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Twenty-Five Years Using the Intermodal Preferential Looking Paradigm to Study Language Acquisition: What Have We Learned?

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Abstract

The intermodal preferential looking paradigm (IPLP) has proven to be a revolutionary method for the examination of infants' emerging language knowledge. In the IPLP, infants' language comprehension is measured by their differential visual fixation to two images presented side-by-side when only one of the images matches an accompanying linguistic stimulus. Researchers can examine burgeoning knowledge in the areas of phonology, semantics, syntax, and morphology in infants not yet speaking. The IPLP enables the exploration of the underlying mechanisms involved in language learning and illuminates how infants identify the correspondences between language and referents in the world. It has also fostered the study of infants' conceptions of the dynamic events that language will express. Exemplifying translational science, the IPLP is now being investigated for its clinical and diagnostic value.

Keywords

language acquisition, intermodal preferential looking paradigm, emergent coalition model

Brown: "Adam, which is better, a sand or some sand?"

Adam: "Pop goes weasel!"

> *Roger Brown's subject Adam's irrelevant response upon being asked to decide which of the two phrases sounded better*
>
> —*R. Brown (1973)*

> Direct description of the child's actual verbal output is no more likely to provide an account of the real underlying competence than in the case of adult language. . .
>
> Obviously one can find out about competence only by studying performance, but this study must be carried out in devious and clever ways. . .
>
> —*N. Chomsky (1964,* p. 36*)*

When the microscope was invented, scientists got a closer look at some of the structures that they had hypothesized about but never seen (Boorstin, 1983). This is a common story in the history of science: The advent of new technological tools makes the invisible visible, permitting scientists to collect new data and sparking the development of new theories (Greenwald, 2012). Before the intermodal preferential looking paradigm (IPLP) appeared (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987), the field of language acquisition had been forced to rely almost exclusively on descriptive studies of young children's language output as generated

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at home or in the lab. Undoubtedly, the focus on language production provided a rich source for language acquisition theories (e.g., Braine, 1963; Brown, 1973; Shatz, 1978). However, a reliance on language production missed important but hidden language sensitivities that both fueled children's language development and could give insights into their understanding of the world. Language production reflected the observable half of children's language ability; comprehension was the other, inaccessible half of what children knew about language. Just as astronomers were not satisfied to study only the light side of the moon, researchers in language acquisition recognized that the dark side—language comprehension—held secrets to a process that had to be unlocked.

When researchers probed children's language comprehension, however, they were often greeted with uninformative responses, especially by children in the proverbial "terrible twos." Commonly used procedures, such as asking children to act out commands or point to pictures, having them make judgments about the felicity of different sentences and phrases, or eliciting production of specific structures, were often met with resistance and noncompliance (e.g., Brown, 1958). Consider the task of pointing at pictures. What appears to be a simple task, given that parents and children engage in reading books together, actually has a number of problems. First, young children do not understand the conventions artists use to indicate action (Friedman & Stevenson, 1975). Those little lines around joints designed to indicate motion have little significance for children until age 5 (Cocking & McHale, 1981). Second, distinctions between who is doing what to whom in events—what sentences are about—may only be incompletely captured in static two-dimensional displays, making it difficult to study children's comprehension of relational terms like verbs. Even when issues with the stimuli are avoided, children may be unwilling to respond to a request despite their understanding of the linguistic structure in question, as in the classic response that Roger Brown got to his inquiry about *some sand* versus *a sand* at the beginning of this article (Brown, 1973). Finally, just as with adults in elicitation tasks or corpus analysis, the absence of a particular structure does not necessarily mean that the structure is beyond children's ken.

What was needed was a method that did not demand overt responses from noncompliant, preverbal children and that might allow them to reveal what they knew of language before it fully emerged.[1] The key question to be addressed was whether many parents were correct: Could children understand more language than they were able to produce? The alternative hypothesis was that parents were inadvertently providing cues to their children (such as gesture, facial expression, and body orientation) that allowed toddlers to appear more linguistically capable than they really were.

But how could researchers study language development before children could talk? In 1974, Horowitz asked whether visual fixation might be used as a window onto language development (and see Colombo & Bundy, 1981). Then Spelke (1979), in a dynamic version of Fantz's (1958, 1964) paired-comparisons method, showed 4-month-olds two events side-by-side (e.g., a person clapping hands and a donkey jumping onto a table) accompanied by an auditory stimulus matching only one of them (e.g., the sound of hands clapping). Infants looked at the event that matched the auditory stimulus longer than the event that did not. Although Spelke's study did not test children's language knowledge, this inspirational study led to the introduction of linguistic stimuli and the birth of the IPLP (Golinkoff et al., 1987; Hirsh-Pasek & Golinkoff, 1996).

In this article, we offer a selective review of the language development research that has used the IPLP and its methodological extensions. Since its introduction to the field 25 years ago, the IPLP has addressed a variety of research questions. We categorize the relevant studies into five areas. First, we review how the classic version of the IPLP has been used to assess infants' emergent language knowledge. Second, we describe the word-learning IPLP used to examine how children learn novel words under laboratory conditions. Third, we describe the looking-while-listening (LWL) procedure, an IPLP offshoot, which offers information about online, moment-to-moment speech processing. Fourth, we present studies using another offshoot of the IPLP, the preferential looking paradigm without language (PLP), which enables examination of the perceptual and conceptual underpinnings of language development (e.g., Göksun et al., 2011). Fifth, we describe recent efforts to turn the IPLP into a clinical and diagnostic assessment. And finally, we reflect on some of the limitations of the IPLP and summarize what we have learned. Unless otherwise noted, the studies we review all used the IPLP or one of its offshoots.

The Classic Intermodal Preferential Looking Paradigm (IPLP): Assessing Infants' Emergent Language Knowledge

Birth of the IPLP

The IPLP showed that children's linguistic comprehension was startlingly in advance of their production.[2] Following the creation of the IPLP, researchers could examine children's burgeoning lexicons as well as their

incipient grammatical competencies. It is also important to note that the advent of videotape made it possible to present dynamic events. And because the paradigm did not require children to respond to commands or perform any overt action, it allowed babies to show their language knowledge well before they produced those words and sentence structures.

Other techniques in the literature had also suggested that young children's language comprehension exceeded their production. Object-selection tasks in which children indicated their word construal by choosing from among a set of objects had been used with children as young as 17 months of age. Questions about the comprehension of object names or children's understanding of common and proper nouns (e.g., Katz, Baker, & Macnamara, 1974), for example, can sometimes be answered using object-selection tasks. But for questions that focus on the comprehension of verbs and events that require motion, videotaped stimulus displays opened a new vista for exploring language knowledge through dependent variables like visual fixation or pointing (e.g., Naigles, 1990; see Hoff, 2011). As will be later discussed, once children are old enough to reliably follow directions, the IPLP can also utilize pointing (e.g., Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008) to ask children to select between two dynamic video displays. The advantage of requiring children to make a selection—either through looking or pointing—offers researchers a window on how children are construing the language they hear.

The first paper using the IPLP (Golinkoff et al., 1987) examined whether 16-month-old infants could comprehend nouns (e.g., dog, shoe) and verbs (e.g., drink, wave). Seated on the lap of a parent whose eyes were closed, infants saw two video clips presented simultaneously on two television monitors and heard a linguistic stimulus from a central speaker. For example, in the noun experiment, infants saw two static objects (e.g., a shoe and a boat) and heard, "Where's the boat? Find the boat!" In the verb experiment, infants saw two dynamic actions carried out by the same actress (e.g., a woman drinking from a coffee cup and the same woman blowing on a sheet of paper) and heard, "One is drinking and one is blowing. Which one is drinking?"

The first two experiments (noun and verb comprehension, respectively) found that 16-month-olds looked significantly longer at and oriented faster to the objects or actions that matched the language they heard than to the displays that did not match. Notably, although these participants had not begun to produce any verbs (based on observation during experimental sessions and maternal reports), they appeared to comprehend the verbs.

That first paper also probed whether 28-month-olds, already using word order in their own sentences, could use the order of words in a sentence to find which member of a pair of dynamic events presented side by side matched the language they were hearing (Golinkoff et al., 1987). English relies heavily on word order for conveying meaning: "Brutus killed Caesar" preserves history, whereas "Caesar killed Brutus" does not. As the visual events in Golinkoff et al. (1987) were constructed to differ only by "who-did-what-to-whom," this was an ostensibly difficult task, requiring that infants first analyze the events to first determine which character was the agent and which was the patient (i.e., who was acted upon) and then use the language offered to find the particular event described. Appendix B shows the design of this study. On one monitor toddlers saw, for example, Cookie Monster tickling Big Bird from behind while Big Bird held a box of toys; on the other monitor, toddlers saw Big Bird tickling Cookie Monster. In the test trial, children heard, "Where's Cookie Monster tickling Big Bird?" Note that since both characters were moving, children could not just look to the event where the named character was in motion to solve the task (an assertion verified in Experiment 4 of Hirsh-Pasek & Golinkoff, 1996).

But could children identify Big Bird and Cookie Monster? Unless they could, the word order test would be invalid. Test trials for word order comprehension were preceded by a *character identification segment* and salience trials (see Appendix B). In the character identification segment, Big Bird appeared and waved to the viewer on one screen and Cookie Monster waved to the viewer on the other screen as the voiceover asked, "Where's Big Bird? Find Big Bird!" (or Cookie Monster; Fig. 1). The character identification segment was followed by salience trials to familiarize infants with the complex visual stimuli before language was overlaid. As Appendix B shows, infants saw Cookie Monster tickling Big Bird on one screen followed by Big Bird tickling Cookie Monster on the other screen. The voiceover said, "Look who's tickling!" without naming either of the actors. Salience trials permitted researchers to examine whether the visual stimuli within a pair were equated for attractiveness. A hidden observer recorded infants' fixation to each side by pressing hand held buttons. Latencies to the matching and nonmatching displays and total visual fixation time to the two displays served as the dependent variables.

In the third experiment, 28-month-old children who were already producing multiword utterances preferred to watch an event that matched the sentence they heard over an event that contained the same participants and same action but depicted a reversed relationship between the participants. This finding offered validity for the use of the IPLP to study grammatical development. Furthermore, building on this finding, Hirsh-Pasek and Golinkoff (1996) showed that 17-month-old infants with as few as two words in their productive vocabularies also used word order to watch the specific event described. These studies

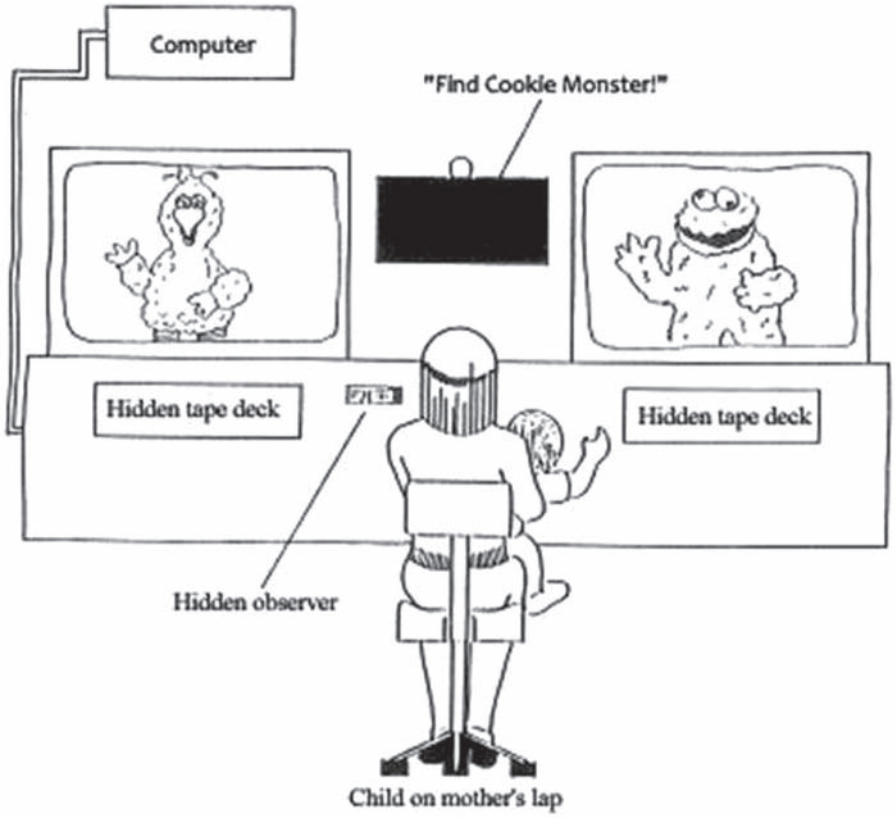

Fig. 1. The Intermodal Preferential Looking Paradigm (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996). The infant is seated on a parent's lap in front of two televisions or one large television with a split-screen. Parents either wear blacked out sunglasses to obstruct a view of the screens or close their eyes. The linguistic stimulus matches only one of the displays shown on the screen. To allow for online and offline coding, a hidden camera below the television records infants' visual fixation. Here, Cookie Monster and Big Bird are shown in the character identification segment prior to the word order experiment in Golinkoff et al. (1987) and Hirsh-Pasek and Golinkoff (1996).

were the first reliable tests of word order comprehension. Until this point, researchers could only speculate about whether young children were sensitive to the grammar of their language prior to actually talking themselves. Yet without demanding that infants act out commands, select objects, point, or even talk, researchers were now in a position to probe the underpinnings of language knowledge. This research also made the general point that language development occurred more rapidly than previously thought. Language comprehension was clearly ahead of language production and could now be used as a vehicle to study burgeoning language knowledge.

Validity of the IPLP

Does the differential visual fixation of two images reliably reflect children's language knowledge? One way to answer this question is to see whether IPLP findings relate to other language measures, such as parental report (e.g., Fenson et al., 1994). A number of studies have validated the IPLP by showing that infants do indeed comprehend words parents reported that their children knew (e.g., Behrend, 1990; Houston-Price, Mather, & Sakkalou, 2007; Robinson, Shore, Hull Smith, & Martinelli, 2000). In fact, the IPLP may be a more sensitive measure of children's language than parental reports. In one study, parents first marked the to-be-tested words as "understood," "heard before but not understood" ("frontier" words), or "never heard before" (Robinson et al., 2000). In an IPLP task, 15-, 18-, and 22-month-old infants showed comprehension of the "understood" words but not of the "never heard before" words. However, the 22-month-olds also showed comprehension of the frontier words. A similar study found that 15-, 18-, and 21-month-old infants preferred to look at target images of even the words that parent's reported as unknown (Houston-Price et al., 2007).

Thus, the IPLP is a valid, sensitive measure of young children's language knowledge. Once the first IPLP studies (Golinkoff et al., 1987) supported what parents had long claimed—that children understood more language than they produced (Benedict, 1979; Goldin-Meadow, Seligman, & Gelman, 1976; Houston-Price et al., 2007)—researchers began to use the IPLP as a tool to examine children's emerging language ability.

There have been several methodological improvements since the first IPLP studies (e.g., Golinkoff & Hirsh-Pasek, 2012; Hollich, Hirsh-Pasek, & Golinkoff, 1998), including the use of a single television with a split screen and the replacement of online coding with offline coding. The intertrial stimulus was also changed from a black screen to more engaging stimuli such as a giggling baby face or a musical interlude. We review offshoots of the original IPLP at relevant places in the following sections. By enabling researchers to probe infants' sensitivity to a range of linguistic stimuli and address many of the theoretical and empirical issues previously raised, the IPLP began to change the landscape of the field of language acquisition.

Assessing Emergent Language Knowledge Through Language Comprehension

To learn a language, infants must detect and distinguish the sounds that are meaningful in their native tongue, discern how particular words map onto the world, and acquire language-specific rules by which speakers construct sentences to convey different meanings (e.g., for reviews, see Hirsh-Pasek & Golinkoff, 1996; Parish-Morris, Golinkoff, & Hirsh-Pasek, 2013; Woodward & Markman, 1998). This next section reviews findings on young children's sensitivity to phonological, lexical, grammatical, and morphological information, findings that might not have surfaced without the IPLP.

Sensitivity to the acoustic properties of language and phonological knowledge

As a listener, speech signals enter the ear as sound waves that are transmitted to the auditory cortex, from which the brain extracts speech sounds and sequences and further activates the meaning of the word (Hu, Gao, Ma, & Yao, 2012; Pulvermüller & Fadiga, 2010; Saffran, Werker, & Werner, 2006). An immediate question arises: Do children attend to the acoustic details of the language input or do they engage in merely a broad-brush analysis? This question is essential because, in order to acquire a language, children have to identify the categorical membership of phonemes and ignore irrelevant information such as the gender or age of the speaker. This problem is heightened when children are learning multiple languages at the same time.

To address the question of how infants heard phonemes in words, IPLP studies examined children's detection of mispronunciations when only one phoneme was changed in a familiar word. If children do attend to acoustic detail, they should notice mispronunciations (e.g., Bailey & Plunkett, 2002; Ballem & Plunkett, 2005; Mani & Plunkett, 2007; Swingley, 2003; Swingley & Aslin, 2000, 2002). By 14 months, infants orient to the matching visual stimuli faster when words are correctly pronounced rather than when they are mispronounced (e.g., *baby* vs. *vaby*) (Swingley & Aslin, 2002). This finding has been replicated with word-initial consonants in newly learned words in 18-month-old infants (Bailey & Plunkett, 2002; Ballem & Plunkett, 2005), with word-medial vowels in 14-month-old English-reared infants (Mani & Plunkett, 2007, 2008), and with word-medial consonants in 19-month-old Dutch-reared children (Swingley, 2003).

Note that infants store more details of the acoustic stimulus than necessary, which causes them to fail to appropriately recognize a word when its acoustic properties change slightly, such as when it is spoken by a different speaker (e.g., Newman, 2008). That is, they do not yet know which are the essential features of phonemes.

Lexical knowledge

With the help of the IPLP, researchers detected some of the earliest evidence of infants' comprehension of words. In two stunning demonstrations, 6-month-old infants were linking phonological forms to meanings (Tincoff & Jusczyk, 1999, 2012). When shown videos of their own parents and strangers, infants demonstrated that they had associated the word "mommy" and "daddy" with their own mothers and fathers, respectively. They also know the words "hands" and "feet." Between 6 and 8 months, infants can associate many common words with their referents (Bergelson & Swingley, 2012).

By probing infants' comprehension with varying visual stimuli, researchers found that infants' words may initially be narrowly construed. This is analogous to what infants do in the domain of phonology. Using the IPLP, studies show that infants' initial understanding of words tends to be limited to prototypical exemplars. This tendency occurs with nouns (Meints, Plunkett, & Harris, 1999), prepositions (Meints, Plunkett, Harris, & Dimmock, 2002), and verbs (Meints, Plunkett, & Harris, 2008). For example, 2-year-old English-reared children looked significantly longer at typical events (e.g., a woman eating an apple) than at atypical events (e.g., eating a houseplant) in a paired display when hearing a verb (e.g., eating; Meints et al., 2008). The narrow-to-broad development in language learning is also demonstrated by children's

initial underextension of familiar verbs. English-reared 20- and 26-month-olds looked significantly longer at the target actions when hearing the familiar verbs *kick* and *pick up* (Forbes & Poulin-Dubois, 1997), but they could not find the target when the actions were performed differently or had new outcomes.

Syntactic knowledge

Some of the most impressive demonstrations of infants' emergent language knowledge are observed in their comprehension of sentences. Grammar allows us to put words into sentences that specify the relations between objects in events. Studies using the IPLP reveal that before uttering their first sentences, or even their first word combinations, infants are already showing rudimentary knowledge of *syntax* or the implicit rules for how sentences are created. When the IPLP came on the scene in the late 1980s, debate raged about whether children began their language journey with exclusively *semantic* knowledge (action role categories such as agent, patient or action receiver, and action) or with *syntactic* knowledge (grammatical categories such as subject, object, and verb) as well (Golinkoff, 1981). In other words, were children using language as adults do or were they merely combining words for the actors in events without really using the grammar of their language? Gleitman (1981) argued for parsimony: Crediting the child with only semantic categories would require another process to explain children's transition to syntactic categories (see Fisher, 2002 for a contemporary version of this debate). Adjudicating between these positions was difficult before the advent of the IPLP.

Before asking about children's early syntactic knowledge, a preliminary question arises: Do children interpret sentences as "packages of words" that bear some relationship to each other or do they simply attend to individual words (Hirsh-Pasek & Golinkoff, 1996)? Researchers showed 13- to 15-month-olds a video of a woman kissing a set of keys while holding a ball and another video of the same woman kissing the ball while dangling the keys. The accompanying linguistic stimulus referred to only one of the events (e.g., "She's kissing the keys!"). Had infants attended only to individual words rather than the relationship among the words, they would have looked equally to both events, which contained exactly the same elements. However, infants looked significantly more at the matching event, suggesting that they recognized that words in sentences form units that specify unique events in the world and are not just isolated elements.

The IPLP also revealed that young children attend to word order, a grammatical device used heavily in English (less so in languages with strong inflectional systems, such as Hungarian; MacWhinney, 1976). Early demonstrations of word order comprehension by Golinkoff et al. (1987) and Hirsh-Pasek and Golinkoff (1996) in the studies mentioned earlier left some remaining issues, however. Perhaps children solved the word order task by relying on knowledge of specific verbs rather than on a more general understanding of the grammatical function of word order (Tomasello, 2000a). In this argument, if infants were familiar with the verb *tickling*, for example, they might look for the agent (the tickler) to come before the verb in the sentence and the recipient of the tickling to come after. This possibility was ruled out by the demonstration that infants could perform the word order task in the IPLP with unfamiliar verbs (Gertner, Fisher, & Eisengart, 2006). Twenty-one-month-old infants preferred to look at a duck doing an action to a bunny rather than a bunny doing a different action to a duck upon hearing, "Look! The bunny is *gorping* the duck."

Another demonstration of surprising grammatical capacity was offered by Seidl, Hollich, and Jusczyk (2003). A test session began with a single event, such as a book moving on its own, hitting some keys, and glancing off. Children were then shown the book and the keys side by side while hearing either a question that asked about the subject (e.g., "What hit the keys?") or a question that asked about the object (e.g., "What did the book hit?"). Notice that the answer to the subject question is not the keys, which are mentioned, but the book, which is not mentioned. Likewise, the answer to the object question is not the book but the keys. By 15 months of age, children showed tremendous linguistic sophistication in their response to the subject question by looking more to the target (the book)—a noun they had not heard mentioned. The only way they could have done that was to rely on grammar to recognize which item was missing in the question. By 20 months, children succeeded with subject and object questions. Given that research suggests that answering "wh-" questions is difficult even for 3-year-olds (Ervin-Tripp, 1970; Tyack & Ingram, 1977), this study suggests that requiring children to produce a verbal response may have masked their understanding whereas the IPLP task allowed children to reveal their syntactic competence (Seidl et al., 2003).

The IPLP further shows that young children appreciate sentences' hierarchical structure. For example, in hearing "I'll play with this yellow bottle and you can play with that one," adults treat the phrase "this yellow bottle" as a noun phrase and assume that the word "one" maps back to the whole phrase, "yellow bottle." This is called a *proform*, analogous to a pronoun where one element stands for another (as in "he" and "Joe"). To find out whether infants understand the hierarchical structure of noun phrases, researchers showed 18-month-old infants a yellow bottle on the screen accompanied by the sentence, "Look! A yellow bottle" (Lidz, Waxman, & Freedman, 2003). At test, children saw two images side-by-side (a yellow bottle and a blue bottle) and heard, "Do you see

another one?" If infants interpreted "another one" as meaning "another bottle," but not necessarily a yellow bottle, they should have looked at the blue bottle. However, children preferred to look at the yellow bottle, suggesting that they interpreted the proform *one* as standing for the whole phrase "yellow bottle." Both of these studies show syntactic precocity not revealed in children's early productions.

Finally, children also show sensitivity to grammatical words as well as to affixes that carry meaning well before they reliably produce them. "Function" words that carry mostly grammatical meaning (such as *the* and *and*) or morphological inflections (such as the plural morpheme *–s*) appear relatively late in children's production, but the IPLP shows they are processed at an early age. For example, 18- and 24-month-olds saw pairs of images of 16 familiar nouns (e.g., a book and a ball) in one of four conditions in which they heard four types of prompts: (a) grammatical ("Can you see *the* ball?"), (b) ungrammatical (". . . *and* ball?"), (c) nonsense (". . . el ball?"), and (d) null (". . . ball?"; Kedar, Casasola, & Lust, 2006). Children at both ages looked longer at the target in the grammatical condition. IPLP research also investigated children's sensitivity to the plural morpheme (Jolly & Plunkett, 2008; Kouider, Halberda, Wood, & Carey, 2006). Children saw a pair of novel images, one of which contained a single object while the other showed a pair of the same objects. The images were accompanied by a sentence containing a novel word with or without the English plural inflection /s/ (e.g., "Look at the jeel/jeels!"). By 24 months, children looked longer at the image that matched the presence or absence of the plural morpheme than at the one that did not match.

In summary, the IPLP has yielded information about young children's linguistic sensitivities that are not apparent in their production. The weight of the evidence suggests that toddlers are engaging in much linguistic analysis prior to speech. There are three reasons why recognizing this precocity is important. First, it alters our view of the process of language development. If so much is happening prior to the production of the first word or sentence, theories of language development need to change to accommodate this precocity. Second, the discovery of "hidden" language skill highlights the importance of early experience for language development. When researchers believed that "preverbal" infants were not analyzing the linguistic stream, there was no need to remind the public about the importance of reading to and talking to their children. Now that we know that differences in early language experience matter greatly for children's future success in school (e.g., Hoff, 2013), the ramifications of these results can find their way into the public consciousness. Finally, once we understand more about the linguistic tasks young children are tackling, we can consider developing targeted early interventions. Hart and Risley (1995) were among the first to point out large differences in the amount and type of language young children were exposed to and the consequences for vocabulary and IQ. Given that IQ correlates with school achievement, interventions to increase children's language are now perceived as important.

The Word-Learning IPLP: Examining Young Children's Novel Word Learning

The first use of the IPLP was to assess infants' language knowledge; later researchers modified the classic IPLP to examine how infants and young children learn novel words. To do so, they added training trials to the word-learning IPLP, in which a single image of an object (or event) is accompanied by a novel word (e.g., "Look at the modi. It's a modi."), allowing children to make a word-referent association (e.g., Houston-Price, Plunkett, & Harris, 2005; Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011; Schafer & Plunkett, 1998). At test, infants are asked to generalize the novel words they are taught during the training trials.

The word-learning IPLP advanced our understanding of the processes of early word learning in two ways. First, researchers probed the resources or cues used in early word learning and how children's reliance on these cues changed over development (Golinkoff & Hirsh-Pasek, 2006). Second, researchers began to study more than noun acquisition, the part of speech that had dominated language acquisition research (e.g., Nelson, Hampson, & Shaw, 1993). Because the IPLP enabled the presentation of well-controlled dynamic actions and events, researchers could turn their focus to verbs—arguably the architectural centerpiece of the sentence (Gleitman, 1990).

This section of the article begins by reviewing a framework—the emergent coalition model of language acquisition (ECM; Hollich et al., 2000)—that organizes the word-learning research into children's use of perceptual, social, and linguistic (both syntax and morphological) cues. It ends by reviewing the debate on whether nouns are easier for children to learn than verbs.

Multiple cues in word learning

Language development depends upon children hearing language and inferring what in their environment that language is about. Thus, language learning requires that infants parse language into its units (e.g., syllables and words) and segment events in the world into their components (e.g., actors and actions). Infants are born pattern seekers who mine the available cues around them to master their native tongue (Golinkoff & Hirsh-Pasek, 1999). Among the available cues are attention-getting

objects and events, speech addressed specifically to infants with pitch exaggerations and exclamations, and the social cues that accompany speech such as parents' pointing and eye gaze. The ECM (Golinkoff, Hirsh-Pasek, & Hollich, 1999; Hirsh-Pasek & Golinkoff, 1996; Hollich, Hirsh-Pasek, Tucker, & Golinkoff, 2000) is a hybrid model that combines contributions from three competing and leading theoretical approaches to word learning: the perceptual (e.g., Brandone, Pence, Golinkoff, & Hirsh-Pasek, 2007; Plunkett, 1997; Smith, 2000; Yu & Smith, 2007), pragmatic (e.g., Nelson, 1996; Tomasello, 2000b), and constraints theories (e.g., Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989; Merriman & Bowman, 1989; Waxman & Kosowski, 1990). The ECM is not an "either/or" theory but rather a "when and how" account of vocabulary growth positing that children use different strategies for word learning at different points in time.

The ECM makes two assumptions that were tested in word-learning IPLP studies. First, children are surrounded by multiple inputs to language acquisition in the form of perceptual, social, and linguistic information. Second, these inputs are differentially weighted over development such that children first rely on perceptual information, then social cues in the service of word learning, and finally linguistic information. It is important to note that none of these sources of information goes away. Thus, even adults may default to perceptual cues, for example, when looking for a referent at a brunch. When the host asks, "May I have the mortadella?" and the guest does not know what mortadella is, the guest might ask herself, "Which object in the refrigerator do I not recognize?" to respond to the request.

By varying the ways in which novel words are taught, the word-learning IPLP offers unique opportunities to examine when and how infants utilize the perceptual, social, and linguistic cues available for word learning. As in the classic IPLP, children are expected to prefer to look at the visual stimuli that match the word they are offered over the stimuli that do not match the offered word. To examine infants' attention to social cues in word learning, and to see whether reliance on social cues increased in comparison to perceptual information, researchers adapted the classic IPLP into the *interactive IPLP* (Hollich et al., 2000). Instead of presenting the visual and auditory stimuli on a television, a human experimenter delivered the stimuli. An infant sits on the lap of a parent whose eyes are closed on one side of a flipboard placed on a table. The experimenter, standing behind the board and facing the child, attaches two objects to Velcro strips on her side of the board. Then she rotates the board to reveal the objects to the infant. The experimenter either prompts the infant to look at the objects (in salience and test trials) or labels only one of the objects (in training trials; see Fig. 2). Critically, when labeling the object, the experimenter can provide social cues such as enthusiastically looking back and forth between the object she

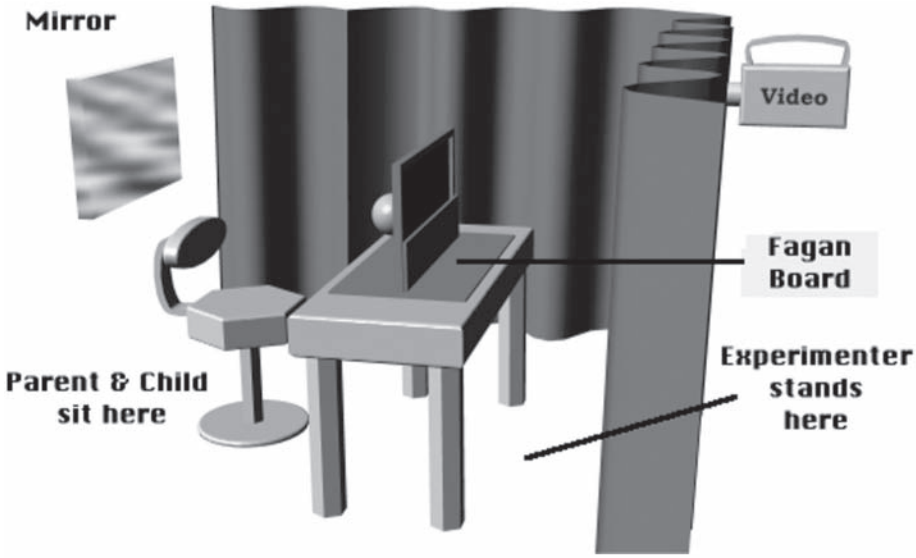

Fig. 2. The Interactive Intermodal Preferential Looking Paradigm (Hollich, Hirsh-Pasek, Tucker, & Golinkoff, 2000). Children sit on a parent's lap (the parent keeps her eyes closed) in front of a rotating board that can flip over to reveal a pair of objects affixed with Velcro. The experimenter stands 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.

intends to label and the child's eyes. We next present findings from studies using the classic IPLP and the interactive IPLP.

Perceptual cues. Perceptual cues, such as the attractiveness of an object and the exaggerated phonological and intonational properties of infant-directed speech, are the first cues infants use in learning new words (Hollich et al., 2000; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006). One study found that 21-month-olds learned novel words presented in the sing-song, exaggerated lilt of infant-directed speech, but not when presented in adult-directed speech; by 27 months, children learned the novel words in both types of speech (Ma et al., 2011). However, children continue to rely on perceptual cues such as voice quality even at later ages. After being taught two novel words, 23-month-olds showed word learning performance when the original speaker produced the word at test, but they failed to do so when a new speaker produced the word at test (Houston & Jusczyk, 2000; also see Newman, 2008 for a review).

Social cues. Social cues from a speaker, such as looking at an object or handling it, become important sources of information for figuring out what the speaker is talking about (Hollich et al., 2000). When 10-month-olds were shown an interesting object (e.g., a colorful noisemaker) and a boring object (e.g., a beige soda cap opener) on the flipboard, they only learned the name for the interesting object (Pruden et al., 2006). In fact, when the experimenter looked at and named the boring object, 10-month-olds reliably mismapped the word to the interesting object, effectively ignoring the speaker's social cues. Twelve-month-olds no longer mismapped a label to the interesting object, although they still failed to learn the name of the boring object (Hollich et al., 2000). By 19 months (and robustly by 24 months), children reliably used the experimenter's eye gaze to learn the name of the boring object, overriding the lure of the interesting object. Other work by Baldwin (1991) also illuminated the importance of social cues for word learning. Children do not act as "associative machines" but wait to discern the intention of the speaker.

Linguistic cues. The ECM posits that as children's linguistic knowledge increases, they eventually use language to learn language. Roger W. Brown (1957), a pioneer in the study of language acquisition, was the first to notice this phenomenon. He showed that 3- and 4-year-olds used sentence structure and morphological cues to map a novel word—"Can you show me a latt?" or ". . . some latt," or ". . . latting"—onto an object, a substance, or an action, respectively. Brown's groundbreaking insights set the stage for later work on children's sensitivity to syntactic cues using the IPLP.

Syntactic cues. In a dramatic demonstration of how children use syntactic cues to learn the meaning of verbs, Landau and Gleitman (1985) found that a blind child (Kelly) could distinguish between the meanings of the verbs *look* and *see*. As Kelly only had access to the syntax in which these words were encountered, they called this process *syntactic bootstrapping* (Gleitman, 1990). The fundamental insight was that children use the syntactic structure in which a new word appears to glean something of its meaning. For example, in English, listeners tend to interpret *blork* as a causative verb when hearing it used in the transitive sentence, "John blorked Mary." But upon hearing that same verb in an intransitive sentence, as in, "John and Mary blorked," it is more likely to be interpreted as something they did together and not as something John did to Mary. The same is true for other parts of speech. Upon hearing, "The blork hit John" a listener is likely to interpret *blork* as a noun and not as a verb (Fisher, 2002; Gertner et al., 2006; Lidz et al., 2003; Naigles, 1990; Naigles, Bavin, & Smith, 2005; Waxman, 2004; Yuan, Fisher, Gertner, & Snedeker, 2007; but see Dittmar, Abbot-Smith, Lieven, & Tomasello, 2008). A critical question for language development is when the syntactic bootstrapping process begins to operate in children's word learning.

In the first IPLP study on syntactic bootstrapping, 25-month-olds were shown a single video of a duck and a bunny performing an action together (arm circles) while, at the same time, the duck made the bunny squat (Naigles, 1990). In a between-subjects design, children heard either an *intransitive* sentence (i.e., "The bunny and the duck are kradding") or a *transitive* sentence ("The duck is kradding the bunny"). At test, the actions separated: One monitor showed the actors doing arm circles without squatting, while on the other monitor, the causative squatting event was shown without arm circles. The same sentences were offered. Now children revealed how they had construed the target sentence during familiarization. Those who had heard the intransitive sentence ("The bunny and the duck are kradding") watched the arm circles event more; those who heard the transitive sentence ("The duck is kradding the bunny") watched the squatting scene more. As *kradding* was a nonsense verb, this finding suggests that different sentence frames carry different meanings and that children can exploit them to interpret a novel verb. A subsequent study showed that 19-month-olds rely on the number of nouns in the sentence to decide which type of syntactic frame is implicated (Yuan, Fisher, & Snedeker, 2012; see also Brandone, Addy, Pulverman, Golinkoff, & Hirsh-Pasek, 2006). This line of research has provided empirical support for the syntactic bootstrapping hypothesis, illuminating our understanding of the processes involved in children's initial verb mapping.

In addition to verbs, children with high vocabulary relative to their peers also use syntax to interpret novel prepositions (Fisher, Klingler, & Song, 2006)—for example, distinguishing between "This is *acorp* my box" or "This is *a corp*" when watching a hand pointing at a duck on top of a box. High vocabulary children interpreted *acorp* as a preposition referring to the spatial relation "on," whereas they interpreted the phrase *a corp* as a noun referring to the duck.

Function words and morphological cues. Young children also use function words and morphological inflections to interpret novel words. Because words like *the* and morphological inflections like "-ing" or "-s" are not produced early, researchers initially assumed that they were not available to young children. Pinker (1984), for example, concluded, "as it would suit my purposes to claim that . . . children have latent control over the morphemes whose presence defines the categorization of certain constituents, it does not seem to be tenable given available evidence" (p. 103; see also Radford, 1990, for another pessimistic view). However, researchers using the word-learning IPLP revealed that children are indeed sensitive to these potentially informative elements in the language stream long before they produce them. On one screen, 24-month-old children saw Big Bird causing Cookie Monster to squat by pushing him down. On the other screen, children saw Big Bird and Cookie Monster squatting together (a noncausal action). When children heard, "Where is Big Bird glorping with Cookie Monster?" girls reliably looked at the noncausal action, recognizing the grammatical function of the preposition *with*. Boys, however, were apparently indifferent to the presence of *with* and watched the causal action, interpreting the "with sentence" as an active transitive sentence (Hirsh-Pasek & Golinkoff, 1996). Research suggests that girls' language development exceeds that of boys in the early years (Fenson et al., 1994).

In summary, the results of the word-learning IPLP studies offer information about how children approach the word-learning task and support for the assumptions of the ECM. Children are capable of utilizing multiple inputs to language acquisition in the form of perceptual, social, and linguistic information. Furthermore, they appear to rely first on perceptual information, then on social cues, and finally on linguistic information as they gain more experience with the ambient language.

Nouns are easy; verbs are hard

Across languages, young children have more nouns than verbs in their early production vocabularies (e.g., Bornstein et al., 2004; Fenson et al., 1994; Gentner, 1982; Gentner & Boroditsky, 2001; Hirsh-Pasek & Golinkoff, 2006). Yet understanding how verbs are used is tantamount to understanding the grammar of one's language. Although this noun–verb disparity was first noticed in production, it was later found in comprehension as well. The noun advantage in early acquisition has been attributed to a variety of factors, including the fact that referents of early nouns are more readily individuated and more imageable than those of verbs (Ma, Golinkoff, Hirsh-Pasek, McDonough, & Tardif, 2009; Maguire, Hirsh-Pasek, & Golinkoff, 2006; McDonough, Song, Hirsh-Pasek, Golinkoff, & Lannon, 2011), which perhaps makes them easier to remember. Unlike concrete nouns, verbs are inherently relational in that someone or some entity must perform the actions they name; for example, *hit* must have an agent (Golinkoff et al., 2002; Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996; Maguire et al., 2006).

A convincing demonstration of the difficulty children have in learning verbs was conducted using the *human simulation paradigm* (Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 2004). Adult participants were shown silent videotaped interactions between mothers and their 18-to 24-month-old toddlers. When the participants heard a "bleep," they were to guess the word that the mother in the videotape was saying to her child. The same exact scenes were used for noun and verb guesses. Adults correctly guessed the missing nouns in 45% of the cases. However, their score for verbs was much lower; only 15% were correct overall, declining to 0% for mental verbs such as "think." That even conceptually sophisticated adults have more trouble guessing the verbs being uttered supports the view that it is harder for toddlers to learn the meanings of verbs than nouns.

But perhaps parents can identify the verbs children know. In fact, parents likely underestimate their children's verb knowledge in comparison to their knowledge of nouns for several reasons. First, adults can infer infants' knowledge of nouns from their reactions to parental labeling. Western middle-class parents frequently ask children to point to things (as in, "Where's the doggie?"). But to demonstrate their knowledge of verbs, children are often asked to act out the actions verbs label (e.g., Goldfield, 2000). Asking a toddler, "Can you dance?" requires infants to perform on command. Second, the conceptual advantage of objects over actions and events may also cause parents to be more likely to recall infants' knowledge of nouns rather than verbs (Piccin & Waxman, 2007). Therefore, the IPLP has been used to investigate whether young children indeed had difficulties in learning verbs relative to nouns and has consistently found that verbs are indeed generally harder for children to learn than nouns (e.g., Childers & Tomasello, 2001; Golinkoff et al., 1996; Kersten & Smith, 2002). For example, when 24-month-olds saw an actor carrying out a

novel action with a novel object, they successfully mapped a novel noun to the novel object. However, to learn the novel verb, children had to observe multiple examples of the target action performed on multiple objects and receive a "contrast" trial in which they saw a different action while hearing "No, that's not glorping" (Waxman, Lidz, Braun, & Lavin, 2009).

Because verb learning is so challenging for infants, researchers adapted the IPLP to examine verb learning in older children. This permitted researchers to present two simultaneous dynamic displays to uncover children's verb construals. In addition, given that many children can reliably point (with some training) starting at about 26 months, researchers also began using pointing at one of the two displays as the dependent variable. Pointing is much less tedious to code than visual fixation time. One disadvantage (as mentioned previously) is that pointing does require an action from the child; a second is that it creates a dichotomous response—an adaptation that loses the advantage of having a continuous outcome variable.

Apparently, children require a new action to be carried out on multiple objects in order to learn an action's name (Waxman et al., 2009). This raises the related question of whether children also learn verbs more readily when shown multiple actors doing the action. The answer to this is "no" (Maguire et al., 2008). Two and a half- and 3-year-old English-learning children were shown a novel action (e.g., jumping jacks) performed by one or four different actors and told, "She's blicking" for each action exemplar. At test, children were shown two new actors, one performing the old action (i.e., jumping jacks) and the other performing a new action (e.g., twisting). They were asked to, "Point to the girl who's blicking!" Children learned the verb *blicking* only when they saw the action performed by one rather than four actors. This may be because humans are inherently interesting to children; they have faces, wear clothing, and move in slightly different ways. The presence of multiple actors may at first distract children from focusing on the relation being acted out. Others too, have shown that young children have difficulty focusing on relations (Casasola & Cohen, 2002; Kersten & Smith, 2002). However, to learn the full meaning of a new verb, children must quickly extend it to multiple actors while noting the common relation being portrayed.

Although the noun–verb disparity has been noted in many languages across the world, there is also evidence that verbs may not be as disadvantaged in some languages as in English (e.g., Ma et al., 2009; Tardif, 1996; Tardif, Wellman, Fung, Liu, & Fang, 2005). In so-called "verb friendly" languages such as Chinese and Japanese, verbs have a relatively higher token frequency than English and can appear in isolation or at the end of sentences (a salient position for memory). These factors have been shown to facilitate word acquisition (e.g., Golinkoff & Alioto, 1995). If children learning verb-friendly languages experience less difficulty in learning verbs in the laboratory than do English-learning children, then verb-learning difficulty might be attributed to the characteristics of the input language. However, if children experience verb-learning difficulties regardless of the language they are learning, then problems in verb learning are likely explained by factors other than properties of the input language. Indeed, cross-linguistic studies have shown support for the latter position. Imai et al. (2008) examined novel noun and novel verb learning among English-, Japanese-, and Chinese-learning children. Children first saw a "standard" event containing an actor performing a novel action on a novel object (e.g., waving it in the air). Depending on the condition, they then heard either the action named or the object named. At test, children saw two events: the actor performing the same action with a new object and the actor performing a new action with the same object. Did noun and verb learning differ and did they differ across languages?

By age 3—regardless of language—all children learned the novel nouns and extended (i.e., generalized) them to new exemplars. However, children learning all three languages did not learn and extend the novel verbs when the action was performed on new objects until age 5. Even then, success was dependent on language-specific conditions. The Japanese children learned and extended the verbs only when they were heard in isolation—as in Japanese—whereas the English-learning children only learned and extended the verbs when they appeared in full sentences, which is how verbs are typically used in child-directed speech in English.

Chinese children, on the other hand, needed pragmatic support as well as appropriate grammatical information to learn and extend the verbs. Chinese lacks morphological inflections (that is, there are no endings on verbs) and frequently drops subjects and/or objects, therefore requiring listeners to attend to the nonlinguistic context for novel verb interpretation. Only when 1 s of object holding was removed from the scenes before the action began, could Chinese 5-year-olds show evidence of verb mapping and extension. They had apparently interpreted the object holding as meaning that the object—and not the action—was about to be labeled.

Research has not only demonstrated that verbs are harder to learn than nouns, it has also begun to probe why verb learning is challenging. The IPLP research revealed that children appear to need just the right mix of limited variability, appropriate linguistic support from their language, and, in some cases, contextual support to learn novel verbs. Yet, demonstrations of verb extension to new exemplars of action show that children have not

just learned the name of the particular action shown during training. That is, when children witness a scene, they do not form a category akin to a proper noun interpretation.

The LWL: Honing in on Infants' Language Processing

The LWL heralds a next generation IPLP. It enables researchers to home in on infants' speech processing and study individual differences more closely because it provides data on the moment to moment time-course of infants' looking behavior. Although the first IPLP study included latency to fixate on the scene that matched the linguistic stimulus as one of the dependent variables (Golinkoff et al., 1987), most IPLP studies used total looking time or proportion of total looking time toward the matching scene as their main measure. When researchers obtain a positive result, they have evidence that children comprehend the language structures tested. However, they do not know how efficiently children processed the language they heard. In this section, we describe some of the exciting findings the LWL has made possible.

The IPLP was modified to capture the speed with which a child orients to a target from a distracter image in real time, thus allowing researchers to observe the actual time course of language processing (Fernald, Zangl, Portillo, & Marchman, 2008). Like the IPLP, the LWL presents two pictures of objects side by side accompanied by a sentence that matches only one of the objects (e.g., "Where's the doggie?" or "Drink the juice."). The major difference between the IPLP and the LWL lies in how visual fixation data are coded and analyzed. Rather than coding infants' accumulated looking time to the target and nontarget scenes, infants' visual fixation to the target or distracter in the LWL is coded during each frame (33 ms) after the onset of the target word. For example, the coding starts after the onset of the first phoneme (*d-*) in *doggie* in "Where's the doggie?" If infants comprehend the word *doggie*, then when the word begins, they should shift their gaze to the picture of the dog if they happen to be looking at the distracter picture (a distracter-initial trial). Or, if they happen to already be looking at the target (a target-initial trial), they should stay put. Researchers then plot the proportion of trials in which infants shift their gaze for both types of trials. (See Fig. 3) 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. Furthermore, better language processing is also reflected in faster shifts away from the distracter and fewer shifts away from the target. These dependent measures can be compared across groups. Fernald et al. (2008) reported that older infants "were able to identify familiar spoken words much more rapidly than [they] had imagined possible" (p. 103).

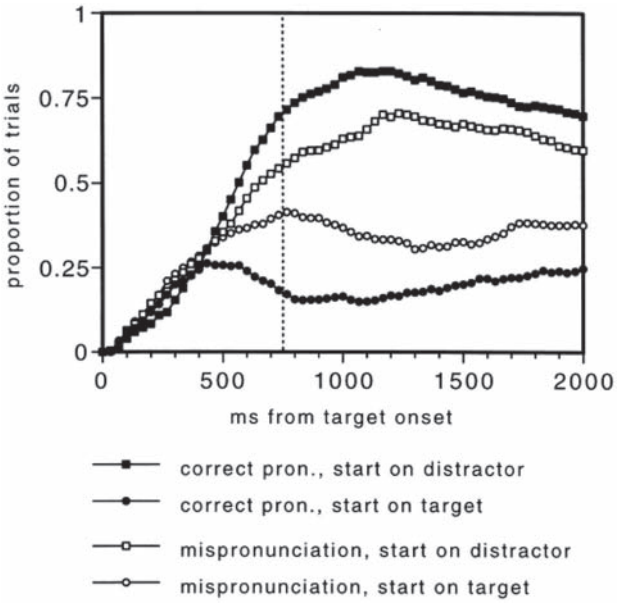

Fig. 3. Children's responses over time, separated by condition and by whether children fixated the target or the distractor picture at the onset of the spoken target word. The *y* axis indicates the proportion of trials on which children were (at that moment) fixating a different picture than the one 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

Using the LWL, researchers have gained a number of insights in infants' speech processing. First, over the second year of life, infants show significant improvements in the speed and efficiency of verbal processing. By 18 months, infants showed word recognition even when only the first 300 ms of the word was heard (Fernald, Swingley, & Pinto, 2001) and by 24 months of age, infants shift their gaze to the correct picture before the end of the target word (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998). Furthermore, infants use the language beyond the target word, recognizing a word's match faster and more accurately when it appears in a familiar carrier sentence (e.g., "Look at the doggie!") rather than in isolation (Fernald & Hurtado, 2006), when it follows a grammatical rather than nonsense article (e.g., *the* car vs. *po* car; Zangl & Fernald, 2007), and when the target and distracter have articles of different grammatical genders. For example, infants are faster on trials showing *la pelota*, "the ball" and *el zapato*, "the shoe" than on trials showing *la pelota*, "the ball" and *la galleta*, "the cookie" (Lew-Williams & Fernald, 2007).

Second, the efficiency of infants' speech processing yields important individual difference information. Infants' LWL performance is associated with vocabulary size as reported by caregivers at 18 months and assessed

by standardized tests by 2 years of age (Fernald, Perfors, & Marchman, 2006; Hurtado, Marchman, & Fernald, 2007; Marchman, Fernald, & Hurtado, 2009), suggesting that the speed with which children resolve linguistic stimuli has long-term consequences for their future language growth (Fernald et al., 2006). Indeed, a long-term follow-up study showed that infants' speed of word recognition and vocabulary knowledge at 25 months predicted their linguistic and cognitive skills at 8 years of age (Marchman & Fernald, 2008). In addition, this link was found among both monolingual Spanish-learning infants (Hurtado et al., 2007) and Spanish–English bilingual infants (Marchman et al., 2009).

More recently, researchers have investigated the potential sources of the variation seen in infants' speech processing (Hurtado et al., 2007). The language of Spanish-speaking mothers when their children were 18 months of age was examined in relation to infants' speech processing assessed in the LWL and reported vocabulary at 24 months. The more language (number of utterances and words) and the more diverse the language (use of unique words or word types and more complex syntax) mothers produced when infants were 18 months, the faster infants recognized familiar words. These children also were reported to have larger vocabularies at 24 months. Hurtado et al. wrote the following:

> . . . this study provides the first evidence that input from caregivers influences both vocabulary knowledge and lexical processing skills . . . richer early language experiences can provide *cascading advantages* to the young language learner. (p. F38, italics added)

A striking new extension of the LWL looked not only at vocabulary development, but also at grammatical development across three languages: Turkish, Chinese, and English (Candan et al., 2012; see also Ilgaz & Hirsh-Pasek, 2012). Their findings with 2- and 3-year-olds suggest that children become faster at processing grammatical devices like word order with age. Further, they found that children learning languages that rely on devices like word order are faster at processing word order than are children who are learning languages that do not rely on word order. Thus type of input and frequency affects the speed of processing for grammatical elements within the home language.

In sum, the LWL, capitalizing on the classic IPLP, has considerably expanded our understanding of the processes children bring to language learning and how individual differences in the speed of language processing play out over the long term. Crucially, differences in children's language processing are associated with their language input. There is wide input variability even among low socioeconomic samples, with children of more talkative mothers hearing seven times more words and sentences twice as long as those heard by children of less talkative mothers (Hurtado et al., 2007). Input clearly matters. These findings take us beyond Hart and Risley's (1995) landmark work and suggest that more input creates a "snowball" or "cascade" effect heightening children's ability to learn more language.

The PLP Without Language: Revealing the Perceptual and Conceptual Underpinnings of Language Development

The IPLP is also used without language accompaniment (the PLP) to study the intersection of language and event processing, bringing together theorizing in linguistics and the burgeoning field of event perception in psychology. Perceiving and conceptualizing the world is the first step in language learning. This entails not only finding the objects named by nouns, but also recognizing the spatial relations between objects named by prepositions and carving the flow of events into the actions named by verbs. The PLP has permitted researchers to study how infants segment and analyze the nonlinguistic motion events that will ultimately be encoded by verbs and prepositions. In this section, we review some of the findings in this expanding research area.

Inspired by Quinn's studies (e.g., see Quinn, 2006) on how infants process static spatial relations such as "between" and "over," and motivated by the question of how infants process events to learn verbs, Pruden and collaborators modified the original IPLP and developed the PLP (e.g., Pruden, Göksun, Roseberry, Hirsh-Pasek, & Golinkoff, 2012; Pruden, Roseberry, Göksun, Hirsh-Pasek, & Golinkoff, 2013). The design of PLP studies is almost identical to that of the IPLP with the exception that no language accompanies the visual stimuli. In the familiarization phase of the PLP, infants see either a repeating identical scene (for a study testing discrimination) or different exemplars that belong to the same action or event category in succession (for a study testing categorization). During salience and test trials, infants see two dynamic visual stimuli side by side, as in the IPLP. In the Discrimination PLP, one of the two stimuli is the same one as shown in familiarization and the other one is a novel stimulus that infants have not seen. In the Categorization PLP, one of the two stimuli is a new exemplar of the category shown in familiarization and the other is a new stimulus from a new category. Throughout the procedure, infants only hear a musical interlude during the intertrial periods. Although superficially similar, the IPLP and PLP capitalize on different processes. Whereas children in the IPLP are prompted by language

to look at the matching stimulus, the PLP is premised on children's reaction to novelty. That is, without language in the PLP, there is no match to be found; children are expected to show discrimination or categorization by watching the event that is novel.[3] Finally, 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 offering a glimpse into earlier competency. Work by Pruden (2007) supports the view that the simultaneous presentation of test events affords children the opportunity to detect differences that they do not detect with sequential presentation.

Despite the fact that no language is used, the PLP yields important information on how infants perceive the world that relational terms name. Learning to label motion events, for example, is different from labeling static objects. Verbs, as Slobin pointed out (2003), are not "verbal film clips of events" (p. 159). That is, they express only parts of an event, such as manner, or how an action is carried out (e.g., is the actor running or jumping?), and path, an actor's trajectory with respect to a ground object. The concept of *path* can surface as a verb (as in *exit* or *climb*) or as a preposition as in *under* and *through* in English (Slobin, 2003; Talmy, 1985). To learn the relational terms that express these concepts, children must first perceive the components of actions these terms name. Research using a habituation design uncovered that 7- and 14-month-old infants could discriminate between changes in path and manner in dynamic events (Pulverman, Golinkoff, Hirsh-Pasek,& Buresh, 2008; Pulverman, Song, Pruden, Golinkoff, & Hirsh-Pasek, 2013). However, learning a verb or a preposition also entails extending the term to other instances. For example, learning the preposition *over* requires forming a spatial category across various instances such as "over a log," or "over a chair." Could infants form categories of path or manner despite the differences among the individual instances?

Research on infants' event processing with the PLP is shedding light on how infants perceive and form these nonlinguistic categories of events. Infants are familiarized with exemplars of an event category: For a path category, they might see different instances of a starfish moving over a ball; for a manner category, they might see a starfish spinning around a ball following different paths. (See Fig. 4) During salience and test trials, infants are presented with two motion events that differ either in their path (e.g., an animated starfish spinning over a ball vs. that same starfish spinning under a ball) or in their manner (e.g., a starfish spinning over a ball vs. a starfish flapping over a ball). Ten-month-old infants abstracted an invariant path from motion events involving different manners (Pruden et al., 2013), and 13-month-old infants could extract an invariant manner across four different changes in path (Pruden et al., 2012). These were the first studies to suggest that the problems children face in learning verbs or prepositions were not likely attributable to their inability to identify components of motion events or forming categories of those components (Parish-Morris, Pruden, Ma, Hirsh-Pasek, & Golinkoff, 2010). However, these events used animated objects in tightly controlled scenes and could therefore be subject to the criticism that they were too simplistic and not enough like real-world events.

Subsequently researchers expanded these investigations to show that infants could form categories of manner with naturalistic actions performed by single and multiple human agents in realistic, real-world scenes across diverse paths (Song, Pruden, Golinkoff, & Hirsh-Pasek, 2013). Studies have also investigated infants' processing of other event components such as figure and ground (Göksun, Hirsh-Pasek, & Golinkoff, 2010; Göksun et al., 2011). Infants learning English or Japanese showed the ability to form categories of different kinds of grounds, even when these grounds would not be encoded in English but only in Japanese. Thus, the PLP allowed researchers to address the question of how event perception might be influenced by the ambient language (Göksun et al., 2010). In the nonlinguistic PLP task Göksun et al. (2011) used, American babies, especially those with larger vocabularies, lost the ability to distinguish between different types of ground encoded in Japanese by 18 months. Japanese babies, on the other hand, retained those distinctions regardless of vocabulary level.

Goksun's findings raise a further question: If languages differ in the nonlinguistic concepts they encode, when might children's verb construal show the effects of the particular ambient language children were hearing? Using both the IPLP with visual fixation and the IPLP with pointing, English-, Japanese-, and Spanish-speaking toddlers (2- and 2.5-year-olds), preschoolers (3- and 5-year-olds) and adults were shown videos of an animated starfish performing a manner (e.g., spinning) along a path (e.g., over a ball) paired with a language-appropriate nonsense verb (Maguire et al., 2010). They were then shown two new events: one preserved the same manner (with a new path—spinning under the ball), and the other preserved the same path (with a new manner—jumping jacks over the ball), and they were then asked to generalize the verb to one of the new events. In all three language groups, toddlers (2- and 2.5-year-olds) revealed a significant preference to construe the verb as a path verb. However, the preschoolers (3-and 5-year-olds) and adults displayed language-specific patterns of verb construal. For example, English speakers showed a large manner bias in their construal of the novel verb. Thus,

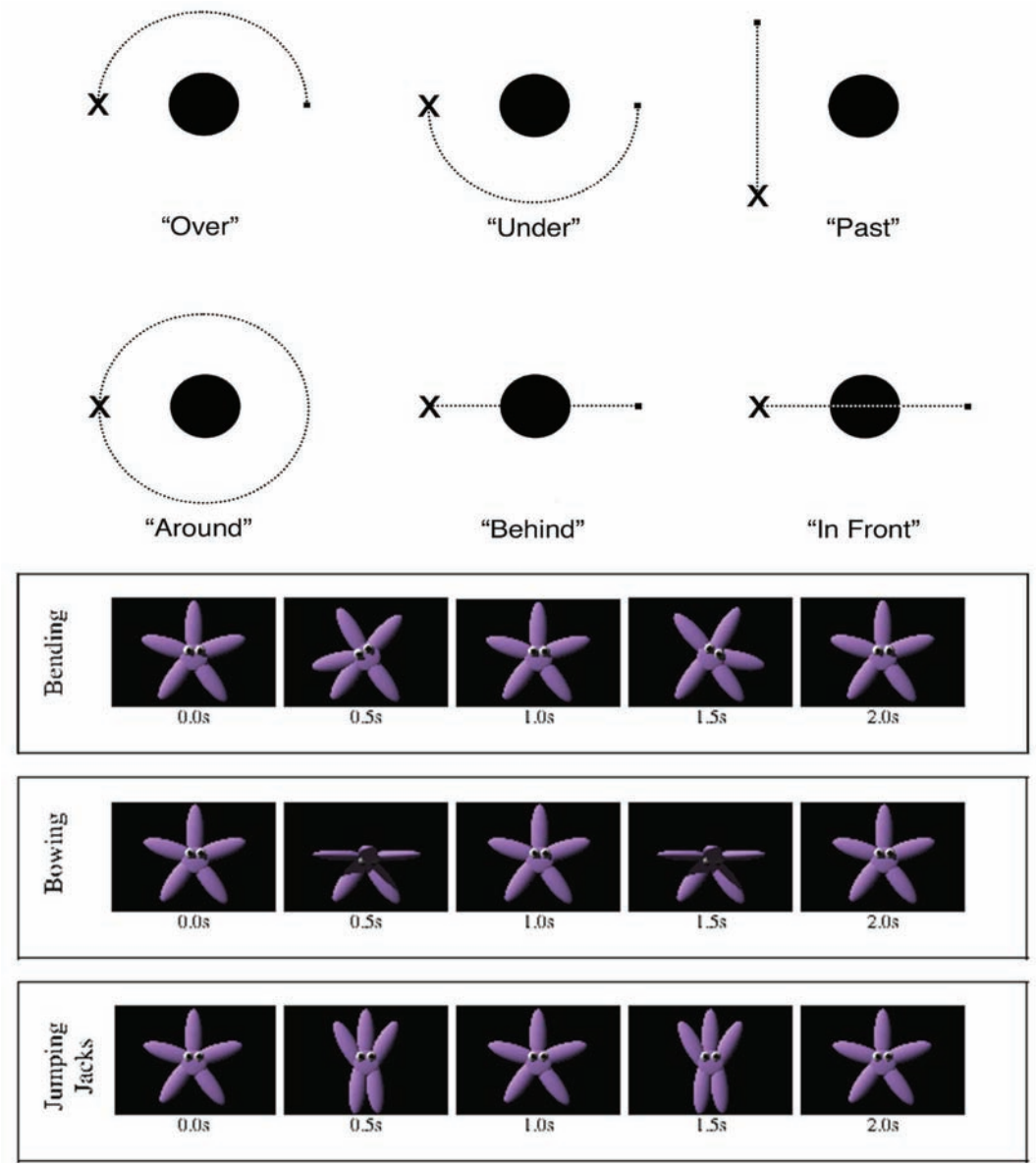

Fig. 4. The six paths (top) and three of the five manners (bottom) created in Pruden, Göksun, Roseberry, Hirsh-Pasek, and Golinkoff (2012) to see if children could form a concept of path across different manners. Each of the manners is shown here as a static picture on a 2-s timescale, though they were presented as dynamic events in the experiment. For the path diagram, the *X* depicts the starting and ending points for each of the paths, and the dotted line shows the path the figure followed.

children begin to show language-specific expectations of verb meanings sometime between 2 and 3 years of age. These findings illuminate how verb construal comes to reflect the properties of the input language over the course of language development.

In sum, the PLP has enabled researchers to not only examine what children know about the nonlinguistic events that language will encode, but also to probe how the ambient language may influence these nonlinguistic events construals in young children learning their native tongue (Göksun et al., 2010; Göksun et al., 2011).

Applications of the IPLP for Clinical Evaluation and Assessment

As the IPLP is being used worldwide for basic research, researchers have also begun to explore its value as a tool for clinical evaluation and assessment. Because children do not need to overtly respond, it is a boon to researchers who wish to study early language acquisition in children with motor impairments, such as cerebral palsy (Cauley, Golinkoff, Hirsh-Pasek, & Gordon, 1989). The word-learning IPLP has also proven useful for studying

the ideal ages for cochlear implantation in deaf children (Houston, Stewart, Moberly, Hollich, & Miyamoto, 2012). Children who received an implant around 1 year of age were indistinguishable from their normal hearing peers at 18 months of age in a task where they were taught two novel-word/novel-object pairings. However, children who received their implant between 14 and 21 months showed no evidence of word learning, suggesting that implantation in the first year of life leads to superior language outcomes.

The Houston et al. (2012) study suggests that the IPLP may well become a clinical tool for early identification of children with high risk for delays in language development. It may also have applicability for children with *auditory neuropathy spectrum disorder*, a recently discovered condition found in some children who show normal amplification of sounds by the outer hair cells in the cochlea but absent or abnormal auditory brainstem responses (Berlin, Hood, Morlet, Rose, & Brashears, 2002). At present, clinicians cannot predict which infants can process spoken language without intervention and which infants will require specific intervention (such as a cochlear implant) to develop normal speech and language. Longitudinal studies of these children may assist in making these decisions.

The IPLP has also been adapted into a computerized vocabulary and morphology assessment. By administering a pointing task with a touch-screen computer, researchers tested preschoolers' (M = 3.6 years) verb vocabulary and comprehension of plural morphology, negation, and noun–verb agreement (Brandone, Golinkoff, & Hirsh-Pasek, 2008). Results revealed significant correlations among performance on this computer-based language assessment, age, and performance on the Preschool Language Scale-4. Friend and Keplinger (2008) tested 16- and 20-month-olds' word knowledge with a standard picture book task and the same task administered on a touch-sensitive screen in an IPLP setup. The computerized task showed better task attention, compliance, and performance than the standard picture book task.

More recently, a computerized language assessment for preschoolers (ages 3 to 5) with both a grammar and a vocabulary module is undergoing development. It presents both static as well as dynamic events and uses children's touch of the correct image on the screen as the response (Golinkoff, Hirsh-Pasek, de Villiers, Aquiles, & Wilson, 2010; Miller et al., 2012). Data suggest that the subtests in each module scale by age. The unique feature of this test is that it probes how much children know (the products of learning) as well as whether they have the processes required for language learning. For example, the test asks whether children can associate a word to a referent after only one or two exposures to the word-referent combination—in this case, adjectives, nouns, and verb meanings. Together, these data suggest that a computer-administered language assessment based on the IPLP is methodologically feasible and can provide a practical and valid means to assess early language abilities.

The benefits of an evidence-based computerized language assessment based on the IPLP are numerous. For one thing, a trained speech–language pathologist is not needed to administer the assessment—it can be given by a teacher or an aide. This means that many more children can be screened quickly and effectively to identify children who might have language delays. Research has long indicated that the earlier language intervention can be offered, the better the outcome. Thus, this test can serve as a screener to identify those children who may need to see a speech–language pathologist as early as the age of three. Second, the software will score the test in various ways that can be used by schools to provide intervention as well as by researchers who need reliable language measures that are easily administered. Finally, the use of a culture- and dialect-free assessment means that it can be used with children who speak a dialect, such as African-American English, without disadvantaging them.

Summing Up: Reflecting on the IPLP and What We Have Learned

Although the IPLP has proven a powerful laboratory tool, it is not without its shortcomings. First, the IPLP may occasionally overestimate children's knowledge. This is because the IPLP may suffer from the "A not A" problem. When presented with two alternatives, children may solve the task through the process of elimination or mutual exclusivity: "I know this one so it must be the other one" (e.g., Halberda, 2006; Markman & Wachtel, 1988). Thus, children might come into a study knowing the vocabulary or sentence structure being tested or they might use this process of elimination on the spot to find the correct alternative (see Newcombe, Sluzenski, & Huttenlocher, 2005, for a parallel argument). Some of this depends on children's age, as infants are less likely to use this strategy (e.g., Hollich et al., 2000).

Second, the IPLP allows researchers to study only a limited number of items, given children's short attention spans. But all measures used with young children suffer from this problem. Finally, children's early comprehension as revealed in the IPLP begs the question of why language production often comes months later. This issue is related to other research in infancy that finds early competencies in visual fixation paradigms with much delayed manifestation of these same competencies in action (e.g., Munakata, McClelland, Johnson, & Siegler, 1997). There are many puzzles in language acquisition yet to solve.

Despite the IPLP's limitations, it continues to reveal competencies in language and concepts that are not apparent on the surface. Its main contribution has been to show that children's language comprehension is well in advance of their language production: A finding that holds for Western children although perhaps less so for non-Western children (Bornstein & Hendricks, 2012). The class of IPLP measures (IPLP, PLP, and LWL) has added to our knowledge base in five areas. First, researchers now know that before infants can say more than a few words, they are analyzing the sentences they hear to find specific events in the world (e.g., Golinkoff et al., 1987; Hirsh-Pasek & Golinkoff, 1996). They are sensitive to the grammar found in sentences (e.g., Lidz et al., 2003) and even use sentence structure to glean something of the meaning of novel words (e.g., Naigles, 1990). Second, infants note details in how words are pronounced (e.g., Swingley & Aslin, 2002) and the significance of morphological endings such as the plural /*s*/ (Jolly & Plunkett, 2008) and function words (e.g., "the"; e.g., Kedar et al., 2006) that modify meaning. Third, we have gained insight into the processes by which infants learn new words (e.g., Hollich et al., 2000) and how, for example, they differentially profit from infant or adult-directed speech depending on their existing vocabulary levels (Ma et al., 2011). Fourth, the LWL has shown us that the speed with which children find the matching scene predicts their later language capability both in the short term (e.g., Fernald et al., 2006) and years later (e.g., Marchman & Fernald, 2008), inviting more study of individual differences in language acquisition. And finally, the PLP has illuminated how infants discriminate and categorize the events that language encodes, suggesting that the apprehension of these events is not the source of children's verb learning difficulties (e.g., Golinkoff & Hirsh-Pasek, 2006). The fact that the IPLP is now being investigated for its clinical and diagnostic capabilities (e.g., Miller et al., 2012) suggests that it may be useful for screening and intervention, taking the basic research into translational science.

Conclusions

The IPLP significantly changed what we know about early language development, allowing us to explore children's budding abilities well before they are manifested in language production. As Greenwald (2012) stated, "Perhaps greater recognition of the value of method in advancing theory can help to achieve resolutions of psychology's persistent theory controversies" (p. 106). The IPLP has surely prompted psychologists to reinvent their view of the human organism as infants' surprising language competencies have come to light.

Appendix A

Glossary

Action category: An abstract representation of an action (say, running) regardless of variation such as the agent performing it or the ground on which the running is taking place.

Adult-directed speech: Speech addressed to adults with false starts and stops, relatively flat intonation contour, interruptions, and long and multiclausal sentences. Vocabulary can be relatively rare. Contrast with infant-directed speech.

Characterization of children by age:

Infant: 0 month to 12 months

Toddler: 1 to 3 years

Young child: Can refer to infants, toddlers, or preschool-age children.

Emergent Coalition Model (ECM): A hybrid view of word learning, this theory characterizes lexical acquisition as the emergent product of multiple factors, including cognitive constraints, social-pragmatic factors, and global attentional mechanisms.

Event components: Agent (the initiator of an action), *patient* (the recipient of an action), *manner* (how the action is performed), *path* (the trajectory the object is taking relative to a ground object), *Ground* (the surface over which the action is taking place), and *Figure* (the animate or inanimate actor in the event).

Function word: High-frequency words that appear late in children's language and that express grammatical information. These include determiners (e.g., *a* and *the*) and conjunctions (e.g., *and* and *but)*. Contrasts with content words such as nouns and verbs.

Habituation: After repeated presentation of a stimulus, the gradual decline in an infant's attention to it. Used to assess discrimination between nonidentical stimuli.

Hierarchical structure: A central concept of syntax that proposes that sentences are more than just ordered sequences of words. Instead, the words in sentences are grouped into phrases (or constituents) that are, in turn, grouped into higher order phrases.

Infant-directed speech: A speech style used by parents, caregivers, and even young children when communicating with infants, usually involving simplified vocabulary, exaggerated melodic pitch, vowel lengthening, repetitive questioning, and a slow or deliberate tempo. Contrast with adult-directed speech.

Interactive intermodal preferential looking paradigm (IIPLP): In contrast to IPLP, a human experimenter delivers the linguistic stimuli, allowing researchers to examine the role of social cues in language learning. Stimuli are real objects affixed to a wooden board that can rotate.

Intermodal preferential looking paradigm (IPLP): A method for the examination of infants' emerging language knowledge that utilizes language comprehension. Two different images (say, a shoe and a hand) are presented side-by-side either on a single screen or on two screens. Only one of the images "matches" an accompanying linguistic stimulus (e.g., "Where's the shoe?"). Young children's language comprehension is measured by differential visual fixation to the matching versus the nonmatching screen.

Intertrial stimulus: An attention getter (e.g., a baby face or a light) that draws children's attention to the center of where stimuli are presented so that they can make voluntary left–right gaze shifts in the next trial.

Language input: The language addressed to a child, not including ambient language from television or radio or speech between present adults.

Latency: The amount of time it takes for a participant to look at the stimulus on the screen after it is presented.

Looking-while-listening (LWL) procedure: An offshoot of the IPLP, it measures the time course of young children's gaze patterns to two images in response to speech, allowing researchers to investigate on line, moment-to-moment speech processing.

Morphological inflection: A particle affixed to a word, which expresses different grammatical categories such as tense, person, and number. Inflections can also express possession, as in "Allison's cat"

Object selection task: A method to assess children's language knowledge or word construal. Children are asked to find a target object from an array of objects by following a verbal prompt such as "find the apple."

Phoneme: The smallest contrastive unit in the sound system of a language. Example: *b*at vs. *c*at.

Preferential looking paradigm (PLP): A method to study the perceptual and conceptual underpinnings of language development, the PLP is the IPLP without language. Events are presented in silence, sometimes alone, and sometimes with one event on each side of the screen.

Relational term: Words referring to the relation among objects including verbs, prepositions, and some nouns such as kin terms (e.g., brother, uncle). Verbs and prepositions take "arguments." That is, they are used with the nouns involved in the relationship the word encodes. Thus, the verb *run* requires a single noun argument (an agent) while the preposition *under* requires two: There is a target noun beneath a covering noun.

Salience trial: A trial used in the IPLP, IIPLP, LWL, and PLP in which two images are presented side-by-side, permitting researchers to examine whether the visual stimuli within a pair are equated for attractiveness before language is used to name one of them.

Social cue: A nonverbal hint that guides conversation and other social interactions. Examples of social cues include facial expressions, direction of gaze, and body posture.

Syntactic bootstrapping: A theory that some of the meaning of words can be deduced from the arguments that surround them. Thus, a sentence like, "John blorks" implies an intransitive action, whereas a sentence like, "John blorks Mary" suggests that John may be doing something to Mary.

Syntax: The study of the principles and processes by which sentences are constructed in particular languages. Depending on one's theoretical vantage point, there can be common word combinatorial properties at a deep structural level that underlie all languages.

Token frequency: How often a particular word appears in a corpus of speech.

Word extension: The application of a word to members of the category in addition to the ones for which it was learned, extension gives words the power to refer categorically. For example, when children learn that a referent (e.g., dachshund) is called *dog*, they appear to assume that dog can be extended to novel within-category exemplars (e.g., to a spaniel).

Appendix B

The Video Displays and Auditory Stimulus in Experiment III on Word Order Comprehension

	Left side	Right side	Audio
Character identification segment	Black	Black	Where's Big Bird?
	Big Bird (BB) waves at the viewer	Cookie Monster (CM) waves at the viewer	Find Big Bird!
	Black	Black	Where's Cookie Monster?
	BB waves at the viewer	CM waves at the viewer	Find Cookie Monster!
Salience trials	Black	BB tickles CM from behind as CM holds a box full of toys	Silence
	CM tickles BB as BB holds a box full of toys	Black	Silence
	Black	BB tickling CM	Look who's tickling?
Orientation to action trials	CM tickling BB	Black	Hey, who's tickling?
	CM tickling BB	BB tickling CM	Silence
	Black	Black	Look! Cookie Monster's tickling Big Bird!
	CM tickling BB	BB tickling CM	Where's Cookie Monster tickling Big Bird?
Test Trials: Word Order Comprehension	Black	Black	Wow! Big Bird's tickling Cookie Monster!
	CM tickling BB	BB tickling CM	Where's Big Bird tickling Cookie Monster?

Note: Adapted from Golinkoff, Hirsh-Pasek, Cauley, and Gordon (1987). In most recent studies, the salience trials are presented simultaneously (Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011).

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The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. The IPLP is not the only method that has contributed to our understanding of language growth. Aside from the sucking response used with infants less than 4 months of age to access phonological discrimination (e.g., Eimas, Siqueland, Jusczyk, & Vigorrito, 1971), other methods have appeared that utilize visual fixation (Thomas, Campos, Shucard, Ransay, & Shucard, 1981) or head turning as dependent variables, such as the habituation method (Shi, Werker, & Cutler, 2006), the switch design (e.g., Werker, Cohen, Lloyd, Casasola, & Stager, 1998), the head-turn preference procedure (e.g., Fernald, 1985; Hirsh-Pasek et al., 1987; Jusczyk et al., 1992), and the conditioned head-turn procedure (e.g., Kuhl, 1983; Werker, Polka, & Pegg, 1997) (see Golinkoff & Hirsh-Pasek, 2012; Hoff, 2011, for reviews).
2. All results presented in this article achieved an alpha level of at least .05. Furthermore, papers reporting IPLP data often present counts of the number of children showing the effect. For a finding to be reliable, typically at least two thirds of the sample must watch the matching events more than the nonmatching events. Individual differences are the norm and observed in all studies. Interested readers are referred to the original articles for detailed data.
3. The PLP works similarly to the widely used habituation procedure (e.g., Cohen, Amsel, Redford, & Casasola, 1998), which repeatedly presents a stimulus before showing a novel stimulus. However, there are two fundamental differences between a habituation study and a PLP study. First, habituation requires that infants' attention to a stimulus drop below a predetermined criterion for them to be shown the test stimuli, whereas the PLP provides a fixed amount (determined by piloting) of exposure to the familiar stimuli. Therefore, decreasing attention during familiarization in the PLP is not a requirement as it is in the habituation paradigm. Second, the two procedures differ in how infants' reaction to novelty is measured. In habituation, infants' reaction to novelty is shown by renewed attention to a test stimulus compared with their attention at the end of the habituation phase. In the PLP, infants' novelty preference is indicated by a difference in attention between the familiar and the novel stimuli presented at test.

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