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### How toddlers begin to learn verbs

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## Abstract

Any theory of language must account for how children learn verbs, the gateway to grammar. Yet verbs can be difficult to learn. Building on Gentner's "natural partitions hypothesis," we suggest that to learn a verb, infants must conceptualize components of events and map verbs in the ambient language onto those components. While toddlers detect and categorize at least some of the conceptual underpinnings of verb categories, the mapping of verbs onto these representations is not transparent. Mapping is a difficult problem in its own right. The Emergentist Coalition Model that has been used to explain noun learning also begins to explain how children move from perceptual to social and then linguistic information to link verbs to actions and events.

## How toddlers learn verbs

### *The Problem of Verb Learning*

Verbs are the gateway to grammar. Thus, any theory of language acquisition must explain how children learn them. When expressing a thought, the choice of a verb determines what other words will be chosen (that is, what kinds of actors can perform the action the verb names) and the way in which words are assembled in sentences (that is, will a grammatical object be needed or not). The verbs children learn can be defined syntactically and semantically. Syntactically, verbs take subjects or objects or both as in “John [subject] blocked Mary [object].” Semantically, verbs encode events and are a cover term for states or processes. They name visible actions (such as “running”), invisible executive processes such as “thinking” [1], and are inherently *relational* as some entity is required to carry them out. For example, the action of ‘jump’ (and the verb that describes it) requires someone or something to carry out the action.

As researchers have long noted [2-4], the fact that verbs label dynamic events and processes poses a special learning problem for young children. In particular, children must take the ever-changing events in the world and transform them into a categorical system represented by language. Thus, even though infants process extensive metric information about continuous events, they must rely on abstract categorical information to express these events in language [5,6]. Advances in methodology that enable the presentation of dynamic events (such as the Intermodal Preferential Looking paradigm [7,8] (Box 1 Fig i), combined with the availability of video editing technology, now empower researchers to test verb learning. This paper examines how research on

children's understanding of event structure and their ability to link word-to-world has boosted our understanding of verb learning [9].

In her "natural partitions hypothesis," Gentner [2] argued that verb learning was dependent upon two capabilities: 1) A conceptual understanding of the events verbs describe; and 2) A recognition of the way in which one's particular language expresses these events. Gentner wrote, "It is not perceiving relations but packaging and lexicalizing them that is difficult" (p. 326). Gentner's hypothesis (and its offshoots) fueled a new area of research that bridges *event perception* and *early verb acquisition*. The former investigates how children perceive and categorize nonlinguistic events in ways that will be relevant to language expression. The latter investigates how children learn to *map* their event conceptualizations into the language they are learning [see also 3,4]. The sheer amount of information in an event makes mapping uncertain since verbs are not "verbal film clips of events" [10, p. 159]. For example, when children hear, "Don't *climb* that!" the verb *climb* refers to the relationship between an agent (the child) and something being ascended (the dresser). The learning problem here is twofold. First, amidst this dynamic and complex event, the child must abstract the spatial component of path, i.e., ascent. Second, the word *climb* must be mapped to the path and not, say, to the little hands grasping the drawers.

In the face of this complexity, relational terms (verbs, prepositions, and adjectives) often lag behind nouns in both studies of natural vocabulary acquisition (e.g., [11,12]) and in laboratory research on verb comprehension (e.g., [13-16]) (Box 2 Fig i). This general finding must be evaluated in the context of data from some Asian languages however, in which verbs appear earlier in *production* (e.g., Chinese, Korean) than they do

in English [17,18], possibly because of characteristics of the input to children. Chinese, for example, allows verbs to appear in isolation. Thus, English requires, “John kissed Mary” while in Chinese “qin1” [kiss] is acceptable, if the listener can infer the meaning from context. Furthermore, Chinese caregivers produce both more verb types and tokens than English-speaking caregivers [17].

### *How Children Detect and Categorize Components of Events*

One reason why verb learning is challenging might be that children have difficulty extracting components of dynamic events. Several areas of research begin to tell this story. The event components that have received the most empirical attention are 1) perceptually accessible; 2) universally represented in relational terms across languages; 3) encoded differently across languages; and 4) are posited to represent a set of foundational concepts from which relational terms are constructed. Among the event components studied are *containment* and *support*, *path* and *manner*, and *source* and *goal* (e.g., [19-22]). To show that infants are sensitive to these components of events requires evidence that they a) *discriminate* these constructs as independent units within events; and b) *categorize* similar event types together [23]. ‘Climbing,’ for example, includes ascent whether done by a tiger or a child, on a mountain or a dresser.

#### *Discriminating and categorizing containment, support, and degree-of-fit.*

*Containment*, called “in” in English, is when an entity is in “...any fully or partially enclosed space...” [20, p. 78, 24]. “On,” the spatial relation *support*, occurs when a figure is supported by, attached to, or encircling an external surface of a ground object. Particularly interesting is the fact that Korean verbs cross cut the English categories of “in” and “on” with the construct *degree-of-fit*, a concept not lexicalized in English

[25,26], that captures the way two surfaces fit together. An example of *tight-fit* (interlocking surfaces) is the way in which Lego blocks fit snugly together; *loose-fit* is exemplified by the way an apple wobbles in a bowl. English reared infants can form categories of loose-fit versus tight-fit before 6 months of age despite the fact that they will not go on to learn Korean [27]. Infants categorize across categories of containment by 6 months of age [28], but not until 14 months across categories of support [29] (Fig 1).

*Path and manner.* *Path* is defined as the movement of a figure with respect to a ground object. *Manner* is how the figure moves within an event (e.g., climbing or walking). Path and manner are represented in all languages of the world but are codified differently. Spanish speakers would likely say, “*Una mujer salió de la casa (corriendo)*” (‘A woman exited the house (running)’)) using a *path* verb [19]. English speakers would say (‘A woman ran out of the house’) using a *manner* verb to describe *how* the figure moves, with the PATH in a satellite prepositional phrase (viz, *out of the house*). English uses many more manner verbs than does Spanish.

Both English- and Spanish-reared babies notice changes in paths and manners in dynamic events by as early as 7 months [23,30] and do so robustly by 14 to 17 months [30] (Fig 2). By 9 months, infants *categorize* paths when performed in the same way over different manners (over, under); by 13 months they categorize manners (bending or twisting) [31]. Thus, path relations are easier to detect and categorize than manner relations.

*Source and goal paths.* The paths described above do not entail goals but are VIA paths, as the figure moves past a referent object. In FROM paths, a figure moves from a referent object that is its source; TO paths are goal-oriented, involving movement toward

some endpoint. The source is the figure's starting point in an event and the goal is the figure's endpoint. Across languages, goal paths are expressed more frequently than are sources. Homologously, 12-month-olds attend preferentially to goal paths over source paths in dynamic, non-linguistic events [21,32]. By 14 months of age children form categories of goals though not of sources [21,33].

In sum, although limited to a subset of the semantic components verbs encode, part of Gentner's [2] natural partitions hypothesis may be correct. Infants appear proficient at perceiving and categorizing many (although perhaps not all) of the event concepts languages encode. "Thinking for speaking" [10 p. 158] requires that infants eventually detect the characteristics of events that find expression in language, even if these event components are not accessible all at once.

#### *How Children Map Verbs to Events*

While infants' conceptualizations of events may not appear problematic, difficulties in verb learning [e.g., 13] may be rooted in word-to-world mapping. Indeed, mapping verbs to referents is even difficult for adults. Yet mapping is not inherently challenging: By 10 months of age, infants can link object words to referents [34]; by 15 months of age, they seem to understand verbs like *dance* and *open* [35]. What then accounts for the generally slow progress of verb learning?

One theory of word learning, the Emergentist Coalition Model (ECM) helps unpack the complexity of verb mapping [8, 36-38]. A hybrid theory, the ECM holds that children rely differentially on multiple cues over developmental time to map words onto referents – whether they are nouns or verbs. At first, infants are sensitive to perceptual

cues – mapping a word to the referent that is most interesting or salient. They then use a speaker’s social intent along with linguistic cues to home in on word reference.

Several aspects of verb mapping might prove difficult for young learners. First, verbs are inherently relational. The actors and objects involved are often more salient than the actions themselves [39,40]. Second, as some verbs are less perceptually available (e.g., *know*, *want*), and as their meanings may turn on small differences (e.g., *chase* versus *flee*), children might require additional support to learn them [41]. Finally, the events verbs name are categorized differently across languages (e.g., the Korean verbs for *degree-of-fit* versus the *in* and *on* of English). Thus, verb learning might wait until children recruit not only perceptual information for word mapping, but also social and grammatical information.

One consequence of this hypothesis is that verbs – at least those that label perceptually less accessible referents -- will be learned later because children cannot use social intent and grammatical knowledge in the service of word learning until roughly 24 months of age (e.g., [42]). Furthermore, sensitivity to grammatical information rests on children learning a number of nouns [43] as well as having sufficient sentential input to note the correspondences between meanings and sentence structures [44]. The ECM makes predictions about the developmental course of verb mapping and suggests why non-relational words like early nouns predominate in early vocabularies [36] (Fig 3).

What is the evidence for this position?

*Perceptual information in verb learning.* If the initial strategy for word mapping is to preferentially attend to referents that are perceptually salient, then words that map to salient objects or events should appear first. Studies bear this out [34,37]. With nouns,



10-month-olds assume that a label maps onto an object they find interesting (a colorful clacker) rather than onto a boring object (a beige gadget) even though the speaker is naming the latter. This results in a systematic *mismatching* [34]. With verbs, Brandone et al. [45] pitted perceptual salience against speaker intention by teaching either the name for an interesting action *with a result* versus a boring action *without a result*. Training took place on a real object while testing occurred in the Intermodal Preferential Looking Paradigm (Box 1 Fig i). At 21 months, children learned the name of an action with a result (i.e., pressing a Morse code key produced a tone) but not the name for that same action when the result was disabled. Only at 33 months could children learn the name of the “result-less” action. Consistent with this finding is the fact that children learn names for their *own* actions prior to learning the names for others’ actions [46]. Actions we carry out ourselves should be highly salient.

Visible actions such as ‘running’ receive higher “imageability” ratings than unseen processes (‘thinking’) and are easier for adults to guess in the Human Simulation paradigm (Box 3) [47]. “Imageability” refers to the ease with which a mental image can be generated, viz., “apple” is easier than “believe.” In English and Chinese, words (both nouns and verbs) for which it is easier to generate a mental image, are learned earlier than words with lower imageability ratings [48]. Early-acquired Mandarin verbs are more imageable than early-acquired English verbs [48], a factor that reflects the fact that Chinese children produce more verbs early on than their English-reared counterparts [17]. Combining imageability ratings and frequency of tokens in the input accounts for 42% of the variance in the age of acquisition for verbs in Chinese [48].

If perceptual factors dominate in early verb learning, children should also be reluctant to extend a verb to a related but unfamiliar event. Indeed, children are notorious for narrow verb extensions, with 3-year-olds' interpretations of novel action verbs more specific than 10-year-olds' and adults' [49,50].

Perceptual factors are so potent for young word learners that an action performed by an unknown agent [40] or by multiple agents focuses children's attention on the agents rather than on the relation and interferes with verb learning. Maguire et al. [39] reported better verb learning in 2.5- to 3-year-olds with exposure to a *single* actor rather than *multiple* actors.

Importantly, even if an event that a verb names is visually accessible and perceptually narrow, ambiguity about verb meaning still remains. In the best case scenario, perceptual data cannot go all the way toward segmenting complex events into the categorical divisions that are the stock of language.

*Social information in verb learning.* As Tomasello and colleagues argue [51,52], language acquisition is embedded in the nexus of social interaction. Verb learning rests on social information in at least three ways: 1) in discerning which *referent action* the speaker is naming; and 2) in discerning the *actor's* intent (did she *mean* to kill Cock Robin or was it an accident?); and 3) inferring the *speaker's* interpretation of the event (e.g., *die* versus *kill*) [53].

A demonstration of the importance of social information in word learning is offered by the case of autistic children. Notoriously poor at interpreting others' intentions, 67% of the variance in the size of autistic children's vocabularies was accounted for by their sensitivity to speaker intent [54]. Using a novel verb for a novel

action -- even one that looks accidental (dropping beads outside a cup) -- influences typical 2-year-olds to believe that the action was done on purpose [55]. Finally, there is evidence that toddlers are sensitive to whether an event was intentional in assigning verb meaning. By 24 months, toddlers can infer that a speaker meant to label an unseen action [56]. By 27 months, children can learn different verbs for similar actions (e.g., *knock over* versus *topple*), if offered nonverbal information for whether the action was accidental or intentional [53].

In sum, attention to perceptual cues for verb meaning precedes children's attention to social intentional cues. However, as extralinguistic context is insufficient for interpreting verb meaning, perceptual and social cues alone leave the verb learner lost in a sea of possible meanings.

*Linguistic cues to verb meaning.* Consider the case of invisible verb referents such as *think* and the fact that identical scenes can be described in various ways (*Mary chases John; John flees from Mary*). Syntactic structure serves as a "zoom lens" [57] highlighting a speaker's perspective and constraining verb meaning. "Syntactic bootstrapping" [57] is the theory that children use the number and arrangement of arguments in the sentence to compute verb meaning [43]. For example, "John spoodled Mary the crick" suggests that "spoodled" must be about actual or metaphorical transfer. Analogous to *put*, "spoodled" takes three arguments: A subject (*John*), an indirect object that is spoodled (*the crick*), and a direct object (*Mary*). Fisher [58] illustrated this point with 2-year-olds, showing them a complex event of one woman pushing another woman forward and back in a red wagon. Hearing either a) an intransitive sentence ("She pilks back and forth!") or b) a transitive sentence ("She pilks *her* back and forth!"), children

were asked to point to static images in response to test questions. As the training sentences only differed in the number of arguments surrounding the verb, children used the syntactic information to decide whether the verb described the agent or the receiver of the action. Syntactic bootstrapping can even be used with languages that allow some argument dropping [59] and even overrides regularity in morphology for signaling verb meaning [60]. It also appears to work in reverse: Shown an event with a single participant, toddlers expect to hear an intransitive sentence. [61].

### *Conclusions*

Children's difficulty with verb learning may lie in their inability to detect and categorize the components of dynamic events or in the mapping process or both. While infants seem sensitive to the components of events, this research is still in its infancy. An interesting question is why some event components (such as path or containment) become available before their counterparts (manner and support, respectively).

The factors that influence mapping seem to undergo developmental change as well. Learners face a challenge in translating dynamic, continuous events into the categorical units required by language. Verb learning is first governed by perceptual factors, with interesting events preferred as verb referents. Even if strong perceptual cues are available however, verb meaning is still ambiguous and hence requires additional scaffolds in the form of social and linguistic information. One model, the ECM, provides a framework for organizing the course of early verb learning, and offers an explanation that invokes the multiple cues that children must coordinate to learn verbs. Why children shift in their use of these cues and how they interact for determining verb meaning are projects for further research.

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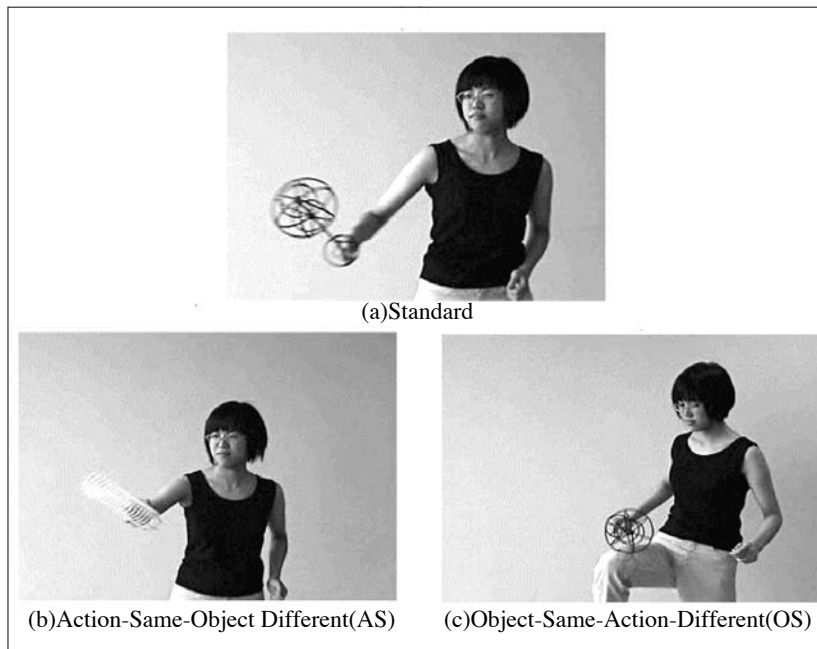
**Box 1 Fig i.** The Intermodal Preferential Looking Paradigm used to study verb learning.



How can we study the process by which young children, notoriously poor participants, learn verbs? In the Intermodal Preferential Looking Paradigm (IPLP) [e.g., 8,13,39,62], using looking time as the dependent variable, children see two simultaneous dynamic events with a linguistic stimulus that matches only one of the events. If children understand the linguistic stimulus, they look (or point when older than 30 months) at the matching scene more than at the non-matching scene. Children might see an actor dancing in one image and waving in another while they hear, “Where’s she dancing?”

The prediction is that they will look more to dancing than to waving. Attention during test trials can be compared to attention during salience trials with “neutral” language.

[Fig. source: Authors]



**Box 2 Fig i.** Nouns are easier to learn and extend than verbs in English, Japanese, and Chinese

Nouns are apparently easier to learn and extend (apply to non-identical instances) than verbs. This is true even in “verb friendly” languages where verbs can appear alone without the possible confusion of surrounding noun arguments. Imai et al. [13] tested English, Japanese, and Chinese children (ages 3 and 5) using videotaped displays in the Intermodal Preferential Looking Paradigm [7,8] (Box 1). In the Standard trial (a), children saw a video clip of a woman performing an unfamiliar action with an unfamiliar object. In the *Novel Noun* condition, children heard, “Look, a twill!” In the *Bare Novel Verb* condition they heard the equivalent of, “Look, twilling!” while in the *Full Argument Novel Verb* condition, they heard a full sentence, e.g., English: “Look,

she's twilling it." At test, children saw both an *Action-Same/Object-Different* (b) event and an *Object-Same/ Action-different* event (c).

In the Novel Noun condition, children pointed in response to, "Where is the twill?" Both age groups were successful. In both verb conditions, children were asked, "Where is she twilling?" Only 5-year-olds, however, successfully extended the *action* label, and only when the training condition matched how verbs are encoded in the target language. Thus, English-reared children succeeded in the Full Argument Novel Verb condition; Japanese children succeeded only in the Bare Novel Verb condition, hindered by full sentences.

When Chinese children -- even at the age of 5 -- did not at first succeed, Imai et al. reasoned that Chinese children might be relying on extralinguistic cues as Chinese uses no verb endings and permits dropping verb arguments. After a one-second segment of object-holding was removed from the beginning of each videotaped scene, Chinese children succeeded in the verb condition, demonstrating exquisite sensitivity to extralinguistic information for determining word meaning. English and Japanese children responded in the same way with and without the object-holding segment. [Fig. source: M. Imai, personal communication]

**Box 3.** Findings on noun and verb learning from the Human Simulation Paradigm.

“The Human Simulation Paradigm” [47] was developed to probe a significant generalization about vocabulary learning: Nouns are learned before verbs. In a fascinating demonstration on the relationship between event observation and word learning, researchers asked adults to guess the words used by mothers videotaped interacting with their children. Hearing a “bleep,” adults guessed the word from maternal speech to 18-to 24-month-old infants.

With extralinguistic observation controlled by presenting the same scenes, would adults replicate children’s pattern of acquisition by finding it easier to guess the nouns than the verbs? With adults, any difference between nouns and verbs could not be attributed to conceptual factors. Varying the linguistic information offered along with the scene allowed exploration of how accompanying language influenced target word identification [43,63].

Adults correctly guessed the missing nouns in 45% of the cases; their score for verbs was only 15%, and for mental verbs, 0%[47]. When language was systematically added [63], ranging from giving adults a list of the nouns that accompanied the verb to a full sentence with the verb omitted, a step function emerged in adults’ ability to accurately guess the verb. Verb identification improves dramatically as more language is offered.

Snedeker et al. [64] conducted the same experiment with Mandarin infant-directed speech. Mandarin speakers guessed the words from the English and the Mandarin samples and Americans guessed the words in Mandarin samples. Both

Taiwanese and American adults duplicated the patterns found in children's acquisition:  
Better identification of nouns than verbs from the English samples and equally good  
identification of nouns and verbs from the Mandarin samples. The source of these  
differences is not clear.



## Figure 1

*Title:* Stimuli Used to Test 6-Month-Olds' Categorization of the Relation of Containment

*Figure 1.* Final frames of dynamic events used to test infants' discrimination of containment from other spatial relations [28]. Infants were first familiarized to a dynamic containment event (first photo). Following familiarization, they were tested with the same familiarized containment event, as well as a containment event filmed from a high angle so that the figure was no longer partially occluded when inserted (second photo); a behind event in which the figure was as occluded as in the familiarization containment event (third photo); and a support event (fourth photo). Infants looked significantly longer at test events that presented a novel relation (the behind and support test events) than they did at the familiar containment event, indicating that they discriminate a containment relation from other relational events. [Fig. source: Casasola, M. (2008) The development of infants' spatial categories. *Cur. Dir. Psychol. Sci.* 17, 21- 25]



Front-angle containment event



High-angle containment event



High-angle behind event




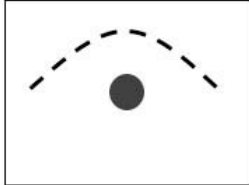
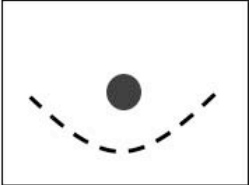
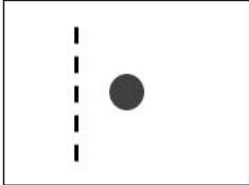


High-angle support event

## Figure 2

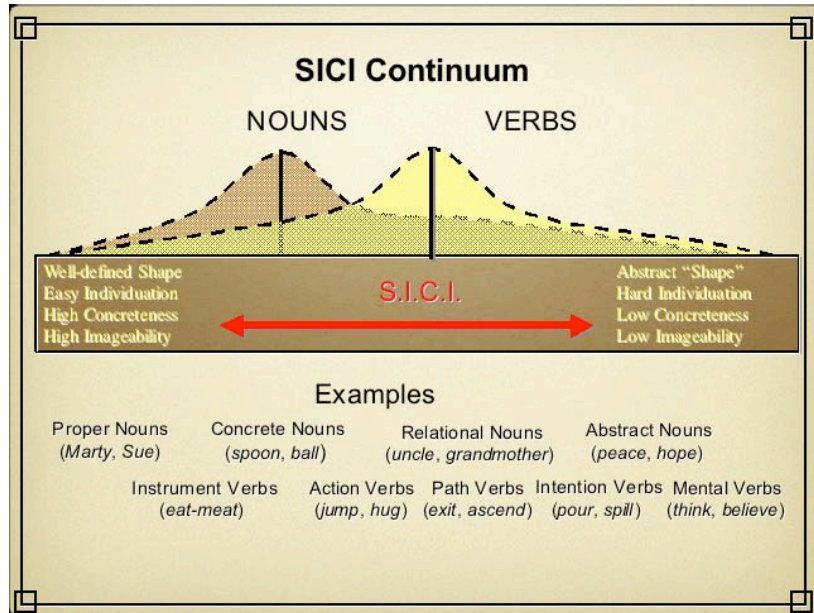
*Title:* Stimuli Used to Test Infants (7 months; 14-17 months) on Discrimination of Path and Manner in Dynamic Events

*Figure 2.* Computer-animated motion events were used to test infants' discrimination of manners and paths [23,30]. In the habituation paradigm, infants saw a moving starfish character (the figure) and a stationary ball (the ground). The starfish performed an action with both a manner (jumping jacks, spinning, or bending at the 'waist') and a path (over the ball, under the ball, or (vertically) past the ball). Once infants became habituated to a single event (e.g., jumping jacks over), they were then tested on four different types of events: (1) a control event identical to the habituation event (e.g., jumping jacks over); (2) an event with the same manner as the habituation event, but a different path (e.g., jumping jacks *under*); (3) an event with the same path as the habituation event, but a different manner (e.g., *spinning* over); and (4) an event in which both the manner and path differed from those in all other events (e.g., *waist bends past*). Children at both ages discriminated between the paths and the manners. [Fig. source: Pulverman et al. (in press). Infants discriminate manners and paths in non-linguistic dynamic events. *Cognition*.]

<b>Jumping Jacks</b>		
<b>Spinning</b>		
<b>Bending</b>		
		
<b>Over</b>	<b>Under</b>	<b>Past</b>

**Figure 3**

*Title:* The SICI continuum: Why some verbs appear before some nouns despite the generalization that nouns are learned before verbs in vocabulary acquisition.



“SICI” is an acronym for the factors (weights yet to be determined) [41,62,63,65,66] that contribute to the learning of nouns and verbs (shape, individuation, concreteness, and imageability). Inspired by theorizing and a related chart by Gentner and Boroditsky [41], the SICI continuum represents the fact that not all nouns are learned before all verbs. The *concepts* words encode can be conceived as falling on a spectrum defined by the reliability and consistency of their perceptual ‘shape’; the ease with which they can be distinguished from other items in the scene (individuability); whether they can be observed and are manipulable (concreteness); and how readily they yield a mental image for adults (imageability). Coupling SICI with a general word learning theory, in this case

the ECM, suggests why children's earliest words will likely be at the more concrete, shape-based end of this continuum with nouns like "cup" learned prior to "uncle" and verbs like "kiss" learned before a verb like "think." [Fig. source: Maguire, M. *et al.* (2006). A unified theory of word learning: putting verb acquisition in context. In *Action Meets Word: How Children Learn Verbs* (Hirsh-Pasek, K. and Golinkoff, R.M., eds), pp. 364-391, Oxford University Press]

## OUTSTANDING QUESTIONS

- Is there a relationship between children's abilities to analyze the subcomponents of events that will be encoded in verb meaning and their ability to learn novel verbs? Since part of the difficulty of verb learning is discovering how particular languages encode events in their verbs, future research should link the perception of events to the discovery of verb meaning.
- Are there individual differences in verb learning that are predictive of later language development? That is, are children who are better at conceptualizing nonlinguistic events also better at learning verbs?
- What are the challenges faced by second and bilingual language learners given that languages package verb meaning differently?
- Can a Bayesian model of word learning incorporate the interactive components of the ECM along with verb frequency to offer a simulation of real verb learning?
- What factors underlie delayed verb learning? Given that the ECM emphasizes the use of perceptual, social, and linguistic cues, perhaps we can determine which of these factors are stumbling blocks for individual children. Should such patterns emerge, how might we craft interventions for children with atypical language development?