The Eyes are a Window on Language Acquisition:

Visual Preference Techniques

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Abstract

The Intermodal Preferential Looking Paradigm and the Head Turn Preference Procedure are the topics of this chapter. The development, instrumentation, and utility of each method is described, including variants of the original paradigms that have evolved over time and use. Also discussed are the different types of questions these methods address and how they have advanced the field. Advantages and disadvantages of the methods are also presented.

Word count: 67

The Eyes are a Window on Language Acquisition: Visual Preference Techniques

The eyes shout what the lips fear to say.

William Henry (1729-1786)

The purpose of visual preference methods to study language acquisition is revealed by changing one word in the quotation above, *The eyes shout what the lips* ***cannot*** *say.* Children know much about language before they can produce it. Prior to the advent of visual preference methods, the field made progress through diary studies (e.g., Brown, 1973) and experiments with older children (e.g., Berko, 1958). In retrospect and from the vantage point of a new millenium, two things were needed to propel the field further. The first requirement was for a theory of language that considered more than its surface manifestation. This was produced by Noam Chomsky's (1957) books *Syntactic Structures* and *Aspects of the Theory of Syntax* (1965) and brought to the field of psychology by George Miller (Miller, 1965). The second was new methods to probe what language learning children knew about the structure of their language. By the time a child says the two-word utterance, "Mommy sock," for example, an enormous amount of language acquisition has occurred. Researchers like Martin Braine (1963) Lois Bloom (1970) and Roger Brown (1973) began to analyze children's early productions for their grammatical properties and their putative underlying structure. To study the *process* by which language emerged, researchers recognized that they needed to start earlier. What did young children know about language before it emerged in speech? How could we get purchase on this question when infants could neither talk nor respond on command?

It should also be noted that part of the new methodology appearing at that time was videotape. The ability to record dynamic events was a boon to the field in two ways. First, it allowed IPLP researchers to test for motion verb comprehension. As verb knowledge is a key component of grammatical knowledge, researchers could now probe how children viewed events that verbs would label (see Hirsh-Pasek & Golinkoff, 2006). Second, reliability of visual fixation could be calculated off line with the use of videotape as participants' performance yield a permanent record.

Modern visual preference techniques have their roots in the work by Robert Fantz (1958, 1964). Interested in visual acuity, he showed that young infants would show differential responding to stripes of different widths. Around this time, researchers speculated that visual fixation might be a window to understand language development (Horowitz, 1974; Colombo & Bundy, 1981). Horowitz (1975) used a visual preference method with infants and discovered that infants would look more to visual displays when they were accompanied by language than when they were presented in silence. Then in 1987, Golinkoff, Hirsh-Pasek, Cauley, and Gordon in a paper aptly titled "the eyes have it" adapted a method to study language acquisition employed by Spelke (1979). Spelke (1979) presented 4-month-old infants with a dynamic, intermodal version of Fantz's paired-comparisons method. Babies saw two events side-by-side (e.g., a donkey jumping on a table and a person clapping hands) accompanied by a single auditory stimulus that matched only one of the actions (e.g., the sound of hands clapping). Infants looked more at the event that matched the auditory stimulus than to the event that did not. Golinkoff et al. asked whether children would look more toward the scene that matched the language they were hearing. When they did, it suggested that infants were eager to find sights that matched the sounds they heard, an attribute that would be useful for uncovering hidden aspects of language

learning! This early work (and Hirsh-Pasek & Golinkoff, 1996) indicated that infants knew more about language than their meager productions revealed. Infants by 16 months were matching words to a visual representation of their meanings (viz, a picture of a shoe to the word *shoe*) and latent grammar was available as well. Sixteen-month-old children, saying as few as two words, were already watching an event that matched a 5-6-word sentence, as in "Where is Big Bird tickling Cookie Monster?" rather than watching an event that did not match what they were hearing (Hirsh-Pasek & Golinkoff, 1996; Golinkoff, Ma, Song, Hirsh-Pasek, 2013).

Simultaneously with the development of the Intermodal Preferential Looking Paradigm (hereafter referred to as IPLP), a simpler procedure was also being developed – the Headturn Preference Procedure (Hirsh-Pasek, Jusczyk, etc., 1987). While preferential looking tasks explicitly test infants' *pairing* of sounds with particular visual stimuli, the Headturn Preference Procedure (hereafter HPP; Kemler Nelson et al., 1995) is designed to probe what infants know about the properties of language, without relying on their understanding the meaning of what they are hearing. A single, visual display (usually a flashing light, sometimes a visual display on a television screen such as a flashing circle or checkerboard pattern) measures infants' relative preference for different auditory stimuli. Since it is not possible to directly measure what auditory stimulus an infant is attending to through behavioral measures, the auditory stimulus is paired with the visual display, and the infant's attention to the visual display is used as a proxy measure for their auditory attention. Hirsh-Pasek envisioned this method while watching her own infant son turn his head back and forth to follow the side on which a speaker was playing. Hirsh-Pasek et al. (1987) first used this measure to examine infants' perception of the prosodic characteristics of clauses. They removed all pauses greater than 1 second from a passage in infant-directed speech and inserted 1-second artificial pauses either at clause boundaries

(consistent with the edges of prosodic units) or at other places within clauses (not consistent with prosodic units but not starkly disruptive as in the middle of words). Infants (7 – 10 months old) preferred the sentences in which the artificial pauses were consistent with clause boundaries, suggesting that they were attuned to the cues that coincide with major phrasal boundaries. A few years later, Jusczyk and Aslin (1995) added a familiarization phase to the basic procedure, allowing the researcher not only to test the preferences that infants bring into the lab from their everyday experiences, but also to allow the researcher to introduce biases through experiences in the lab that are then tested within the same paradigm.

The primary advantage that the IPLP and the HPP share is that the infant's response is minimal but meaningful. Shifts in eye gaze or a turn of the head require very little from the infant, thereby reducing the need for complex motor behaviors, carrying out any commands, or decision-making. These methods rely on the idea that infant looking behavior captures low-level affinities for finding structure in the world -- characteristics such as "matching/non-matching", "coherent/incoherent", "familiar/unfamiliar", "consistent/inconsistent." They also rest on an even more fundamental assumption: That infants are motivated to respond to language stimuli well before they can talk and to find the regularities therein.

Basic Paradigm

Both the Intermodal Preferential Looking Paradigm and the Headturn Preference Procedure rely on a key assumption that infants' looking behavior toward a visual stimulus can be used to make inferences about their linguistic sensitivity. In the case of Preferential Looking methods, infants' looking behavior while hearing an auditory stimulus is compared across two visual displays, as a means of determining whether infants consider the auditory stimulus to be a better 'match' with one or the two displays. In the case of HPP methods, looking toward a visual

display is used as a proxy measure for their interest in an auditory stimulus. Because there are numerous variants of each, we will start out with a description of the "basic" methodology, and then describe some of the variants that have been used.

The Original Intermodal Preferential Looking Paradigm (IPLP)

The IPLP enables the exploration of underlying mechanisms involved in language learning, discovers how infants identify the relationships between language and referents in the world, and makes it possible to study infants' conceptions of the dynamic events expressed by language. The IPLP is used to assess infants' emergent language knowledge in a number of ways. First, it tests for the language knowledge that children bring to the laboratory. That is, IPLP is used to ask about children's vocabulary knowledge and the grammatical structures they are already capable of using. Second, the IPLP can explore the process by which children learn new lexical items, and how they interpret various linguistic structures that, in the real world, would never be put into opposition.. That is, children's construal of sentence structures or word meanings can be investigated by presenting stimuli that could have two interpretations. For example, White and Morgan (2008) presented infants with mispronunciations of familiar words (e.g. "tup" instead of "cup") and examined whether infants would look more toward the mispronounced target (a picture of a cup) or an unfamiliar object (i.e., a new object that might be called a "tup"). Thus, the IPLP allows us to study infants' initial understanding of words, grammar, morphology, syntax, semantics, and pragmatics.

Overview of Method and Data Analysis

In the IPLP, infants' visual fixation time to two simultaneous images is measured. The hypothesis is that infants will allocate more looking time to the scene that matches an accompanying auditory stimulus relative to a scene that does not match what they are hearing.

The prediction is never that children will allocate *all* their looking to the matching image, since eyegaze is not static. Further, the stimuli are designed such that each has interesting properties. In these models, greater attention toward one visual target over another (e.g., 67% looking towards one vs the other stimulis) can indicate detection of a relationship between the auditory and one of the visual targets. The stimuli are created to be of equivalent salience by controlling for a number of parameters, including the size of the images, the degree of movement (when relevant), and degree of affect if faces are seen, just to name just a few.

The original IPLP used two separate television monitors with the auditory stimulus delivered through a central speaker. With the arrival of big screen televisions, stimulus displays can appear on a single screen (see Figure 1) and the auditory stimuli can sometimes emanate from the television itself.[1] Infants are seated on a parent's lap facing a large monitor, and visual stimuli are shown as left and right split-screen displays at infants' eye level. Importantly, to avoid "Clever Hans" effects, the parent is either asked to close their eyes, or to wear blacked-out sunglasses, or some other eye obstruction. A hidden camera records the infant's gaze for later offline coding by a trained researcher who is blind to the location of the target visual stimulus. Infants' relative eyegaze toward the left or right display is used as a measure of preference for the visual display that matches the auditory stimulus. Another important feature of the set up is that a single central stimulus (sometimes a video of a laughing baby or a flashing light) is used during intertrial intervals to attract infants' attention back to the middle of the screen. This is done for two reasons. First, it keeps infants from 'sticking' to a single side of the television; and second, it invites comparison between new stimuli starting from a central fixation spot.

[1] Caution is suggested here if the acoustic stimuli have been artificially modified such as by low-pass filtering – preprocessing in television speakers can sometimes alter the intended output, a problem one of the authors encountered.

--- Insert Figure 1 about here ---

In its simplest form, data analysis is usually accomplished via measurements of *total visual fixation time* over the trial to the matching versus the non-matching image. This means that a computer program cumulates the amount of time infants look to the matching display, to the non-matching display, and away from the screen based on the coder judging the location of the infant's eyegaze. Reliability of this coding is usually very high and can be easily measured by having two researchers code the same video separately. Other researchers have used a comparison of the longest look to each trial (Ma et al., 2011; Schafer & Plunkett, 1998) or the proportion looking toward the target versus the distractor across the trial (Tincoff & Jusczyk, 1999). Statistical tests are typically simple t-tests or analyses of variance that compare mean looking times across trial types. Multiple trials are offered and an IPLP test can be as long as 3-4 minutes and still maintain many infants' attention.

In a simple example, a shoe and a hand are presented side by side on a single screen. Only one of the images matches an accompanying linguistic stimulus (e.g., "Where is the shoe?" – Golinkoff et al., 1987; White & Morgan, 2008). The question evaluated is whether children look at the shoe longer than at the hand. In addition, latency of fixation to the matching versus the non-matching visual display can be used as a measure of preference. This analysis answers a slightly different question: How long did it take the child to find the matching display? Resesearchers often also include a count of how many of the participants show an overall preference for the target across trials, as a check to ensure that the effect is not a result of a small subset of the sample. Some laboratories also analyze the data using non-parametric tests for this reason. Once children are old enough to reliably follow directions, children's pointing to one or

the other display can be used as the dependent variable (e.g., Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008; Verdine, Lucca, Golinkoff, Hirsh-Pasek, & Newcombe, 2015).

The IPLP: A Study Sampler

Word order is one of the first grammatical devices found in children's early utterances in English. The IPLP enables researchers to examine whether children can use word order *before* they produce utterances that contain it to find events that matched what they are hearing. That is, researchers were able to find out whether young children processed more than single words and whether they 'glued" the units together using grammatical structure. The first paper to use the IPLP (Golinkoff et al., 1987) found word order comprehension in 28-month-old children already producing two- or more word sentences. Expanding on this work, Hirsh-Pasek and Golinkoff (1996) used the IPLP with familiar verbs and reported word order comprehension in 16-month-olds not yet producing two-word utterances. An ongoing debate in the field of language acquisition is whether children are learning how individual words work grammatically or whether they are learning broader grammatical rules.

Gertner, Fisher, and Eisengart (2009) attacked this issue using the IPLP in a study that presented 21- and 25-month-old children with novel verbs. Their design had three phases. In the first, character identification phase, Gertner et al. made sure that children could identify the duck and the bunny when they were requested by name, e.g., "Find the bunny!" This confirmed that the infants recognized the protagonists, and also provided some initial warm-up to the looking task. In the second "practice" phase, Gertner et al. showed children the duck and bunny on each screen engaged in two different familiar actions (hug and feed), the only difference being who was was the agent and who the patient of the action. Thus, for example, children saw the duck hugging the bunny and the bunny hugging the duck and heard, "The bunny's hugging the duck!"

Finally, in the test phase, children were shown the bunny and the duck performing a pair of novel actions. In one, the bunny wheeled the duck back and forth in a wagon; in the other, the duck tipped the bunny in a rocking chair. Half the children heard "The bunny is gorping the duck" and half heard the sentence with the characters reversed. Results showed that infants in both age groups used word order immediately after hearing the novel verbs. These findings suggest that infants can use their early-developing syntactic knowledge to learn the meanings of new verbs, a procedure called *syntactic bootstrapping* (Gleitman, 1990). The IPLP made it possible to distinguish between these two theoretical accounts of children's early grammatical knowledge.

The IPLP can also be used to study the language learning process as it occurs in the lexical realm. Ma, Golinkoff, Houston, and Hirsh-Pasek (2011) trained children to learn two new words instead of testing them on words they might already know. The purpose of their study was to evaluate whether infants would learn new words more readily if they heard sentences in infant-directed versus adult-directed speech. Although prior studies had documented that infants preferred hearing infant-directed speech, none had shown that its use actually advanced word learning (Golinkoff, Deniz Can, Soderstrom, & Hirsh-Pasek, 2015). Monolingual, English-learning 21- and 27-month-olds were randomly assigned to either infant-directed or adult-directed speech describing two novel objects.

As Table 1 shows, the study began with a *task familiarization phase* using familiar objects. The child was asked to look at each of the known objects on one trial to get them used to making similar choices. A *salience trial* followed of the two objects to be seen at test. The purpose of this trial is to demonstrate whether infants have an *a priori* preference for either of the test objects prior to training and test. Four training trials followed during which toddlers were shown a single novel object and told its name on sequential trials. For example, when children

were shown one novel object they were told, "Blick! Where's the blick? Look at the blick! There's the blick!" At the same time, the novel object was programmed to drop down to the bottom of the screen, to bounce, and to engage in other movements designed to motivate children to continue to watch.

--- Insert Table 1 about here ---

During the *test phase*, infants were presented with the static version of the two novel objects side-by-side. There were two blocks of testing (4 trials in each block) with a *reminder trial* in between. During test trials, infants were directed to look at one of the objects on half the trials and the other novel object on the other half of the trials (e.g., *"Blick! W*here's the *blick?*). During the last second of each trial, the "target" (i.e., the named object) bounced to reinforce or encourage looking to it. The two reminder trials offered children another opportunity to learn the novel names, followed by the second block of 4 test trials. Visual fixation was coded frame-by-frame. The dependent variable was the single longest look at the target and non-target in each test trial, although using total visual fixation time yielded the same outcome. In addition, the caregivers completed the Short Form of the MCDI (MacArthur Communicative Developmental Inventory) - words and sentences (Fenson et. al. 2000) – as it is informative to look for links between children's language level and their performance on IPLP tasks..

The results showed that only 21-month-old infants in the infant-directed speech condition looked significantly longer to the target than to the non-target which suggested that children learned the words only in infant-directed speech. However, children who were in the top half of the vocabulary distribution relative to their peers also appeared to learn the words when presented in adult-directed speech. By 27 months, children learned the novel words whether they heard infant- or adult-directed speech (Ma et. al., 2011).

Variants of the Intermodal Preferential Looking Paradigm

Interactive Intermodal Preferential Looking Paradigm (IIPLP)

One limitation of the original IPLP is that the presentation of stimuli is all screen-based. Therefore, the ability to examine the influence of social cues on language learning is limited. Hollich, Hirsh-Pasek, and Golinkoff (2000) introduced a three-dimensional version of the IPLP called the "Interactive Intermodal Preferential Looking Paradigm, IIPLP" to address this problem.

Overview of Method and Data Analysis

During IIPLP (see Figure 2), in contrast to IPLP, a human experimenter delivers the stimuli, allowing researchers to examine the role of social cues in language learning (Golinkoff et. al., 2013). In the IIPLP paradigm, stimuli are real objects affixed by Velcro to a wooden flipboard that can rotate just as in Fagan's infant intelligence test (Fagan, Holland, & Wheeler, 2007) . On one side of the table, an infant sits on the parent's lap and the parent closes his or her eyes. On the opposite side of the table, the experimenter stands behind the board. Because the board rotates, the experimenter can face the child and attach or remove objects on her side of the board. She can rotates the board to reveal the objects to the infant, controlling the time of exposure. The experimenter either prompts the infant to look at the objects, or, labels only one of the objects. When labeling an object, the experimenter can provide social cues such as enthusiastically looking back and forth between the object and the child's eyes. Timing of the stimulus presentation is tightly controlled. A mirror on wall behind the parent and child captures what the child is seeing on the flipboard and when the board flips. A camera captures the child's visual fixation and the objects on the board for later coding and reliability testing. During test

trials, the experimenter ducks down behind the flipboard so as not to influence where children's choose to look.

--- Insert Figure 2 about here ---

Analyses are conducted in the same way they are in the IPLP and often with the same types of trials. That is, analyses of variance can be used to examine whether children looked longer to the matching versus the non-matching object affixed to the flipboard.

The IIPLP: A Study Sampler

Hollich et al. (2000) and Pruden, Hirsh-Pasek, Golinkoff, and Hennon (2006) conducted their research using the Emergentist Coalition Model of word learning. That model asserts that infants first use perceptual cues to identify which object is the referent of a speaker's naming and then begin to use social cues such as eye gaze and object handling. Finally, toddlers use linguistic cues (as in morphology and position in the sentence) and by 29 months, they could even override social cues, using language to identify the correct referent of a novel word (Nurmsoo & Bloom, 2008). In a series of 12 experiments, Hollich et al. traced the course of this process by asking when infants use perceptual versus social cues to learn new words. They designated one of the objects as "interesting" (e.g., a colorful noisemaker) and the other as "boring" (e.g., a beige soda cap opener) based on infants' interest in the objects. Perceptual cues were used most at 12 months and children more readily learned the name for the interesting over the boring object when the interesting object was being named; they did not learn the name of the boring object when it was named. But by 19 months, children were able to use social cues such as looking at the object or handling an object, to figure out which object the speaker was naming (Hollich et. al., 2000).

Was there a time at which younger children would systematically *mismap* words through the use of perceptual cues alone, taking the name for both the interesting and the boring object to be for an interesting object? Pruden et. al. (2006) used the same design as above to address this question with 10-month-olds. Results showed that the infants only learned the name of the interesting and not the boring object when it was labeled. When the experimenter looked at and named the boring object, 10-month-olds mismapped the word to the interesting object, apparently ignoring the speaker's social cues (Pruden et. al., 2006). In the Hollich et. al. (2000) study, 12-month-olds no longer mismapped a label to an interesting object, while they still failed to learn the name of the boring object (Hollich et. al., 2000), a finding that represented progress when compared to the 10-month-old findings.

The looking-while-listening paradigm (LWL)

One significant expansion of the IPLP retains the same basic set-up, but introduces a different form of analysis that allows for very detailed timecourse explorations of infants' eyegaze. The unit of analysis is the time to get to the match and remain on the match during a trial, rather than collecting cumulated looking times across trials. This variant, referred to as the "Looking-while-listening paradigm" has been instrumental in showing relationships between early processing speed and the timing of vocabulary acquisition (Fernald, Perfors, & Marchman, 2006; Marchman & Fernald, 2008; Hurtado, Marchman, & Fernald, 2008).

Overview of Method and Data Analysis

During the LWL, as with IPLP, two pictures of objects are typically presented next to each other accompanied by a sentence that matches only one of the objects (e.g., "Drink the juice," or "Where is the doggie?"). Regions of interest during the trial are identified for timecourse analysis (typically at a 33 ms resolution due to video frame rates) based on the onsets

of particular targets. For example, the coding starts slightly before the onset of the first phoneme *(d*-in *doggie* in "Where is the doggie?"). If infants comprehend the word "doggie," and they are already looking at the picture of the dog, they should stay there. But if they are looking at the distractor (say, a cookie), their gaze should shift to the dog upon hearing the word (Fernald, Perfors, & Marchman, 2006). Timecourse analysis allows for detailed comparisons that take into account both the proportion of trials in which infants are looking toward a given visual display at each point in the timecourse, and the speed of shifting (see Figure 3). Better language processing is reflected in faster shifts away from the distracter and fewer shifts away from the target, and, if infants understand the target words, the prediction is that the proportion of trials in which gaze shifts occur is high for distracter-initial trials and low for target-initial trials.

--- Insert Figure 3 about here ---

LWL: A Study Sampler

An influential study using the LWL procedure (Hurtado, Marchman, & Fernald, 2007) examined Spanish-speaking mothers' language input to their children and their toddlers' speech processing. The age range of child participants was 15 months to 37 months, with a mean of 24 months, and they all came from Spanish-speaking Latino families who had recently immigrated to the U.S. (Hurtado et. al., 2007). There was a wide range of input: Children of more talkative mothers were reported to hear seven times more words and sentences twice as long as those heard by children of less talkative mothers.

As in the IPLP, children were shown a pair of objects as they listened to speech naming one of the objects. Speech stimuli consisted of Spanish sentences in which a target noun was presented in a simple carrier phrase (e.g., *Donde esta el/la* – the target—? Where is the target? *Te gusta?* Do you like it?). The eight target nouns were chosen based on their familiarity to children

learning Mexican Spanish in this age range (i.e., *el perro*- doggie; *el bebe*- baby; *el carro*- car; *el globo*- balloon; *el zapato*- shoe; *el platano*- banana; *la pelota*- ball; *la galleta*- cookie). Fixation times to each image and shift in gaze between images were recorded (Hurtado et. al., 2007).

The results indicated that the language (number of utterances, word tokens and types) directed to children when they were 18-months-old did not correlate with their speed in arriving at the target when they were tested at 18 months. However, by 24 months, the children with the larger vocabularies and the greatest amount of language input at 18 months, were faster at recognizing familiar words. This is one of the first studies to show that speech processing efficiency appears to be affected by the amount of language children have addressed to them. Input quantity also affected the vocabulary growth children showed from 18 to 24 months.

Marchman and Fernald (2008) used the LWL to predict children's language and general cognitive functioning from 25 months to 8 years of age. As speed of processing is a core construct in accounting for general cognitive differences, the authors hypothesized that children who were fast at spoken word recognition at 25 months would have a better language and cognitive profile at age 8. Their analyses showed that vocabulary size at 25 months accounted for unique variance in predicting children's language, IQ and working memory skills at 8 years. These findings suggest that processing speed and early language skills are fundamental to intellectual functioning,

Preferential looking paradigm without language (PLP)

Another variant of the IPLP involves videos without an auditory component. Hence this is not an "intermodal" paradigm. The IPLP uses language to examine language comprehension, while the PLP is premised on children's reaction to novelty in the events they are shown. Via PLP, researchers can explore perceptual and conceptual relationships between visual displays,

such as how infants segment and analyze the nonlinguistic motion events that will ultimately be encoded by verbs and prepositions.

Overview of Method and Data Analysis

Typically, in the familiarization phase of the PLP, infants see either a repeating identical scene or different examplars that belong to the same action or event category. During salience and test trials, infants see two dynamic visual stimuli next to each other. In the discrimination PLP, one of the two stimuli is the same as shown in familiarization and the other one is a novel stimulus. In the categorization PLP, one of the two stimuli is a new exemplar of a category shown in the familiarization and the other is a new stimulus from a new category (Golinkoff et. al., 2013). Sometimes infants hear a musical interlude during the inter-trial periods.

During PLP, children are expected to show discrimination or categorization only by watching the novel event, since no language is used. Because the PLP allows children to compare two simultaneously presented events at test, it may heighten their attention to the differences between them - thus minimizing memory demands and demonstrating earlier competency. Simultaneous presentation of test events may afford children the opportunity to detect differences that they do not detect with sequential presentation (Pruden, Shallcross, Hirsh-Pasek, & Golinkoff, 2008).

PLP: A Study Sampler

Goksun, Hirsh-Pasek and Golinkoff (2010), and Goksun, Hirsh-Pasek, Golinkoff, Imai, Konishi and Okada (2011) used the PLP with infants learning English or Japanese to investigate how event perception might be influenced by the ambient language (Goksun et. al., 2010). Japanese has different verbs for the type of grounds an individual is crossing while English just uses the general verb *cross* for travel across various ground types. Both sets of 13-to 15-month-

old infants showed the ability to form categories of different kinds of grounds (e.g., grounds like a bridge with borders vs grounds like a field with no clear borders) even when these grounds would not be encoded in English but only in Japanese (Goksun et. al., 2010). Via the use of the nonlinguistic PLP task, it was also shown that American babies, especially those with larger vocabularies, dampened their attention to different types of Japanese grounds by 18 months of age. Japanese babies, on the other hand, retained those distinctions regardless of vocabulary level. These findings suggest that infants begin language learning prepared to make many distinctions that might or might not be encoded in their language. When they are not encoded (as in verbs for different types of ground-paths), babies no longer attend to these distinctions in events. This work with the PLP is among several studies that have examined the perceptual underpinnings of linguistic categories (e.g., Pruden, Goksun, Roseberry, Hirsh-Pasek, & Golinkoff, 2013).

Headturn Preference Procedure

Not all questions in language acquisition are about the mappings between sights and sounds. Researchers who wished to uncover what infants know about the structure of the language qua language created the HPP so that auditory stimuli could be presented without visual displays. Thus, the HPP asks whether infants discover aspects of language structure in the auditory stimulis itself. They measure this by asking whether babies prefer one kind of auditory stimulus over another in order in to index discriminative skills or to see, for example, if infants prefer hearing their own name over other names

Method Overview and Data analysis

In the HPP, infants are seated in a 3-sided booth, with a flashing light or other visual display to their front and on both sides (Figure 4). Typically the infant is seated on a caregiver's

lap, although sometimes an infant seat is used. Although an infant seat may reduce interference from the mother toward the infant, or from being a source of distraction, it may cause problems when testing in cultures or families for which separation from the parent is a source of distress. As with the IPLP, the presence of the caregiver is a cause of concern for a "Clever Hans" effect. Therefore, if the caregiver is present, they typically wear headphones that play music. An experimenter, usually located in an adjacent room (so that they are blind to the exact condition of a given trial) and watching via closed-circuit camera, indicates by pressing a button whether the infant is looking at, or away from, a located either to the left or right side of the infant, as an indirect indicator of the infant's preference for the sound originating from a speaker located on the same side. Each test trial begins with a light flashing at the front to orient the infant forward. When the infant is looking forward, the front light extinguishes, and one of the side lights appears. Randomization of side of presentation across trials and stimulus types is preferred as children may have side biases. When the infant orients to the side display, the auditory stimulus begins to play from a speaker adjacent to the flashing light and continues to play until the infant looks away for a criterion time (usually 2 s) or the maximum trial length is reach (usually 20-30 s). The infants' looking time toward the side light (excluding any short looks away that are less than the criterion time) is used as the dependent measure and is assumed to be a measure of infants' interest in continuing to listen to the auditory stimulus. Usually there are 2-4 warm-up trials prior to the presentation of 8-16 test trials. Warm-up trials are typically either additional trials similar to the test trials that are excluded from analysis, or consist of music. The total number of trials is kept short, as infant boredom becomes a significant factor after a relatively small number of trials. Test trials are divided into 2-4 categories (e.g. ungrammatical vs.

grammatical, familiar vs. unfamiliar) and a mean looking time is calculated across all the test trials of each categories.

HPP: A Study Sampler

Mandel, Jusczyk, and Pisoni (1995) were interested in examining when infants recognized their own names. They tested 4.5 month olds, presenting them with test trials of four types: repetitions of the child's own name (e.g, *Harry*), a stress-matched foil (e.g., *Peter*), and two different-stress foils (e.g., Gerard, Emil). Mandel et al, used a repeated measures ANOVA across the 4 trial types, as well as planned comparisons between "own name" and the other trial types..

Bortfeld, Morgan, and Golinkoff (2005) followed up on Mandel's finding to ask how recognizing the sound pattern of one's name might assist language acquisition. Could knowing the sound patterns of their own names help infants segment adjoining words from the stream of speech? Perhaps infants could useby the familiar sound pattern of their own name, to detect words that begin immediately following that name. Bortfeld et al. found that at 6 months of age, infants recognized a novel word that followed their own name but could not do so with an unknown name – regardless of its stress patterns. Furthermore, the effect generalized to whatever appellation their mother used for herself. So if a mother called herself *Mommy* that name was contrasted with *Tommy* to see if infants were using bottom-up statistical cues. When *Tommy* did not elicit children's recognition of the word that followed, it was concluded that even by 6 months of age infants were breaking into language with the use of top-down cues.

HPP has also been used to examine another type of top-down cue -- infants' incipient knowledge of grammar – at least how it might coincide with prosodic units at the sentence level (Hirsh-Pasek et al., 1987). These studies were among the first to probe whether infants taskle

language learning by attending to is suprasegmental aspects. Santelmann and Jusczyk (1998) used the HPP to test for toddlers' preference for grammatical versus ungrammatical auxiliary verbs in sentential contexts. They showed that 18-month-olds preferred to listen to a series of grammatical sentences of the form ("A man is baking") over ungrammatical sentences where *is* was replaced with *can* ("A man can baking"). This finding has been expanded to other languages like German (Höhle, Schmitz, Santelmann, & Weissenborn, 2006), Dutch (van Heughten & Johnson, 2010) and French (Legendre, Barriere, Goyer, & Nazzi, 2010), and in younger infants (Soderstrom, White, Conwell, & Morgan, 2007). In addition, a variety of studies (e.g. Gerken, Jusczyk, & Mandel, 1994; Hirsh-Pasek et al., 1987; Soderstrom, Seidl, Kemler Nelson, & Jusczyk, 2003) have explored the influence of prosodic characteristics on infants' early perceptions of grammatically-relevant units.

Variants of the HPP

Two significant changes are sometimes implemented with the HPP. The first is that some recent versions use a television screen as the visual display on each of the three sides (see Figure 4) rather than a flashing light. The screen could display a flashing circle, a checkerboard pattern, or even a meaningful visual display of relevance to the auditory stimulus.

--- Insert Figure 4 about here ---

Just as the IPLP can be used to teach new words or grammatical structures, the "modified" HPP familiarizes infants to a particular target stimulus which is then presented in some of the test trials. Typically, infants accumulate a certain amount of listening time (~30 s) to each target stimulus during the "familiarization" phase. For example, in Jusczyk and Aslin (1995) 7.5 month old infants heard two target words (e.g. "bike" and "feet") during the familiarization phase, and then were tested on sentences containing these words or words that

were not heard during familiarization. The reverse condition was also tested, in which the passages were heard during the familiarization phase and infants were tested on target words and new words presented in isolation at test. Infants preferred to hear the words they were familiarized to whether the familiarization was of single words or whether the words appeared in a passage. These findings suggest that well before infants can speak, they are storing information about the acoustic properties of the language stream.

Advantages and Disadvantages of the IPLP and HPP

Advantages. Because these methods do not require infants to respond to commands or perform any overt action, they have made it possible to examine questions about infants' linguistic knowledge and perceptual capabilities well before they produce words and sentence structures. They have therefore significantly advanced our knowledge of some of the earliest stages of language development and have caused a proliferation of research on infant speech perception. The popularity of these methods in particular stems from their relative simplicity (in methodology and equipment) compared with methods such as habituation or conditioned head turn.

The assumptions underlying the behavioral measures are straightforward and justified both theoretically and in practice – infants will continue to look longer at stimuli that hold their attention. Hardware consists of basic audiovisual and computer equipment that can be purchased off the shelf of any local electronics store. Until recently, it was by far the most inexpensive approach to examining infants' linguistic perceptions. One difficulty posed for the resource poor researcher, however, was that there has been no off-the-shelf software available to run the basic methods. Individual labs have developed in-house software to run the procedure. Another innovation that is having an impact on this methodology is the increasing affordability of eye-

tracking equipment, which allows for the automation of the coding of infants' looking behavior. As these automated methods are becoming more reliable, portable and affordable, they are increasingly becoming a high-tech option for implementing what has traditionally been a low-tech procedure.

HPP and IPLP are attractive also because the statistical analyses needed to interpret the findings are direct and accessible. Although there is a trend away from p-values and hypothesis testing toward effects sizes, and the rise of mixed model analyses has begun to have an influence, t-tests and analyses of variance are still the most common means of evaluating statistical findings in preference studies. In large part, this is because what is typically important is simply a "yes or no" answer to a question like, "Do infants of a particular age prefer stimulus X over stimulus Y?, "rather than the *size* of the difference between groups. One exception to this is the timecourse analysis of LWL studies that address the relative time it take infants to look at a particular visual stimulus accompanied by language. The LWL can therefore be used to probe for individual differences as well as responses to different stimuli.

The IPLP and the HPP enable the study of underlying mechanisms associated with language learning. Both methods enable researchers to examine infants' linguistic analyses prior to speech and this has had a profound impact on the field. The discovery that language development is occurring prior to the production of the first word at a prodigious rate, has changed the field's view of the "prelinguistic" child. In addition, the discovery of the infant's burgeoning language skill underscores the importance of early experience for language development. Practices such as talking with children and reading to them are seen as mattering earlier for children's future success than before these findings emerged (Hoff, 2013; Hirsh-Pasek et al., 2015).

Another benefit of these methods is their use for assessments. Because these methods lend themselves to probing children's early language competencies, there have been adaptations of the IPLP for tests of language ability. Friend and Keplinger (2008) developed a vocabulary test for toddlers and Pace, Morini, Golinkoff, de Villiers, Hirsh-Pasek, Iglesias, & Wilson (in preparation) created an assessment for 3- to 5-year-olds that tests vocabulary, grammar, as well processes of language learning.

Disadvantages. One issue that continues to plague preferences studies (as well as many other aspects of research in the social sciences) is the problem of replicability of statistical findings. This is a particular challenge for preference studies. For one, recruitment limitations often mean that studies are published with a very small N, and a resultant low power. Furthermore, infants' looking behaviors are driven by a host of uncontrolled factors in addition to the preference being examined within a study, contributing to the variance. Small differences in equipment set-up such as light levels, sound levels, or the structure of the test trials, can have unintended effects on infant behavior and drive differences between studies in ways that we do not yet understand well. The number of familiarization trials for example, can apparently cause children to exhibit a familiarity preference or a novelty preference at test. There is at present no way to predict whether either type of preference will occur (Thiessen, Hill, & Saffran, 2007). While it is important to deal head-on with these issues, the insights generated by these conceptually elegant methodologies have radically altered our understanding of early language development, and continue to drive a broad spectrum of research programs. Furthermore, by now there have been a large number of replications and extensions of research findings using these methods (e.g., Golinkoff et al., 2013).

Although these methods are powerful laboratory tools, they paradoxically may overestimate children's knowledge (Golinkoff et. al., 2013). When presented with two alternatives, children may solve the task through the process of elimination or mutual exclusivity (e.g. "I know this one, so, it must be the other one") (Halberda, 2006; Markman & Wachtel, 1988). For HPP, demonstrations that infants prefer one stimulus over another do not tell us *why* they have this preference, and these preferences may be quite superficial. It is therefore important not to overinterpret HPP findings but to follow up with additional research to probe the source of effects. Another way to say this is that we do not really understand the mechanisms underlying infants' responses.

Another potential limitation of using both methods is that they allow for only a limited number of items, given infants' short attention span. Finally, the fact that both methods indicate that language analysis and comprehension proceeds language production may not be true to the same degree for some non-Western societies (Bornstein & Hendricks, 2012).

Conclusion

We have described the goals, methodology, analyses, and questions addressed by two popular visual preference methods used with infants and toddlers to study language acquisition. Despite the advent of neurological measures, we hypothesize that these methods, relatively inexpensive and easy to implement, will continue to provide us with significant new insights into the process of language acquisition.

Key Terms: visual preference, language acquisition, grammatical development, lexical development

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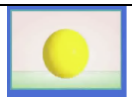
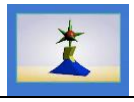
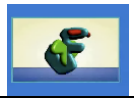
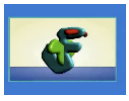
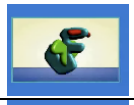
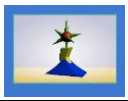
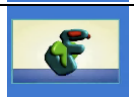
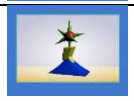
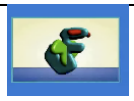
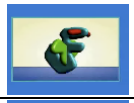
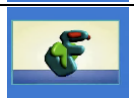
Table 1. *Visual and Linguistic Stimuli Used to Teach Two Novel Words in Either IDS or ADS from Ma et al. (2011)*

	Left side	Right side	Audio
Task familiarization phase			*Book! Look for the book! Can you find the book? That's the book.*
			*Ball! Look for the ball! Can you find the ball? That's the ball.*
Salience			No audio
Training Animations of objects (4 trials: 24 seconds each) The 2 trials (modi & blick) repeat.			*Look here! It's a modi! See the modi. That's the modi. Look what the modi is doing? Now the modi is going over here. Where's the modi going? Where's the modi? Modi! There's the modi!*
			*Look here! It's a blick! See the blick. That's the blick. Look what the blick is doing? Now the blick is going over here. Where's the blick going? Where's the blick? Blick! There's the blick!*
Test block 1 (4 trials: 2 for each word; 7 seconds each test)			*Modi! Where's the modi? Look at the modi! There's the modi.*
			*Blick! Where's the blick? Look at the blick! There's the blick.*
Reminder 1 (2 trials: 7 seconds each			*Modi! That's the modi. See the modi. It's a modi!*
			*Blick! That's the blick. See the blick. It's a blick!*
Test block 2 (4 trials: 2 for each word; 7 seconds each test)			*Modi! Where's the modi? Look at the modi! There's the modi.*
			*Blick! Where's the blick? Look at the blick! There's the blick.*

Note: An empty cell means one side (left or right) of the monitor is blank. The name assignment (*modi* and *blick*) and the side of presentation of the two novel objects are counterbalanced in four conditions in IDS and ADS respectively.

Figure 1. The Intermodal Preferential Looking Paradigm. The mother's eyes are closed and she has her arms wrapped around the baby. The auditory stimulus is saying, "Wow, look at the dog! See the dog!" Source: Photograph by R. Golinkoff. Appeared in Golinkoff, R. M. & Hirsh-Pasek, K. (2008). How toddlers begin to learn verbs. *Trends in Cognitive Science, 12,* 397-403.

Figure 2. The Interactive Intermodal Preferential Looking Paradigm (Hollich et al., 2000). Children sit on a parent's lap (the parent keeps her eyes closed) in front of a rotating board that can flip over to reveal a pair of objects affixed with Velcro. The experimenter stands or stoops behind the board and, using a script, presents the linguistic stimuli. A hidden camera records children's looking preferences toward the two objects on the board. A mirror filmed behind the child indicates which objects are displayed.

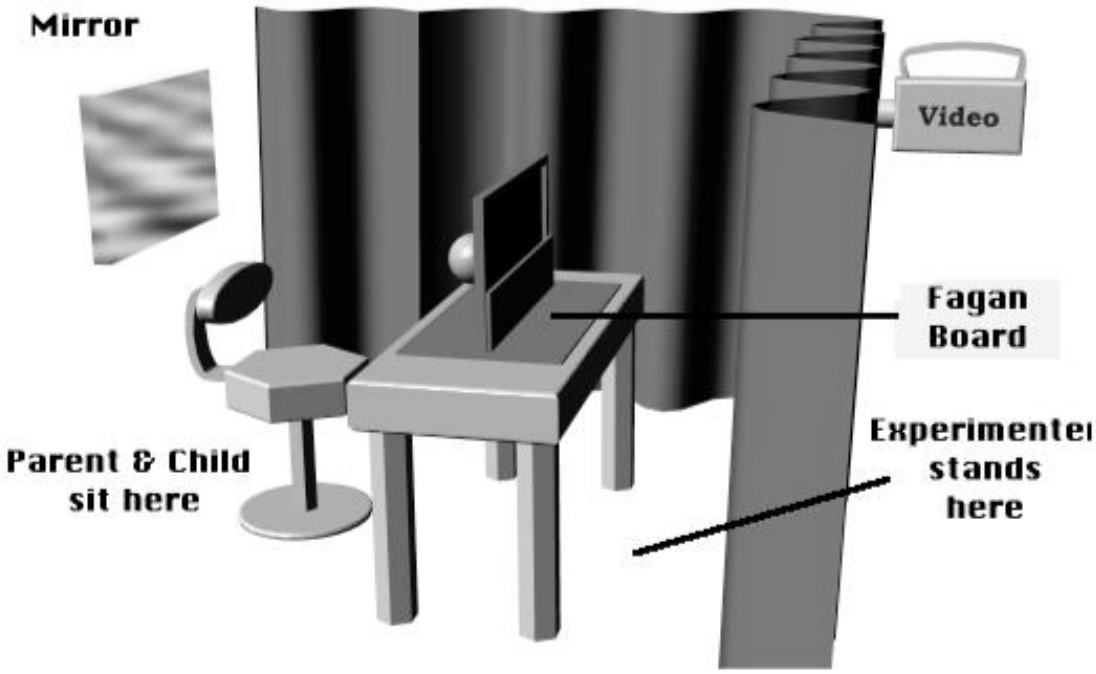


Figure 3. Children's responses over time, separated by condition and by whether children fixated the target or the distractor picture at the onset of the spoken target word. The y axis indicates the proportion of trials on which children were (at that moment) fixating a different picture than the one they fixated at the onset of the target word. The dashed vertical line indicates the average offset of the target word (Swingley & Aslin, 2000; p. 158). Pron. = pronounciation

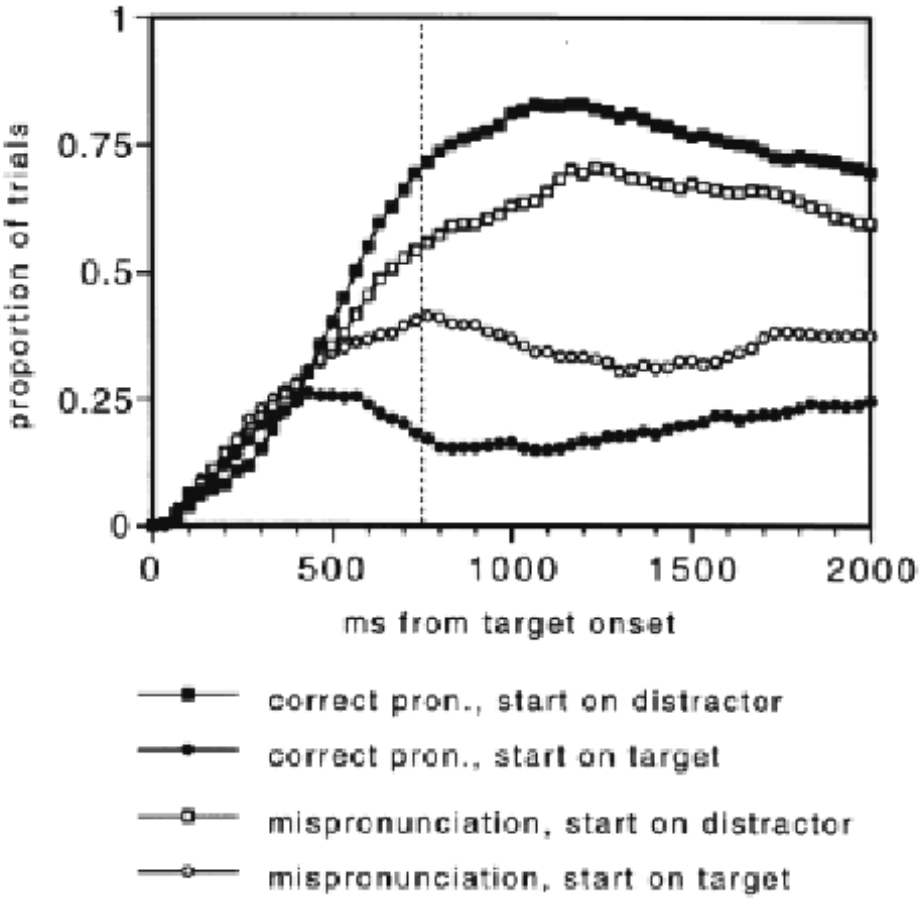


Figure 4. A recent version of the Headturn Preference Procedure using video screens. Baby (not in view) is situated in the mother's lap facing forward. Each trial begins with a circle flashing in the front screen (Panel 1). When the infant looks toward the front screen, the front panel goes blank and a circle flashes on one of the side screens (panel two). When the infant looks to this side screen, it is replaced by a static colourful checkerboard pattern and the sound stimulus begins to play from a speaker located under the screen. A video camera is located below the screen and the experimenter records the baby's looking (and therefore controls the screens) from an adjacent room. Source: Soderstrom et al. (2003).