Language Development:
The View from the Radical Middle

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Words are the conceptual building blocks of language. Despite over a millennium of discussion from Plato's *Cratylus* to Wittgenstein's *Tractatus Logico-Philosophicus* to Brown's *Names for Things*, however, we have yet to understand how we map words to world. This paper examines the question anew by focusing on how children learn their first words and come to imbue them with meaning. Do children link the words they hear to the most perceptually salient features of the environment? Do they "read" social cues from master word users who guide them toward the correct referent? Or might an understanding of word meaning be scaffolded by attention to grammatical information, serving to refine the way words represent objects, actions and events? An abundant body of literature can be marshaled to support each of these possibilities. Over the past 15 years, however, there is emerging consensus that the process of word learning will not be best described through deference to one approach or the other. Rather, it will require a comprehensive theory that unites perceptual, social and linguistic information in the service of word learning. Bloom (1993) wrote, "cognitive developments bring the infant to the threshold of language only in conjunction with other developments in expression and social connectedness" (p. 52). Woodward and Markman (1998) echoed, "word learning depends on an ability to recruit and integrate information from a range of sources" (p. 371). Finally, Baldwin and Tomasello (1998) suggested that word learning "...requires an explanation encompassing both its social and cognitive roots" (p. 19). This paper takes these charges seriously, proposing an integrated model of word learning that is comprehensive, developmental, and empirically testable across time: the Emergentist Coalition Model (ECM).

The following argument unfolds in three parts: First, we present the tenets of the ECM model (e.g., Golinkoff, Hirsh-Pasek, & Hollich, 1999; Hirsh-Pasek, Golinkoff, & Hollich, 2000; Hollich, Hirsh-Pasek, & Golinkoff, 2000), a hybrid developmental model describing the factors involved in lexical acquisition and how the importance of those factors might change over time. Second, we present a selection of research conducted in our laboratories that both validate the ECM as well as expand it. We describe studies that explore the learning of object names (nouns) and action names (verbs) as well as studies demonstrating how the hybrid model can be applied to language development in children with autism (Parish, Hennon, Hirsh-Pasek, Golinkoff, & Tager-Flugsberg, 2007). Finally, we discuss the implications of a radical middle approach for both theory and application.

1. The Emergentist Coalition Model (ECM)

1.1. A Short History

The ECM was inspired by three strands of research in the field of language development. First, the competition model proposed by Bates and MacWhinney (1982; MacWhinney, Pleh, & Bates, 1988) suggested that children develop language syntax by attending to both grammatical and semantic cues in the input. This groundbreaking work not only enabled researchers to predict how multiple cues might work together to explain language at any given point in time, but also sparked cross linguistic studies and the examination of individual differences in both typical and atypical children over time (Bates, Bretherton, & Snyder, 1988). In many ways, Bates and MacWhinney were pioneers of systems-based models for language. Second, the ECM was inspired by new methodologies that allowed us to examine language from the perspective of comprehension rather than production. As Hirsh-Pasek and Golinkoff (1996) argued, comprehension is a window into children's knowledge of grammar that permits the separate manipulation of children's differential reliance on prosodic, linguistic and social features of the input. Finally, the ECM was influenced by work from Bloom (1970; 1993) who reinforced the need to look at a "whole active child" who draws together information from multiple sources as she constructs her grammar. By 1996, these influences had coalesced in a theory -- forecasting the direction we would take in the study of word learning. We suggested that distinct aspects of language (phonological, semantic, syntactic) served as *systems* of developing knowledge that were mutually informing and always available, but that were weighted differently across developmental time. Such a vision provided us with a non-linear framework for development (Hirsh-Pasek, Tucker, & Golinkoff, 1996, p. 464).

1.2 Charting the Landscape in Word Learning: A Caricature

The ECM (Hollich et al. 2000) offers a model with testable predictions that combines contributions from three competing and leading theoretical approaches: the perceptual, pragmatic, and constraints theories. The ECM is not an *either/or* theory but rather a *when* and *how* account of vocabulary growth, positing that children use different strategies for word learning at different points in time. It addresses two key questions that continue to dominate the study of word acquisition: 1) How do children break the language barrier with their first words, and 2) How do they become master word learners within a year's time? Several theoretical answers to these questions emerged in the 1980s and 90s.

The constraints/principles theories emphasized the importance of cognitive heuristics in word acquisition (e.g., Markman, 1989; Merriman & Bowman, 1989; Waxman & Kosowski, 1990; Golinkoff, Mervis, & Hirsh-Pasek, 1994). Children begin the task of word learning with a set of biases that assist them in linking words to objects, actions, and events. For example, as early as 12 months, children take a novel name as referring to the whole object rather than to its parts or properties (Hollich, Golinkoff, & Hirsh-Pasek, 2007). Using a dichotomy created by Hirsh-Pasek and Golinkoff (1996) to characterize theories of language acquisition, word learning is thus guided from the "inside-out" (what the child brings to the task) with domain-specific principles for word learning rather than from the "outside-in" (from environmental guidance) with more domain general principles of learning. By way of example, under a constraints theory, children might come to the task of word learning with a principle of "reference" (Golinkoff et al., 1994) or with the inherent assumption that words symbolize, or stand for, objects, actions, or events.

The social-pragmatic view, in stark contrast, highlights the role of adult-child interaction to prime word learning (e.g., Nelson, 1996). Under this scenario, word learning can be viewed from the "outside-in" as children mine the social environment, noting social cues like eye gaze and pointing (Carpenter, Nagell, & Tomasello, 1998). By just 14 months, toddlers begin to interpret social intent (Woodward, Sommerville, & Guajardo, 2001; Gergley & Csibra, 2003) and by just 18 months, evidence suggests that they can use social intentional cues to assist in word learning Hollich et al., 2000). Children have a driving need to share the contents of their mind and to understand others in ways that push them towards a socially informed strategy for word learning (Bloom, 1993; Bloom, 2000; Golinkoff, 1993; Tomasello & Akhtar, 2000). Under a social-pragmatic theory, children are apprentices to master word users.

Finally, a third response to the word learning challenge is a domain-general associationist account that highlights the role of "dumb attentional mechanisms" and memory processes in word development (e.g., Smith, 2000; Plunkett, 1997). Children attach labels to the items that grab their attention and stand out from the context. Calculating the frequency of co-occurrence between words and referents, children form the associations that constitute vocabulary acquisition.

Each of these potential answers to the word learning challenge seems plausible, even in caricature as presented above. Furthermore, each of these theories notes that children use multiple mechanisms for word learning; they simply favor one mechanism over the others. The fact that the character of word learning changes over the second year of life (e.g., Clark, 1983; Golinkoff et al., 1994), however, raises interesting questions with respect to the dominance of one theoretical perspective over the other. That is, the novice learner of 12 to 18 months of age acquires words slowly and often one at a time. The more mature learner of around 24 months, in contrast, is a master word learner acquiring up to 9 words a day. Perhaps the mechanisms used by expert word learners are not characteristic of those used by novice learners. Perhaps one learning mechanism is not paramount for all children, such that there are individual differences or multiple pathways for atypical language learners—like those with autism. The ECM is a developmental account hypothesizing that the shift in word learning seen across the first two years can be explained as a change in the weighting of multiple factors, attentional, social, and linguistic. The ECM recasts the issue of word learning by asking which *components* of which *theories* govern word learning across development, and then combines them in a novel way to allow for testable predictions. Rather than providing snapshots of word learning, it tracks shifting strategies of word learning over time.

1.3 Assumptions of the ECM Model

The ECM makes three fundamental assumptions. First, children are sensitive to multiple cues in word learning: perceptual, social, and linguistic (see Figure 1). Second, cues for word learning change weights over time. Although a range of cues is always *available*, not all cues are equally utilized in the service of word learning at any given period of development. Children beginning to learn words rely on a perceptual subset of cues in the coalition, as evidenced by a tendency to label that which is bright or interesting – rather than attending to what the speaker intends to label. This child views reference as a "goes with" relationship. Only later in the second year do children recruit social cues like eye gaze and handling to learn words and to move towards reference as a "stands for" or more symbolic relationship.

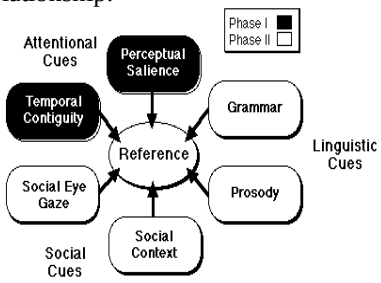

Figure 1. The coalition of cues available for establishing word reference is utilized differently across developmental time. Children shift from a reliance on attentional cues (how compelling an object is - perceptual salience - and the coincident appearance of an object and a label - temporal contiguity) to a greater dependency on social and linguistic cues, like eye gaze and grammar, respectively.

Third, the principles of word learning are emergent, changing over time. As in Bates and MacWhinney's competition model (1982; MacWhinney, Pleh, & Bates, 1988), the ECM posits that development progresses as children come to learn which cues (perceptual or social, for example) are more or less reliable for mapping word to world. Thus, infants may start with an immature principle of reference relying on perceptual cues such that a word will be mapped to the most salient object from the *infant's* point of view. Later, children become sensitive to speaker intent and map a word onto an object from the *speaker's* point of view by noting social cues for word mapping (such as eye gaze and handling).

Progress has been made using this hybrid account (e.g., Hollich et al., 2000). By examining infants' shifting use of associative and social strategies across time, we offer a glimpse of evidence for one piece of the ECM.

1.4 Validating the Model

The ECM makes testable predictions about how words are learned. To evaluate these hypotheses, however, we needed to go beyond existing methodologies to develop a method that: (a) could be used with young children; (b) made minimal response demands; and crucially, (c) allowed for the manipulation of multiple cues from the attentional, social and linguistic realms within one paradigm. The first method that met these criteria was the Intermodal Preferential Looking paradigm (IPLP; Golinkoff, Hirsh-Pasek, Cauley Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996). The infant is seated on a blindfolded parent's lap midway and in front of two laterally spaced video monitors or a single large screen TV. Two images can be shown simultaneously or sequentially. After attracting the child's attention toward the center of the screen, an audio speaker plays a linguistic stimulus that matches only one of the displays. For example, the display (see Figure 2) might portray a boat (screen left) and a shoe (screen right) while the linguistic message is "Do you see the boat? Find the boat!"

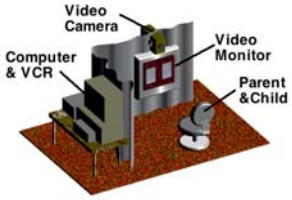

Figure 2. The Intermodal Preferential Looking Paradigm.

The total amount of time that the infant spends watching the matching versus the non-matching screen is the dependent variable. The logic of this procedure is that children look longer at the screen displaying the targeted object (the boat) than at the screen displaying the non-targeted object (the shoe). Infants attend more to the video event that *matches* the linguistic message than to a video event that does not match. This method offers the opportunity to display dynamic stimuli and to examine perceptual and linguistic cues placed in competition with one another. One thing the standard IPLP does not allow however, is the manipulation of social cues – even television images of speakers are not the same as live speakers offering social cues about what they are naming. The interactive Intermodal Preferential Looking Paradigm (interactive IPLP) overcame this shortcoming. A live, 3-D version of the IPLP can be used with children from 10 to 24 months of age (Hollich et al., 2000).

As Figure 3 shows, infants are seated on their blindfolded mother's lap facing the experimenter and positioned midway in front of the testing apparatus.

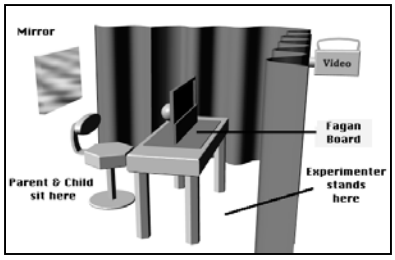

Figure 3. The Interactive Intermodal Preferential Looking Paradigm.

The experimenter presents real objects for the child to play with and look at– a pair of familiar toys on some trials and a pair of novel toys on others. The toys are then velcroed onto one side of a two-sided black board that can be rotated so that the toys can go in and out of view for a specified period of time. Hiding behind the board, the experimenter asks the child to look at one or the other of

the toys, asking, for example, "Where's the boat?" Looking time to the matching or non-matching object serves as the dependent variable. Importantly, controls are in place for side of match, salience of the test objects and side of toys.

2. Testing the predictions

2.1. Data from the learning of object labels

Equipped with theory and method, we evaluated the principle of reference. Two questions framed our investigation. First, how do infants break the word-learning barrier? The ECM predicts that children begin the word learning process as associative learners guided by perceptual salience when making word mappings. Second, how does the word learning process change over the second year of life? The ECM suggests that children should gradually begin to switch to a more reliable, socially-informed strategy for word learning that uses information about a speaker's social intent to determine word to world mapping.

To investigate this shift in strategy, children were taught new words in the interactive paradigm. In one of the two conditions, the *coincident* condition, we labeled the novel, interesting toy that coincided with children's preferences (e.g., a sparkling wand). In the other, *conflict* condition, we labeled the novel, boring toy that did *not* coincide with the children's preferences (e.g., a beige plastic bottle opener). Children confirmed our intuitions about whether the object was "interesting" or "boring" in a salience trial. We reasoned that learning the word in the coincident case should be easy for children because all of the "cues," attentional, social, and linguistic, were in alignment. In contrast, learning a novel word in the conflict condition should be more difficult because the coalition of cues was not acting in concert (Golinkoff & Hirsh-Pasek, 2006) and because perceptual and social cues were placed in conflict (Hollich et al., 2000).

Children operating at the associative level and who fail to use social cues should simply attach the label to the object they found most interesting regardless of where the speaker was looking. Alternatively, children sensitive to social cues should learn the name for the object that the *speaker* labeled, even if it was boring.

We began our investigation with 10-month olds, an age at which Fenson et al, (1994), suggest that vocabulary starts to amass. Across ages, the results confirmed our predictions. Ten-month-olds were indeed pure associationists, mapping a novel word onto the object that *they* found the most interesting, regardless of which object the speaker labeled. Indeed, ten-month-olds acted as if social cues to reference did not exist (Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006). Just two months later, twelve-month-olds showed an entirely different pattern. Social information was necessary, but not sufficient, to ensure word learning. These children only learned the novel word when social and perceptual cues were "in alignment" - when the speaker labeled the interesting object. They failed to learn a word when the speaker labeled the boring object.

Had 12-month-olds been pure associationists, they should have mismapped like the 10-month olds, thinking that every word referenced the interesting object! The fact that they did not do this suggests they detected the speaker's social cues. Nineteen-month-olds were attracted to perceptual cues but *could* use social information to learn the label for the boring object. Finally, by 24 months of age, children convincingly used social information, learning the name for both the interesting and boring objects (Hollich et al., 2000).

These results confirm the predictions made by the ECM. Beginning as associationists, children gradually begin to *attend* to social cues, and then to *recruit* a speaker's social cues to affix a label to an object. Children use multiple inputs, differentially weighted, as they become word learners. These findings suggest that theoretical accounts that appear incompatible (such as the associationist and social-pragmatic accounts) actually capture the process of word learning at different points in developmental time.

2.2. Data from the Learning of Action Labels

Our first test of the ECM examined relatively simple object words. A complete theory of word learning, however, must be able to account for the learning of words from other classes, e.g., action verbs. Is there a shift from reliance on perceptual to social cues when learning labels for actions? Abundant research suggests that verb learning is complicated, often lagging behind noun leaning (Bornstein et al., 2004; Gentner, 1982; but see Tardif, 1996). As Gentner (1982) suggests, verbs do not label actions in the same way that nouns label objects. Nouns commonly refer to objects that are naturally perceived as distinct units. Verbs, however, refer to relations within events, and any event can be conceptualized in terms of a multitude of different components, including, but not limited to, *path* (the trajectory of an action with respect to some reference point, e.g., approach, enter), *manner* (how an action is carried out, e.g., walk), or *result* (e.g., open, fill; Talmy, 1985). Which relation or relations in an event is the verb referent? To learn verbs a child must disentangle a variety of simultaneously occurring components and must choose between a plethora of possible meanings.

Are perceptual, social and syntactic cues weighted differently, or recruited later for verb learning than for noun learning? To test developmental predictions of the ECM for verb learning, we created a situation that was analogous to the noun-learning work of Hollich et al. (2000) and Pruden et al. (2006). By pitting cues against one another, we asked whether young children are biased to learn verbs based on perceptual salience or on speaker information, when speaker information includes both social intent and grammar.

Brandone, Pence, Golinkoff, and Hirsh-Pasek (2007) presented children with a pair of actions performed on a bright metal box. They were taught the name for one of these actions using a combination of perceptual and speaker

cues. Perceptual salience was defined by whether or not the action produced an interesting result (e.g., a switch made a light go on). An action that produced a result was more salient than an action that had no result.

Each child was exposed to a pair of actions. To create a conflict between perceptual and speaker information, half of the children received a label for the action with a result (the coincident condition), whereas the other half received a label for the action without a result (the conflict condition). If perceptual salience is central for verb mapping, it should be easy for children to learn the name of the action with a result (because perceptual cues coincide with speaker information) and more difficult for them to learn the name of the action without a result (because perceptual cues and speaker information conflict). On the other hand, if children rely on social intent and language cues for verb learning, they should be able to learn the name of the action regardless of whether it produces a result.

Across three studies, our predictions were borne out. Twenty-two-month-olds attached a verb to one of two actions only when perceptual cues (presence of a result) coincided with speaker cues, but not when these cues conflicted (absence of a result; Experiment 1), and not when both possible referent actions were perceptually salient, i.e., both had results (Experiment 2). By 34 months, children were able to override perceptual cues and utilize more reliable speaker cues to learn the name of an action that was not perceptually salient (Experiment 3). Results demonstrate an early reliance on perceptual information and the emergent use of speaker information for verb mapping.

Although most work within the ECM has examined how children attach novel labels to object referents (but see Poulin-Dubois & Forbes, 2006), these findings extend the story to the domain of verbs. Interestingly, children who are old enough to demonstrate mastery of noun learning nonetheless experience difficulty with verb learning. Although the pattern of results in our verb-learning experiments nearly parallel those of the noun learning experiments (Hollich et al., 2000; Pruden et al., 2006), equivalent verb-learning abilities are not observed until over one year later. These results lend further support to the ECM by extending the model to include the learning of verbs. Yet, the results also force us to ponder *why* it takes so much longer to attach word to world in the context of verb learning – a question that we now address.

2.3. Stepping back: Why verbs are hard

It has long been known that verbs are more difficult to learn than nouns (Gentner, 1982; Bornstein et al, 2004). However, some verbs are learned quite early (Tardif, 1996; Naigles & Hoff, 2006) leading to what we have called the "verb learning paradox" (Maguire et al., 2006). Although verbs are hard to learn in the laboratory they nonetheless appear in children's earliest vocabularies. Why is this so? Unpacking this apparent inconsistency led us to a series of

studies that lent more support to the ECM model. To preview the findings, we learned that in the first year of life, children have at least some of the conceptual prerequisites for verb learning. Yet, as has been suggested before (Gilette, et al., 1999; Gentner, 1982), inherent ambiguity in word to world *mapping* for verbs makes the task of reference and hence verb learning more difficult on average than noun learning. To solve the reference problem, children first appeal to perceptual salience and only later utilize syntactic cues and cues to speaker intent.

Many have now suggested that mastery of the verb system requires children to conquer several preliminary tasks (Golinkoff, Chung, Hirsh-Pasek, Liu, Bertenthal, Brand, Maguire, & Hennon, 2002; Golinkoff & Hirsh-Pasek, 2006). First, they must attend to and discriminate between actions in their environment. Second, infants must be able to discriminate and *form categories* of actions without language. The action of jumping, for example, refers to a decontextualized category of jumping motions that include different kinds of jumps made by the same actor (e.g., Elmo jumping off tables and chairs), and the same action performed by different actors (e.g., Elmo or Lala jumping off the chair). Third, children must be able to map words to actions and action categories in language-specific ways. We explored each of these skills across a number of studies.

2.4. Infants can Find Actions and Action Components in Events

Verbs label a subset of the many, often simultaneously occurring semantic components that exist within motion events. As noted earlier, these components include *motion* (the general fact that motion is taking place), *figure* (the prominent entity in the event), *manner* (the way in which the action/motion is carried out), *path* (the trajectory of the figure with respect to some reference point), *ground* (the reference point for the event's path), and *cause* (the cause of the figure's motion), among others (Talmy, 1985). For example, when a man passes through the banner at the end of the New York Marathon, the figure is the man, the manner running, the path through the banner, the ground the banner itself, and the cause the internal motivation for running the race (Pulverman, Hirsh-Pasek, Pruden, & Golinkoff, 2006). All of the elements of motion events may simultaneously meet the eye. Yet, only some of them will be relevant to learning any particular verb. Furthermore, what is relevant to verb mapping or "packaging" (Tomasello, 1992) differs across languages. For example, in English one can say, "The man limped down the stairs". In this case, the verb encodes the manner of limping and the path appears in a preposition. In Spanish the sentence would read, "El hombre bajó las escaleras cojeando," and would be translated as, "The man went down/descended the stairs limping." Thus, the verb encodes the path of the man, and the manner (limping) is an optional addition. Although we know that infants are keenly aware of movement and use

movement to individuate objects (e.g., Mandler, 1992, 1998) and actions (Wynn, 1996; Sharon & Wynn, 1998), surprisingly little research examines whether infants have the conceptual prerequisites to learn a verb (but see Mandler, 2004; Hespos & Spelke, 2004; Casasola & Cohen 2002, Casasola, Bhagwat & Ferguson, 2006). We started our investigations by focusing on two dynamic components - path and manner - that appear in most languages and that are packaged differently across languages. Can infants attend to path and manner?

Pulverman, Sootsman, Golinkoff, and Hirsh-Pasek (2007) asked this question with 14- to 17-month-olds in a habituation task. Infants viewed silent, computer-animated motion events involving 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; see Figure 1). Once infants habituated to a single event (e.g., jumping jacks over), they were 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*). The results suggested that 14- to 17-month-old infants discriminated between paths and between manners. They readily dishabituated to the path change, the manner change, and the both change events. These initial results motivated several additional studies, all of which affirm the main findings. For example, Pulverman and Golinkoff (2004) found that even 7-month-olds successfully dishabituated to changes of manner, changes of path, and changes of both manner and path. Even before word learning begins, infants notice differences between events that could potentially distinguish one verb from another. For older children, the data also suggest that manner and path are treated as *independent elements within a motion event*.

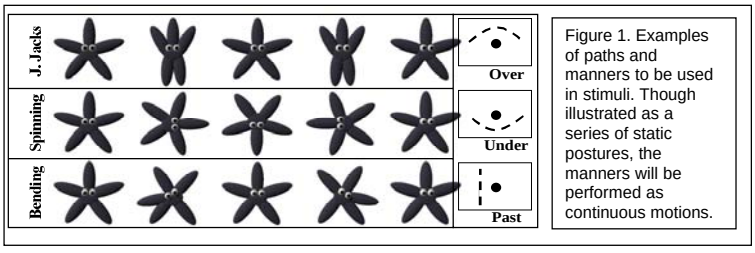

Figure 4. The paths and manners used by Pulverman and Golinkoff (2004).

One additional finding of interest emerged when Pulverman and Golinkoff examined how children's attention to these independent elements in events related to maternal report of their vocabulary. English reared children with greater receptive vocabularies were more sensitive to manner changes than their small vocabulary peers. Data from a replication with infants learning Spanish demonstrated that Spanish reared infants who prefer manner changes have relatively lower reported vocabularies than their peers (Pulverman, Golinkoff, Hirsh-Pasek, & Jackson-Maldonado, 2005; Pulverman et al., 2007).

Taken together, the data seem to suggest that both English reared and Spanish reared infants can discriminate the components of events that will be codified in their verbs. Furthermore, differential attention to the dynamic components of these events can influence infants' lexical acquisition. This is but a first step in understanding how infants process dynamic events for language or – as Slobin (2001) called it – master thinking for speaking.

2.5. Infants can also Form Categories of Actions

Infants are not only capable of noticing changes in both *path* and *manner* (Pulverman, et al., 2007) and treating those changes as independent elements of events by 14 to 17 months, but are also capable of *categorizing* these components prior to acquiring extensive language. Using the same animated and tightly controlled stimuli as Pulverman et al. (2007; see Figure 4), Pruden, Hirsh-Pasek, Maguire, and Meyer (2004) asked whether infants could detect an invariant manner across varying paths (e.g., *spinning* around, *spinning* past, etc.) and an invariant path among varying manners (e.g., spinning *past* a ball, twisting *past* a ball). Three age groups, 7- to 9-, 10- to 12-, and 13- to 15-month-olds were tested using the IPLP (Hirsh-Pasek & Golinkoff, 1996) *without language*. During familiarization, infants viewed an animated starfish performing the same path across four distinct manners. At test, infants were shown two events simultaneously: one depicting a novel exemplar of the familiar category and the other depicting a novel exemplar of a novel category. For example, infants who were familiarized with the path "over" saw the event clips "touching toe *under*" (i.e., novel *manner* and novel *path*) and "touching toe *over*" (i.e., novel *manner* and same *path*). Seven- to nine-month-olds did not have a significant preference for either test event. In contrast, older infants showed a significant preference for the *familiar* event during the test phase. Thus, infants as young as 10 months can create a simple category of path. The next study investigated whether infants at the same ages could abstract an invariant *manner* across multiple exemplars of *path*. Here, only the 13- to 15-month-olds showed a significant preference for the *novel* test event.

Testing the ability to abstract an invariant *path* or *manner* only begins to address the question of categorization, as categorization is much richer than simply abstracting invariants from scenes. However, these preliminary studies

provide an important advance in our understanding of the categorization of dynamic action and are key to understanding infant's prerequisite skills for verb learning. They also allow us to examine what parameters enhance or hinder action category formation (Pruden, Hirsh-Pasek, & Golinkoff, 2007; Pulverman, 2006). For example, results from Pruden (2006) show that adding a label (the nonse word "javing") to the same task assisted 7- to- 9-month-olds who could not form a category to do so. In another study, 7- to 9-month-olds could form a category of path when the stimuli during familiarization were shown side-by-side, enabling comparison. Category formation is also possible when the agent is varied in "real life" examples. For example, Song et al. (2006) examined infants' ability to categorize *manner* using 4 distinct actors performing the same action in four distinct ways. Ten- to 12-month-olds showed increased attention at test to the actor performing the novel action. Results from studies on spatial constructs like containment and support as well as on manner and path parallel those found in our lab (Casasola, & Cohen, 2002; Casasola,et al.,2006; Choi, 2006).

In sum, it appears that children can (1) isolate event properties that will be encoded in verbs such as changes in manner and path (e.g., Pulverman et al., 2007); (2) form invariant categories of manner and path (e.g., Pruden, 2006); and (3) form a category of manner across much variation with human actors (e.g., Song et al., 2006). Although research is only starting to unveil infants' processing of event structure, evidence suggests that trouble with conceptual underpinnings does not explain children's difficulty in learning verbs.

2.6. Even toddlers have trouble mapping actions onto words: Perceptual salience to the rescue

If children have the requisite conceptual structure to learn verbs, then the root of the verb learning problem must come from mapping words to world. Several lines of evidence (including our own) converge to suggest that verb mapping is particularly difficult – even for adults.

One compelling study comes from Gleitman and her colleagues' (Gillette et al. 1999; Snedeker & Gleitman, 2004) Human Simulation paradigm. In their studies, adults viewed a series of silent video clips depicting a mother and child playing. The participants' task was to guess what word the speaker might have used in place of a beep. Adults correctly guessed the missing nouns in 45% of the cases; correct guesses for verbs were a paltry 15%. In fact, if responses for mental verbs were considered alone, the proportion of correct verb "guesses" dropped to zero! Adults undoubtedly have all the requisite concepts on which verbs rest. Nonetheless, they have difficulty inferring which verbs are being spoken in a natural interaction between mother and child. Mapping from action or mental state to word is considerably more challenging than mapping from object to word.

Further, verb mapping proves difficult in languages that are reputed to be 'verb friendly', where verbs may appear in isolation or at the end of sentences. For example, Imai, Li, Haryu, Hirsh-Pasek, Golinkoff, and Shigematsu (2007) examined fast mapping and extension of nouns and verbs in English, Chinese, and Japanese. Whereas all children performed well with nouns at the age of 3, they were at chance for verb learning and extension. In a laboratory task, children did not readily map and extend a new verb until the age of 5. Even then, they mapped verbs to correct actions only when they were provided with the grammatical supports afforded by their language. English speaking children, for example, solved the task when the verb was introduced with full syntax and not otherwise. Japanese children solved the mapping problem when the word was offered alone (consistent with their pro drop language) but not when full sentences were used. Given that languages differ in (1) their use of verbal inflectional morphology, (2) which semantic elements they encode, (3) whether they allow argument dropping, and (4) how widely a verb can be extended, it is no wonder that children rely first on perceptual salience to do the work of verb learning and extension. As Snedeker, Li, and Yuan (2003) wrote, "early word learning is limited by the child's initial representation of the input. Because novice language learners know few words and little syntax, they initially learn words from the real-world contexts in which they occur" (p. 2).

What might help children link words and meanings? Until they are savvy enough to utilize social intent and grammatical cues in the service of word meaning, the ECM suggests that perceptual salience offers a natural starting point for word reference. Evidence that children rely heavily on perception in early verb learning comes from a number of sources. Recall the study by Brandone et al. (2007) suggesting that social cues do not "win out" over perceptual cues until children are 34 months of age. That the appearance of an action is crucially important for early verb meaning is further supported by Behrend (1990) and Forbes and Farrar (1995). First verbs seem to map onto perceptually salient actions and are only narrowly extended (Seston et al., 2006).

Research by Snedeker, Li, and Yuan (2003) provides further evidence that the appearance of an action is partially determinative of ease of word learning. Snedeker et al. showed Mandarin and English-speaking adults videos of Mandarin mothers and children interacting in the Human Simulation paradigm. In this study, both adult groups were better at guessing the Mandarin than the English verbs! If the difference between nouns and verbs vanished when Snedeker et al.'s subjects guessed words from Mandarin scenes, we can entertain the idea that form class per se (e.g., noun and verb) is not determinative of when a word is learned. Rather, perceptual salience might rule.

Based on findings supporting a strong role for perception in early word learning, we hypothesized that words labeling more perceptually salient objects and actions, as well as words with higher imageability (e.g., cat and run) would be learned faster than those with lower salience and/or imageability (e.g., idea

and think). Words that are relatively more imageable tend to label referents that easily conjure up a mental image, are easily detectable, and are individuable (Paivio, Yuille, & Madigan, 1968). Indeed, in Gleitman and colleague's work, imageability ratings served as a kind of proxy for perceptual salience. Imageability was highly correlated with the number of subjects who guessed a word correctly (Gillette et al., 1999; Snedeker & Gleitman, 2004).

McDonough, Hirsh-Pasek, Lannon, and Golinkoff (2006) and Ma, Golinkoff, Hirsh-Pasek, McDonough, and Tardif (2006) expanded on prior work by offering a direct test of the *imageability hypothesis.* Imageability ratings in English were extracted from published rating sets and correlated with the age of acquisition of nouns and verbs on the MacArthur Communicative Development Inventory (CDI; Fenson et al., 1994). McDonough et al. found that early nouns were significantly more imageable than early verbs in English. Thus, the noun advantage may not be a function of form class *per se* but of the differences in imageability in words from these classes. Further, the earliest acquired nouns and earliest learned verbs were indeed those that were most imageable.

Ma et al. (2006) investigated the scope of this imageability hypothesis by testing it in a language with a different pattern of early acquisition than English, viz., Chinese. Their research posed two questions: (1) Can imageability ratings predict when a word will be learned in Chinese; and (2) Why do early Chinese vocabularies contain a higher proportion of verbs than early English vocabularies (Tardif, 2006)? Ma et al. obtained imageability ratings in China from native speakers. Importantly, there was no difference in imageability ratings between English and Chinese participants on a subset of 31 verbs with close meanings across languages. Ma et al. found that imageability was negatively and strongly correlated with age of acquisition on the Chinese version of the CDI and was a far better predictor than grammatical class (Tardif & Fletcher, 2006). This study was the first to show that imageability is a reliable predictor of age of acquisition in a language very different from English. Chinese and English children's *nouns* do not differ in imageability ratings. Chinese children's early verbs, however, were more imageable than English children's first verbs. The finding that early Chinese verbs have higher imageability ratings than early English verbs is in accord with the observation that Chinese-speaking children learn more verbs and learn them earlier than their English-speaking counterparts (Tardif, 2006). While nouns are easier to learn than verbs because they are, on average, more imageable than verbs, some verbs are highly imageable and hence are learned early.

Why are the early Chinese verbs more imageable and learned earlier than English verbs? One possibility is that imageability is correlated with the individuability of the action labeled by the verb. This is consistent with the finding that the first verbs children produce or understand usually describe actions or events that encode physical motion rather than the invisible mental

status of an agent (Bloom, Lightbown, & Hood, 1975; Snedeker & Gleitman, 2004).

High imageability might also make it easier for children to extract the invariant action across multiple instances of an action or the *"verbal essence"* (Golinkoff et al., 2002). For example, to learn the verb *drink*, one has to abstract the common relation of drinking from a range of drinking actions that include different agents, different drinks, different locations, etc. High imageability may also be correlated with context specificity. Chinese, for instance, has 26 verbs for *carry*, each encoding a different - more context specific - way of carrying (e.g., on the back versus with the hand extended downward). These verbs received imageability ratings from Chinese-speaking adults that ranged from 5.60 to 6.27 on a 7-point scale and were acquired at a mean age of 17.25 months. In English, there is only one verb for *carry*, regardless of the particular way in which the carrying is done. It received an adult imageability rating of 3.81 (Masterson & Druks, 1998; McDonough et al., 2006) and is acquired at 23 months. For children faced with the task of abstracting a common relation, a verb that encodes a more specific set of actions should be easier to learn than a verb that names a broader set of actions (see also Tardif, 2005).

Imageability is, in part, a measure of the perceptual availability of a concept. It is not the only factor that explains the verb learning paradox (see results on word frequency combined with imageability by Ma, Golinkoff, & Hirsh-Pasek, 2007). It does, however, offer a toehold on a problem that has plagued researchers for the last 25 years. It also feeds into a more comprehensive conceptualization of early word learning. According to the ECM, the words children initially learn will be perceptually available and contextually bound. This will be the case *irrespective of syntactic word class* since the ECM is blind to word class and operates as a general framework for explaining *all* vocabulary acquisition. Note that we are not claiming that linguistic form class does not exist for the young child. For the development of early vocabulary, however, we *are* suggesting that linguistic form class per se is not what drives the word learning system (Maguire et al., 2006). Rather, children's early and narrow verb meanings appear to be built upon a perceptual base.

2.7. Beyond perceptual cues for verb mapping

Up until now we have emphasized the first phase of the ECM – children's reliance on perceptual information for word learning. But eventually, children learn words in circumstances in which perceptual cues are not available. Words like the noun "idea" and the verb "think" have weak perceptual links and 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. Gleitman (1990) has long argued that once

children know some nouns and can use the arrangement of the argument structure around the verb, they can avail themselves of a process she calls "syntactic bootstrapping." Syntactic bootstrapping rests on the assumption that there are reliable linking rules between argument structures and meanings. For example, causatives in English typically (although not invariably) occur with an argument on either side of the verb. Thus, encountering "John blorked Mary" one can assume that this means John might have done something to Mary. By now a number of studies have shown that at around 2 years of age children become able to exploit these syntax-to-semantics regularities to learn more about verb meaning (e.g., Naigles, 1990; Hirsh-Pasek, Golinkoff, & Naigles, 1996; Fisher & Song, 2006; Imai et al., 2006).

Additionally, many verbs turn on intention – either of the speaker or of the actor. Subtle social cues discriminate between, for example, the verbs "pour" and "spill" or "kill" and "die". These distinctions are difficult for children to learn (Bowerman, 1974) because they are only distinguished by whether the action was done on purpose or accidentally. Poulin-Dubois and Forbes (2002, 2006) demonstrated that before age 21, toddlers do not distinguish between perceptually similar but pragmatically distinct verbs. As Poulin-Dubois and Forbes (2006) write, " It would appear that between 21 and 28 months of age, children's verb learning strategy transitions from a reliance on the overall appearance of verb referent events to a reliance on behavioral and linuistic cues about others' behavioral and verbal semantic intentions.." (p. 277) Clearly, attention to the grammatical and social/pragmatic cues of input will help children refine word meaning and learn more about the regularities in word to world mapping. Furthermore, attention to these kinds of input cues might prove particularly important for discerning verb meaning.

2.8. The ECM and verb learning

The process of mapping words onto actions and events contains a number of stumbling blocks for young language learners. A burgeoning literature (as well as our own studies) confirm Gentner's (1982) suggestion that it is "not perceiving relations, but packaging and lexicalizing them that is difficult" As words become more relational (Gentner & Boroditsky, 2001) and more referentially ambiguous, the ability to link words to world requires stronger support from grammar and from cues to social intent.

The ECM suggests that when children are learning their first words, be they nouns or verbs, they rely on perceptual salience as a cue to reference. Reference at this point is more of a "goes with" than a "stands for" relationship. The research we reviewed strongly endorses this claim, revealing that across word categories, those words that are more perceptually salient and contextually bound are learned first. This is true when learning nouns or object words (Hollich et al., 2000), appears in a parallel task with verbs (Brandone et al.,

2007) and is evident in the imageability studies of both Chinese and English nouns and verbs.

The ECM not only predicts that mapping will begin with deference to perceptual cues, but also that perceptual information will give way to children's reliance on social intent and grammar. More abstract, relational, and less imageable words are harder to learn and require more grammatical and social support. As Gentner and Boroditsky (2001) suggest, verbs are more likely than nouns to have these characteristics. Thus, for word learning, the ECM predicts that more concrete words - generally nouns - will be learned first and hence nouns will often appear before verbs. The ECM not only offers an explanation of the verb learning paradox, but also provides some account for why the pace of word learning seems to increase during the second year. When children use social and grammatical input in the service of word learning they become not only more reliable word learners, but also faster word learners.

3. Implications of the ECM for Language Disorder: The case of autism

The ECM provides a systems-based model for word learning that can also serve as a framework for examining the nature of language disorders. Because the ECM is a hybrid model of word learning it implicitly states that words can be acquired through a number of pathways. If perceptual cues, social cues, and linguistic cues are all available for word learning, then it may be possible to preserve abilities by, a) determining which set of cues are not being utilized; and b) supplementing the input by strengthening other cues (Hennon, 2000). Using this logic, we reasoned that children with autism, who tend to have problems noting social intent but may have average or superior perceptual abilities, should be able to learn words that have perceptually salient referents. Thus, during the first year of life, when perceptual learning dominates, children with autism and typically developing children should follow the same word acquisition trajectories. Furthermore, we hypothesized that within a population of children with autism, those who have more access to social intentional cues should be better word learners than those who have less access.

Guided by these testable predictions from the ECM, Parish-Morris, Hennon, Hirsh-Pasek, Golinkoff, and Tager-Flusberg (2007) explored word-learning in children diagnosed with autism (AD). Children with autism were matched to two groups of typically developing (TD) children on (1) language outcome (PPVT) and (2) non-verbal intelligence. Four experiments were conducted using tasks that tapped children's ability to (1) *attend* to social cues outside the word learning situation (2 separate tasks), (2) *discern the intention* of another in a non-verbal enactment task, and (3) *interpret intention* in a word learning task. Results demonstrated considerable variability in the performance of all three groups, but particularly in the AD group.

The findings suggest that *all* children pay attention to social cues to some degree. Social *attentional* cues are manifest when a child follows a line of regard and uses social information (e.g., eye gaze, pointing, handling) as a 'perceptual flashlight'. AD children could use social attentional information to not only follow a speaker's line of regard towards an object, but also to learn the word for a perceptually interesting object indicated by the speaker. Consistent with the literature, these same AD children had more trouble learning words for objects that were not interesting to them even when the speaker indicated that object through eye gaze, pointing, or handling. That is, social *intentional* cues were more opaque for the AD children. Only TD children consistently utilized a speaker's social intentions to label a "boring" object. TD children were also much more likely to complete the experimenter's intended but unfulfilled action (e.g., finding a named but never seen object in a search task). By examining the AD group alone, we found that performance on these social intentional tasks was the most powerful predictor of vocabulary, accounting for a very large percentage of the variance (68%).

Taken together, these findings suggest that children can learn words through perception alone, and that children with autism can learn new words when a referent is highly salient. Social cues are not necessary for word learning. These findings, however, also suggest that social intent is related to better word learning, since AD children who demonstrated access to a speaker's social intent also had bigger and richer vocabularies.

4. Implications of a Radical Middle Approach: Three Take-Home Messages

The research from noun and verb learning as well as from word acquisition in children with autism suggests that the ECM is a valid model generating clear predictions about *how* children learn their first words and *why* the character of word learning changes over time (Golinkoff & Hirsh-Pasek, 2006). As such, the model is quintessentially developmental. The ECM embraces dominant theories of word learning and simultaneously integrates these theories into a broader framework. In so doing, the ECM stands at the radical middle of language theories not by default, but rather, by design. While the ECM is a start, it is not without its limits. For one, it can be argued that it is but a description of how word learning progresses rather than an explanation of mechanisms. What makes something perceptually salient? What accounts for the shift from perceptual governance to social mediated word learning? We are currently working on computer models to address some of these questions. At present, however, we can only speculate about how a child comes to rely more on certain cues over others during development.

To date all of our work has been cross-sectional rather than longitudinal. Such an approach falls short of considering change over time and short of providing an explanation for the source of individual differences in word

learning. Here the model has enormous - though unrealized - potential. The alternative pathways for word learning that can be used by different children across different contexts and ages will only be revealed once we understand children's individual profiles.

The model is also limited in that we have only tested some of the very preliminary predictions made by the ECM about when children move from perceptual to socially informed strategies of word learning. Much more needs to be done to flesh out the model by documenting the change to a reliance on grammatical information. Furthermore, factors like frequency of input, phonological form, etc., are also important for word learning and have yet to be built into the model.

Even with the current limitations, however, the ECM and the research accumulated to date leave us with several take home messages. First, complex problems like language learning are best examined by looking at multiple factors. In the interest of parsimony, researchers often examine one contributor to development to the exclusion of others, paying only lip service to other equally important and interacting motors for growth (Hollich et al., 2000). The science that is reflected in Bates and MacWhinney's (1982) competition model and Bronfenbrenner's (1993) systems theory is taking hold across much of developmental psychology. Language development - and word learning - is likely influenced not only by what the child brings to the task, but also by the perceptual, social and linguistic information that the child constructs and construes across various contexts.

Second, when a developmental approach is taken seriously, it offers a compelling way to unite theories that may appear incompatible. The attentional word learning theories of Smith and colleagues (2000), the more social-pragmatic theories of Tomasello and Akhtar (2000) and Bloom (2001), and many others each have theoretical merit and empirical support. Viewed across time, the mechanisms proposed by these approaches can be seen as laying on a developmental continuum wherein strategies become more refined and more reliable as the child moves from novice to expert. In contrast, a myopic approach forces one to overlook possible interactions among cues. Had the experiments by Hollich et al. (2000) and Brandone et al. (2007) been motivated by mutually exclusive hypotheses, there would have been no opportunity to observe the richness of word learning as children begin to coordinate the many cues at their disposal. Thus, to understand the word learning process, the key is to study the interactions among multiple cues.

Third, a developmental model emphasizing multiple factors holds the promise of revealing individual differences and pathways of development. Our tradition (though see Bates et al., 1988) is to look at small sample sizes whose data is treated in the aggregate. Such an approach might mask different trajectories of development. Furthermore, a move towards an individual difference approach might help us re-envision how we think about typical versus

atypical development. Perhaps atypical development manifests itself as an extreme version of individual differences in typical development. As such, once we determine how multiple factors interact in word learning we can better understand what components are heightened or depressed in certain populations of children and what interventions might prove most useful for optimizing language growth.

These take-home messages speak not only to the value of a radical middle approach and to the progress it has yielded thus far, but also to the gaps that are yet to be filled. The question of how we map words to world and how these words become imbued with meaning is a complex one that deserves a complex answer. The hybrid model that we call the ECM offers one small step towards embracing that complexity.

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