an established paradigm in the field of animal behavior, to assess infant preference for infant-directed speech. While previous work has shown that the preference for IDS emerges early in life [25], little is known about the mechanisms underlying this demonstrated preference. In a departure from traditional looking-time paradigms, CPP was used to measure the reward value of IDS and ADS after the presentation of the speech stimuli, rather than concurrently with their presentation. Additionally, rather than relying on eye gaze, CPP allowed us to collect a more robust measure of preference, as the infants

had to be motivated to locomote into their preferred context. While infants failed to demonstrate a preference when unimodal (speech only) stimuli were presented, we saw a robust preference for IDS when the speech was paired with videos of a social partner (multimodal stimuli). Critically, infant looking at the speech source during conditioning trials did not correlate significantly with infant preference at test, suggesting that we successfully disentangled orientation and arousal from the reward of IDS.

The rewarding qualities of multimodal IDS facilitated Pavlovian-like conditioning, resulting in a place preference to the context in which the IDS stimuli were experienced. Infants' failure to develop a place preference in the unimodal condition, however, suggests that the reward value of IDS for 10- to 12-month-old infants is rooted in properties beyond the raw acoustic characteristics of speech. IDS may acquire predictive power over time as infants learn that IDS reliably signals the presence of a social partner. In Exp 1, the social predictive power of IDS was eliminated, as IDS and ADS were played from an overhead speaker and there was no social partner present. Exp 2 incorporated a video of a social partner in addition to her speech, leveraging the associations that have been built over development between IDS and social partners. Including a video more closely approximated a social interaction, thus allowing us to compare the reward value of IDS and ADS while maintaining the predictive validity of speech signaling a social partner.

There are three major benefits to using CPP to measure infant preference for stimuli. First, the paradigm does not rely on infant eye gaze. As previously discussed, it is impossible to disentangle preference and arousal in looking-time studies [18, 19]. Thus, experiments relying on looking time may present misleading conclusions about what habituation and novelty or familiarity preferences actually mean. The changes in looking time attributed to novelty or familiarity preferences are based in part on stimulus complexity and experimental design. These preferences are typically measured by exposing infants to a stimulus until they are familiarized with it (but not habituated) and then presenting the now familiar stimulus side-by-side with a novel one (e.g., [10]). Preference formation is dependent on information processing – the longer an infant is exposed to the familiar stimulus, the more likely they are to prefer the novel stimulus and the more robust their novelty preference becomes [28]. Thus, when measuring preference with looking time, researchers are also measuring the infant's basic attentional, learning, and memory abilities [10].

A second benefit of using CPP is that it measures infant preference after the stimuli have been removed. If infants demonstrate a preference in CPP, then successful conditioning took place – meaning that the unconditioned stimulus (in this case, IDS) was in fact rewarding. Third, with CPP, preference is demonstrated via approach behaviors to the context in which a stimulus was presented, which are more robust than transient looking behaviors, as they require more energy expenditure.

There is, however, a notable limitation to the CPP paradigm. CPP is only appropriate for infants who can locomote independently, limiting the age range of its use in experiments. One additional limitation, specific to the presented work, is small sample sizes. There is a possibility that with more subjects a preference could have been demonstrated in Exp 1. Our sample sizes are similar, however, to previously reported studies on preference for IDS that collected data from 12-20 infants [17,25].

V. Conclusions

We replicated findings that infants prefer IDS over ADS with the CPP paradigm, but only when speech was paired with a social partner. Our results suggest that while the pitch contours of IDS may be inherently rewarding to infants early in life [25], this explanation falls short when describing older infants' preference for IDS. Over time, IDS gains reward value as it becomes predictably associated with social interactions. The developmental trajectory of preference deriving from acoustic structure to social signaling merits further study. We have also demonstrated that CPP, traditionally a paradigm used in animal research, can be a useful tool in developmental research to disentangle the arousing features of a stimulus from its reward value, allowing for a more objective study of infant preference.

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