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Differentiation of Words and Gestures in an 18-Month-Old's Lexicon:

Evidence from a Disambiguation Task

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Master of Arts

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An abstract of
A thesis submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
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Abstract

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In the early stages of word learning, children are equally receptive to words and symbolic gestures as object labels, suggesting that a general symbolic mechanism may underlie both word and gesture learning. In two experiments, I investigated the lexical organization of words and symbolic gestures; in particular the extent to which words and symbolic gestures form a single lexicon. As a window into the structure of the lexicon, I employed a disambiguation task and examined the extent to which 18-month-olds avoided word-word, word-gesture and gesture-gesture overlap. In Experiment 1, children reliably mapped a novel word onto a novel object (as opposed to a familiar one), consistent with the notion that children tend to avoid lexical overlap. In contrast, children mapped a novel gesture onto a familiar object. The fact that children avoided word-word overlap but sought word-gesture overlap suggests that words and gestures may not form a single lexicon. In Experiment 2, children avoided word-word overlap but did not avoid gesture-gesture overlap, suggesting that in at least some ways the principles underlying word learning diverge from those underlying gesture learning. These findings are discussed in terms of their implications for (1) the structure of a child's early lexicon, (2) the notion of a common symbolic mechanism underlying word and gesture learning, and (3) the development of a mutual exclusivity word learning strategy.

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Differentiation of Words and Gestures in an 18-Month-Old's Lexicon: Evidence from a Disambiguation Task

A child's remarkable ability to acquire language has long intrigued scholars across disciplines. For over half a century, developmental cognitive scientists have attempted to identify the cognitive mechanisms that underlie a child's acquisition of such a complex system. One question central to this endeavor is to what extent the processes that drive language acquisition are specific to language or shared across other domains. This debate on specificity is evident in research on speech perception (Cutting & Rosner, 1974), word segmentation (Saffran, Aslin & Newport, 1996; Saffran, Johnson, Aslin, & Newport, 1999) and syntactic development (Saffran, 2002). Most relevant to the current proposal is the debate on children's lexical acquisition.

Arguably, the main goal for word-learning theorists is to explain how a child discovers the meaning of a word given the nearly infinite possible meanings (Quine, 1960). To illustrate, imagine a child playing with a novel spherical object and hearing her mother say the word "ball". The label "ball" could mean numerous things including but not limited to: (a) all objects one plays with, (b) the color of the ball, (c) the shape of the ball, and (d) the activity of playing with a round object. How does the child limit the possible meanings of this novel word and establish likely set candidates? Attempts to answer such a question have come from three distinct approaches that vary in the degree to which the proposed mechanism is domain specific for language. The first approach suggests that the child comes to the word learning process with a set of default biases or assumptions that allows the child to constrain the potential meanings of words. Such assumptions, often termed lexical constraints, may include the belief that words tend to refer to whole objects rather than their parts (Golinkoff, Mervis, & Hirshpasek, 1994; Markman, 1989), the principle that they refer to classes of things and not individuals (Golinkoff et al., 1994; Markman, 1989; Markman & Hutchinson, 1984), and the bias that objects generally have only one name (Markman, 1989; Merriman & Bowman, 1989). Most proponents of a lexical constraints view (Golinkoff et al., 1994; Markman, 1989) generally argue that these biases are specific to language and do not extend to other non-linguistic domains.

The other two approaches to explaining how children limit the possible meanings of words suggest that children recruit mechanisms not specific to the linguistic domain. Two distinct arguments have been made for this domain general view. One is that in the task of word learning, children primarily recruit their developing understanding of others' intentions and use social contextual cues to infer their interlocutor's communicative intention. Such an approach has been termed a social-pragmatic account (Akthar & Tomasello, 2000; Bloom, 2000; Diesendruck, 2007). A separate approach, also domain-general in nature, is that word learning develops primarily from the universal mechanisms of associative learning and other general cognitive principles (Smith, 2000; Smith, Jones & Landau, 1996). This approach argues that children recruit general cognitive skills, such as memory, attention, and pattern recognition in the service of acquiring a lexicon. It is important to note that these two domain general accounts are not necessarily mutually exclusive and often make similar behavioral predictions (Akhtar, Carpenter, & Tomasello, 1996; Samuelson & Smith, 1998).

Central to the debate on mechanism specificity in word learning is whether the processes posited by the accounts above apply when learning the meanings of signals that are non-linguistic. A set of studies has demonstrated that children appear to learn words and non-verbal symbols (e.g., symbolic gestures) as labels for objects with equal facility (Acredolo & Goodwyn, 1985, 1988; Caselli, 1994; Hollich et al., 2000; Namy & Waxman, 1998; Namy, 2001; Shore, Bates, Bretherton, Beeghly, & O'Connell, 1994; Smith, 2000; Woodward & Hoyne, 1999).

These researchers have argued that their findings demonstrate that early words and gestures are equipotential in the mind of the child and that both word and gesture learning may be driven by a domain general symbolic capacity. I begin this thesis with a review of the evidence for and against an equipotential status between words and other symbolic forms. I then describe a basic phenomenon in word learning known as mutual exclusivity, which demonstrates a word learner's tendency to avoid lexical overlap. I then present findings from two experiments designed to test the extent to which avoidance of "lexical" overlap extends across symbol types as a means of characterizing the structure of the lexicons for both verbal and non-verbal symbols. I end with a discussion of the findings and their implications for a number of aspects related to children's early gesture and word learning.

Are Words Special? Observational Evidence

Over two decades, observational, case, diary, and training studies have documented the prevalence of symbolic gestures in young children's communicative repertoires. These gestures, also referred to as *representational gestures* (Iverson, Capirci, & Caselli, 1994; Caselli, 1994), are different from deictic gestures such as pointing in that they refer to specific referents or kinds of referents. Examples of these symbolic gestures include the act of sniffing in response to seeing a flower, extending ones arms out to indicate an airplane in the sky, and producing a panting action when seeing a dog depicted in a picture book. Researchers have highlighted the following parallels between children's symbolic gestures and early words as evidence consistent with a shared symbolic system.

Words and Gestures Share a Similar Age of Onset

One clear similarity between the two symbol types is the age of onset of their production. A number of studies have reported that children begin producing symbolic gestures at roughly the same age (around 12 months) at which they produce their first words (Capirci, Montanari, & Volterra, 1998; Goodwyn & Acredolo, 1998; Shore et al., 1994). Acredolo and Goodwyn report that once children begin to produce words and gestures, the two symbol types develop side-by-side, with children's gestural vocabulary growing in parallel with their verbal vocabulary (Acredolo & Goodwyn, 1988). Further, in one case study (Acredolo & Goodwyn, 1985), these same authors also document that the production of their subject's first word-word combination occurred on the same day as the production of her first gesture-gesture combination.

Words and Gestures Share a Similar Communicative Function

In addition to a similar age of onset, the findings from these naturalistic studies reveal that symbolic gestures and early words tend to serve similar functions (i.e., to label or request) and tend to represent similar types of referent (e.g., food, animals, toys, Acredolo & Goodwyn, 1988; Iverson et al., 1994; Caselli, 1994). Particularly relevant for the current investigation is the intriguing observation that although symbolic gestures and words appeared to refer to similar semantic domains, children rarely acquired both a word and a symbolic gesture for the same referent (Acredolo & Goodwym, 1988; Iverson et al., 1994; Caselli, 1994; Shore et al., 1994). In other words, children's early words and symbolic gestures were mutually exclusive. Further support for a mutually exclusive status between the two symbolic types comes from a training study where a group of infants underwent a gestural training program which involved parents' simultaneous modeling of a gesture and word as a symbol for a particular object (Goodwyn & Acredolo, 1998). Even though parents provided both a gestural and verbal symbol, infants typically only produced one of the symbols to refer to the object and very rarely learned *both* gestural and verbal symbol.

Words and Gestures Undergo a Similar Process of Acquisition

Another parallel between the two symbolic media is both the context and process by which they are acquired. In one study, Namy, Acredolo and Goodwyn (2000) observed that parents produce verbal and gestural labels within the same rich interactive, joint-attention contexts (see also Iverson, Capirci, Longobardi & Caselli, 1999). Further, Acredolo, Goodwyn and others report that infants first produce both types of symbols in the specific context in which they were acquired (Acredolo & Goodwyn, 1988; Caselli, 1994; Shore et al., 1994). Over time however, both types of labels follow a similar process of decontextualization where the child begins to produce these labels outside the original context of acquisition.

Correlation between Verbal and Gestural Development

The last source of observational support for a common mechanism underlying symbolic gesture and word production are the correlations between verbal and gestural development. Acredolo and Goodwyn (1988, 1994) report a positive relationship between children's production levels of symbolic gestures and their verbal vocabulary. That is, children who had a greater number of symbolic gestures as measured by weekly parental diaries also had a greater vocabulary size at 17 months (Acredolo & Goodwyn, 1994; for a similar correlation see Shore et al., 1994). At the earliest stages of acquisition, infants who had a larger number of symbolic gestures were also quicker to reach a 10-word vocabulary level (Acredolo & Goodwyn, 1988). Finally, in one training study, parents who provided their children with gestural training had children who outperformed control subjects on thirteen out of seventeen receptive and expressive language assessments at 36 months of age (Goodwyn & Acredolo, 1998), suggesting the possibility that experience in the gestural modality may have accelerated language development.

The results from these naturalistic studies provide a strong argument for a domain-general symbolic capacity underlying early word learning. The data these studies present are rich and detailed, particularly in their description of the developmental progression of symbolic gestures and words, and also the natural contexts in which gestures and words occur. However, observational data lack the methodological control experimental studies provide. Indeed, some diary studies of symbolic gestures have produced differing results, leading some researchers to argue that in fact distinct mechanisms underlie word and symbolic gesture production (Petitto, 1992; 1993). For this reason, I next turn to the experimental findings on the issue.

Are Words Special? Experimental Evidence

A growing body of experimental findings complements the observational findings described above, supporting the notion that a general symbolic capacity underlies word learning in the earliest stages of lexical acquisition. In general, these studies have demonstrated that at the early stages of word learning, the robust patterns of mapping, extension, spontaneous production, inductive inference and reliance on social referential cues that are observed in children's learning of words also apply to symbolic gestures and other symbols such as non-verbal sounds and pictograms (Campbell & Namy, 2003; Graham & Kilbreth, 2007; Namy, 2001; Namy, Campbell & Tomasello, 2004; Namy & Waxman, 1998, 2000, 2002; Smith, 2000; Woodward & Hoyne, 1999).

Symbolic Mapping, Production, Extension and Generalization

Namy and Waxman (1998) investigated infants' symbolic interpretation of words and symbolic gestures employing a forced-choice task previously used in word learning studies (e.g., Waxman & Hall, 1993). Eighteen- and 26-month-olds saw a triad of toy replicas, for example an apple, a car and a van. In a word-condition, target objects were labeled with a nonsense word (e.g., "blicket") while in a gesture condition targets were labeled with an open-hand gesture (e.g., a dropping motion with fingers extended). In a third no-label control condition, the experimenter simply drew attention to the objects without labeling them. Following this labeling phase, infants in each condition participated in a series of test trials including mapping trials where the experimenter requested a target object using the taught label (word or gesture depending on the condition). In extension test trials, the experimenter requested “another [label]” while presenting novel instances from the target category. Namy and Waxman found that 18-month-old infants interpreted both gestures and words as object labels. Not only did children show similar patterns of mapping for words and gestures, they also showed similar patterns of extension. That is, if infants learned that a blue plane was labeled using a particular gesture, they would extend that gesture to other novel planes as well.

Woodward and Hoyne (1999) found similar results when comparing young infants’ willingness to accept words and non-linguistic sounds produced as object labels. Most recently, Namy and colleagues have both replicated the findings with gestures (Namy, Campbell & Tomasello, 2004) and non-linguistic sounds (Campbell & Namy, 2003), and also extended the finding to visual pictograms (Namy, 2001). Additionally, Hollich and colleagues (2000) showed that in certain situations, even infants as young as 12 months successfully associate a non-verbal sound with an object. Together, these studies have convincingly demonstrated young children’s flexibility in what can be a name for an object.

Social Context

If words and non-verbal symbols are driven by a similar learning mechanism, one might expect that the contexts in which they are acquired (and are not acquired) to be similar. A wealth of literature on early word learning stresses the importance of the social and referential context supporting word learning (Baldwin, 1993; Baldwin et al., 1996; Tomasello & Barton, 1994; Tomasello, Strosberg & Akhtar, 1996). For example, Baldwin et al. (1996) demonstrated that infants map a novel word to an object if the experimenter produced the word while participating in a joint-attention episode with the child. However, when a second experimenter out of the view of the infant produced the label while the infant was attending to the object, mapping did not occur. Is the acquisition of non-verbal symbols also similarly reliant on a rich, social, interactive context?

In an attempt to answer this question, Campbell and Namy (2003) taught 13- and 18-month-olds a novel word or a novel non-verbal sound as a label for an object. Similar to Baldwin and colleagues' study above, the labels were presented either in a referential context or in a non-referential context (emitted by an electronic baby monitor). Campbell and Namy found that the referential context in which infants successfully mapped words also held true for non-verbal sounds. Similarly, the non-referential context in which word learning did not occur, also failed to produce successful mapping of non-verbal sounds.

Inductive Inference

Previous research has demonstrated that words play a powerful role in children's inferences about object properties (Gelman & Markman, 1986; Gelman & Coley, 1990; Jaswal & Markman, 2007). For example, Gelman and Coley found that children infer that if two dissimilar looking things (e.g., dodo bird and bluebird) share a label (i.e., bird), they will also share a non-obvious property (e.g., lives in a nest). If they do not share the same label, children rely predominantly on perceptual similarity as a basis for inferring a non-obvious property (Gelman & Coley, 1990).

Given these findings, a general symbolic capacity view would predict that at the early stages of word learning, non-verbal labels should also share the inductive power that words possess. A recent study by Graham and Kilbreath (2007) explored exactly this issue. Fourteenand 22-month-old infants were presented with novel objects that differed in perceptual similarity. Similar to the findings by Gelman and colleagues, they found that when items were not labeled, infants inferred that similar shaped objects would produce a non-obvious property (e.g., it could produce a squeaking sound when squeezed). Additionally, when perceptually dissimilar objects shared the same linguistic label, infants inferred that the two objects would share a non-obvious property. The critical finding is that 14-month-old infants also inferred that two dissimilar objects shared a non-obvious property when the objects were labeled with a common gesture.

Neural Processing of Words and Gestures

Further evidence of a common mechanism underlying words and gestures is a recent study comparing the neural activation elicited during the semantic processing of gestural and verbal labels (Sheehan, Namy, & Mills, 2007). Using event related potentials (ERPs), Sheehan and colleagues compared patterns of brain activity linked to processing the meaning of gestures and words. Previous studies investigating infants' processing of word meaning have employed a word/picture mismatch paradigm where infants are presented with a word (e.g., "car") followed by a picture that was either a match or mismatch. These studies find what is known as the N400 congruency effect, meaning greater negative going activation peaking around 400ms post-stimulus following a mismatch picture compared to a match picture (Mills, Conboy & Paton, 2005). It is believed that the N400 component is related to semantic integration. Following a word-picture match, the amplitude of the component is reduced. In contrast, the amplitude is heightened when processing a word-picture mismatch.

Sheehan and colleagues were interested in whether the N400 congruency effect would hold true for processing gestures as well as words, and if so, whether it would display similar patterns of distribution. In their study, infants were presented with a video clip of an actor producing either a word (e.g., "bunny") or gesture (e.g., two fingers held up like bunny ears while producing a hopping motion). Following the labeling clip, a picture appeared that either matched (i.e., picture of a rabbit) or mismatched (e.g., a car) the proceeding clip. Results revealed that 18-month-olds not only displayed an N400 congruency effect in response to gestures, but showed a similar magnitude, timing and scalp distribution of the effect for words and gestures, suggesting that the processing of the two symbolic forms activated similar neural systems. This neurophysiological evidence complements and bolsters the observational and behavioral studies described above.

The results described so far are all consistent with the notion that early word learning may be driven by a domain-general mechanism supporting multiple symbolic media. The findings come from studies employing a range of scientific methods: diary and case studies, observational studies, behavioral experiments and most recently neurophysiological methods. Together these studies have documented the following parallels between early words and gestures: similar age of onset, similar referent types, similar communicative function, similar context of acquisition, similar mapping and extension patterns, similar inductive inference power, and finally, similar underlying neural mechanisms of processing.

Do Words Become Special?

Most studies documenting similarities between the acquisition, processing and use of words and gestures report that the parallels are short-lived. That is, while there is convincing evidence that at some early point in development, words and gestures share an underlying mechanism, the trajectories of words and gestures follow divergent paths over development. For example, Iverson and colleagues (1994) observed that while gestures and words seemed to both serve as labels at 16 months of age, words and gestures took on separate roles in communication by 20 months. Words showed continuity in that they continued to be employed representionally. Although gesture production actually increased from 16 to 20 moths of age, the gestures produced (primarily pointing) were not used to represent objects but instead were employed to establish joint attention (Iverson et al., 1994).

Additionally, Namy and Waxman (1998) found that whereas 18-month-olds accepted symbolic gestures as labels for objects and readily extended those gestures as labels for similar objects, 26-month-olds did not. Although, 26-month-olds were capable of mapping a gesture to an object following extensive training, they clearly did not do so spontaneously as their younger counterparts did. Sheehan et al.'s investigation of the neural activity underlying word and gesture processing confirms these results. Unlike 18-month-olds, 26-month-old infants did not show an N400 semantic congruity effect when processing match vs. mismatch gesture-picture pairs (Sheehan et al., 2007). Further, Graham and Kilbreth found a similar developmental trend in their investigation of infants' basis for inductive inferences. Although 14-month-old infants rely on both words and gestures to guide their inferences, 22-month-olds use only words.

The picture these results paint is that early in development, young word learners show flexibility in which modality they are able to recruit for symbolic communication. Over development however, as hearing children become more experienced and immersed in language, they develop a preference for speech as the primary mode of linguistic communication and they experience a narrowing of the types of symbols they readily accept as object labels.

This thesis extends the investigation of the relationship between words and symbolic gestures in the stages of early word learning. The studies presented below examine the extent to which young children treat the two symbolic forms as equivalent items in the developing lexicon. That is, are words and gestures stored and organized together in the child's lexicon, the stock of symbols a child can draw on in communication (Clark, 1993)? One possibility is that in addition to having a similar underlying learning mechanism for words and gestures, words and gestures also form an integrated and undifferentiated lexicon. The second possibility is that despite a common mechanism driving the acquisition of symbolic gestures and words, word learners still represent their verbal vocabulary separate from their gestural vocabulary. These studies were designed to distinguish between these two possibilities.

To address this issue, I apply a robust phenomenon in the word learning literature showing that children tend to avoid lexical overlap (i.e., multiple verbal labels for the same referent). The question I ask here is whether the same avoidance of overlap applies across symbol types. Will children view word and gestural meaning as mutually exclusive? If so, this would be convincing evidence of an equipotential status between words and gestures. Before describing the proposed experiments, it is important to motivate how mutual exclusivity in children’s word learning can be applied to ask the current research question. Below I review briefly the research on mutual exclusivity, in particular some key findings that are directly relevant to the proposed studies.

Mutual Exclusivity in Word Learning

I began this thesis by describing the theoretical approaches to how children limit the possible meanings of words, one of which is the lexical constraints view. One of the most studied constraints is the principle of mutual exclusivity (Markman, 1989; Markman & Wachtel, 1988; Merriman & Bowman, 1989). The principle of mutual exclusivity states that children have a default tendency to accept only one label for each object category (Markman, 1989). In a thorough analysis of the principle, Merriman and Bowman (1989) describe in detail a number of different behavioral effects predicted by such a principle. For the purposes of the current proposal, I will focus on the most studied effect, namely the *disambiguation effect*, the observation that in the presence of a familiar and novel object, word learners will choose the novel object as the referent of an unfamiliar word (Golinkoff, Hirsh-Pasek, Bailey & Wenger, 1992; Graham, Poulin-Dubois & Baker, 1998; Hutchinson, 1986; Markman & Wachtel, 1988; Mervis & Bertrand, 1994; Vincent-Smith, Bricker & Bricker, 1976).

To illustrate this effect, in one study investigating mutual exclusivity, Markman and Wachtel (1988) presented three-year-olds with a familiar-unfamiliar object pairing (e.g., a spoon and a lemon wedge-press). One group of children was then asked to show the experimenter the referent of a novel label (e.g., "Show me the blicket"). A second preference control group was simply asked to show "one" to the experimenter. Markman and Wachtel found that in response to the novel label children would preferentially choose the novel object compared to the familiar object. In the control condition, however, children chose randomly between the novel and familiar object (Markman & Wachtel, 1988).

Although a number of researchers have found similar effects in comparable tasks (Diesendruck & Markson, 2001; Golinkoff et al., 1992; Graham et al., 1998; Hutchinson, 1986; Mervis & Bertrand, 1994; Vincent-Smith et al., 1976), mutual exclusivity (the assumption that one object has only one label) is not the only explanation for the mechanism driving this pattern of behavior (see Merriman, Jarvis & Marazita, 1995, for a detailed review). For example, Golinkoff and colleagues (1992) suggest that instead of rejecting the novel label as a name for the familiar object, word learners are instead positively motivated to map novel labels onto novel objects. This reasoning is termed Novel-Name-Nameless Category (N3C) principle. Others have argued that the bias is a product of the child's developing theory of mind (Bloom, 2000; Diesendruck & Markman, 2001; Disendruck, 2007). In a break down of the argument, which is largely based on Eve Clark's *principle of contrast* (Clark, 1988), Bloom describes the process of disambiguation as follows. The child sees two objects: one familiar (e.g., spoon) and one novel (e.g., wedge press). The child then hears the experimenter request an object using a novel name. The child reasons that if the experimenter had meant to indicate the spoon, she would have said "spoon". However, the experimenter did not say "spoon"; she said something else. The experimenter must have meant something other than the spoon. Because there are only two objects to choose from, it must be this other object (Bloom, 2000). Thus although the pattern of behavior is clear and robust, scholars differ on the underlying mechanisms driving the behavior.

Age of Onset of Mutual Exclusivity

For the purposes of the current investigation the precise basis for the behavior is less critical than the uncontroversial conclusion that children tend to map a novel label onto the novel object if given both a familiar and novel choice. A separate source of disagreement, one that is particularly relevant to the current study, is at what point in development mutual exclusivity emerges. Employing different procedures to tap the behavior, Markman and colleagues (Littschwager & Markman, 1994; Markman, Wasow, & Hansen, 2003) have shown that certain mutual exclusivity effects can be seen in infants as young as 16 months of age. These findings have led the authors to conclude that the principle is available from the onset of word learning and therefore serves the purpose of getting word learning off the ground.

Others argue that mutual exclusivity emerges later in infancy and therefore does not aid the learning of a child's first words. Mervis and Bertrand (1994) investigated the extent to which 16- to 20-month-old infants would map novel names onto novel objects. They found that half of their subjects successfully mapped (average age: 17 months 19 days) whereas the other half did not (average age: 17 months 24 days). What differentiated the two groups was not their age but instead was their vocabulary size. Indeed, once the non-mappers (who were followed longitudinally) had matched the vocabulary size of their mapping counterparts , they successfully demonstrated the disambiguation effect (Mervis & Bertrand, 1994; for similar results, see Graham, et al., 1998). Golinkoff, Hirsh-Pasek and colleagues contend that mutual exclusivity behavior is a secondary lexical principle that emerges only after other foundational principles are established. For example, one of these foundational principles is termed the principle of categorical scope, which states that words label objects and that they label whole objects as opposed to object parts or attributes. Foundational principles such as object scope, they argue, are necessary and sufficient for word learning to get off the ground. These principles, through their experience with language and social-pragmatic cues, evolve into more elaborate principles such as the N3C principle, which Golinkoff, Hirsh-Pasek and colleagues invoke to explain behaviors such as the disambiguation effect (Golinkoff, et al., 1994; Hirsh-Pasek, Golinkoff, & Hollich, 2000).

A related argument that has been proposed is that infants possess a weak form of mutual exclusivity early in word learning (under the age of two) that grows in strength during the months following the child's second birthday (Evey & Merriman, 1998; Merriman, 1991). Evidence for this view stems from studies demonstrating that in young two-year-olds, the disambiguation effect is easily affected by both demands of the experimental procedure, such as contingent rewarding (Evey & Merriman, 1998), and demands of the experimental material, such as the typicality of the object (Merriman & Schuster, 1991), the familiarity with the object (Merriman & Bowman, 1989; Merriman & Schuster, 1991), and phonological properties of the novel and familiar name (Merriman & Marazita, 1995). In one study employing a preferential looking procedure, Halberda (2003) similarly concluded that the developmental progression of the word learning strategy is more nuanced than a change from an absence to a presence of the bias.

The Generalizability of Mutual Exclusivity

A second aspect of mutual exclusivity important for the current investigation's purpose is whether the behavioral effect is observed only in the word learning domain (thus strictly a lexical principle) or whether it is also seen in non-lexical domains. Few studies of mutual exclusivity have directly addressed this issue. One exception is a study conducted by Diesendruck and Markson (2001) in which the disambiguation effect was compared in the domain of words and facts. In the word condition, three-year-olds were presented with two unfamiliar objects. The experimenter labeled one of the objects with a novel label (e.g., "mep"). Later, the experimenter presented the same two objects again but requested an object using a different novel label (e.g., "jop"). As expected from previous studies, children chose the unlabeled unfamiliar object in response to the second novel label. Children in the fact condition saw a similar presentation except that instead of teaching the children novel labels for objects, children were taught a specific fact about the object (e.g., "this is the one my sister likes"). In the critical test, children were presented with the two novel objects and an experimenter elicited a choice using a different fact (e.g., "can you hand me the one my dog likes to play with?"). Interestingly, Diesendruck and Markson found that children in the fact condition performed comparable to children in the word condition. These authors contend that their findings support a social pragmatic explanation of mutual exclusivity. That is, in both the word and fact conditions, the child reasons that if the experimenter had meant the first novel object (the one initially labeled with a word or a fact), then the experimenter would have used the first label or fact. But since the experimenter used a second novel word or fact, the child reasons the experimenter's intention must be to refer to the second novel object (Diesendruck & Markson, 2001; see also Bloom, 2000).

Thus it seems likely that if children would apply a mutual exclusive strategy similarly to words and facts, they should also apply the strategy to the domain of gestures and non-verbal symbols. However, it is important to note that Diesendruck and Markson's participants (aged 3 to 4 years) are significantly older than the target age in the current studies (17 to 19 months). In fact, Scofield and Behrend (2007) tested two-, three- and four-year-olds in Diesendruck and Markson's task and found that two-year-olds did not extend mutual exclusivity beyond the domain of words to the domain of facts. However, Brojde and Colunga (2006) found that 20-month-old infants applied the mutual exclusivity principle both to words and to animal sounds (e.g., "ruff-ruff"), so long as a human mouth produced the label.

Given these mixed findings regarding the extension of mutual exclusivity strategies to other domains, whether children will expect mutual exclusivity in gestures is an interesting question in its own right, regardless of the implications of such a finding on the structure of the child's lexicon.

Mutual Exclusivity as a Test of Lexicon Structure

The goal of the current set of studies is to employ a mutual exclusivity task to investigate whether words and gestures are interchangeable to the early word learner. That is, to what extent do children store their gestural labels separate from their verbal vocabulary? One line of research that may be directly applicable is the study of lexicon differentiation in bilingual language acquisition (Deuchar & Quay, 2000; Genesee, 1989; Pearson, Fernandez, & Oller, 1995; Pye, 1986; Volterra & Teuscher, 1978). Bilinguals, of course, by definition must violate mutual exclusivity in order to communicate successfully about the same referential content using two distinct verbal forms. Whether there is a period in bilingual language acquisition in which bilinguals maintain an undifferentiated lexicon is debated.

Compared to the abundance of work in monolinguals, much less is known regarding mutual exclusivity in bilinguals. However, two questions have been addressed by a handful of studies. The first is whether the bilingual experience, which includes exposure to more translational equivalents compared to a monolingual experience, would have an effect on word learners' tendency to honor the mutual exclusivity principle. In other words, does hearing the translational equivalent across languages influence the extent to which bilinguals differ from monolinguals in their use of mutual exclusivity *within a language*? Studies addressing this issue have found mixed results. Davidson and colleagues have demonstrated that in some cases bilinguals (aged 3-4 and 5-6 years) show a weaker reliance on mutual exclusivity compared to monolinguals (Davidson et al., 1997; Davidson & Tell, 2005). Further Byers-Heinlein and Werker (2009) recently demonstrated that 17- to 19-month-old monolinguals were much more likely to exhibit behavior consistent with mutual exclusivity compared to their bi- and tri-lingual counterparts (see also Houston-Price, Caloghiris, & Raviglione, 2009). However, Frank and Poulin-Dubois found that their bilingual subjects (27 to 35 months) were as likely as monolinguals to reject a second novel English-word as a label for an already English-labeled object (Frank & Poulin-Dubois, 2002).

Perhaps more relevant to the current proposal is the question of whether bilinguals would honor mutual exclusivity *across languages* (i.e., whether they maintain distinct lexicons). Not surprisingly, studies of bilingual adults and older children (4-8 years of age) report that bilinguals suspend the principle of mutual exclusivity (Au & Glussman, 1990; Merriman & Kutlesic, 1993). For example, Au and Glussman (1990) found that bilingual adults and children aged 4-6 were willing to accept two labels for an object if it was clear that the two labels came from different languages (e.g., if the two labels were produced by two different experimenters, one English-speaking and the other Spanish-speaking). However, in a study of younger children (27 – 35 months), Frank and Poulin-Dubois (2002) found that bilinguals do not treat violations of mutual exclusivity across languages differently than violations within a language. Such a finding is consistent with the notion of an early period of bilingual language acquisition in which children maintain an undifferentiated lexicon (Volterra & Taeschner, 1978[1]).

Overview of Main Research Goal

Are symbolic gestures and words also maintained in an undifferentiated lexicon similar to the proposed lexical organization observed early in bilingual development? This question is the central goal of the current investigation. I extend previous investigations that compare words and symbolic gestures by exploring the extent to which young word learners make similar inferences about the meaning of a novel word and novel symbolic gesture. Will mutual exclusivity (a robust behavioral pattern where children tend to map a novel word to a novel object) be applied to both words and symbolic gestures?

In the following two experiments I presented 18-month-old infants with a disambiguation task used in previous studies (Hutchinson, 1986; Markman & Wachtel, 1988; Vincent-Smith et al., 1976). As reviewed above, this is an age at which infants spontaneously interpret multiple symbolic forms as names for objects (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). It is also an age at which a number of researchers have found that infants adhere to the principle of mutual exclusivity (Graham et al., 1998; Halberda, 2003; Littschwager & Markman, 1994; Mervis & Bertrand, 1994) albeit to a lesser degree than older children (Evey &

[1] Although consistent with the concept of bilingual children maintaining an undifferentiated lexicon proposed by Volterra and Taschner (1978), Frank and Poulin-Dubois' subjects were at an age at which Volterra and Taschner predicted bilingual children to have two distinct operating lexicons.

Merriman, 1998, Merriman & Bowman, 1989). To the extent that comparable effects are absent or diminished across the different modalities, these studies will inform the shared versus distinct nature of verbal and gestural lexicons and the mechanisms driving verbal and gestural learning.

Experiment 1

Experiment 1 served as a first step in examining the equipotential status of words and symbolic gestures in the early stages of language acquisition. I employed a standard disambiguation task (Hutchinson, 1986; Markman & Wachtel, 1988; Merriman & Bowman, 1989) in which the experimenter presented a familiar object (for which children had a name) and a novel object and then presented a novel label and asked the children to select the object to which the label referred. Importantly, the novel label was either a novel word (e.g., “blicket”) or a novel gesture (e.g., a dropping motion). I expected that, as in previous research using this paradigm, children in the word condition would map the novel label to the novel object. Of interest was whether children in the gesture condition would be equally likely to infer that the novel label referred to the novel object.

If young word learners possess an undifferentiated lexicon consisting of words and gestures, then children should be just as inclined to avoid word-gesture overlap as they would word-word overlap. That is children should be just as likely to map the novel gesture onto the novel object as they would map the novel word onto the novel object. Alternatively, if young word learners separate their word and gesture into different lexicons, there is no reason to believe that children would show avoidance of word-gesture overlap.

Method

Participants

Thirty-two 18-month-olds (M = 18.4, range = 17.2 – 19.6) from the greater Atlanta area participated in this study. Half of the participants were female. Participants were from predominantly middle class families recruited through direct mailings and online advertising (Caucasian: 67%, African American: 16%, Asian: 13%, Hispanic: 3%, Other: 2%). Data from an additional 11 participants were excluded from analysis due to failure to complete at least eight of twelve trials (7) or displaying a side preference on 11 or more trials (4).

Stimuli

Stimuli consisted of four pairs of small plastic toy replicas of objects (for a complete list, see Table 1). Each pair consisted of a familiar and a novel object. Familiar-Novel pairs were matched for salience through piloting and thus fixed across children. All objects were similar in size, interesting to young children, easy to manipulate, and visually distinct. Familiar objects were selected from a pool of objects for which children tend to have names prior to 18 months, as reported by the Macarthur Communicative Development Inventory normative data (Fenson et al., 1994). Novel objects were objects for which children typically do not have names. Parents completed a vocabulary-checklist (described below) that was used to confirm children's familiarity with the familiar objects and unfamiliarity with the novel objects. For each child, I selected the three pairs that maximized children's familiarity with the familiar object and unfamiliarity with the novel object, based on parental report. An additional pair of familiar objects (a shoe and a car) was used for the warm-up phase.

Novel words were two syllable strings that adhered to the phonotactic constraints of English. Novel gestures were arbitrary and unrelated to any of the objects. The gestures had been used in previous studies (Namy & Waxman, 1998) and were originally patterned after the hand shapes and motion trajectories used in sign languages. A list of these novel words and novel gestures are presented in Table 2. For each participant which novel word or gesture was used to elicit a choice from which object pair was random.

Measures

Vocabulary Measure. Parents filled out two forms on their child's language development. The first was the MacArthur Communicative Development Inventory (MCDI) Short Form (Fenson et al., 2000), which was used to estimate their children's overall productive vocabulary. The form is a checklist of 100 words that children typically acquire at various points in development. The short form has been shown to be a reliable indicator of productive vocabulary and scores on this form are also highly correlated with grammatical development (Fenson et al., 2000).

Word and Gesture Checklist. Parents filled out a second form specific to the current study (see Appendix). The form consisted of a number of sections. In the first section, parents rated on a scale of 1 to 4 their child's familiarity with the labels of a number of familiar and novel objects including the ones used in the study. The higher the rating, the more familiar children were with the object's label according to parental report. In the second and third sections, the parents reported whether their child had experience with communication in the manual modality. Specifically, parents reported whether their child had used baby signs (Acredolo & Goodwyn, 1996) and/or spontaneous gestures and estimated how many signs and gestures their child knew. In the final section, parents reported whether their child regularly labeled any of the familiar and novel objects using gestures.

Design

Children were randomly assigned to either the word or gesture condition. The experimental procedure was identical in the two conditions, with the exception of the type of novel label employed by the experimenter. Children completed four trials within each of the three object sets (each set consisted of one familiar-novel object pairing). For each set, the experimenter administered two target trials (in which the experimenter asked the child to choose the referent of a novel label) and two control trials (in which the experimenter asked the child to simply choose "one"). Children therefore completed a total of twelve trials, including six target and six control trials. The experimental design was thus a 2 x 2 with Condition (Word vs. Gesture) as a between subjects factor and Trial Type (Target vs. Control) as a within subjects factor.

Procedure

After providing written consent, parents completed the forms mentioned above. At this time, the experimenter played with the child, familiarizing the child to the experimenter and surroundings. The experimenter then guided the parent and child into the testing room where the child was seated at a table across from the experimenter. Children either sat on a booster seat or on their parents' laps. The procedure consisted of three phases: a warm-up phase, a familiarization phase, and a test phase. The familiarization and test phases were repeated three times, once for each stimulus set.

Warm-up Phase. During a brief warm-up phase, children were familiarized with the forced-choice procedure. The experimenter allowed the child to play briefly with two familiar objects and then removed the objects from the child's reach. The experimenter then re-presented the two objects simultaneously and familiarized the child to both trial types sequentially. First in the preference control trial, the experimenter asked the child to choose one of the objects (e.g., "Can you show me one?" or "Which one can you get?"). Following the request, the experimenter then advanced the objects within the child's reach, one on each side and equidistant from the child's midline. While eliciting the choice, the experimenter's gaze was directed at the child's face. After the child selected an object, the experimenter repeated this procedure but now modeled a target trial (e.g., "Can you show me the Car?"). The order of trial type (control trial followed by target trial) in the warm-up phase was fixed across children. Previous piloting in the lab employing a within subject control task suggests that presenting the control trial first during the warm-up phase helps the child understand that some trials simply measure the child's preference. During the warm-up phase, children's correct choices were reinforced (i.e., clapping and cheering) and incorrect choices corrected. (Selecting either object was reinforced on control trials). Following warm-up, the experimenter told the child that they were going to play a game with some new toys.

Familiarization Phase. For each set, children were presented with one familiar object and one novel object simultaneously. They were encouraged to explore the two objects prior to the test phase. This object familiarization period reduces the novelty of the novel object (Graham, Turner, & Henderson, 2005) thus making choices of the novel object less likely due to an overall novelty preference (Merriman & Schusster, 1991). The experimenter ensured that the child directed attention to each object equally by highlighting any neglected object. After this brief familiarization phase of approximately 30s, the experimenter removed the two objects from the child's reach.

Test Phase. The experimenter then proceeded immediately to the test phase. In the test phase, the experimenter administered four trials: two target and two control trials. In the target trials, the experimenter asked the child to select one of the objects using a novel label: saying, for example, "Which one can you get? Blicket! Can you get it? Blicket!" Following the second production of the label, the objects were advanced in a similar manner to that described above in the warm-up phase. The label was a novel word or novel symbolic gesture depending on the condition. The labels were introduced in syntactic isolation to assure that the wording would not be unnatural-sounding for the gesture condition. In control trials, the experimenter instead said: "Which one can you get? Can you get one?" Once the child made a choice (regardless of whether it was the familiar or novel object), the experimenter simply said "Okay, Thank you" in a neutral tone and proceeded to the next trial. If the child failed to make a choice, the experimenter repeated the request once. If the child still failed to choose an object following the second request, the experimenter removed the objects and proceeded to the next trial. To reduce noise, the order of target and control trials were fixed across sets but counterbalanced across children. Also to reduce noise, presentation order of the two trial types were blocked (e.g., two target trials followed by two control trials) and fixed across sets but counterbalanced across infants. Within a set, the novel object appeared once on the left and once on the right for both trial types.

Coding

A primary coder blind to trial type analyzed videotapes of all participants with the sound muted. For each trial, children's choices were characterized as choosing the novel object, the familiar object, or neither, on each trial. Children's responses were considered choices if the child touched, picked up, or handed one of the two objects to the experimenter. If the child picked up one object followed by the other, the first object touched was considered the child's choice. If the child touched or picked up both objects simultaneously or in rapid succession, the object the child handed to the experimenter was considered the child's choice. The response was coded as no choice if the child picked up both objects simultaneously or in rapid succession and did not hand one to the experimenter. Children who made a choice on fewer than eight of the twelve trials (four of each trial type) were excluded from analysis. A second coder, blind to the experimental design and trial type, coded a random selection of 25% of the children in each condition. Inter-coder agreement was 97%.

Familiarization Coding. Also coded were the children's interactions with each object during the familiarization phase to ensure that any response in the test phase was not due to either over-engagement or under-engagement with either object. This also tested for any possible experimenter bias in highlighting either object during familiarization. The coder simply recorded the amount of time the child interacted with each object during the familiarization phase. Children's interaction with each object was comparable in both conditions (Word: $M_{familiar}$ = 18.34, $SD_{familiar}$ = 6.56; M_{novel} = 18.79, SD_{novel} = 7.93, $p > .10$; Gesture: $M_{familiar}$ = 18.29 $SD_{familiar}$ = 5.36, M_{novel} = 17.70, SD_{novel}= 7.122, $p > .10$)

Measure Scoring

Children's Vocabulary Level (MCDI). For each child, I tallied the number of words the parent reported their child produced. I then converted this number, based on Fenson and colleagues' norming study, into a percentile rank. This rank reflects where the child stood relative to other children of the same age and gender (Fenson et al., 2000). Children's percentile rank ranged from 5th to 90th (*M*= 43.59 , *SD*= 27.86). There were no differences between the ranks of children in the word (*M* = 39.69, *SD* = 31.17) and gesture (*M* = 47.50, *SD* = 24.49) conditions ($p > .10$).

Known Label Familiarity. For each child, I averaged parental rating of the child's familiarity with the known label for the three familiar objects used. As expected based on normative data (Fenson et al., 1994), parents reported their children to be familiar with these objects. There was no difference in known label familiarity between children in the word (M = 3.11, SD = .72) and gesture condition (M = 2.88, SD = .90), $p > .10$.

Children's Use of Symbolic Gestures. For each child, I recorded parental estimates of the number of symbolic gestures their child produces. The average number of gestures produced was slightly higher for children in the gesture condition (M = 2.69, SD = 3.23) than the word condition (M = 1.78, SD = 3.37). However, this difference was not statistically significant, $p >$ .10.

Additional Measures. I also scored variables such as knowledge of novel object label, experience with baby signs and children's gestural labels for the familiar objects. However, these variables were not included in subsequent analyses due to low variability. All parents in the word condition and all but three parents in the gesture condition were "certain their children did not have a word for any of the novel objects". All but four parents (two in each condition) reported that their children did not produce signs or gestures in reference to any of the familiar objects. Finally, approximately half of the parents reported their children's use of baby signs. However in an exploratory analysis, experience with baby signs was not correlated with task performance in either condition (*p*s > .10). This may be in part due to the fact that the most common baby signs (such as "more" and "all done") are not used as object labels. Perhaps more important is the fact that most parents reported that their children used baby signs at an earlier stage and were not actively using signs at the time of the experiment.

Results

For each trial type in each set, the number of times children selected the novel object was summed and divided by the total number of trials completed of each trial type yielding a proportion choice of novel object. Adherence to mutual exclusivity was operationalized as a greater mean proportion of choosing the novel object in target compared to control trials as well as a greater proportion of choosing the novel object in target trials compared to chance responding (.50).

A Condition (Word vs. Gesture) x Trial Type (Target vs. Control) analysis of variance (ANOVA) on proportion choosing novel object yielded no main effects of Condition (p = .196) or Trial Type (p = .973). It did, however, reveal a significant interaction between Condition and Trial Type, $F(1,30) = 14.22$, $p < .005$, $\eta^2_p = .322$. As can be seen in Figure 1, children in the word condition selected the novel object in the target trials (M= .61, SD= .04) more than in the control trials (M= .46, SD= .04), $t(15) = 2.92$, $p < .05$, thus exhibiting behavior consistent with mutual exclusivity. In contrast children in the gesture condition displayed the *opposite* pattern, selecting the novel object reliably less often in the target trials (M= .40, SD= .04) than in control trials (M= .54, SD= .04), $t(15) = -2.46$, $p <.05$.

Comparisons to chance were consistent with the results of the ANOVA. In the word condition, a one-sampled t-test revealed that children selected the novel object in target trials significantly more often than predicted by chance, $t(15) = 2.49$, $p < .05$. Responding in control trials did not differ from chance, $p > .10$. Conversely in the gesture condition, children selected the novel object in target trials significantly *less* often than predicted by chance, $t(15) = -2.10$, $p =.05$. That is, they reliably mapped the novel gestures to the familiar objects. Proportion selecting the novel object in control trials was not different than chance, $p > .10$.

Patterns of Individual Responses

To investigate how representative these group data were of individual children's performance, I examined individual patterns of responding. Table 3 presents the number of children in the word and gesture conditions who selected the novel object *more* often in target compared to control trials and the number who selected the novel object *less* often in target compared to control trials. The remaining children (1 in the word condition and 4 in the gesture condition) who selected the novel object equally often in the two trial types were excluded from this analysis. A chi-square test of independence revealed that the distribution of individual response patterns varied as a function of condition, χ^2 (1, N = 27) = 8.57, $p < .01$, consistent with the group-level analyses indicating that children in the word condition reliably mapped novel words onto the novel objects whereas those in the gesture condition reliably mapped novel gestures onto the familiar objects.

Correlations between Performance and Parental Report Measures

Finally, I explored whether children's performance was correlated with their vocabulary levels and familiarity with the known objects. I calculated a difference score between proportion of choosing novel object in target trials and proportion of choosing novel object in control trials (hereafter Mutual Exclusivity (ME) score), which was used as my measure of children's performance. I chose this variable over others (such as proportion choosing novel object) because this difference score reflects children's selection of the novel or familiar object in response to the novel label above and beyond any baseline object preference (as indexed by the control trials). Other researchers have used this different score as a measure of mutual exclusivity (Byers-Heinlein & Werker, 2009; Halberda, 2003). A high positive ME score reflects adherence to mutual exclusivity, a preference for selecting a novel object in response to a novel label. A high negative ME score reflects a preference for selecting the familiar object in response to a novel label.

Table 4 presents the correlation coefficients between the above predictor variables and ME scores for both word and gesture conditions. As depicted in the table, for children in the word condition, vocabulary rank was significantly correlated with ME score, suggesting that children with higher vocabulary levels were more likely to select the novel object as the referent of a novel label. Further, children's familiarity with the known objects was also significantly correlated with their difference score, suggesting that the more familiar the child was with the known object's label, the more likely the child was to reject the novel label as referring to that known object. As might be expected for children in the word condition, children's gesture production was not correlated with task performance.

In the gesture condition, children's verbal vocabulary level was not correlated with their ME score. Their familiarity with the known objects showed a marginally significant negative correlation with performance. Thus, in contrast to the relationship observed for children in the word condition, those encountering gestural labels were less likely to map the gesture to the novel object when the label of the known object was more familiar to them. Finally experience with symbolic gestures was also negatively correlated with task performance. That is, children who produced more symbolic gestures outside the laboratory were less likely to map the novel gesture to the novel object (i.e, they were more likely to map the gesture to the familiar object). This result, while suggestive,should be interpreted with caution for a number of reasons. First, the questionnaire used to probe children's symbolic gesture production has not been validated. Second, production estimates were highly variable and positively skewed (*Mean* = 2.68, *Mode* = 0, *Median* = 1.5, *Range* = 0-13). Finally, when parents were asked to give examples of symbolic gestures, many parents included deictic gestures (such as pointing) and conventional gestures (such as "waving bye-bye" or "blowing kisses"). Thus it is likely that symbolic gesture estimates were conflated with estimates of non-object based gestures.

Discussion

This first experiment investigated the relative status of words and gestures in a young word learner's lexicon. Children selected between a familiar and novel object as the referent for either a novel word or a novel gesture. I found that when presented with a novel word, children reliably selected the novel object, a pattern of behavior consistent with mutual exclusivity. This finding adds to a growing number of studies demonstrating that even young word learners demonstrate a preference to map a novel word onto a novel object as opposed to a familiar one (Byers-Heinlein & Werker, 2009; Graham et al., 1998; Halberda, 2003; Houston-Price et al., 2009; Littschwager & Markman, 1994; Mervis & Bertrand, 1994).

In contrast, when presented with a novel gesture, children reliably selected the familiar object. The fact that children avoided overlap between two words but were receptive to overlap between a word and a gesture suggests that children differentiate their words and gestures into separate lexicons, which contradicts a handful of previous behavioral observations (Acredolo & Goodwyn, 1988; Caselli, 1994; Iverson et al., 1994; Shore et al., 1994; but see Petitto, 1992).

It is interesting that children not only failed to show avoidance of word-gesture overlap but actually *sought* word-gesture overlap. This pattern of mapping a novel gesture onto a familiar object was unexpected. Why would children prefer to map a novel gesture onto a familiar object? One possibility is that this reflects children's observations of how gestures are employed in their communicative experience, as co-occurring with verbal labels. Alternatively, children may have mapped the novel gesture onto the familiar object because children saw the novel gestures as loosely resembling conventional gestures associated with the familiar object. I return to these issues in the general discussion.

Experiment 2

The results of Experiment 1 demonstrated that 18-month-olds maintain distinct lexicons for their word and gestural labels. This was evidenced by children's avoidance of word-word overlap but not word-gesture overlap. The goal of Experiment 2 was to examine avoidance of overlap *within* the gesture domain. Although children appear to violate mutual exclusivity across words and gestures, research by Namy and others (Namy & Waxman, 1998; Namy et al., 2004; Sheehan et al., 2007; Graham & Kilbreth, 2007, Woodward & Hoyne, 1999) has shown that many word-learning phenomena apply to the learning of other non-verbal symbols. These results have been taken as evidence of a general symbolic capacity underlying both word and gesture learning. If a shared symbolic mechanism operates on children's word and gesture lexicons, then children should recruit mutual exclusivity within each domain similarly.

To address this goal, in Experiment 2 children learned either a novel word or a novel gesture as a label for a novel object. In a subsequent test phase, children viewed this newly labeled novel object and a second, unlabeled novel object. In both the word and gesture conditions, the experimenter elicited a choice using a *second* novel label from the same modality as the first. Of interest is whether children interpreted the second novel label as referring to the second unlabeled novel object. Note that the structure of this task is analogous to the one used in Experiment 1 in that once children have established a label for one object, the mutual exclusivity assumption should lead them to infer that the second label referred to the remaining, unlabeled object.

Methods

Participants

Thirty-two 18-month-olds (M = 18.3, range = 17.6 – 20.1) from the greater Atlanta area participated in this study. Nineteen participants were male (Caucasian: 63%, African American:

24%, Asian: 8%, Hispanic: 6%). Data from an additional 15 participants were excluded from analysis due to failure to complete at least eight of twelve trials (8), displaying a side preference (6) or parental interference (1).

Stimuli

Stimuli were similar to that in Experiment 1 with the exception that both objects in each of the three pairs were novel (see Table 5). Objects within a pair were matched for salience through piloting. These pairings were fixed across all participants. Which object was labeled (hereafter, the *labeled object*) during the labeling phase and order of presentation of the target and distractor object were counterbalanced across children. As in Experiment 1, two familiar objects were used for the warm-up phase. Parents completed the same measures described in Experiment 1.

Design

Similar to Experiment 1, Experiment 2 was a 2 x 2 design with Condition (Word vs. Gesture) as a between subjects factor and Trial Type (Target vs. Control) as a within subjects factor. Children were randomly assigned to either the word or gesture condition, which differed only in the type of novel labels employed by the experimenter. Children were tested with three sets of objects. Order of presentation of the object sets was randomly determined for each child. For each set, the experimenter administered two target trials (in which the experimenter asked the child to choose the referent of a second novel label) and two control trials (in which the experimenter requested the child to choose “one”). Children therefore completed a total of twelve trials, including six target and six control trials.

Procedure

As in Experiment 1, parents provided consent and completed a set of questionnaires prior to their child's participation. The experimental procedure consisted of a *warm-up* phase followed by a *labeling phase* and *test phase* that were repeated for each of the three object pairs.

Warm-up Phase. Children participated in a warm-up phase identical to the one in Experiment 1. Note that children in both the word and gesture condition participated in identical warm-up phases. Thus the warm-up phase was truly meant to familiarize children with the forced-choice task *procedure*. Once children were familiar with the forced-choice procedure, the experimenter proceeded to the labeling phase for the first pair of objects.

Labeling Phase. In the labeling phase, the experimenter presented children with a pair of novel objects. For each object within the pair, the experimenter held up and drew attention to the object several times. The manner in which the experimenter referred to the object differed for the labeled and unlabeled objects. When presenting the labeled object, the experimenter introduced a novel label for the object. In the word condition, the experimenter said for example, "Look at this! Blicket! See this? Blicket!" In the gesture condition, the experimenter said for example, "Look at this! [dropping gesture]; See this? [dropping gesture]" Following initial labeling, the experimenter then handed the object to the child. As the child inspected the object, the experimenter labeled the object four more times. Thus, the experimenter named the labeled object a total of six times When presenting the unlabeled object, the experimenter drew the child's attention to the object an equal number of times as the target object but without labeling it (e.g., "Look at this one! Do you see this one?"). Order of presentation of the labeled and unlabeled objects was counterbalanced within each condition.

Test Phase. The test phase immediately followed the labeling phase. The experimenter first removed the objects from the child's reach. The experimenter then administered a series of four forced-choice trials including two target trials and two control trials. In target trials, the experimenter established eye contact with the child and held up the two objects simultaneously, asking the child to select one of the objects by saying “Which one can you get? [LABEL] Can you get it? [LABEL]” The label used in the target trials was a different novel label from the same modality as the one used in the labeling phase. The experimenter then extended the objects within child’s reach, one on either side of the child and equidistant from the midline. Control trials were identical to target trials except that the experimenter did not use a label, saying instead, “Which one can you get? Can you get one?” The counterbalancing of trial order and target object position was identical to the first experiment. Similar to Experiment 1, only mild non-contingent reinforcement was provided (e.g., “Thank you”). After completing the test phase, the experimenter repeated the labeling and test phases with the remaining two sets.

Coding

Similar to Experiment 1, a primary coder blind to trial type analyzed videotapes of all participants with the sound muted. Identical criteria for characterizing choices as well as criteria for inclusion were used across the two experiments. A second coder, blind to the experimental design and trial type, coded a random selection of 25% of the children in each condition. Inter-coder agreement was 99%.

Familiarization Coding. A similar coding of the familiarization phase was also conducted. A coder simply recorded the amount of time the experimenter and child interacted with the labeled and unlabeled object during the labeling phase. Interaction times were similar between the labeled and unlabeled objects across both conditions (Word: $M_{labeled} = 30.22$, $SD_{labeled} = 5.90$; $M_{unlabeled} = 29.52$, $SD_{unlabeled} = 5.61$, $p > .10$; Gesture: $M_{labeled} = 33.55$, $SD_{labeled} = 6.06$, $M_{unlabeled} = 33.36$, $SD_{unlabeled} = 5.03$, $p > .10$).

In addition to coding the familiarization phase, I also coded for experimenter bias in a second way (one which was not possible to do for the first experiment). The goal of this second coding procedure was to examine whether there was any experimenter bias either in the manner in which the experimenter presented the objects in the test phase or in rewarding the child's choices. To do this, I created video-clips of each child that included only the test phase for each set such that coders were blind to which object had been labeled. The coder viewed the entire test phase (with audio) and determined based on the available video footage which of the two objects she believed was the labeled object. If there was any experimenter bias, the coder should be able to guess the labeled object at above chance levels (.50). Two separate coders completed this coding of experimenter bias. Neither coder correctly guessed the labeled object significantly above chance in either condition (p's > . 20). Further the proportion of times the two coders agreed which was the labeled object was also not significantly above chance in either condition, p's > .20.

Results

For each trial type in each condition, I calculated the mean proportion of trials on which children selected the unlabeled object. Adherence to mutual exclusivity, or avoidance of lexical overlap, was operationalized as selecting the unlabeled object on target trials reliably more often than on control trials and reliably more often than predicted by chance (.50).

A Condition (Word vs. Gesture) x Trial Type (Target vs. Control) analysis of variance (ANOVA) of children's proportion selecting the unlabeled object, reveal no main effects of Condition ($p = .658$) or Trial Type ($p = .778$). It did, however, reveal a significant interaction between Condition and Trial Type, $F(1,30) = 18.24$, $p < .001$, $\eta^2_p = .378$. As can be seen in Figure 2, this interaction reflects different patterns of responding on target trials in the two conditions. Children in the word condition appear to be adhering to mutual exclusivity, selecting the unlabeled object more often on target (*M* = .63, *SD* = .06) than control trials (*M* = .46, *SD* = .04), $t(15) = 2.90$, $p < .05$. In contrast, children in the gesture condition appear to preferentially map the second novel label onto the *labeled* object, selecting the unlabeled object *less* often on target (*M* = .44, *SD* = .05) than control trials (*M* = .59, *SD* = .05), $t(15) = -3.21$, $p < .01$.

Comparisons to chance bolster this interpretation. In the word condition, the proportion choosing unlabeled object on target trials was significantly higher than predicted by chance performance, $t(15) = 2.22$, $p < .05$. The proportion on control trials did not differ from chance, $t(15) = 1.07$, $p > .10$. In the gesture condition, the proportion of choosing unlabeled object on target trials did not differ from chance performance, $t(15) = -1.18$, $p >.10$. Proportion selecting unlabeled object on control trials was marginally higher than predicted by chance, $t(15)= 1.80$, $p = .09$.

These comparisons to chance in the gesture condition appear to suggest that any difference in performance between target and control trials may be due to high proportion of selecting the unlabeled object in control trials as opposed to a low proportion of selecting unlabeled object in target trials. Follow-up analysis investigating performance on individual sets reveals that the high proportion on control trials appears to be largely driven by children's performance in the third and final set. The proportion selecting unlabeled object in control trials of this last set (75%) was higher than the proportion in the first two trials (59% and 47%) and higher than chance (50%), $t(15) = 2.47$, $p < .05$. I speculate that this object preference may have to do with fatigue as evidenced by the following observations. First, on average children in the gesture condition completed a lower number of trials in the third set (3.12 out of 4) compared to the first (3.81) and second sets (3.81). This difference was marginally significant, $t(15) = -1.84$, *p*

= .08. Second, the number of children excluded from analysis in the gesture condition (*n* = 9) due to failure to complete a sufficient number of trials or side preference was somewhat higher than in the word condition (*n* = 6). Fatigue in this experiment, particularly in the gesture condition, may have been due to the possibility that children are relatively less familiar with gestures than they are with words combined with the fact that this experiment (in contrast to Experiment 1) included both a labeling phase and a test phase. Importantly, and regardless of the source of the effect in the gesture condition, the results clearly demonstrate a very different pattern of responding in the gesture condition than in the word condition.

Analysis of Individual Response Patterns

Individual patterns analysis confirmed the differing response patterns between conditions. Table 6 reports the number of children who selected the unlabeled object more often on target than control trials, equally often, and less often on target than control trials. Most children in the word condition selected the unlabeled object more often on target than control trials. In contrast, most children in the gesture condition selected the unlabeled object less often on target than control trials. A Chi-Square test of independence revealed that the distributions of individual response patterns of children in the word condition differed from that of the gesture condition, χ^2 (1, N = 24) = 10.97, $p < .01$.

Correlations between Performance and Parental Report Measures

As in Experiment 1, I explored possible correlations between task performance and parental report measures. As can be seen in Table 7, the mutual exclusivity effect (proportion selecting unlabeled object on target trials minus proportion selecting unlabeled object on control trials) in the word condition was significantly positively correlated with children's verbal vocabulary level. In contrast, performance in the gesture condition did not appear to be correlated with children's vocabulary level. Thus consistent with the findings in Experiment 1, the larger a child's verbal vocabulary, the more likely the child avoided verbal lexical overlap. There appears to be no correlation between children's symbolic gesture production and performance in either condition.

Discussion

In Experiment 2, I investigated whether a mutual exclusivity word learning strategy would be applied within the gesture domain. As in Experiment 1, children in the word condition used a mutual exclusivity word learning strategy to infer the meaning of a novel word, mapping a second novel word onto a previously unlabeled object. In contrast to previous research highlighting the remarkable similarities between word and gesture learning (Graham & Kilbreath, 2007; Namy & Waxman, 1998; Sheehan et al., 2007), children in the gesture condition did not apply mutual exclusivity. These children actually demonstrated a comparable pattern of behavior to their counterparts in Experiment 1, mapping a second novel gesture onto a previously labeled object. These findings demonstrate that in at least some ways word and gesture learning are driven by different expectations (see also Namy & Waxman, 2000).

General Discussion

The results of these two experiments clearly indicate that children interpret words and gestures differently within the context of ambiguous reference. When presented with two objects -one familiar (or previously labeled) and one novel (or previously unlabeled)-, 18-month-olds reliably mapped a novel word onto the novel object. In contrast 18-month-olds reliably mapped a novel gesture onto the familiar object.

Children's pattern of novel word mapping is consistent with a mutual exclusivity word learning strategy, which biases children to have only one label for any object (Markman &

Wachtel, 1988; Merriman & Bowman, 1989). Because children already had a label for the familiar object, children mapped the novel word onto the novel object. These results are consistent with previous findings demonstrating that children under the age of two display at least a weak form of this learning strategy (Byers-Heinlein & Werker, 2009; Graham et al., 1998; Halberda, 2003; Littschwager & Markman, 1994; Markman et al., 2003; Mervis & Bertrand, 1994).

In contrast, children's pattern of novel gesture mapping was not consistent with a mutual exclusivity strategy in gestures. Children's systematic mapping of a novel gesture onto a previously labeled object suggests differing inferences about novel words and novel gestures. This finding was surprising for two reasons. First, a large body of observational and experimental research reviewed above has demonstrated many commonalities between word and gesture learning in early lexical acquisition, suggesting that a general symbolic capacity underlies both word and gesture learning (Acredolo & Goodwyn, 1988; Graham & Kilbreath, 2007; Namy, 2001; Namy & Waxman, 1998; Sheehan et al., 2007). Based on these findings, I predicted that children would show similar mapping patterns between words and gestures in a disambiguation task. Second, recent work has demonstrated that older children display mutual exclusivity outside of word learning, mapping novel facts (Diesendruck & Markson, 2001) and animal sounds (Brojde & Colunga, 2006) to objects for which previous information of the same nature had not been supplied, suggesting that general learning principles may underlie mutual exclusivity. These findings, led me to hypothesize that a mutual exclusivity strategy would govern both word and gesture mapping.

In what follows, I discuss the implications of the current findings for: (a) the organization of a child's developing lexicon, (b) the specialization of the mechanisms underlying children's early word learning, and (c) the development of a mutual exclusivity word learning strategy.

Early Differentiation between Words and Gestures in the Child's Lexicon

The current data do not support claims that "gestures and words form a single lexicon" (Clark, 2003, p. 96), or that "there is one lexicon constructed partially from gestures and partially from words" (Caselli, 1994, p. 65). If gestures and words did form a single lexicon, children should have avoided lexical overlap regardless of symbolic form. The fact that children avoided word-word overlap but not word-gesture overlap implies that, by at least 18 months of age, children separate their words and gestures into separate lexicons. The differences observed may reflect the fact that by 18 months, children have come to realize words are subject to principles of usage that do not apply to gestures or other symbols more generally.

Several researchers have argued that the verbal and gesture input children encounter should lead infants to regard words and gestures as sharing the same communicative, symbolic function. Namy (Namy et al., 2000; Namy & Nolan, 2004; Namy, Vallas & Knight-Schwartz, 2008) and Iverson and colleagues (1999) report that words and gestures are produced during the same socially rich joint attention episodes between parent and child. The similar social-referential context in which words and gestures are produced may provide a basis for the equipotentiality of words and gestures in the mind of the child (Namy et al., 2000). A number of observational reports on children's word and gesture production support this notion (Acredolo & Goowdyn, 1985; 1988; Casseli, 1994; Iverson et al., 1994; Shore et al., 1994). For example Acredolo and Goodwyn (1985; 1988) observed that children tended to symbolize an object with either a sign or a word, not both, suggesting that words and gestures serve complementary functions in the lexicon. Further, once children acquired verbal labels for objects for which they previously signed, they dropped those signs from their communicative repertoire, providing further evidence that words and gestures are mutually exclusive in the lexicon.

Although there is reason to expect infants to regard words and gestures as equipotential forms of symbolic reference based on the input they encounter, eighteen-month-olds' experience in the language domain is nonetheless both quantitatively and qualitatively different from other symbolic domains. According to some measures, parents direct 300 to 400 words each hour to their children (Hart & Risley, 1995), a rate that outstrips their exposure to non-verbal symbols (Iverson et al., 1999; Namy et al., 2000; Namy & Nolan, 2004; Namy et al., 2008). Further, children are exposed to words but not gestures embedded in a rich linguistic structure consisting of phonologic, morphologic and syntactic regularities. Children's growing sensitivity to these regularities central to words may separate word representations from simple symbol-referent links (Clark, 1993), whereas hearing children's gestural labels may never be elaborated upon beyond simple symbol-referent associations.

At least two methodological issues may be at the center of the discrepancy between the current experimental evidence and past observational reports. First, most of the observational reports were of younger infants, typically just around their first birthday (12 to 16 months of age). Participants here were on average a few months older (18 months of age). Perhaps in the very earliest stages of lexical acquisition, children's words and gestures are stored together with minimal overlap, and only later in development does the lexicon split into a verbal lexicon and a gestural lexicon. This development from one undifferentiated lexicon into multiple lexicons is consistent with some observations of lexical development in children acquiring multiple spoken languages (Volterra & Taeschner, 1978; but see Pearson, Fernandez & Oller, 1995; Quay, 1995) and in children acquiring one spoken and one signed language (Prinz & Prinz, 1981). This developmental account is also consistent with other findings suggesting that this particular age (18 months) may be an important transitional period where word learning may begin to diverge from general symbolic processing (Iverson et al., 1994; Namy & Waxman, 2000). Future research should directly address differences in lexicon structure over development. However, given the fact that this paradigm has not been successfully employed in children younger than 17 months, this future research would necessitate a more indirect measure of mapping (e.g., eye-tracking, Halberda, 2003).

A second methodological difference between the current experimental findings and past observations concerns how word and gesture knowledge was measured. The experimental paradigm used here tapped children's verbal and gestural comprehension. In contrast, observational studies typically report children's verbal and gestural production. It may be that children comprehend both a gesture and word for a given object (a sign of a differentiated lexicon), but fail to reveal it in spontaneous production within the context of naturalistic child-caregiver interactions. A child may limit production in these familiar interactions to symbols previously established as communicative conventions between the child and her caregiver, leading to the appearance of mutual exclusivity across modalities.

The Specialized Nature of Children's Early Word Learning

As mentioned throughout this paper, early word learning and gesture learning show remarkable similarities in patterns of mapping, extension and inductive inference, highlighting the domain-general nature of the processes underlying early word learning (Graham & Kilbreath, 2007; Namy, 2001; Namy & Waxman, 1998). Here however, I find a pattern of behavior that occurs in word learning but not in gesture learning, suggesting that in at least some ways word learning deviates from gesture learning.

Namy and Waxman (2000) reported an additional way in which word learning diverges from general symbol learning. In their study, Namy and Waxman introduced an important manipulation to their standard word- and gesture-learning task (Namy & Waxman, 1998). They taught 17-month-olds words and symbolic gestures in either a typical naming phrase (e.g., "Look at this [symbol]! "Can you find another [symbol]!") or stripped of any sentential context (e.g., "Look! [symbol]"; "What else can you find? [symbol]!" Namy and Waxman found that 17-month-olds learned gestures regardless of the naming context. In contrast, 17-month-olds learned words only when presented within the typical naming phrase. These results demonstrate that although children are equally willing to learn words and gestures as object labels, experience in the word-domain narrowed the range of contexts in which children expected words to label objects (Namy & Waxman, 2000). Why do some word learning phenomena (i.e., mapping, extension, inductive inference) apply to gesture learning while others (i.e., mutual exclusivity, sensitivity to sentential context) do not?

There appear to be at least two characteristics that can distinguish between phenomena that are shared between word learning and gesture learning and phenomena that are not. The first is the point in development at which these behaviors emerge. The second is the extent to which these behaviors tap processes outside of learning symbol-to-referent mappings.

Age of Acquisition as a Predictor of Shared versus Distinct Phenomena

If one closely examines the emergence of apparently domain-general (mapping, extension, and inductive inference) and apparently domain-specific (mutual exclusivity, syntactic context) phenomena within the *word* domain, it appears that domain-general behaviors are those that emerge at an earlier age. For example, researchers have shown using a range of experimental methods that children between 12 and 15 months of age reliably map words onto objects (Hollich et al., 2000; Werker et al., 1998; Woodward et al., 1994; Schafer & Plunkett, 1998). Others have documented that by 14 months, children extend object labels to other exemplars belonging to the same object category (Booth & Waxman, 2009; Waxman & Booth, 2001). Finally, Graham and colleagues have found that 13-month-olds rely on shared labels to make inductive inferences about how to generalize objects' functions (Graham, Kilbreath, & Welder, 2004). All these behaviors appear prior to 16 months of age. These early-onset behaviors are precisely those that transfer to non-verbal symbols, including symbolic gestures (Campbell & Namy, 2003; Graham et al., 2007; Hollich et al., 2000; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

In contrast, word learning phenomena such as mutual exclusivity which fail to extend to symbolic gestures appear slightly later in development. Littschwager and Markman (1994) demonstrated mutual exclusivity-like behaviors in 16-month-olds and Halberda demonstrated that 17- but not 14 or 16-month-olds succeed at a preferential-looking version of the disambiguation task. These are the only findings demonstrating mutual exclusivity prior to 1.5 years.

One could view age of acquisition as diagnostic of the amount of experience in a domain required for a certain behavior to emerge. Under this view, all symbol-learning processes are domain-general in the sense that any behavior has the potential to emerge in any domain given sufficient and appropriate experience. This may imply that similar behaviors for word and gesture learning are actually due to separate learning mechanisms developing in parallel (Pettito, 1992). On this account, differences in learning between the two modalities become apparent only later in development as knowledge becomes more elaborated in one domain but not the other. By 17 to 18 months, children's experience in the word domain is sufficient for all the behaviors mentioned above. In contrast, children's experience in the gestural domain may be sufficient to give rise to mapping, extension and inductive inference but insufficient to yield mutual exclusivity.

The notion that domain-specific experience may be the impetus by which word learning differs from more general symbol-learning processes receives support from previous research. For example, in both the current and past research (Graham et al., 1998; Lederberg, Prezbindowski & Spencer, 2000; Mervis & Bertrand, 1994), verbal mutual exclusivity is positively correlated with verbal vocabulary. Further, a number of word learning models have demonstrated that basic domain-general learning processes such as associative learning, attention, memory and competition may give rise to domain-specific behavior such as mutual exclusivity (Frank et al., 2009; Merriman, 1999; Regier, 2003; 2005).

Type of Behavior as a Predictor of Shared versus Distinct Phenomena

In addition to age of onset, another important characteristic that may distinguish between behaviors shared by words and gestures and those that are unique to word learning is the extent to which these behaviors engage additional cognitive processing outside of symbol mapping. Label generalization and label-based inferences are two behaviors that children readily show in both the word and gesture domains. The processes underlying these behaviors have as much to do with object categorization as they do with object label learning. That is, to spontaneously extend an object label to other members of that object's category relies not only on a sensitivity to which objects receive the same labels but a sensitivity to which objects belong in the same category. Although categorization is clearly intertwined with learning category labels, they are not synonymous.

In contrast, behaviors that appear specific to word learning, such as mutual exclusivity and sensitivity to linguistic context, are primarily based on experience with symbol mapping such as noticing the regularity that one label typically goes with one object category (Colunga & Smith, 2002); or the regularity with which labels tend to occur in certain sentential and pragmatic contexts (Fernald & Hurtado, 2006; Namy & Waxman, 2000).

Whether amount of domain-specific experience is the sole determining factor that distinguishes domain-specific behavior from domain-general behavior or whether other factors play a role remains an open question. The results of this study together with those of Namy and Waxman (2000) highlight that although many behaviors are shared between word and gesture learning, some are not. Others have similarly found that some behaviors are exhibited across word and fact learning, while others are not (Markson & Bloom, 1997; Waxman & Booth, 2000; Behrend, Scofield & Kleinknecht, 2001).

Children's Mapping of Gestures onto Familiar Objects: Implications for the Development of Mutual Exclusivity

Finally, I now turn to the least expected finding across the two experiments which is that children preferentially mapped novel gestures onto *familiar* objects. Although unanticipated, this pattern of mapping a novel symbol to a familiar object is not without precedence in the mutual exclusivity literature. In one preferential looking study, Halberda presented 14- to 17-month-olds with a picture of a familiar object (a car) and a picture of a novel object (a phototube). Infants then heard sentences such as, "Wow, Look at the dax!" Halberda recorded infants looking patterns following this sentence. Consistent with mutual exclusivity, 17-month-olds looked longer at the novel object compared to the familiar one. In contrast, 14-month-olds looked longer at the familiar object (Halberda, 2003).

In a second study, Scofield and Behrend (2007) compared the disambiguation of novel words and novel facts. They found that four-year-olds mapped both novel words and novel facts onto novel objects, consistent with mutual exclusivity in both words and facts. In contrast, two-year-olds mapped novel words onto novel objects but mapped novel facts onto *familiar* objects (Scofield & Behrend, 2007). A comparison of these two studies with the current findings where 18-month-olds mapped novel gestures onto familiar objects, suggests that across learning domains (words, facts, gestures) more experienced learners display a mutual exclusivity expectation while less experienced learners display preference for mapping information to the familiar object. Why would novice learners map a novel word, fact or gesture onto a familiar object? There are at least two possible accounts of this pattern.

Gesture Conventions Hypothesis

One possible explanation for children's mapping of gestures to familiar objects in this disambiguation paradigm is that children's mapping somehow reflects their sensitivity to how gestures are used in communication. As in adult communication (Goldin-Meadow, 2009), child-directed communication includes co-speech gestures (Iverson et al., 1999; Namy & Nolan, 2004). For example in an examination of gesturing in mother-child interactions, Iverson and colleagues (1999) found that gestures that co-occurred with speech were almost twenty times more likely than gestures that occurred alone. Further, the function of mother's gestures was more often to reinforce information in speech rather than to disambiguate or add additional information (Iverson et al., 1999). Although Iverson and colleagues' primarily focused on deictic gestures (such as pointing), Namy and colleagues (Namy et al., 2000; Namy & Nolan, 2004;

Namy et al., 2008) have similarly found that parents' symbolic gesturing also tends to co-occur with speech.

Further evidence of gesture's complementary role to speech has come from studies of children's gestural productions. Previous researchers have found that children produce co-speech gestures that reinforce verbal information (Iverson & Goldin-Meadow, 2005; Morford & Goldin-Meadow, 1992) and will revert to gestures when verbal communication fails (Golinkoff, 1983; Pettito, 1992). Given these findings, perhaps children are sensitive (either through explicit knowledge of gestural conventions or implicit association) to the role gestures play in communication. That is, gestures rarely stand alone and typically complement speech. Children may then interpret gestures produced in the absence of speech as an elaboration upon something they already know (i.e., the familiar object).

Although this argument is consistent with the findings of Experiment 1 in which children were familiar with the verbal label for the familiar but not the novel object, this account cannot explain children's performance in Experiment 2 in which both objects were novel and children did not have a verbal label for either object. In this context, there would be no apparent reason for them to privilege the object previously labeled by another gesture as the recipient of a second gestural label. A second explanation for children's gesture mapping patterns may account for the findings across both experiments.

Weak Representation Hypothesis

In the context of Experiment 2, children's mapping of a second novel gesture onto an object for which they already have an initial gesture label may be due to children's weak representation of the form of the initial gestural label. During labeling, children may have noticed the reliable co-occurrence between the initial gesture and its referent. However they may have failed to encode the gestural form precisely, perhaps due to lack of experience in gesture learning or limited information processing capacity in the context of a great deal of new information (i.e., about both the toys and the gesture). When the experimenter requested an object using a second novel gesture, children may have failed to recognize the second gesture as distinct from the initial gesture and thus interpreted the experimenter's request as referring to the initially labeled object.

This explanation would not necessarily imply that children aren't capable of discriminating perceptually between two manual gestures. I endeavored to generate gesture pairs in which the two gestural forms were quite distinct by pairing gestures that differed on three dimensions: the shape of hand (open vs. closed fist), the direction of motion (left-right vs. up-down), and hand orientation (facing down vs. sideways). However, hearing children may find it taxing to not only encode the differences in gestural form but also maintain specificity in the relation between gestural form and meaning. Even in the domain of word learning, research has shown that although young infants show sensitivity to minimal-pair phonemic differences in word forms (e.g., "bih" vs. "dih"), they fail to track this difference when required to differentiate which of the two forms refers to an object (Curtin, Fennell, & Escudero, 2009; Stager & Werker, 1997; Werker, Fennell, Corcoran, & Stager, 2002).

How might poor gestural form encoding explain the findings of Experiment 1 where children mapped the novel gesture onto the familiar object? None of the parents reported that their children had a gestural label for these objects. Thus, children apparently did not have any prior gestural labels with which they would confuse the novel gesture. Although children may not have known symbolic gestures for these familiar objects, children were familiar with these objects and were aware of the typical manual actions performed on these objects. When children engaged with the familiar objects during the familiarization phase, they often performed typical behaviors associated with these objects (e.g., banging the table with the hammer). Prior research has shown that such behavior is predictive of children's use of symbolic gestures (Acredolo & Goodwyn, 1988; Namy et al., 2008; Pettito, 1992) and is consistent with the notion that children derive their symbolic gestures from play routines they observe (Lock, 1978; Werner & Kaplan, 1963). Perhaps children here were associating the novel gestures with familiar actions performed on the familiar objects.

In future work, it will be important to distinguish between the *gesture conventions hypothesis* and the *weak representation hypothesis* as explanations for children's mapping of novel gestures to familiar objects. There are at least two studies that might arbitrate between the two hypotheses. First, in a variant of Experiment 2, children might first be taught a novel word for a novel object and then tested in a disambiguation task with a novel gesture. According to the *gesture conventions hypothesis,* children should select the just-labeled object as the referent of the gesture because there is verbal information associated with that object. However, the *weak representation hypothesis* would predict no preference in novel gesture mapping, because they would be unlikely to confuse the second symbolic form with the first, given that they were drawn from distinct (auditory v. visual) modalities. A second means of testing these two accounts would be a more direct analysis of the effects of similarity between the novel gestures and conventional gestures children may have for the familiar object (e.g., 'scooping gesture' for spoon). According to the *weak representation hypothesis*, the closer the resemblance between novel gestures and conventional gestures, the more likely children would be to confuse the novel gesture with the conventional one, leading them to select the familiar object. In contrast, according to the *gesture conventions hypothesis*, children should map novel gestures onto familiar objects regardless of similarity between the novel and conventional (previously learned) gesture.

Implications for the Development of Mutual Exclusivity

When considered in combination with the research reviewed in this discussion, the current data support the notion that mutual exclusivity appears to be governed by domain general learning processes. This is an odd claim to make from data that demonstrate mutual exclusivity in word learning but not gesture learning. However I argue that the different mutual exclusivity expectations for words and gestures can be traced back to the differing levels of experience in the two domains. A number of findings mentioned throughout this discussion support this notion. First, the current results as well as previous findings demonstrate that the strength of verbal mutual exclusivity is positively correlated with verbal vocabulary size (Graham et al., 1998; Lederberg et al., 2000; Mervis & Bertrand, 1994). Second, studies of novice learners in the domain of words (Halberda, 2003) and facts (Scofield & Behrend, 2007) demonstrate the same familiar-object mapping preference found here in gestures. If this pattern of mapping is simply a phenomenon common to novice learners across domains, then children with larger gestural vocabularies should not show this pattern and instead demonstrate gestural mutual exclusivity. Finally, attention-based (Regier, 2005), competition-based (Merriman, 1999) and inference-based (Frank et al., 2009) models of early word learning have demonstrated that mutual exclusivity behavior emerges without being specifically built in as a constraint in the model. Some models further demonstrate that greater vocabulary sizes and more precise word-form representations led to higher likelihood of demonstrating mutual exclusivity (Merriman, 1999; Regier, 2005).

Conclusion

Early in development, children are equally receptive to words and symbolic gestures as object labels, suggesting a common symbolic capacity underlying word and gesture learning. In this thesis, I examined the extent to which 18-month-olds store words and gestures in a single shared lexicon subject to the same learning principles. Employing a disambiguation task, I found that novel words and novel gestures elicited different mapping patterns. These results suggest that 18-month-olds maintain distinct verbal and gestural lexicons, subject to different expectations regarding mapping. The results highlight that although a number of commonalities exist between the mechanism underlying word and gesture learning at 18 months of age, word learning appears to be diverging from more general symbolic processing at this point in development. Finally, the unexpected finding that children reliably mapped novel gestures onto familiar objects is consistent with behavior shown in novice word and novice fact learners. The commonalities across domains illustrate the domain-general origins of mutual exclusivity as well as the importance of experience in the development of a mutual exclusivity word learning strategy.

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Appendix

Word and Gesture Checklist

I. Words

We are interested in children's processing of familiar and unfamiliar words and objects in the early stages of language acquisition. In today's session, we will present objects for which your child may or may not have names. To be able to distinguish between familiar and unfamiliar objects, we will ask you to rate the objects below.
Please go through the list below and check under:

"1" if you are certain s/he does **NOT** have a word for the object (*either understanding or saying*)
"2" if you are fairly sure s/he does **NOT** have a word for the object (*either understanding or saying*)
"3" if you are fairly sure s/he **DOES** have a word for the object (*either understanding or saying*)
"4" if you are certain s/he **DOES** have a word for the object (*either understanding or saying*)
"DK" if you **DO NOT KNOW** whether s/he has a word for the object

A child probably has a word for an object if s/he reacts to or says it in more that one specific situation. For example, if a child points to or says "cat" in the presence of only one cat, that is less strong evidence for knowing the meaning of a word that if s/he reacts to several different cats in the same way.

If your child uses a different word from the one we have on the list (for example, "nana" instead of "grandma" or "buggy" instead of "stroller") or a different pronunciation of a word (for example, "raffe" instead of "giraffe"), check the word but write your child's version in the space provided. Also, please note if your child knows the conventional word in addition to his/her version.

Please feel free to consult the pictures of the following objects on the accompanying page.

Word	**1**	**2**	**3**	**4**	**DK**	**Other Form**
Hat						
Dog						
Car						
Keys						
Cup						
Shoe						
Spoon						
Hammer						
Rabbit/Bunny						

Garlic Press						
Strainer						
Whisk						
Popsicle Holder						
Juicer						
Aspirator						
Level						
Maracas						
Paint Roller						
Basting Brush						

II. Gestures

In our studies, we are also interested in any gesture symbols (sometimes called "Baby Signs") your child uses or understands. We will ask you to answer some of the following questions regarding your child's gesture use (Please circle answer where necessary).

1. Is your child exposed to Baby Signs? YES NO

If Yes, Please give some examples of ones your child produces and/or understands:
How many signs do you think your child understands/produces? ___________________

2. When first learning to communicate, some infants produce gestures to refer to objects. Examples include *sniffing* to refer to flowers OR *throwing motion* to refer to balls. For more examples of these gestures, please see the attached "Gesture Example List".

   Have you seen your child produce such gestures to refer to objects? YES NO

If YES, please give some examples: Note: a. We are primarily interested in your child's gestures for objects. b. Please note the situation in which these gestures occur. For example, if your child gestures "dog" only for certain dogs or only in certain situations
How many gestures do you think your child produce? ___________________________

3. If your child produces signs or gestures, does he/she have signs or gestures for any of the above words? Please check and describe in the column below. For examples of Gestures for some of these objects, see attached Gesture List.

	Yes/No	Description		Yes/No	Description
Hat			Garlic Press		
Dog			Strainer		
Car			Whisk		
Keys			Popsicle Holder		
Cup			Juicer		
Rabbit/ Bunny			Aspirator		
	Yes/No	Description		Yes/No	Description

Spoon			Maracas		
Hammer			Paint Roller		
Shoe			Basting Brush		
			Level		

4. If you would like to include any additional related information you think is relevant to what is addressed by the questions above, please include in the space below.

THANK YOU!!!!

Table 1

Objects Employed in Experiment 1

Novel Objects	Familiar Objects
Juicer	Hammer
Whisk	Cup
Garlic Press	Spoon
Roller	Keys

Table 2

Novel Words and Novel Gestures used in Experiment 1 and 2

Novel word	Novel gesture
Blicket	Repeated simultaneous extension of index and middle finger from a closed fist
Daxen	Side-to-side motion, hand extended as if to shake hands
Seebow	Dropping motion with closed fist opening, palm down
Toma*	Closed fist, thumb and pinky finger extended, facing down, rocking side-to-side*
Riffle*	Hand oriented verticaly, up-and-down knocking motion facing child*
Foppick*	Slicing motion with hand extended towards child at a 45 degree angle *

* Additional words and gestures employed in Experiment 2

Table 3

Experiment 1: Distribution of Individual Patterns of Responses in Each Condition

Proportion Selecting Novel Object	Condition	
	Word	Gesture
Target Trials > Control Trials	11	2
Target Trials < Control Trials	4	10

Table 4

Experiment 1: Pearson Correlation Coefficients between Task Performance and Parental Report Measures in Each Condition

Parental Report Measure	Condition	
	Word	Gesture
Verbal Vocabulary	.575*	.264
Familiarity with known label	.538*	-.427^
Symbolic Gesture Vocabulary	.251	-.707**

*Note: * Significant at $p < .05$, ** Significant at $p < .01$, ^ Marginally Significant at $p = .09$*

Table 5

Novel Object Pairs used in Experiment 2

Novel Object Pairs	
Juicer	Aspirator
Whisk	Garlic Press
Roller	Juicer

Table 6

Experiment 2: Distribution of Individual Patterns of Responses in Each Condition

Proportion Selecting Novel Object	Condition	
	Word	Gesture
Target Trials > Control Trials	11	1
Target Trials < Control Trials	3	9

Table 7

Experiment 2: Pearson Correlation Coefficients between Task Performance and Parental Report Measures in Each Condition

Parental Report Measure	Condition	
	Word	Gesture
Verbal Vocabulary	.598*	-.218
Symbolic Gesture Vocabulary	.233	-.345

*Note: * Significant at* $p < .05$

Figure Captions

Figure 1. Experiment 1: Mean proportion selecting novel object on target and control trials in each condition

Figure 2. Experiment 2: Mean proportion selecting unlabeled object on target and control trials in each condition

Figure 1

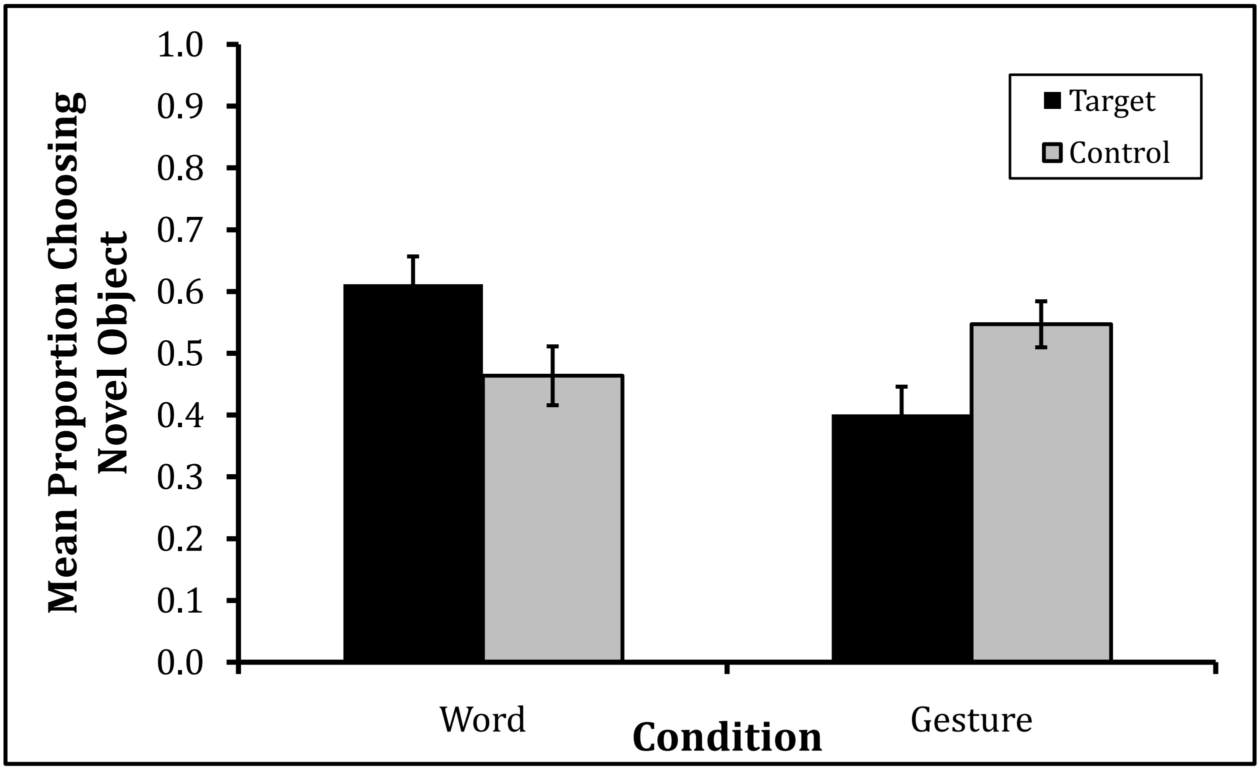
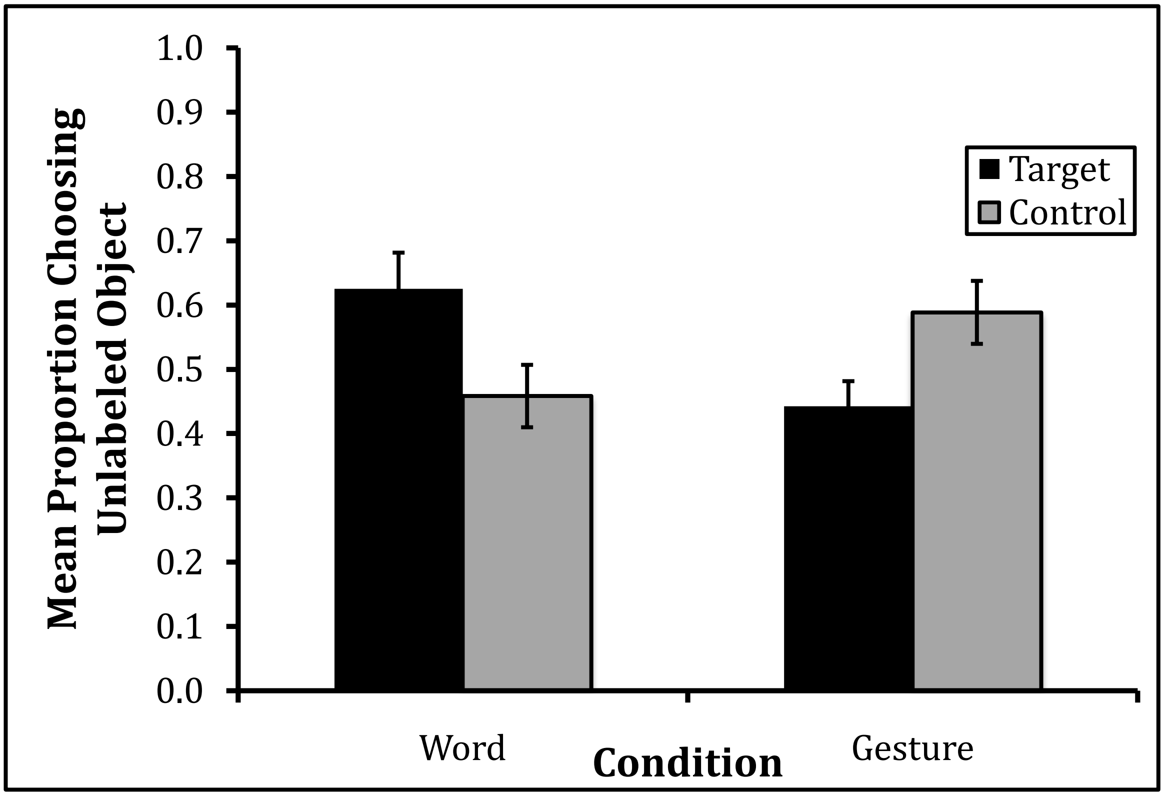

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Mean Proportion Choosing Novel Object
Target
Control
Word
Gesture
Condition

Figure 2


Mean Proportion Choosing Unlabeled Object
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Target
Control
Word
Gesture
Condition