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A unified theory of word learning: Putting verb acquisition in context

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The last decade has witnessed unparalleled research on the study of early verb learning. Rather than projecting a coherent story of how children learn their first verbs, however, the literature seems to offer a set of somewhat disjointed facts. For example, most concur that nouns are generally learned before verbs (Gentner, 1982). Words like *shoe* and *car* appear in children's lexicons before words like *run* and *drive*. Most, but not all also find this pattern to be universal (Bornstein et al., 2004). On the other hand, research demonstrates that some verbs appear in children's earliest vocabularies and that this "verb preference" is especially pronounced in languages like Chinese (Tardif, Gelman, & Xu, 1999) and Tzeltzal (Brown, 2001). Finally, we not only find that some verbs arrive very early, but also that some nouns like *passenger* (Hall & Waxman, 1993; Keil & Batterman, 1984) defy the universal trend by arriving relatively late in development. As of yet, no theory has been able to explain all of these findings in a unified, coherent way. This is the goal of this chapter.

Here we build on suggestions by Gentner and Boroditsky (2001) and Snedeker and Gleitman (2004) to suggest that the contrasting findings emerging in the verb learning literature may not be about nouns and verbs, but about word learning in general. We argue for a comprehensive approach to word learning that accounts for why some words are learned before others, regardless of form class. Words that label more perceptually accessible concepts might be learned early while those that label abstract or relational concepts require additional support from social and linguistic sources and are thus learned late. We further propose that this pattern will hold not only for words *across* syntactic classes like nouns and verbs, but also for words *within* syntactic classes (see

Tardiff, this volume; Snedeker & Gleitman, 2004). In this paper, we expand our broad based developmental theory of word learning (the Emergentist Coalition Model (ECM), Hollich, Hirsh-Pasek, Golinkoff, 2000) to illuminate how children acquire language with a specific focus on verb acquisition. In so doing, we demonstrate how the theory of word learning originally developed for the understanding of noun learning can encompass the study of verbs. We also explain a persistent paradox in verb learning -- why some verbs appear early even though the class of verbs is generally hard to master.

This paper is divided into three parts. First, we review the traditional account of verb learning highlighting why verbs in general are so difficult to learn. Second, we present the tenets of the ECM, how the ECM accounts for noun learning, and how it can be extended to verbs. Here we introduce a continuum that spans all word classes to explain why some nouns and verbs are learned early while others are learned late. Finally, we conclude that our framework for verb learning offers a coherent view of the current literature and an explanation for what we have dubbed the *verb learning paradox*: why in general verbs are harder than nouns, and why some verbs nonetheless appear early in children's vocabularies.

Part I. The traditional account: Verbs are hard

In 1982, Gentner wrote a classic article articulating the many reasons why verbs might be harder to learn than nouns. Her work spurred a flurry of activity that spanned 25 years of prolific research from languages that covered the globe (Behrend, 1995; Brown, 2001; Choi & Bowerman, 1991; Choi & Gopnik, 1995; Fisher, 2002; Forbes & Farrar, 1993; Gallivan, 1988; Gleitman & Gillette, 1995; Golinkoff, et al., 2002; 1995; Hirsh-Pasek, et al., 1988; Imai & Haryu, 2001; Imai & Gentner, 1997; Naigles, 1990;

1996; Poulin-Dubois & Forbes, 2002; Sandhofer, Smith, & Luo, 2000; Slobin, 2001; Smiley & Huttenlocher, 1995; Snedeker & Gleitman, 2004; Tardiff, 1996; Tardiff, Gelman, & Xu, 1999; Tomasello & Merriman, 1995). Though there is still some debate (Tardiff, this volume), most conclude that verbs are universally harder to learn than nouns (see Bornstein et al., 2004). Accumulating research also echoes suggestions made by both Gentner and Boroditsky (2001) and Snedeker and Gleitman (2004) that the problem in verb learning might be more about *mapping* a specific verb onto an action or event than about learning the underlying relational concepts that the verb or relational term encodes.

The mapping dilemma. Picture a child running to a sliding board, climbing the ladder, sliding down, and skipping around the slide to mount the ladder again. When compared to the paltry number of nouns that describe this scene (e.g., boy, ladder, sliding board, ground, etc.), the choice of verbs is abundant. This example defines the difficulties inherent in verb learning relative to noun learning. If the scene were accompanied by a novel verb, say, "blicking", children would have many different possibilities for what that novel verb might mean, from playing to running to smiling. That is, children would face the "packaging problem" (Tomasello, 1995; Gentner, 1982) and relatedly what Gleitman and Gleitman (1992) discuss as a kind of "perspective problem" (Gleitman, 1990) in discerning the meaning of "blicking." The packaging problem refers to the fact that many elements of meaning can be encoded in a single verb. Gentner (1982) writes,

> A language has more degrees of freedom in lexicalizing relations between coherent objects than in lexicalizing the objects themselves. Thus, for verbs and other relational terms, children must discover how their language combines and

> lexicalizes the elements of the perceptual field…verb meanings are learned as part of a system of semantic distinctions… (p. 324-325).

The perspective problem, in contrast, addresses which aspect of a scene the speaker highlights based on the verb used. For example, "The dog fled from the cat" offers one perspective while the "The cat chased the dog" offers another perspective on the exact same scene. The perspective problem captures the fact that observation of a scene is insufficient to "nail" the meaning of a verb; additional linguistic information is needed to capture the speaker's view on an event.

The packaging and perspective problems are two among many factors that make verbs harder to learn than nouns (Gentner, 1982; Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996). Importantly, they are also problems that relate to how children map words onto concepts rather than problems central to the conceptual foundation for relational terms. That is, accumulating evidence from both adults and children suggest that the verbs might be harder to learn than nouns because it is more difficult to figure out the mapping between word and world when relational terms are involved. Research during the past 10 years provides ample evidence of mapping difficulty.

Even adults have trouble mapping verbs. Perhaps the strongest data on the difficulty of mapping verbs comes from studies by Gleitman and her colleagues (Gillette, Gleitman & Gleitman, & Lederer, 1999; Snedeker & Gleitman, 2004). In their human simulation studies, adults viewed a series of silent video clips of a mother and child playing. A beep or nonsense word occurred coincident with either the missing noun or verb. The participants' job was simply to guess what word the speaker might have used in place of the beep. The findings were dramatic. Adults, who presumably had no

conceptual difficulties with the objects and events represented on the tapes, correctly guessed the missing nouns in 45% of the cases. In stark contrast, the proportion of correct guesses for verbs was a paltry 15%. In fact, if only responses for mental verbs were considered, the proportion of correct verb "guesses" dropped to zero! Mapping from action or mental state to word is considerably more challenging than mapping from object to word.

Children also struggle with mapping verbs. Research in our lab with young children also offers a dramatic example of the mapping problem. Following our work with noun acquisition, we assumed that once children formed a category of actions they would easily attach a label to this category and extend that label to similar exemplars.

A series of tasks began to examine this untested assumption. We started with actions that seemed to be relatively straight forward, intransitive whole body actions (see also Behrend, this volume). In a *nonlinguistic* habituation study, Salkind, Golinkoff, Sootsman, and Hirsh-Pasek (2002) introduced a set of novel aerobic actions, each consisting of a person doing an action that involved movement of both the arms and legs. For example, one action was a modified jumping jack, in which the legs kicked out as in jumping jacks, but the arms reached up in alternation. Salkind et al. (2002) habituated toddlers 9 to 11 months of age to video clips of two different females performing the same novel jumping jack action. When attention dropped below a criterion, children saw three clips, order counterbalanced across subjects: 1) a *control* clip of the jumping jack action from habituation; 2) a *novel* actor performing the *familiar* jumping jack action; and 3) the same *novel* actor performing a *novel* action (knee lifts with arms punching forward).

If babies recognized the action, they should be bored with the control clip. If they noted that a new agent was present, they should watch the novel actor/old action significantly more than the control event. And if they could distinguish between the new action and the old action, then they should watch novel actor/novel action event longest of all. The findings indicated that half of the children in the sample with the largest comprehension vocabularies on the MacArthur (mean = 23) *could* form a category of action despite a change in the actor. This finding was replicated in a fully counterbalanced design using with 3 different full body actions. Thus, in a nonlinguistic task, toddlers with more language skill than their peers, distinguish between novel actions –above and beyond changes in the actor – by as early as 10 months of age (see Figure 1).

-- Insert Figure 1 about here --

Mapping labels to action categories. The natural next step was to ask whether children could map a verb to the action category they had formed. Here, we used the Intermodal Preferential Looking Paradigm (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996), with looking time as the dependent variable. Based on the ease with which children discriminated and categorized the actions in Salkind et al. (2002), and our success with prior comprehension studies (e.g., Hirsh-Pasek & Golinkoff, 1996), we started with 18-month-olds. After all, in Hollich et al. (2000), 12-month-olds were learning novel object labels with only a few exposures and in Hirsh-Pasek, Golinkoff, Pruden, and Hennon (under review), babies at 10 months of age were able to learn a novel object label! Surely by 18 months of age, children should be able to learn a novel verb.

Children sat on a parent's lap watching a large screen television. During the training portion of each study, they saw one of the target actions (e.g., modified jumping jacks) as they heard sentences describing the event *("Hey, she's blicking!").* We created two conditions in which children were trained on two novel action names. The children in condition 1 saw only *one actor* performing the target action multiple times. The children in condition 2 saw *four actors*, each performing the target action. Prior research suggested that children are conservative in their verb extensions (Forbes & Farrar, 1993). Thus, it might make it easier to extend the new verb to a new agent if they saw one or multiple actors carrying out the same novel actions. During test trials, children saw a completely new actor performing the target action on one side of the screen, and a different novel actor performing a new intransitive action on the other side of the screen.

To our surprise, children *at all ages* tested (18, 24, and 30 months) uniformly **failed** to map the word onto the correct action. They watched the old and new actions to the same degree at test. Given the ease with which children formed nonlinguistic categories of these actions by 10 months of age we wondered why mapping a verb to these same categories was so difficult nearly 2 years later!

More verb learning failures. Though English-speaking children have an early noun bias, many claim that children speaking other languages have a verb bias (Choi, 2000; Choi & Gopnik, 1995; Choi & Bowerman, 1991; Sandhofer et al., 2000; Tardif, 1996; Tardif et al., 1999; Tardif, Shatz, & Naigles, 1997; yet see Kim, McGregor, & Thompson, 2000 for conflicting results). Perhaps the difficulty children have in learning verbs is not about the mapping of words to relations, but rather a problem specific with

word mapping in *English*. Our recent research in English and Japanese, however, suggests that the mapping problem exists across languages.

In our cross-linguistic experiment, English-speaking (Meyer, Leonard, Hirsh-Pasek, Golinkoff, Imai, Haryu, Pulverman, & Addy, 2003) and Japanese-speaking (Imai, Haryu, & Hiroyuki, 2003; in press; this volume) 3- and 5-year-olds participated in a preferential pointing task. Participants saw a person doing an *unfamiliar action* with an *unfamiliar object*. Children were exposed to one of three between-subject conditions. In the first, "noun" condition, they were asked to "*Look at the blick*," drawing for a noun interpretation. In the "bare-frame verb" condition, children heard a novel verb in a bare syntactic frame while watching the scene, *("Look, blicking! Watch blicking!*"). In the "rich-syntax verb" condition, children were given additional syntactic information *("Look, she's blicking it!"*).

During test trials, children simultaneously saw the old object engaged in a new action in one scene, and the old action being performed with a new object in the other scene (see Figure 2). At test, children again heard the noun *("Where's the blick?"),* the bare-verb *("Where's blicking?"),* or the rich syntax audio *("Where's she blicking it?").*

-- Insert Figure 2 about here --

In both languages, 3- and 5-year-olds had no difficulty mapping the noun to the object in the noun condition. Further, in both languages, 3-year-olds were unable to map the verb to the action in either language, performing at chance levels. This finding challenges the assumption that all words are initially interpreted as nouns or objects by young children (see also Echols & Marti, 2004; Kersten & Smith, 2002; Kersten et al., this volume). It also clearly demonstrates that children can map words to objects before

they do so for actions. Most importantly, it demonstrates the difficulty even 3-year-olds have mapping a verb to an action, regardless of native language. The proposed differences emerged only in the pattern of result for the 5-year-olds.

At age *five*, Japanese children correctly mapped the verb to the novel action in both verb conditions. Five-year-old English-speaking children, however, still had trouble mapping the verb to the novel action in the bare-frame verb condition. They could not solve the mapping problem unless they were given rich syntax in the form of a full sentence (*"She's blicking it*") during training. In this condition, children seemed to infer that the pronoun "it" appearing after the verb blocked the noun interpretation for the word.

The differences between the two language groups can be explained in terms of grammatical differences between English and Japanese. While it is rare for transitive verbs to appear in bare-frames in English, it is acceptable and common in Japanese since it licenses argument dropping. As a result, the bare-frame was unnatural for transitive verbs in English, making mapping more difficult for English-speaking children.

What is most striking about these studies is the late age at which children in both language groups map a word to an action. It is not until 5 years of age that any consistency is seen in verb mapping (see Imai, Haryu, Okada, Lianjing, & Shigenatsu, this volume). This finding has recently been replicated in Chinese (Haryu, Imai, Okada, Li, Meyer, Hirsh-Pasek & Golinkoff, in press). Mapping from word to world is difficult in lab-based studies regardless of the language being learned!

Additional studies attest to the difficulty of verb learning. The studies noted above make clear that children's struggles with the packaging problem are not based solely on

conceptual problems in forming categories of actions, nor on general problems with mapping (they readily mapped nouns to objects). The problems children encounter appear to be in mapping words to actions. Several other studies converge on the same interpretation. Childers and Tomasello (2002, this volume) tested where the breakdown occurred in verb learning. They attempted to teach 2-year-olds new nouns and verbs in either massed or distributed learning paradigms with responses in either comprehension or production. Findings revealed that children could learn an action associated with a particular object, but nonetheless demonstrated difficulty learning a word for that action. These findings suggest that children are not having a conceptual problem, but something about *mapping* that retards verb acquisition. Verbs were considerably more difficult to master (especially to produce) than either nouns or action/object pairings without language.

In sum, regardless of age, conceptual abilities, experience, or the specific language to be learned, mapping verb labels is hard even when the underlying nonlinguistic category is formed easily. It is no wonder that the literature has been shaped by a noun/verb debate in which nouns are deemed easy to learn while verbs are thought of as difficult. The goal of the study of language development, however, is not to find separate theories of word learning for different word classes, but rather to find one unified theory to explain all word learning.

Part II. Towards a broad-based developmental theory of word learning

The ECM model. The Emergentist Coalition Model (ECM; Hollich et al., 2000; see also Poulin-Dubois & Forbes, this volume) holds the promise of creating a unified theory of word learning. Developed to explain the course of early word learning and the

developmental transformations it undergoes, the ECM states that children have access to a number of different inputs (perceptual, linguistic, and social) for uncovering the referent of a new word (Hollich et al., 2000; Poulin-Dubois & Forbes, this volume). The model answered the call made by many who investigate word learning in terms of a complex, multifactor, interactive theory (e.g., Baldwin & Tomasello, 1998; Bloom, 1993; Nelson, 1996; Woodward & Markman, 1998). As Hollich et al. (2000) wrote,

> 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. The model makes three assumptions: (a) that children cull from multiple inputs available for word learning at any given time, (b) that these inputs are differentially weighted over development, and (c) that children develop emergent principles of word learning, which guide subsequent word acquisition (p. v).

Although this theory was developed for noun learning, the ECM's position is that the acquisition of *all* lexical items is driven first by children's reliance on perceptual information and later through attention to social and linguistic information. Evidence from a number of sources suggests not only that young children place more weight in perceptual information for mapping words to concepts (Behrend & Scofield, this volume; Forbes & Farrar, 1993; Smiley & Huttenlocher, 1995), but that in mapping words, they move to a reliance on more social and linguistic information through development (Fisher, 2002; Fisher et al., 1994; Hirsh-Pasek & Golinkoff, 1996; Hirsh-Pasek, Naigles, Golinkoff, Gleitman, & Gleitman, 1988; Hollich et al., 2000; Naigles, 1996). Importantly, children are sensitive to both linguistic and social information in the input

from a very early age (Hollich et al., 2000). Yet, early in word learning, around 10 months of age (Hirsh-Pasek et al., 2005), they put initial stock in perceptual cues that guide word-to-world mapping. Thus, the word *cup* will be easier to learn in the presence of a cup than will more perceptually abstract noun *patriot*. Indeed, Bird et al. (2001), Gillette et al. (1999) and our own work (Lannon et al., in preparation) show that words appearing in the earliest vocabularies are the most perceptually accessible across both verbs and nouns and are those that more readily generate mental images.

At this early stage, children also approach word learning from their own point of view rather than from the speaker's point of view. For example, in the presence of an interesting and a boring object, the youngest child of 12 months is likely to assume that the word "goes with" the more interesting object, even if the adult is naming the more boring object and non-verbally indicating it through the social cue of eye gaze. The 19-month-olds' followed a speaker's eye gaze to learn a novel name for a boring object. They used subtle social cues to decipher word meaning (Hollich et al., 2000; Fisher & Song, in press).

Linguistic cues to word learning become prominent at about the same age. For example, 24-month-olds can use grammatical cues such as the frame in which a verb appears to discern the meaning of a novel verb (Fisher, 1996; Hirsh-Pasek & Golinkoff, 1996; Naigles. 1990; 1996). Echols (1988) also found that children could direct their attention to an object when asked to look at *the blick*, and to an action when *blicking* was requested.

According to the ECM theory then, the words children initially learn will be perceptually tied and contextually bound. This will be the case irrespective of syntactic

word class. Word learning, however, requires that children learn words in circumstances in which perceptual cues are not available. Words like "idea" and "think" have weak perceptual links. They are also weak in the imagery they generate. Thus, to learn *any* word – noun or verb -- children must coordinate perceptual, social, and linguistic inputs to uncover more precise word meanings. The ECM is blind to word class. It operates as a general framework for explaining vocabulary acquisition across word classes. Thus, children's earliest words might be organized and learned, not by linguistic word classes, but on the basis of other overlapping features. Importantly, we are **not** making the claim that linguistic form class does not exist for the young child. Indeed, to use and interpret words correctly in sentences, children must be aware of the linguistic role that words play in sentences. For the development of early vocabulary, however, we *are* suggesting that linguistic form class, per se, is not what drives the word learning system. An alternative emerging from neuropsychology and developmental cognitive psychology is presented below (see Figure 3).

--- Figure 3 (of ECM) about here ---

Rethinking the noun/verb dichotomy. Borrowing from literature suggesting that *all* concepts encoded by words fall along a single continuum of "abstractness," we dub this continuum "SICI." Following work by Golinkoff et al. (1995), Bird, et al. (2000b; 2003), Black and Chiat (2003), Gentner and Boroditsky (2001), and Gillette et al. (1999), we next describe how together the SICI continuum and the ECM explain not only noun learning, but also illuminate the verb learning paradox and the developmental path children follow as they learn verbs. Consistent with Gillette et al. (1999) and Gentner and Boroditsky (2001), children can map words onto verbs if the actions they denote are

relatively concrete. Mastery of verb mapping, like noun mapping, requires the use of grammatical and social inputs that lessen the ambiguity of the verb referent. Here we explore what it means to be "relatively concrete" for both nouns and verbs.

The SICI continuum. In reaction to the field's initial focus on noun acquisition, many researchers branched out and focused on the acquisition of other syntactical classes such as adjectives (Waxman & Klibanoff, 2000), verbs (Fisher, 2002; Golinkoff et al., 1995; Huttenlocher, Smiley, & Charney, 1983; Maguire, et al., 2002; Merriman, et al., 1996; Naigles & Hoff-Ginsberg, 1995, 1998; Tomasello, 1995**),** and pronouns (Campbell, Brooks, & Tomasello, 2000). As a result, much of our current understanding of language acquisition is compartmentalized and is primarily based on syntactic class. For many this seemed to be a natural partition, resulting in a flurry of research that compared the learning of nouns to verbs (see Tomasello & Merrimen, 1995 for review, see also Bornstein et al., 2004). Syntactically, nouns and verbs clearly perform different roles. Additionally, there is evidence showing that nouns and verbs are processed differently. This evidence is clear in language acquisition (Gentner, 1982; Imai, Haryu & Hiroyuki, 2003; Meyer, et al., 2003; Sandhofer, Smith, & Luo, 2000; Theakston et al., 2002) and in adult neurolinguistic research with brain damaged patients (for review see Gainotti, Silveri, Daniele, & Giustolisi, 1995), using Event Related Potentials (ERP's) (Brown, et al, 1973; Khader, Scherag, Streb, & R et al., 2003; Molfese, et al., 1996), and functional Magnetic Resonance Imaging (fMRI) (Damasio, & Tranel,1993; Cappa & Parani, 2002) research.

On the other hand, more recent research indicates that nouns and verbs might not fall neatly into a dichotomous categorical system from a conceptual point of view.

Rather, there might be more of a continuum between the processing of nouns and verbs (Bird et al., 2000a; 2003; Black & Chiat, 2003; Gentner & Boroditsky, 2001; Gillette et al., 1999). For example, aphasic dissociations between nouns and verbs are more ambiguous than originally proposed, with subtle abilities and faults between and within syntactical categories (Bird et al., 2000a; Durks & Masterson, 2003). Further, researchers often oversimplify the classifications 'noun' and 'verb' by testing thin categories of *objects* and *actions* and making inferences about the general categories of *nouns* and *verbs*. Investigators often overlooked the considerable overlap between concepts encoded in the nouns and verbs of a language (consider for example, *Eating* is a fun activity vs. She is *eating* her lunch) (but see Nelson, 1995).

Many now propose that children's difficulties in learning verbs lie not in the syntactical category of "verb" *per se* but in abstracting and mapping complex, relational, semantic information compared to simpler information (Gentner & Boroditsky, 2001; Smiley & Huttenlocher, 1995). Verbs as a class tend to be more conceptually abstract than nouns, and this distinction is even more drastically drawn when we limit the study of noun and verb categories to objects and actions (Snedeker & Gleitman, 2004). Yet, when we consider the range of nouns, from *cup* to *justice*, and verbs, from *running* to *being*, these categories begin to blur. This view suggests that the word learning problem children face is to learn words that fall on a *continuum* of concepts. The question that arises is how we should characterize this continuum.

"SICI" is an acronym for the many factors that scale the difficulty of learning a particular word (shape, individuation, concreteness, and imageability). In creating this continuum, we again borrow from Gentner and Boroditsky (2001), Snedeker and

Gleitman (2004), research in neurolinguistics (Bird et al., 2000b; Black & Chiat, 2003), and our own work (Golinkoff, Hirsh-Pasek, Mervis, Frawley, & Parillo, 1995; Golinkoff, et al., 2002). We use SICI instead of relying on any one feature of the continuum for two reasons. First, the literature uses these terms somewhat loosely and different terms are used across related but different literatures (as in neuroscience). Rather than select any one term to label the continuum, we use an amalgamation. Second, to the extent that these factors play a role in word learning, it is unclear at this time how much weight each one should be given. Thus, because all of these features appear to be important in understanding the continuum of concepts, we take a broad view.

SICI: The S is for SHAPE. Golinkoff et al. (1995) argued that early in verb learning, and analogous to the shape bias in noun learning (Smith, 2000), young children abstract the "shape" of the main event (as Pinker, 1989, called it) when they observe an action. Indeed, Golinkoff et al. (1995) predicted that the first kinds of verbs children would learn and extend would be those that lent themselves to the abstraction of an invariant "shape" (like *dancing*) as opposed to those verbs that described less visible actions (like *thinking*). They wrote,

> …the shape of an event is different from that of objects, for which shape refers to a persistent, palpable object contour. For actions, shape lasts only as long as the event and refers to the overall configuration of the action. To say that the child abstracts the shape of the main event …allows the infant to lose the detail of each individual event (i.e., to 'bleach' it) and to represent a class of events with a single representation (p. 198).

Although Golinkoff et al. (1995) did not scale various verbs for the likelihood that they share a common shape (the verb "dancing" would undoubtedly get a higher score than the verb "wishing", but lower than "walking" for example), they did bring this notion to ground in two different studies. Golinkoff et al. (1995) asked whether toddlers could fast map and extend new action names as younger toddlers had shown with object names (Golinkoff et al., 1992). Thirty-seven-month-olds saw static pictures with various Sesame Street characters performing actions, some familiar and some novel (see Figure 4). In response to a novel verb, toddlers selected the unknown action demonstrating mutual exclusivity in verb labels. Further, they then extended the new verb to another character whose body showed the same shape, e.g., arms and one leg extended for an arabesque. In this experiment stimuli were static, two-dimensional drawings so it was unclear whether children could extend verb labels to ongoing actions. However, the findings showed the importance of body shape in extending a verb label.

-- Insert Figure 4 about here --

In a second paper, Golinkoff, et al. (2002) presented children (mean age 37 months) with "point light" displays of actions. "Point light" displays show only dots of light on the major joints (elbow, shoulders, knees, etc.) of a human performing an action against in the dark. In this study, children were shown four pairs of eight possible, known actions (kicking, dancing, etc.) in point light displays on a split screen. The scene was accompanied with a verb label corresponding to one of the two actions. For example, children heard "Look at her dancing!" when dancing and kicking were shown. Despite the fact that children only saw lights moving about on a screen, they were able to find the match in the Intermodal Preferential Looking Paradigm (Hirsh-Pasek &

Golinkoff, 1996) when asked to locate a particular action. These findings suggest that children extend verbs based on an averaged representation of what that action looks like, its "verbal essence" (Golinkoff et al., 2002). "Verbs of motion have … *a typical appearance, a physiognomy*"'(Marconi, 1997, p. 159, italics ours).

Since research has established that a major basis of noun extension (although not the only basis – see Kemler-Nelson et al., 2000; Golinkoff et al., 1995) is shared shape (Smith, 2000), perhaps it is not surprising that when possible, children use shape for verb extension. Undoubtedly object shape is more reliable and consistent than the generalized shape of actions that unfold in time. Nonetheless, verbs could be scaled for how much shape consistency they offer (Golinkoff et al., 1995). This argument was originally made within word class, but we propose it extends across them. "Dancing" is also more consistent in shape than the verb "thinking", but it is also more consistent in shape than the noun "idea". Thus, there may be substantial overlap across word classes in terms of a shape continuum.

SICI: I is for Individuation. Other researchers agree that the complexity of the concept a word labels influences word learning. Gentner and Boroditsky (2001) posited a continuum they labeled the *Division of Dominance* to understand why nouns are acquired before verbs. At the cognitive dominance end of the continuum, items are individuable and available from observation of the world. For example, the referent of a concrete noun like "cup" can be readily observed in the world, as can the referent of any proper name for an individual. Anchoring the linguistic dominance end of the continuum are grammatical elements, such as determiners and conjunctions, which can only be learned *through language*; there is no individuable element in the world that corresponds to

"and." Gentner and Boroditsky placed verbs and spatial prepositions closer to the linguistic dominance end. Thus, to learn a verb, the child has to know at least some language since "…their meanings are linguistically embedded: … invented or shaped by language to a greater degree than is the case for concrete nouns" (p. 216). Yet Gentner and Boroditsky recognized that not all nouns are at the cognitive end of the dominance continuum. Not all nouns label concrete objects available for inspection in the world. Nouns like "uncle" (meaning male sibling of one of my parents) that specify kinship relations and are defined within a system fall closer to the middle of the continuum. Gentner and Boroditsky posit that the individuability of a concept determines the ease with which it can be learned. On this theory, in general, verbs lie at the more difficult end of this continuum and are thus harder to learn compared to nouns. Though Gentner and Boroditsky's continuum allows for distinctions within word class, they did not fully explore the possibility of overlap between word categories. Here we argue that this individuation continuum may be extended in this way to help explain all of word learning.

SICI: C is for Concreteness and I is for Imageability. The concepts of concreteness and imageability have also be discussed in relation to the noun/verb distinction (Bird, Howard, & Franklin, 2000a; 200b; 2001; Black & Chiat, 2003; Gillette et al.,1999). In much of the literature on memory and aphasia, the terms concreteness and imageability are used interchangeably. Here we include both to stay consistent with that work. "Imageability" is defined as the ease with which a word gives rise to a sensory mental image (Paivio, Yuille, & Madigan, 1968). This is distinct from "concreteness" (Paivio et al., 1968) that refers to the ability to see, hear, and touch something.

Imageability thus includes, for example, "emotion" words, like *joy* or *hate* that one can imagine but not touch. Imageability ratings generally occur on a 7-point scale from "not imageable at all" (1) to "extremely imageable" (7); (Bird et al., 2001; Gillette et al., 1999). Ratings of imageability would ordinarily however, be highly correlated with ratings of concreteness (Paivio et al., 1968).

Imageability ratings are more predictive of word acquisition than the grammatical categories of noun and verb. Bird et al. (2001) found that *regardless of grammatical category* (including verbs and function words), age of acquisition is significantly correlated with imageability. Further, imageability can predict the ease with which one can determine the referent of a novel word in context. In the human simulation study by Gillette et al. (1999), adults' difficulty in identifying absent verb labels compared to noun labels disappeared completely when imageability was controlled. As they stated,

> … it is not a difference between nouns and verbs *per se* that accounts for the ease with which words are identified…The account is a more mundane and ultimately tautological one, namely that only observables – the most "picturable" or "imaginable" items – can be efficiently acquired by observational operating alone" (Gillette et al., 1999, p.153).

Thus, imageability, even for adults, determines the ease with which a novel word is identified, regardless of syntactic class. This further supports the claim of a continuum spanning across word class and allowing for overlap between word classes instead of a dichotomy for understanding noun and verb acquisition.

In sum, words can be thought of as falling on a continuum that characterizes the reliability and consistency of their shape; the ease with which they can be distinguished

from other items in the scene (individuability); whether they can be observed in the world at all and are manipulable (concreteness); and how readily they yield a mental image for adults (imageability). Importantly, while nouns differ in their position on this continuum, so do verbs. In fact, nouns and verbs can even overlap in where they fall.

If we couple SICI with a general word learning theory, in this case the ECM, we might gain some purchase on the way the earliest words are learned. Children's earliest words will likely be at the more concrete, shape-based end of this continuum across word classes. Thus, a noun like "cup" will be learned prior to "uncle" and the verb "kiss" will be learned before "think."

How the ECM, in combination with the SICI continuum, helps us understand verb learning. Verbs in general lie on the more abstract end of the SICI continuum. As a result, mapping is more ambiguous and requires children to utilize multiple cues to narrow down candidate meaning.

A major tenet of the ECM is that children begin by relying on perceptual information and shift their attention to social and linguistic information in learning words. A large body of research supports this claim with respect to noun learning (see Hollich et al, 2000 for review). Here we expand this argument by showing similar support within the class of verbs and across word classes Support for this argument is in 3 parts. First, we suggest that children's early vocabularies reveal that words are learned through a perceptual bias. Second, we review evidence for the increased use of social cues as children master verb acquisition. Third, we review empirical support for the children's increased use of linguistic cues in uncovering verb meaning. In the end, we

argue that given the SICI continuum as a conceptual base, the ECM can explain both word mapping for nouns and verbs.

Initial perceptual bias in verb concepts. Many of the verbs that appear early in children's vocabularies follow the characteristics of words on the concrete end of the SICI continuum. Throughout the literature, the argument for a perceptually biased, concrete word learner is made in a number of ways. One argument is that children's early verbs are more likely to be available to perception (such as *eat* or *run*) as opposed to later verbs that cannot be as readily observed (such as *think*, *wish*, or *dream*) (Mandler, this volume; Smiley & Huttenlocher, 1995; Snedeker & Gleitman, 2004). A second version of this argument is that children's early verbs are more likely to be used in specific contexts and linked to routines as opposed to used more broadly in a wider range of contexts (see Naigles & Hoff, this volume, and Tardif, this volume). A third version of the perceptually biased verb learner is that children's early verbs are more likely to require fewer inferences about the speaker's intentions and goals than later verbs (e.g., *pour* versus *spill*) (Behrend, 1995; Behrend & Scofield, this volume; Smiley & Huttenlocher, 1995; Poulin-Dubois & Forbes, this volume). A last version of this argument is that children's early verbs are more likely to be used in limited, nonmetaphorical extensions as opposed to broader extensions (Behrend, 1995; Forbes & Farrar, 1993). The evidence that children's initial verb meanings are quite perceptually based, as the ECM would predict, is extensive for each of these overlapping arguments.

Further research with both nouns and verbs suggests that children's early word meanings are relatively concrete compare to those of adults (Gentner, 2003). For example, children use abstract relational terms, like *uncle*, without any apparent

understanding of the kinship system implied. Instead, they interpret such complex relational nouns as more concrete, perceptually based concepts, e.g., an uncle is a nice man with a pipe (Keil & Batterman, 1984). This conforms to predictions of the ECM and suggests that children interpret more complex, relational nouns as falling at the more concrete end of the SICI continuum than they really do. Children map *uncle* not as an abstract kin relationship (viz, a parent's brother), but as a perceptually salient feature, e.g., the man who looks like my dad and plays football with me (see also Hall and Waxman, 1993).

Evidence in verb learning also shows that the verb meanings children encode are more concrete than adults' meanings (Forbes & Farrar, 1993; Maguire et al., 2002; Smiley & Huttenlocher, 1995). For example, Gallivan (1988) interviewed children (ages 3 to 5 years) and adults about the meaning of 10 verbs common in early vocabularies. While children gave definitions concerning perceptual similarities between exemplars (agent, object and instrument), adults gave more conceptual responses, such as the intentions of the agents and descriptions of the scene. These findings support the theory that younger children use perceptual information as a basis for their understanding of verbs, while adults use more informative aspects such as intentions of the actor.

Forbes and Farrar (1993) taught 3-year-olds, 7-year-olds, and adults novel verbs for novel actions and asked them to judge whether the verb applied to new situations. There was a developmental progression in which adults were more liberal in their extensions than 7-year-olds, and 7-year-olds were more liberal than the very conservative 3-year-olds. For 3-year-olds there could be very few perceptual changes, for example in the result or the instrument, for the novel verb to be extended to a new exemplar. Thus,

the conceptualization of the novel verb was much more concrete on the SICI continuum for 3-year-olds than 7-year-olds or adults, who could abstract the meaning from the perceptual scene.

Additionally, Theakston, Lieven, Pine and Rowland (2002) showed that even for apparently simple verbs like "go," children between the ages of 2 and 3 years do not have a single, unified concept of *go* despite its frequent use. Instead at younger ages there were very specific situations for each grammatical instantiation of the word *go*. Thus, while children appeared to use a verb competently, they really used it with many different, unrelated meanings.

How do children move beyond their perceptual biases? According to the ECM, they become increasingly able to mine the social and linguistic cues afforded to them as they learn concepts further along the SICI continuum.

Use of social cues. Two forms of intentional understanding are vital to learning novel verbs (1) inferring the speaker's attentional focus and communicative intent (Tomasello, Strosberg & Akhtar, 1996); Baldwin, 2000) and (2) inferring the intent of the actor (Poulin-Dubois & Forbes, 2002; this volume; Smiley & Huttenlocher, 1995).

Akhtar and Tomasello (1996) showed that children infer the intent of a speaker to name a novel action when they learn a label for an action that they never saw performed! Here the experimenter told the child that they would *meek* Big Bird. Then after searching the experimenter informed the child that she could not find Big Bird. The target action was then performed with other objects, but never labeled. As a test, a novel object appeared and the children were asked to *meek* Cookie Monster. These children were still able to produce the action with the novel object at the same rate as children who heard

the label as the action was performed. Thus, children used the intent of the speaker to interpret the meaning of the novel verb.

Children not only need to be able to follow the intent of the speaker with respect to which aspect of an event is receiving a label, but to understand the intent of the *actor* in order to learn the names of similar actions. Poulin-Dubois and Forbes (2002) found that 27-month-olds, but not 21-month-olds, could use social cues when distinguishing between novel actions that looked quite similar except for barely detectable social information. Specifically, 27-month-olds attended to the subtle cue of eye gaze when determining whether a verb meant something like *topple* or *knock over* when viewing the same action. At this young age children understand that actions can look similar, but have distinct labels because of the intentions of the actor.

Another example of children's ability to utilize subtle social cues comes from the work of Imai, Haryu, Okada, Lianjing, and Shigematsu (this volume) with Chinese-speaking children. When they discovered that even children as old as 5 years could not map a novel verb to a novel action, they reasoned that it might have something to do with the social cues available in the scene. Prior to hearing an unseen speaker offer a label for a novel action performed on a novel object, the actor held up the object that was to be used for a few seconds. Imai et al. reasoned that the extra seconds during which the object was held up may have suggested that the new word was a *noun*. When the extra seconds of object holding was removed, many more children now attached the new word to the new action.

Children's exquisite sensitivity to social cues when the speaker and the actor were the same also surfaced in a study by Behrend and Wittek (2003; Behrend & Scofield, this

volume). An actor performed a novel *intended* action (putting a string of beads into a cup) or a novel *unintended* action (dropping the string of beads next to the cup) either accompanied by a novel verb label or without a verb. Behrend and Wittek hypothesized that if the unintended action was given a label, children would believe the action was intentional. Results, though not as strong as predicted, did show that 30-month-olds were more likely than younger children to reproduce the unintentional looking action (dropping beads next to the cup) if it was labeled during training. Thus, children take the presence of a verb as a sign that a novel action is being named. On the other hand, the weakness of this effect is also informative for it shows the overwhelming influence of intentionality on children's understanding of human actions. Children ordinarily avoid labeling a seemingly unintended action (see also Childers and Behrend, 2003).

To fully master verb learning requires a strong understanding of both actor and speaker intent. Many potential referents for verbs exist simultaneously. Being able to interpret speaker and actor intent is essential to arriving at the correct verb meanings.

Use of linguistic cues. Syntactic frames serve to constrain the possible interpretations of a novel verb, because frames have semantic implications for the verbs that appear in them (Fisher, 2002; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman & Gillette, 1995; Naigles, 1990; 1996). For example, a child may hear *bring* while holding a doll and could assume the word means *bring*, *carry*, or *walk*. But if the child hears "Are you bringing me the doll?" the use of two objects in the frame V NP NP suggests that bring is a verb of transfer, eliminating hold, carry, and walk (Naigles, 1996).

Research using the Intermodal Preferential Looking paradigm found that, by 2 to 2.5 years of age, children are sensitive to the implications different verb frames have for

meaning (Hirsh-Pasek & Golinkoff, 1996; Hirsh-Pasek, Naigles, Golinkoff, Gleitman, & Gleitman, 1988; Naigles, 1996; see also Fisher and Song, this volume). For example, children who heard a verb in a transitive sentence frame such as, "Oh, see Big Bird glorping Cookie Monster?", watched a causal event in which Big Bird made Cookie Monster do something more than a noncausal event in which Big Bird and Cookie Monster performed a novel action together. The opposite result occurred when children heard an intransitive sentence such as, "Oh, see Big Bird is glorping with Cookie Monster!" Hearing this sentence, children watched the noncausal event more than the causal event (Hirsh-Pasek, et al., 1996). This finding indicates that by around 2 years children understand that cause is encoded in a transitive sentence frame. Other empirical support for the role that linguistic information plays in cueing verb meaning comes from work by Fisher (2002; Fisher et al., 1994; this volume) and Naigles (1990, 1996; Naigles & Kako, 1993; Naigles & Hoff, this volume). These findings indicate, as predicted by the ECM, that by around the second year, toddlers are beginning to use grammatical cues in their language to narrow the possible referents of a novel verb.

Children can also use information in the syntactical frame to decipher which *aspect* of an event a verb labels. Maguire (2004) tested toddlers' ability to use prepositions to interpret a novel verb label. Twenty-five and 31-month-olds saw video clips of an animated character ("Starry") performing one manner across four different paths in relation to a stable ball. Starry could spin over the ball, spin under the ball, spin past the ball, and spin in front of the ball. The scenes were labeled in one of two ways: either with the correct preposition *("Look, Starry's blicking over the ball. Now he's blicking under the ball"),* or without a preposition *("Look Starry's blicking").* During

the test trials, toddlers were shown a novel manner across one of the familiar paths (e.g., *bending* over the ball) or the familiar manner across a new path (e.g., spinning *behind* the ball) and were asked to "Look at Starry blicking". Only in the condition where children were offered additional linguistic information in the prepositional phrase, did they successfully extend a novel verb to the *manner* of the action.

Thus, as children develop they become better able to use all of the resources available (perceptual, social and linguistic) to them in deciphering word meanings. While perceptual cues can help to a large degree with nouns, words that lie on the more abstract end of the SICI continuum are less accessible through perceptual cues alone. These require social and linguistic support to narrow down the candidate meaning for a word. Because verbs generally, though not always, lie on the more abstract end of the continuum, mapping most verbs and some nouns awaits children's ability to coordinate use of the multiple cues at their disposal in the service of word learning. The result is that abstract, relational words are not fully mastered until children can recruit these resources successfully.

Part III: A more coherent and unified view of word learning.

We began with a statement of the facts on noun and verb learning that have predominated in our literature. Traditionally, the literature in our field finds that verbs are harder to learn than nouns. Perhaps we can explain the differences in noun and verb learning through appeal to a broad-based theory of word learning (ECM) that is blind to form class. Building on Snedeker and Gleitman (2004) and Gentner and Boroditsky (2001) we suggest that words lie on a continuum from more concrete to more abstract. As we move conceptually towards the more abstract end of the continuum, mapping from

word to world becomes too ambiguous to solve without added support from social and linguistic cues. The ECM predicts that children will first map words onto concepts that are more perceptually salient, only later recruiting social and linguistic cues in the service of word learning. This will be true for all words, including nouns, verbs and even adjectives. This broader view of vocabulary building turns our attention to common mechanisms that might be responsible for learning words providing a more parsimonious story of vocabulary acquisition. Further, the argument for a broader framework for word learning helps us better understand the emerging and often contrasting pattern of findings that have evolved in our literature.

Next we return to the facts about verb learning we pointed out at the start of the paper, facts that seemed unrelated and possibly incoherent. Armed with the ECM, we have a grasp now on what those facts mean and how they fit together.

1) *Why are nouns generally learned before verbs?* Because, on average, nouns and especially object nouns of the sort studied in our literature, fall at the more concrete end of the SICI continuum than do verbs. These more imageable words are learned earlier than less imageable words, regardless of syntactic class (Bird, Franklin, & Howard, 2001). Preliminary data in our labs (Lannon et al., in preparation) suggests that adult ratings of imageability correlate with age of acquisition on standardized material checklists, like the MacArthur Communicative Inventory (Fenson et al., 1994) irrespective of word class in both English and Chinese.

2) *Why does this pattern appear to be universal (Bornstein et al., 2004)?* Despite the fact that verbs in some languages appear to be favored, research suggests that even in those languages verbs are generally more difficult to learn than nouns. For example, languages

like Chinese and Japanese allow the verb to appear in isolation or in potent sentence final position. Nonetheless, research conducted in laboratory settings reveals that children often struggle with learning new verbs even when in situations where they readily learn new nouns (Imai et al., this volume; Meyer et al., 2003). This is because the packaging and perspective problems are universal to verbs across languages.

3) *Why do some verbs appear in children's earliest vocabularies, a finding that is especially pronounced in languages like Chinese (Tardiff, Gelman, & Xu, 1999) and Tzeltzal (Brown, 1998)?* We have discussed two reasons why some verbs appear early in children's vocabularies for at least two reasons. First, the verbs that appear in these languages are on the more concrete end of the SICI continuum. Although the average noun is more concrete than the average verb there is variability around the mean. There is within class variation on the SICI continuum just as there is between class variation in where items fall. As Snedeker and Gleitman (2004) have argued, motion verbs will be acquired earlier than mental verbs. Similarly, those verbs that are more perceptually available and contextually bound will be learned before verbs that are not. The specificity of verbs in other languages may explain their early acquisition. For example, in Tzeltzal there are different, context specific verbs for *eat meat* (ti'), *eat soft things* (lo') and *eat crunchy things* (k'ux) (Brown, 2001). Each of these verbs is produced by children in the one-word stage. The specificity of their meanings may make them easier to acquire than the more abstract English *eat*. Those verbs found at the concrete end of the SICI continuum are easier to acquire, just as the ECM and SICI would predict. Indeed, Tardif (this volume) suggests that the early verbs learned by Chinese children are

more perceptually accessible and context bound, a finding echoed in by Naigles and Hoff (this volume).

The second explanation for children's early verbs comes from the apparent contradiction of children using verbs like *think* and *know* that seem to fall at the abstract end of the SICI continuum. Here the research suggests that children might have only partial knowledge of the meanings of these verbs (Gallivan, 1998; Theakston et al., 2002). That is, while children may use these verbs, they probably do not use them in adult-like ways.

Thus, the verbs that enter children's vocabularies early have meanings that are either (1) accessible to a young child through perception and context-specificity; or (2) have meanings that are different than adult meanings by being less abstract then they appear. The predictions of the ECM, combined with the SICI continuum, help explain why verbs appear in early vocabularies even though the class of verbs is learned relatively late.

4. Finally, why are the conceptual meanings of some nouns like passenger or uncle acquired relatively late in development? As with verbs, nouns demonstrate within class variability on the SICI continuum. Indeed, sometimes the noun distribution will overlap with the verb distribution because these nouns are more abstract. Like verbs, these more difficult nouns *can* enter children's vocabularies early, but when they do, their meanings are not the same as adult meanings. Such is the case with nouns like *passenger* and *island*, which for children are rooted in perceptually based, concrete notions (Hall & Waxman, 1993; Keil & Batterman, 1984). Just as with verbs, learning abstract relational nouns will require the coordination of social and linguistic information in additional to

perceptual cues. In short, a wide angle lens on word learning helps to explain what appear to be divergent findings in the verb learning literature.

Conclusions

During the past ten years, the study of word learning has become more inclusive. Instead of focusing solely on ways in which children learn object nouns, we now have data on how children learn verbs, adjectives, and pronouns. It is possible that each word class will require different learning rules. For example, the packaging and perspective problems might be unique to verbs and adjectives. Yet, an alternate and perhaps more parsimonious approach to the study of word learning posits that one framework might be able to account for all word learning and that differences in noun and verb learning might be a product of natural variation among the kinds of things that these syntactic form classes tend to label. The ECM offers one such unified account. It is an account that is sensitive to data from linguistics, psychology, and neuropsychology. It also allows us a way to explain seemingly disparate findings in a coherent way.

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Figure Captions

Figure 1. Visual fixation data for attention to the novel agent/novel action test trial in comparison to the novel agent/familiar action test trial. Represented here are the toddlers with high comprehension vocabulary (Salkind et al.. 2002).

Figure 2.

Figure 3. The weighting of the cues that contribute to word learning over developmental time in the Emergentist Coalition model (Hollich et al., 2000).

Figure 4. Stimuli from Golinkoff et al. (1996) showing three known and one unknown action ("arabesquing").

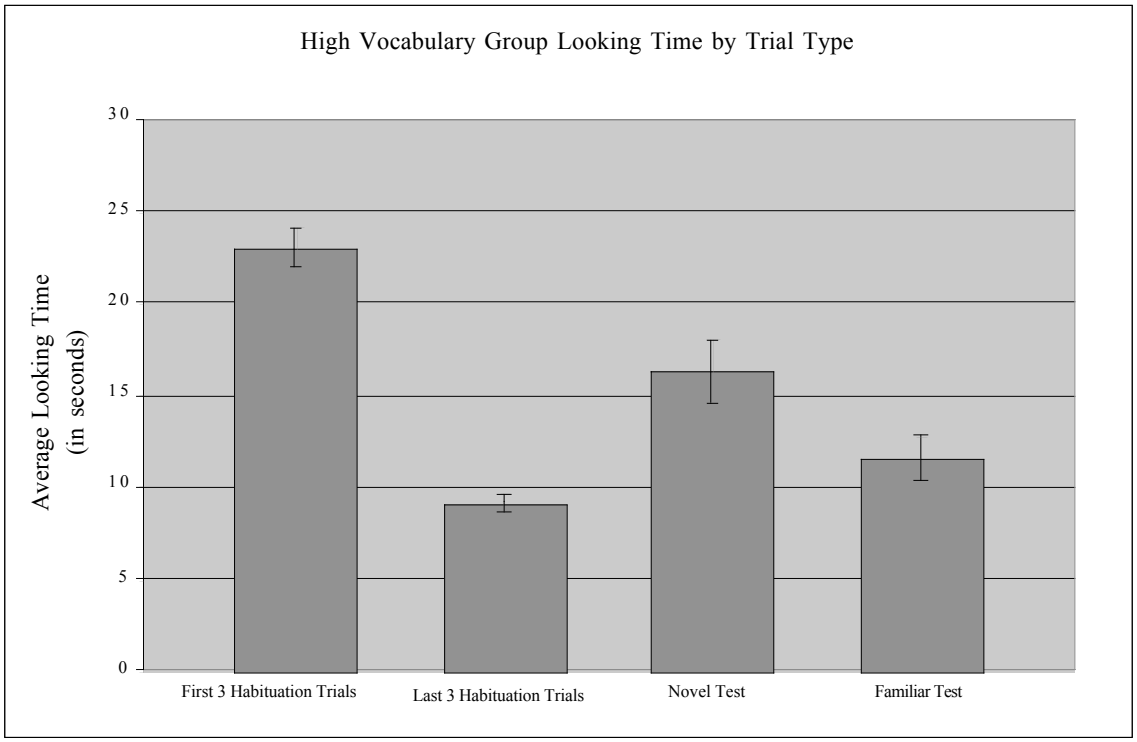

High Vocabulary Group Looking Time by Trial Type
Average Looking Time (in seconds)
30
25
20
15
10
5
0
First 3 Habituation Trials
Last 3 Habituation Trials
Novel Test
Familiar Test

Figure Captions

Figure 1. Results of Salkind, et al. (2002). The distribution of looking times for high vocabulary 10-month-olds after habituating to a novel action performed by a novel actor.

Figure 2. Stimuli from Meyer, Pruden, Hirsh-Pasek, and Golinkoff (2003) comparing noun and verb learning based on syntactic cues available.

Figure 3. The Emergentist Coaltion Model (ECM).

Figure 4. Stimuli from Golinkoff et al. (1996) investigating children's use of shape cues in determining verb extensions.

Figure 1.

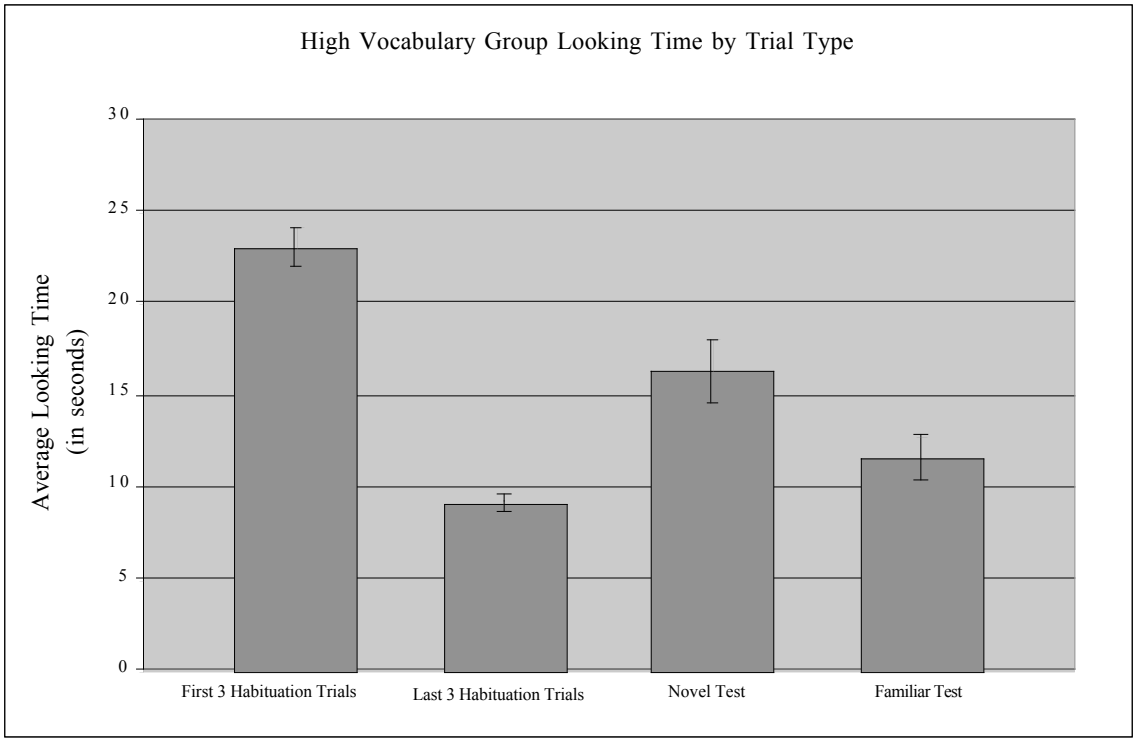

High Vocabulary Group Looking Time by Trial Type
Average Looking Time (in seconds)
30
25
20
15
10
5
0
First 3 Habituation Trials
Last 3 Habituation Trials
Novel Test
Familiar Test

Figure 2.

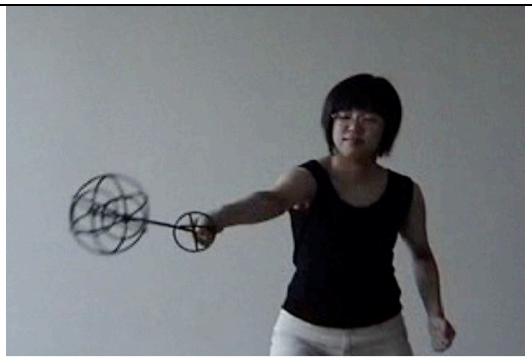
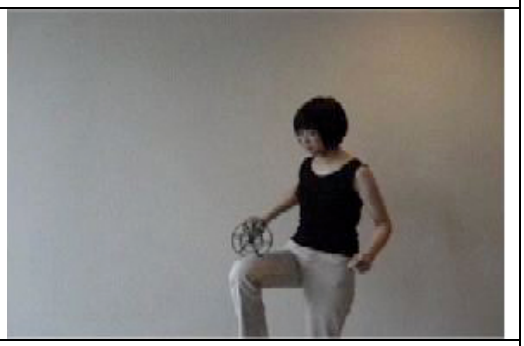
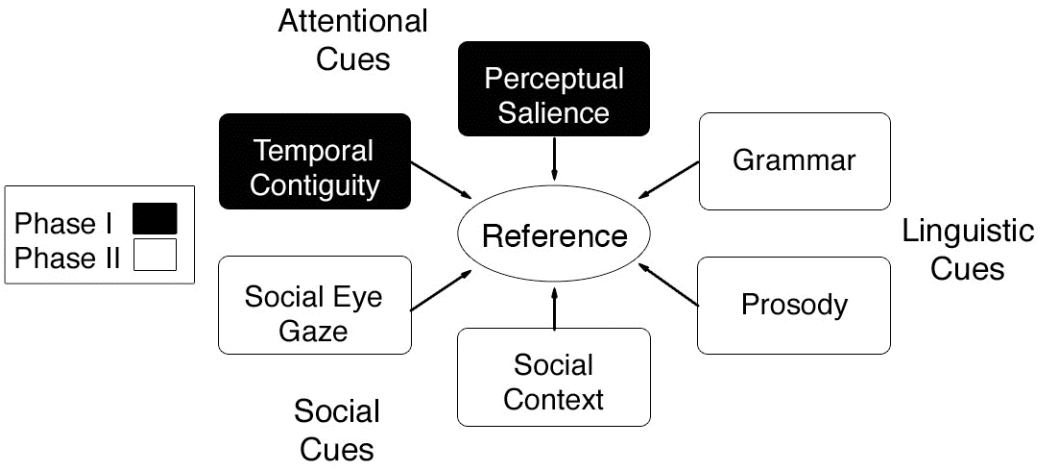
	TRAINING
	
Noun	"Look, at the blick!"
Bare-frame	"Look, blicking!"
Rich-syntax	"Look, she's blicking it!"
	TEST
	 
Noun	"Where's the blick?"
Bare-frame	"Where's blicking?"
Rich-syntax	"Where's she blicking it?"

Figure 3.


Attentional Cues
Perceptual Salience
Temporal Contiguity
Grammar
Phase I
Phase II
Reference
Linguistic Cues
Social Eye Gaze
Prosody
Social Context
Social Cues

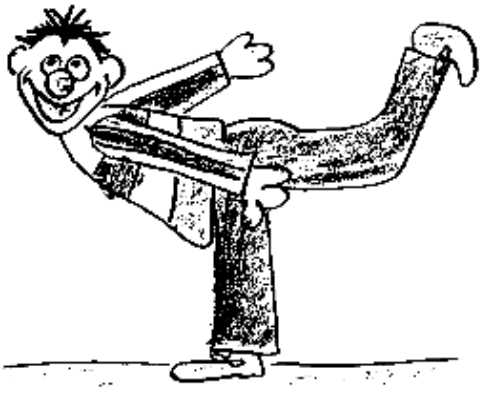
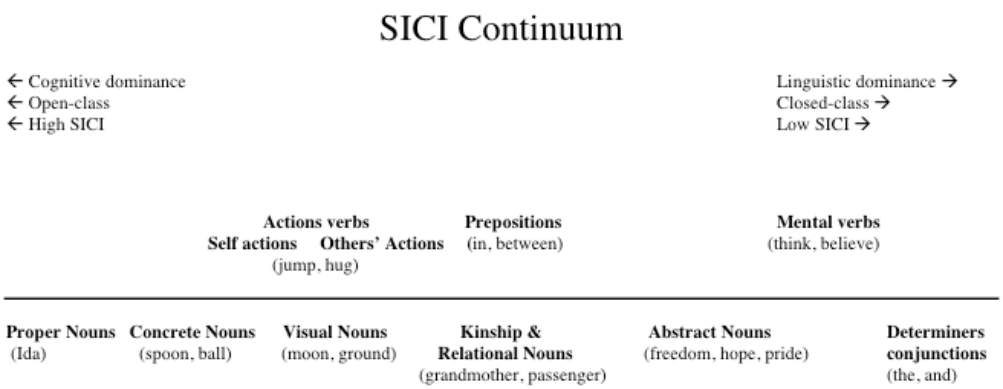


Figure 4.

Optional Figure.



Anything else?