

# Adapting Infant Looking Time Paradigms for the Web

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## 1. Introduction

Investigating what knowledge infants have about the language(s) they are learning is a central enterprise in the field of language acquisition. Due to infants' limited linguistic production, research methods in infant studies often rely on measuring their visual attention given certain speech stimuli. One such measure, the head-turn preference procedure (HPP) was developed in the 1990s and remains among the most important infant research methods in the field to date (Nelson, Jusczyk, Mandel, Myers, Turk & Gerken, 1995). In the central-fixation adaptation of HPP, infants typically sit in the lap of a blinded parent while listening to speech stimuli. Researchers probe linguistic knowledge by measuring how long the infant's attention is held by the speech stimuli relevant to the language they are learning.

While some infant looking time paradigms have been adapted online (e.g., preferential looking: Scott, Chu & Schulz, 2017), HPP has historically required a highly controlled lab environment and has thus remained restricted to the lab. For instance, HPP normally requires a highly-trained researcher to observe the infant's looking behavior as the experiment unfolds, using these real-time observations to determine whether to advance the experiment to the next trial. Further, because infant looking behavior may be influenced by small perturbations in the environment, researchers have taken great care to minimize environmental distraction in the lab, conducting experiments in sound-attenuated booths and ensuring parents are blind to the experimental stimuli. Over the web, not only are these careful controls not possible, the results may be influenced by additional noise contributed by an infant's home environment, different computers, web connection, etc.

In the present study, we provide the first demonstration that, despite these concerns, HPP *can* be adapted successfully for web data collection. To illustrate, the Online HPP (OHPP) method we conducted is an online replication of Shi, Cutler, Werker and Cruickshank's (2006) Experiment 1, which employed the

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central-fixation adaptation of HPP to determine whether functors like ‘the’ facilitate the extraction of novel nouns in 11 month olds. We leveraged the Lookit platform (<https://lookit.mit.edu/>) to recruit and run this experiment online. Our results indicate it is feasible to conduct HPP experiments over the web, providing new opportunities for infant studies during the pandemic and into the future.

## **2. Shi et al.’s (2006) study**

We first describe Experiment 1 from the original Shi et al. (2006) study. We chose this experiment to replicate because the results are quite robust, allowing us to potentially observe differences in looking behavior with Online HPP, despite having less control over the environment than one would in the lab. Shi et al.’s (2006) study examined whether 11-month-olds can use functors like ‘the’ to facilitate the extraction of novel nouns. The experiment consisted of a familiarization phase and a test phase. In the familiarization phase, infants heard six trials alternating between two novel nouns: one preceded by ‘the’ and the other by ‘kuh’, a mispronunciation of ‘the’ (e.g., ‘the breck’ and ‘kuh tink’). The presentation order of the two novel nouns and their combination with the two functors were counterbalanced across infants. At test, infants heard four alternating trials of ‘breck’ and ‘tink’ in isolation. All trials had a fixed length of 16 seconds. If infants can use ‘the’ to facilitate novel noun extraction, then they should be able to extract the pseudoword that occurred with ‘the’ during familiarization as a novel noun, but not the pseudoword that occurred with ‘kuh’. Since previous studies using this paradigm found longer looking time to familiar items, Shi et al. (2006) predicted that infants’ looking time would be longer to the novel noun familiarized with ‘the’ than that with ‘kuh’. As predicted, Shi et al (2006) found significant longer looking time to the ‘the’ noun, suggesting that ‘the’ but not ‘kuh’ facilitated 11-month-olds’ extraction of novel nouns.

## **3. Methods**

### **3.1. Design**

In order to adapt HPP to collect data online, we made several modifications to the original study design. Our modifications are summarized in Table 1. The original Shi et al. (2006) was conducted in a sound attenuated chamber, whereas our study was conducted at the infants’ home over the web. As in other typical HPP studies, the original study also adopted parent blinding: Parents were asked to listen to masking music over headphones during the experiment. However, since compliance would be difficult in an unsupervised online study, parents were neither asked to close their eyes nor to wear headphones in our study. Rather, we instructed parents to simply hold their baby on their lap, in view of the webcam. The original study did not specify what was used to capture infants’ attention between trials; our study used a video of a laughing baby after each trial, inspired by Kidd, Piantadosi and Aslin (2014). In Shi et al (2006), a trial was started by a researcher whenever the infant looked back at the screen; in contrast, in our study, a trial started automatically after the laughing baby video, which had a fixed

length of 5 seconds. The visual stimulus in the original was a black and white checkerboard. But because home was likely more distracting than the lab, infants in our study were assigned to one of two visual conditions: low visual interest condition, where infants saw a colorful checkerboard on each trial, and high visual interest condition, where infants saw a video of a toy popping out of a box on each trial, which is supposed to be more attractive to infants (also inspired by Kidd, Piantadosi and Aslin (2014)). The toy and the box differed on each trial, so that the infants would not learn any mapping between the visual stimuli and the sound stimuli. Finally, for exclusion criteria, in addition to all the criteria used in the original study, we also excluded infants with unusable videos.

**Table 1. Summary of differences between Shi et al. (2006) and the current study (Online HPP).**

	Shi et al. (2006) In lab	Online HPP Online via Lookit
<b>Setup</b>	Sound-attenuated chamber	Home over the web
<b>Parent blinding</b>	Masking music over headphones	None
<b>Attention getter</b>	None reported	Laughing baby video after each trial
<b>Trial started</b>	By a researcher when the infant looked at the screen	After the laughing baby video finished (fixed 5s)
<b>Trial length</b>	Fixed 16s	Fixed 16s
<b>Visual stimuli</b>	Checkerboard	Checkerboard (low interest) or toy-in-box (high interest)
<b>Exclusion criteria</b>	Fussiness; equipment failure; infant failed to reach 15s of cumulative looking for each token during familiarization	As in Shi et al. (2006) <i>plus</i> unusable video (e.g., baby not visible in webcam recording)

### 3.2. Participants

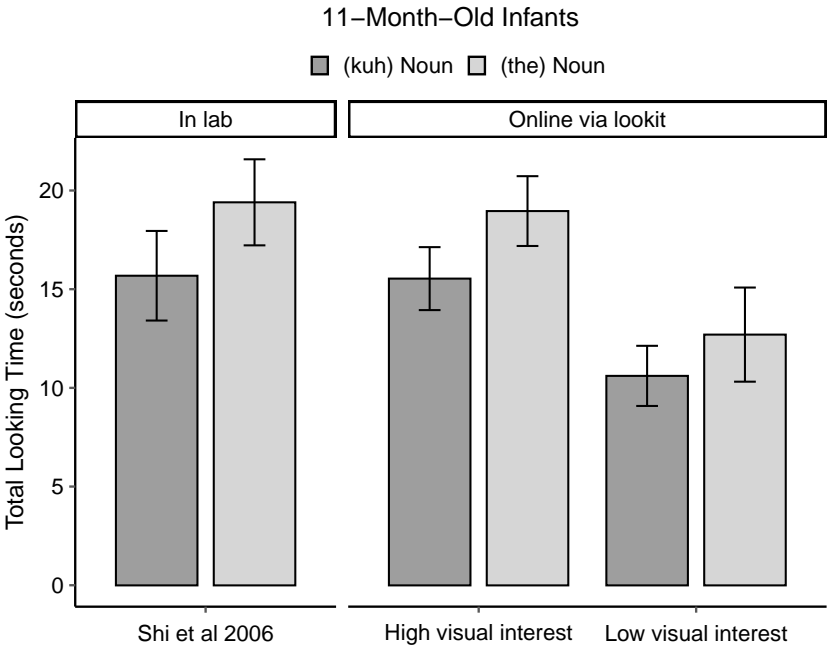
Our participants were 62 11-month-old infants recruited on Lookit: 14 in the low interest condition, 29 in the high interest condition, and 19 excluded based on the exclusion criteria in Table 1. Of those infants who were excluded, 10 didn't finish the study or withdrew their consent; 4 had unusable video recordings; 5 failed the familiarization. The exclusion rate is comparable to Shi et al.'s (2006) original study, where 34 infants participated, and 10 were excluded.

3.3. Data coding

We coded the webcam videos (captured by Lookit) for how long the infant looked at the screen during each trial — a measure of infant attention to the auditory stimulus. The videos were coded with ELAN. In specific, we coded any change of state in the infant: the precise timestamp when the babies stopped looking at the screen (away state) and when they looked back at the screen (screen state). Lookit provides precise timestamp data, so we knew exactly when the webcam started recording, and exactly when the audio started playing and when it stopped playing on each trial.

4. Results

Figure 1 shows our results compared to the original results from Shi et al. (2006). As can be seen in the figure, infants’ looking time in the lower visual interest condition was overall lower, which is expected since the home environment is more distracting than the lab; but across both conditions, infants’ looking time to the ‘the’ noun was longer to that to the ‘kuh’ noun, which is consistent with the original finding.



**Figure 1.** Infants’ mean total looking time (with standard errors) to pseudo-nouns in the test phase by functor (English ‘the’ or novel ‘kuh’).

We analyzed the results using mixed effects regression (Table 2). The dependent variable was each infant's total looking time across 'breek' trials and 'tink' trials separately. The fixed effects included Functor ('the' vs. 'kuh'), Condition (high vs. low visual interest condition), and their interaction. We found that Functor ( $X^2(1) = 5.58, p = 0.02$ ) and Condition ( $X^2(1) = 5.11, p = 0.02$ ), but not their interaction were significant predictors of looking time. This suggests that infants in the high visual interest condition looked longer overall, but importantly we replicated the Shi et al. (2006) results in both conditions: all infants looked longer to novel nouns familiarized with 'the'.

**Table 2. Statistics from mixed effects regression model.**

Fixed effects	looking (s) ~ function * condition				
	$\beta$	SE	<i>t</i>	<i>p</i>	
(Intercept)	14.458	1.230	11.755	<0.001	***
Functor - the	2.757	1.334	2.067	0.045	*
Condition - High visual interest	5.594	2.460	2.274	0.028	*
Functor $\times$ Condition	1.331	2.668	0.499	0.621	

## 5. General discussion

In summary, we have shown that HPP can be adapted for the web. Back in Section 1, we discussed the challenges for adapting HPP online, including assumptions that substantial researcher control is required; sound-attenuated booth is required; parent-blinding is required; and differences in looking behavior are very subtle and would be eliminated over web. With the current results, we have demonstrated that those challenged can be overcome. While we do agree that some or all of those assumptions may be true, we suggest that in many circumstances it may be possible to relax some of these constraints in order to open the door to be able to conduct such studies online.

While the major takeaway of the current study is that HPP can be adapted successfully for the web, we do not intend to argue that all HPP studies will necessarily successfully adapt to an online method. As a starting point, we have replicated one study which is known to have very robust difference in looking behavior. It is possible that some HPP studies where the looking time differences are more subtle may not be well-suited to the Online HPP method. In specific, for researchers who plan to adopt Online HPP in their own work, we recommend using high visual interest visual stimuli for experiments with subtle distinctions, since we do observe a significant difference between our two visual interest conditions. We also recommend using Online HPP to replicate an existing study before attempting any new experiments to ensure the method adapts well to your research questions.

We suggest that our results create new opportunities for infant studies both during the pandemic and beyond. Many parents may still be concerned about

bringing young infants to the lab in person, so the online method could enable researchers to have access to more infants. The method could also be helpful for infant studies the future, since infants and their families may find it more convenient and comfortable to participate in research from home. Theoretically, online methods such as Online HPP can also create access to a globally more diverse population, which will also benefit the broader impact of infant studies.

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