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Tracking Linguistic and Attentional Influences on Preferential Looking in Infancy

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Tracking Linguistic and Attentional Influences on Preferential Looking in Infancy

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Dedication

This Dissertation is dedicated to my wife Clarissa, whose patience, support, and encouragement has been a blessing, and to my child, who will (with a little help from God) soon experience first-hand the learning described herein.

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Tracking Linguistic and Attentional Influences on Preferential Looking in Infancy

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One unresolved issue in early word learning research is the relationship between word learning, categorization, and attention. Two distinct cognitive processes, attentional preferences related to categorical processing and inter-modal matching are involved in this relationship. Keeping the effects of these processes separate and controlled can be a difficult task. Not doing so can potentially confound the interpretation of research in this area. In a series of four preferential looking studies, the effects of referential assignment and novelty seeking in infancy were teased apart. In Study 1, 13-month-olds preferred to look toward a monitor on which the stimuli changed category on every trial, and away from a monitor on which the stimuli were drawn from a single category. This preference developed in conditions in which infants listened to labels, non-language sound, or participated in silence. In Study 2, 18-month-olds developed the same preference when listening to non-language sounds or when participating in silence, but developed no preference when listening to labels. Results of studies 3 and 4 suggest that the lack of

preference by 18-month-olds in the label condition result from competing behaviors of novelty seeking and referential assignment.

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Chapter 1: Introduction

What does it mean to refer to something? Intuitively, we might feel that there is something symbolic involved, something representational, maybe something communicative. Anything further than a cursory contemplation of the act, though, reveals just how complex a behavior it is. Indeed, philosophers have been trying to get a handle on reference for ages, and psychologists have more recently added their own empirical explorations.

DEFINITION OF 'REFERENCE' (SCOPE OF THE PROBLEM)

To define reference is no small matter, and has been a topic of great consternation for philosophers across many cultures for centuries. As Deacon (1997) recently quipped, "More philosophic ink has been spilt over attempts to explain the basis for symbolic reference than over any other problem" (p. 43). Indeed, discussions on reference have spurned great argument over such exotic sounding topics as Descriptivism (Frege, 1892; Russell, 1917), Semantic Externalism (Burge, 1979; Kripke, 1980), and Zoosemiotics (Sebeok, 1973). Despite all the spilled ink, however, the central question of reference, How do words refer? is still an open question. The goal of this dissertation is to add to the debate on reference an empirical investigation of early factors in the development of the use of symbols for reference. This focus will bring its own set of issues, including the determination of what may or may not be a symbol, how unique symbolic relationships may be to humans, how to describe the mechanism by which symbols refer, and how and when the ability to use symbols develops. Specifically, I'll focus on the development of language as symbolic reference. As such, we will need some notion of reference and some definition for symbol use. Thankfully, though, there has been a general direction in the flow of that ink spill described by Deacon, reflected in J.S. Mill's description of

proper names, "a proper name is but an unmeaning mark which we connect in our minds with the idea of the object, in order that whenever the mark meets our eyes or occurs to our thoughts, we may think of that individual object" (Mill, 1872, p. 22). This central idea, that reference requires placement of attention onto the referent, is still quite useful, and was a pivotal idea in a recent discussion by researchers describing constraints in their own empirical method. In testing the ability of 14-month-olds to associate labels with objects, Werker, Cohen, Lloyd, Casasola, and Stager (1998) emphasized Mill's point (perhaps more readably than he did) that their experimental design was for testing for association, in which a label might "go with" an object, rather than reference, in which a label would "stand for" the object. Despite several recent attempts to explicate "stands for," however, this central notion remains relatively undefined and relatively philosophical. For an empirical investigation of symbolic reference, a more highly specified, behavioral definition of symbolic reference would be very useful.

Developmental Aspects of the Behavior of Symbolic Reference

There are three component behaviors that we can examine in infants' developing use of reference: identification of the components (symbol and referent), identification of an association between the components, and a redirection of attention from the symbol to the referent. First, in order to understand that some symbol refers to a referent, one must be able to identify both the symbol and the referent, that is, to partition the component parts as figures in the surrounding ground. In the case of language as the symbolic medium, this means identification of units of speech and of categories of objects and qualities of objects. Scientists have determined that infants' ability to segment words from a stream of speech grows increasingly more sophisticated during the first year of life, making better use of more and more complex sensory information (Echols, Crowhurst, & Childers, 1997; Jusczyk, Houston, & Newsome, 1999; Jusczyk, Luce, &

Charles-Luce, 1994). Likewise, scientists have determined that very early in life, infants can build the types of categories that might be represented by noun labels. This includes a developmental progression from a relatively simple level of complexity among line drawings of animals at 7 months to more complex categories of line drawings and real objects at 10 months (Younger & Cohen, 1986; Cohen & Caputo, 1978; Younger & Cohen, 1983). According to one philosophical position, argued by Saussure (1916), identification of the symbol-form and referent is all that needs to be described in order to understand what a symbol is. Saussure argued that a symbol consists of two parts, the form of the sign and the referent with which the sign is associated. Saussure's two-part definition of the symbol has several issues that leave the definition lacking, though. Saussure argues that the parts of a linguistic sign are the sound image and a concept. Saussure's view of symbol might also be agreed to by Mill, whose view of reference situated the meaning of a label in the actual object to which the label refers. This type of solution, however, leaves the psychologist in a phenomenological pickle, lacking a theoretical mechanism for explaining how information external to the mind is manipulated by the mind. In terms of language as symbol, this would leave us with no room for discussion of how a set of acoustic waves generated by another person can play a role within a mind. It then becomes quite awkward to try to define the role of stimulus in an empirical investigation.

Furthermore, Saussure's conception is insufficient for explaining some of the more interesting recent findings. For instance, development of the ability to identify components is not a simple, increasing linear function. Illustrating a dynamic interaction among systems of identification and association, as children begin to develop functional use with these components, their ability to identify symbol or referent may be hindered

(Stager & Werker, 1997). The very act of trying to use identified referential components seems to make it harder to identify the individual components.

For these reasons, a second philosophical position, argued by Pierce (1955) better suits our needs. Pierce argued that sign and reference are external to the mind, and that a go between, which he termed the "interpretant" associates the two. The contribution of psychological investigation will be an examination of the mechanism by which the two components are related. Building this relationship, the simple association between symbol and referent, is the second component of referential behavior. Psychology has already contributed quite a bit to the discussion of the mechanism of association itself. This tradition dates back to Hume (2001), was explored well by the behaviorists, and is still actively explored today. Recently, many are investigating the use of the mechanism of association in the development of reference.

Finally, reference involves a redirection of attention. When one perceives a symbol, one's attention is directed toward the referent for that symbol (or some mental representation of the referent). This may be a criterial feature of symbolic reference that lies behind intuitive argument by Werker et al. (1998) that symbols "stand for" something else, whereas an association "goes with" something else. A symbol acts as a placeholder in a system in which the bulk of cognitive processing is performed on the referent. Not so for association, in which cognitive processing is performed on either associated component equally. It is possible, then, that his third behavioral aspect of reference can be used as a behavioral marker for symbol use that is qualitatively different than association.

This behavioral description will serve a purpose. If we are able to track the focus of attention, then we will be able to measure the use of reference. To the extent that we can say that the onset of a symbol redirects attention to a referent, we can measure the use

of symbolic reference. Thus, in addition to the behavioral description of reference above, a discussion of the mechanism of symbol use is also in order.

Note on the order of development for the three behaviors

These three behaviors do exist in a hierarchy of dependency. The third depends on the ability to perform the second, and the second depends upon the ability to perform the first. As such, one might be tempted to conclude that they necessarily develop in order from first to third. This, though, is not necessarily the case. The ability to distinguish and define a referent category, for instance, may develop in conjunction with learning which symbols are associated with the category. Indeed, there is evidence from adult learning studies that categories are learned better with explicit references (Lupyan, 2006). Developmental scientists, also, have begun to examine the extent to which learning a category is influenced by learning labels that are associated with them (Balaban & Waxman, 1997; Echols & Marti, 2004; Fulkerson & Haaf, 2003; Nazzi & Gopnik, 2001; Roberts & Jacob, 1991; Waxman, 2003).

The Mechanism of Symbol Use

Traditionally, philosophers have defined symbolic reference by degrees of how arbitrary is the relationship between symbol and referent. These degrees are similar to the forms of association discussed by Hume (2007), who outlined three methods by which objects or ideas might be associated. Two things might become associated by virtue of: resemblance (they might look alike), contiguity (they might occur together), and causality (they might have an abstract, reason based relationship of cause and effect).

Reflecting these methods, and expressing a common thread of thought in Semiotics, the study of symbols and symbol systems, Pierce (1955) outlined a three-tiered system of reference. Pierce defined reference in terms of iconic, indexical, and

symbolic terms. Iconic reference involves a referent concept that is activated by virtue of similarity to the symbol-form. A picture of a leaf, for instance, is a reference to a real leaf. Indexical reference involves a relationship that is built from repeated contiguous presentations of what are the referents of two objects. After repeated pairing, presentation of one (the symbol, or primary concept), will trigger activation of the other (the referent, or secondary concept). A picture of a golden leaf, for example, can act as a reference for autumn because leaves of that color occur during the season of autumn. Symbolic reference involves a relationship determined by social convention. A maple leaf can be a reference for Canada simply because Canadians say that it might be.

Deacon (1997) defines a structure that may underlie the three-tiered definition of reference, and might provide a developmental theory and a criterial definition for "symbol" that sets it apart from association. His definition of reference is very wide and encompasses not only word usage, but also animal calls and symptoms (smoke can be a reference to fire). He builds from Pierce's three-tiered structure for the meaning of signs a "hierarchy of reference" with developmental implications. Iconic reference, according to Deacon, is similar to stimulus generalization. It is the activation of a memory of a stimulus or a concept by way of a different stimulus due to an inability to notice a difference between the activating stimulus and the activated concept. The iconicity of a stimulus is directly related to the physical similarity between the stimulus and the activated concept. Indexical reference, according to Deacon, is built on top of iconic reference. It is a reference formed by association, in the sense of Hume. In order for someone to learn a referential relationship by way of association, according to Deacon, they must be able to grasp the iconic relationship that exists between all exemplars of a given category. For example, in order to transfer the information gained from some event such as a cat chasing a dog to a second cat chasing a second dog, the child must have an

iconic relationship between the first and second cats, and the first and second dogs. In the same way, symbolic reference, a relationship defined by convention, is built on top of indexical reference. Children must recognize repeated concurrences between words and objects, for example, before they can understand that a word stands for an object. Developmentally speaking, this suggests that children must either a) spend some span of time using iconic and indexical reference without the capability of symbolic reference, or b) enter the world with the capability of all three forms of reference. In this developmental hierarchy, Deacon provides a very specific mechanism by which a child might transition from the simple iconic and indexical forms of reference to the more advanced symbolic.

In addition, Deacon hypothesizes two critical distinctions between what are associative and what are symbolic relationships. He argues that symbolic relationships are stronger than are associative, able to survive extended periods without exposure in situations in which associative relationships might extinguish. He also argues for a systematicity among symbolic relationships, such that learning new symbols will have an effect on all other symbols. Unfortunately, as far as I am aware, researchers have yet to test these two hypotheses as methods for distinguishing association and reference.

The systematic nature of symbol use touched on by Deacon was expounded upon by Frege (1892), who famously posited a distinction between sense and reference as two sources of meaning for symbols. For Frege, the meaning of a given symbol is not only determined by what may or may not have been associated with it in the past (reference), but also in the moment it is used by how that symbol is situated within a context (sense). As an example, the two terms “morning star” and “evening star” have the same reference, which is the planet Venus. The same two terms, however, have different senses, one being the planet Venus as it appears in the morning, and the other as it appears at night.

Anyone interpreting one of the two terms might rely on sense and reference to different extents in determining a meaning by which a larger thought might make sense.

The developmental psychologist Piaget hypothesized 2 stages in the development of symbolic reference (Piaget & Inhelder, 1969). The first stage, adopted by young infants, he termed "Prerepresentational." In this stage, the referent is merely associated with the symbol by way of co-involvement in a single stimulus event. Piaget called these precursors to true symbol use indicators: aspect, part, temporal antecedent, etc. For instance, whiteness might be a prerepresentational indicator for milk, or an opening door might be an indicator for the mother who enters through it. During late infancy and toddlerhood, however, children develop the ability to differentiate the represented from the representation, and the symbolic function develops in earnest. This dual representation allows for a truly arbitrary relationship between referent and symbol, and distinct representations of symbol. In this way, symbol and referent are not different aspects of a single event or representation, but are separate and parallel representations of the same thing.

Most recently, two perspectives have been published on developmental aspects of symbolic reference (DeLoache, 2002, 2004; Namy & Waxman, 2005). Both of these perspectives take a criterial approach to the definition of symbol, listing features of symbols that the authors feel are necessary for defining or detecting symbol use.

Namy and Waxman (2005) attempt to synthesize traditional approaches to reference as a set of criteria, then extend that set with additional criteria of their own. They conflate features of conventionality and systematicity under a single "traditional" feature, and then argue that one is necessary, but not the other. In order for something to serve as a symbol, the symbol/referent pairing need not be agreed upon by a large population. They argue that an idiosyncratic symbol known only to two individuals, such

as mother and child, is likely to use the same mechanism as a symbol more widely agreed upon, as is the more typical case with labels. They would, however, preserve a constraint of systematicity, arguing that all symbols are necessarily interpreted within context. Namy and Waxman would also add a constraint of intentionality. Symbols, they argue, are used intentionally. There are no accidental symbols. A symbol user intends either to produce something as a symbol or to receive something as a symbol. Normally, the intended production and the intended reception are in agreement, and successful communication takes place. However, they also argue that productive and receptive intentions aren't necessary tied together. One or the other might occur without the other. Namy and Waxman also argue that the traditional property of conventionality, in which a system of signs is agreed upon in a community, is too stringent. Idiosyncratic signs, which might be used by individual dyads, might be ruled out under the traditional account, but not by Namy and Waxman.

There are two primary shortcomings of the Namy and Waxman (2005) approach. First, the requirement that symbol use must be intentional is too stringent. As a criterion, the necessity of intentionality is not entirely consistent within their own argument. If neither receptive intentionality nor productive intentionality were necessary (as they argue), why would either be necessary? Under a more general argument, much symbol use is actually hindered by a conscious awareness of the reference. A recent movie about the ancient battle of Thermopylae has been getting some attention for symbolism that either is decidedly pro-war (Kahane, 2007), or decidedly anti-war (Gatollari, 2007), depending on the reviewer. The producers of the movie, for their part, argue they intended no such symbolic meaning (Chocano, 2007). One would guess that the viewers of the movie aren't going for a lecture on the morality of current geo-political activities, but it's highly likely that their views are affected by how they judge what they see in the

film. In this example, the producer and the receiver use symbols without intent. Entire schools of psychology are founded upon the idea that we unintentionally use symbols throughout our daily lives. This criterion might better be expressed in a more general form as a redirection of attention from the symbol onto the referent. Whether that redirection is intentional or not is a separate issue.

Second, the removal of the constraint of contextualization is not well worked out. Under what they call the traditional criterion of "conventional", the authors conflate two different concepts, "socially agreed upon" and "systematic." The authors would like to keep one as a criterion, but would like to remove the other. They implicitly argue for keeping systematicity as a criterion, arguing that symbols must be interpreted within a context. For labels, I would also add that a large portion of the context is determined by a limited range of sensory information (that acoustic space occupied by language). While the necessary understanding of contextual factors might more efficiently be learned and used within a social setting, it is not necessarily so. Any evidence that language related behaviors are unique to a limited range of sensory information is evidence that those language related behaviors exist within some limited system of use, and therefore evidence of one mechanistic component of language.

The second of the recent approaches to reference is by DeLoache (2004), who has devised a very specific definition for what she considers a symbol, "a symbol is something that someone intends to represent something other than itself." (p. 66). With this definition, she emphasizes several points. First, that anything might perform the role of symbol. That is, the relationship between symbol and referent might be arbitrary. Second, that symbols are necessarily representational. When a symbol is used, attentional focus is not on the symbol itself, but is on what the symbol represents. Third, that people use them intentionally. With this third constraint, DeLoache limits her

discussion to symbol use by humans, and rules out the possibility of accidental symbol use.

DeLoache shares with Piaget an emphasis on the necessity of dual representation for symbol use. For DeLoache, the ability for infants to learn to properly process symbols as both concrete objects in and of themselves and as representations of something else (a referent) is criterial in the development of symbol use. In a series of studies involving the use of symbols that are visually very similar to their referents (iconic symbol), she has explored some rather interesting aspects of this development. First, infants who are just beginning to make use of symbols can sometimes have trouble interpreting symbols that are perceptually similar to the intended referent (such as photographs or miniature toys). For these infants, decreasing the physical salience of the symbols may allow for better dual representation, and greatly increase the functionality of the symbol (DeLoache, 2004). For symbols that are extremely similar to their intended referent, however, small children can display a tendency to confuse what might otherwise be a symbol with the referent (DeLoache, Uttal, and Rosengren, 2004; DeLoache et al. 1998; Pierroutsakos & DeLoache, 2003), leading to error in the symbolic function. When this happens, infants might try to pick up objects in a photograph, or try to sit in a miniature car, or slide down a miniature slide.

These are indeed interesting findings, but represent a departure from the tack taken in this paper, which is to explore the development of label use as a case of symbol use. Labels are inherently arbitrary and are, relative to the range of possible referents, low in salience. The perceptual difference between symbol and referent may actually make it easier for infants to use a symbol. It is perhaps for these reasons that infants are able to step into label learning early in life, at an age several months (or even years)

younger than those studied by DeLoache. It is notable that this possibility is somewhat in contrast to the more traditional story, in which similarity is an aide to symbol use.

From these arguments, we can define a set of testable criteria that can help us to measure referential development. First, I would include a constraint of indication, which is simply that in a referential relationship, attentional focus is on the referent, and is directed there by the symbol. Second, I would include a constraint of decontextualization, which is that the referential relationship remains free of the more general context in which it was initially built. Lastly, I would include a constraint of systematicity, hoping to encompass the notion that symbolic reference occurs within a dedicated, constrained informational domain from which symbols are pulled. This includes the system of rules that govern meaning for a symbol. In language, it would be the phonetic and syntactic factors.

RECENT EMPIRICAL STUDIES

Developmental studies of early symbol related behavior often take the form of label learning studies. There are two common methodologies, motivated by two separate theoretical positions that are used in these types of studies.

Theoretical Models Driving Methodology

There are two theoretical models that have been used to help researchers understand the mechanisms underlying children's behavior in these situations. The Hunter and Ames (1988) model of familiarity and novelty preferences provides an explanation for infants' looking behavior as it relates to the simple processing of stimuli. Intermodal Matching (Golinkoff, et al., 1987) provides an explanation for children's behavior in relation to matching acoustic and visual stimuli. These two models make different predictions for infant behavior in some situations (Houston-Price & Nakai,

2004). Disentangling those predictions is important to the general area of word learning research, and is the goal of the research proposed here.

Familiarity and Novelty Preference

According to the Hunter and Ames (1988) model of infant looking behavior, the tendency for infants to prefer to look at a familiar or a novel stimulus is determined by such factors as exposure time to the familiar stimulus, complexity of the stimulus, and age of the infant. In a nutshell, as infants process a stimulus, they will spend some amount of time with a preference to look at that object rather than a novel object. With further exposure, however, they will switch to prefer to look at a novel object, rather than the familiar object. This should be true for object categories, also. With exposure to a set of various members of a single category, infants should for some time prefer to look at novel members of the familiar category before switching to prefer to look at novel objects from an unfamiliar category. Given a more complex stimulus, or a more complex stimulus set, infants will spend more time preferring to look at what is familiar before switching to prefer what is novel. There are also developmental aspects to this model. As infants mature, they become more efficient processors of stimuli, and what once was complex enough to elicit a familiarity preference may no longer be sufficient. Older infants should spend less time preferring the familiar stimulus than will younger infants. Finally, the model has been used to test for infants' ability to make associations between various stimulus components (Werker et al., 1998). In a switch design, for instance, infants are habituated to 2 label-object pairs. After habituation, the pairing of labels and objects is switched, such that all components of the test stimuli are equally familiar, but the association between components is novel. The reliability of a novelty preference after habituation allows for the prediction that if infants are able to learn the association

between labels and objects, then they will look longer to the novel pairing than to a familiar pairing.

For the purpose of investigating early word learning, familiarization and habituation procedures have several benefits and drawbacks. First, used properly, with habituation to a strict criterion, the expectation of novelty preferences is reliable (Cohen, 2004). Otherwise, infants with familiarity preferences may be analyzed in a group with infants displaying novelty preferences, ambiguating an entire data set (Roder, Bushnell, & Sasseville, 2000). Also, using a switch design provides an excellent test of association in that all parts of the association are equally familiar (Werker, et al., 1998). Though the habituation procedure may be excellently suited to teaching and testing simple stimuli and associations, it may not be the best procedure for testing reference. Schafer & Plunkett (1998) have argued that, because the novelty preference following habituation involves looking away from what would be the referent, the paradigm fails to test for referential behavior. A better test would involve infants looking toward a referent during testing. For this, intermodal matching (or some derivative thereof) may be best (Houston-Price & Nakai, 2004; Schafer & Plunkett, 1998). Finally, it is not clear what the effects of prior experience with test stimuli may be on the habituation process. This is of utmost importance in word learning studies, for learning a word for a known category may be a different process than learning a word and an associated category simultaneously.

Intermodal Matching

In conjunction with the looking behavior accounted for by the Hunter and Ames model, researchers also often make use of intermodal matching behavior by infants. This is the tendency for infants, when presented with multiple visual stimuli and an accompanying acoustic stimulus, to look toward the visual stimulus that matches the

acoustic stimulus. For instance, Bahrick (1983) presented 7-month-old infants with two videos, one of two bricks banging together, and one of two sponges being banged together. The videos played simultaneously on two separate monitors while a single soundtrack was played from a speaker situated between the monitors. Importantly, the soundtrack matched one of the two videos being played. Children spent more time looking at the video that matched the soundtrack. This matching behavior was based on preexisting knowledge - children entered into the testing situation with the match that was to be tested. It is also possible to use a short training (or familiarization) phase to allow children a chance to associate a word with an object, and then use matching behavior to test for that association.

This methodology has been used to test simple word learning by infants (Schafer & Plunkett, 1998), children's understanding of syntactic frames (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987), and verb learning (Golinkoff, et al., 1987; Hollich, Hirsh-Pasek, Tucker, & Golinkoff, 2000). Here, we'll concentrate on issues related to simple word learning.

Hollich, Hirsch-Pasek, Tucker, and Golinkoff (2000) have designed what they call the interactive intermodal preferential looking procedure. This procedure is essentially the same as that used by Schafer and Plunkett to teach words to 15-month old infants, with a couple of important distinctions. Real objects are used instead of slide presentations. Also, a live experimenter is used to present stimuli to the participants, instead of a computer-controlled timing mechanism. These manipulations serve several functions. First, the manipulations are intended to be more engaging for older infants, extending the functional age range of a standard procedure. Second, they present more possibilities for experimental manipulation. Texture can be applied to objects, for instance, and social cues can be delivered by the experimenter. All of this is meant to

increase the ecological validity of the testing situation. With this increase, however, necessarily comes some loss of experimental control. Many of the important results in this area rest on group differences of a second or less in looking time. Without computer-controlled presentation of visual stimuli, human error in the timing of stimulus presentation can increase random errors in presentation time to unacceptable levels. Also, the inclusion of a human labeler necessitates increased training time for experimenters, and presents the ever-present possibility that differences in experimenter behavior can at best present unacceptable levels of error into the procedure, and at worst, present error that coincides with test conditions, leading to serious confounds.

Apart from these issues particular to the interactive intermodal preferential looking paradigm, the use of intermodal matching for the study of word learning also carries a set of benefits and drawbacks. Importantly, using a shortened familiarization period (or none at all) may mean that looking behavior is driven by simple familiarity preference, as described by Hunter and Ames (1988) rather than matching behavior. As mentioned above, researchers have not successfully tested what will happen to matching behavior after extended exposure to test stimuli. There have been a few tests of prior experience on matching behavior (Schafer, Plunkett, & Harris, 1999), but effects on word learning have not been fully fleshed out. Intermodal matching does carry much promise for this area of research, though. In providing infants with a choice, this procedure may more directly test referential behavior than does the sequential presentation typical of habituation designs.

Possible Ambiguity in Predictions For Some Situations

As may be clear from the discussion above, the ability to predict matching behavior after extended exposure would be of great benefit to research in early word learning. What makes such prediction difficult is that the Hunter and Ames model of

familiarity and novelty preferences and intermodal matching make different predictions about infant looking behavior after extended processing. Hunter and Ames' model predicts preference for novelty, while intermodal matching predicts looking towards the previously experienced (familiar) stimulus.

REFERENTIAL PROCESSES TESTED WITH NOVELTY PREFERENCE AND INTERMODAL MATCHING

Recent investigations have tested a host of cognitive processes that are related to the three behavioral components of reference that are listed above and to the methods that are used for testing. These processes include label assignment and referential looking, process facilitation, the uniqueness of speech, auditory overshadowing, and the role of social cues.

Label Assignment

Werker, Cohen, Lloyd, Casasola, and Stager (1998) used this expectation of novelty to teach and test for word-object associations to 14-month-old infants. They showed infants 2 word-object pairs, one per trial during an initial habituation phase. After per trial looking time fell below a predefined criterion, children were shown a series of test trials. The critical test trial consisted of a "switch" between word and object, so that what might have been called a “Lif” in habituation was called a “Neem” in test. Increased looking time by 14-month-olds on the critical switch trial indicated that they had processed and stored the word-object pairings during the habituation exposures. Studies involving children less than 12 months of age showed that younger infants did not process the word-object pairings.

Of note in the design used by Werker, et al. (1998) is the use of habituation to a strict criterion. By ensuring that infants processed the stimuli to the point of losing interest (as measured by a decrease in looking time), the researchers were able to guard

against including subjects that were still in a familiarity preference. Habituation to criterion ensures the reliability of novelty preferences during test. Also of note is the "switch" trial used in test. Because all relevant test stimuli, including both acoustic and visual components, were used equally throughout the habituation phase, all components were equally familiar to the infants. The only novelty that might attract their attention would be the novel association between acoustic and visual components.

Redirection of Attention

Schafer and Plunkett (1998) employed a simple and highly controlled preferential looking paradigm in order to investigate cross-modal matching between newly learned word-object pairings. Fifteen-month-old infants were exposed first to a training phase in which they were trained on 2 novel word/object pairings, and then a test phase. The training phase consisted of the presentation of one of the objects along with the associated auditory label on either of two monitors situated within the child's view. Order of objects and side of presentation were pseudo random throughout training. Each training trial consisted of the appearance of one of the training objects on a monitor for 1 second without a label, after which a single presentation of the label occurred. Each novel label was used 6 times during a training phase. Interspersed throughout training were familiar object/label pairs. These familiar trials were included in hopes of both retaining the children's attention and of cuing the child in to the notion that the words were meant to represent the objects on the screen. The test phase consisted of 6 trials. In each of the test trials, two images appeared, accompanied by an auditory stimulus. The auditory stimulus matched either the image on the left monitor, the image on the right monitor, or neither image. The child was exposed to each of these conditions twice. In each of the test trials, the images appeared for 3 seconds without any auditory label, and remained on the screens for another 7 seconds as the label was repeated 3 times. The

entire procedure was performed twice, so that each child underwent a training phase, a test phase, another training phase, and a final test phase. Measures of both total looking time during test and of longest looking time both indicated that children were looking during test at the object that matched the auditory label more than at the object that did not match the label.

A preferential looking paradigm, such as that used by Schafer and Plunkett (1998) may have advantages over the sequential presentation typical of the habituation and familiarization designs discussed above. This paradigm may be less sensitive to general effects of attention, and by virtue of providing a choice to participants, will more directly isolate behaviors of reference.

As essentially a comparison test, in which infants compare side by side stimuli, it is of great importance to know if infants might prefer to look at one object more than another, outside of the influence of controlled test factors. Schafer, Plunkett, and Harris (1999) demonstrated that prior knowledge of an object-label relationship could have an influence in a testing situation, even without the presence of labels at test time. They employed a preferential looking paradigm with 17 month old infants (14 - 19 months) to investigate any preference infants might have for objects for which they have a label. Each trial in the study consisted of presenting to the children two images of objects that were equally familiar to the children. Familiarity was determined by parental report. One of the objects in each trial was an object for which the participant had a label, the other was one for which the participant did not have a label. Mean preference for the image of the object for which children had a label was 52.9%, which was significant. The authors present several possibilities for why children prefer to look at name-known images. It may be, they argue, that names add an extra dimensionality to an object. They further argue that this extra dimensionality may be a motivating factor in the facilitation of

categorization that is a central topic to the studies proposed here. A second possibility presented by the authors is that certain objects are inherently more attractive to children, which would lead to label learning and to the behavior shown in the study. Schafer, Plunkett, and Harris did control for past experience, using a parent-report questionnaire to choose for each infant stimulus objects for which an infant had equal prior experience. This control insures that the difference in effect was due to the presence or absence of labels, and not for differences in past experience with the test objects. They did not, however, report on the effect of different levels of experience as an independent variable. This possibility remains unexplored in the published literature.

Identification of Sign and Referent (Process Facilitation)

There is a second area of language development in which the Hunter and Ames model has helped to formulate predictions. Several researchers have proposed that although infants younger than 14 months might not form a reliable association between words and objects, labeling a set of objects might reliably influence infants' processing of those objects (Balaban & Waxman, 1997; Echols & Marti, 2004). Specifically, they argue that the presence of labels will facilitate categorization behavior by pre-linguistic infants. This line of research focuses on what is essentially a hypothetical behavior that might be seen as a precursor to symbolic reference, and gets at the question of order of development among the three component behaviors described above.

Balaban and Waxman (1997) used a simple familiarization/preference design to test this hypothesis. Infants were familiarized to a set of line drawings of objects from a single category (either pigs or rabbits were shown one drawing at a time). Familiarization was performed either with words or tones presented simultaneously with the line drawings. In a third condition, familiarization was performed with content filtered words. These content filtered words were recordings of words that had been acoustically

filtered such that intelligibility of the words was removed while much of the acoustic complexity of the language was retained. The infants were then tested in a preferential looking trial with a novel object from the same category and a novel object from a different category. The preferential test trials were presented in silence, so that matching behavior played no role in test-trial looking behavior. During this preferential looking trial, infants displayed a greater preference for out of category stimuli after familiarization to words or content-filtered words than after familiarization to tones.

The authors interpreted the greater preference for novelty in the word condition as a facilitation effect by the labels that were presented. The infants, argued the authors, had in the word condition categorized the stimuli, such that the new within category stimulus was treated as familiar and the new out of category stimulus was treated as novel, drawing a looking preference. This greater preference, however, was not always significant, and was sometimes dependent on a novelty preference in the label condition, and sometimes on a familiarity preference in the tone condition. Some of this ambiguity may have come from the short familiarization phase. Not continuing this phase until infant looking time falls to a criterion makes the interpretation of looking behavior difficult (Cohen, 2004). Some infants may have processed the familiarization stimuli enough to move into a novelty preference, while others may not have, and may still have preferred familiarity. Also of note in the Balaban and Waxman (1997) study are the stimulus materials. In a posttest interview, the authors asked parents whether or not their infants were already familiar with the objects used in the tests. Across all of the studies reported, roughly one-third of the infants tested were familiar with the test objects before the test started. It is not clear how much experience infants need with objects in their world before they possess what may be called a category of those objects, but it is not inconceivable that many of those infants in Balaban and Waxman's study who had prior

experience also possessed category knowledge of those objects. This presents a serious uncontrolled factor for a study investigating the ability of infants to categorize stimuli under different conditions. Finally, the use of simple tones and content-filtered speech as non-speech acoustic controls brings up a very interesting issue. Balaban and Waxman claim that categorization behavior related to the content-filtered speech results from the speech-like quality of the content filtered speech, as opposed to the non-speech like simple tone. The same results, however, might result from a difference in acoustic complexity. The categorization effect may result simply as an effect of complex acoustic stimuli, rather than language.

Indeed, Roberts and Jacob (1991) provide data suggesting that at 15 months, at least, the categorization effect might not be language specific. Across 2 studies, these authors tested categorization by infants in the presence of either labels (study 1) or music (study 2). In these studies, infants were habituated to three animal exemplars. Importantly, infants of this age do not categorize these exemplars without the presence of acoustic stimuli (Roberts & Cuff, 1989). However, when habituated with either labels or music, the infants responded more in a test phase to novel out of category exemplars than to novel within category exemplars. This differential response to novel within and novel out of category exemplars suggests that in the presence of non-linguistic acoustic stimuli, infants were categorizing objects that they did not categorize in the absence of acoustic input. Also of note is that labels were present in the test phase. These 15 month-olds responded with a novelty preference following habituation rather than by intermodal matching.

One issue of great importance in these types of studies is the amount of variation in the stimuli presented during the familiarization or habituation phase. Werker, et al. paired each label with a single object, essentially testing for an association between the

single word and the single object. Balaban and Waxman (1997) and Roberts and Jacob (1991), on the other hand, tested for the effects of a label as applied to a set of like objects. The amount of variation in the stimulus set is a measure of complexity under the Hunter and Ames model of looking preferences, and therefore a direct factor in determining familiarity and novelty preferences. Several researchers have manipulated the extent of variation in the to-be-associated set of objects to test for differential effects of labeling at different category levels.

Waxman and Markow (1995) tested whether any facilitation of categorization might be exclusive to categorization at the basic or global level. They also tested whether the categorization effect is an effect of labeling per se or if the effect might result from the presentation of any linguistic stimuli. Infants from 9 to 20 months of age were tested in a familiarization/preference test very much like the one described above. The set of objects in the familiarization phase formed either a single basic level category (green car, orange car, blue car, red car) or formed a global category (horse, tiger, bear, and panda or sports car, roadster, truck, and airplane). Test objects for the basic level condition consisted of a novel colored object from the same basic category (white car) and an object of the same novel color from a different category (white airplane). When objects in the familiarization phase formed a basic-level category, children showed a preference for the out of category test object. This preference occurred whether a label was applied during familiarization ("Look, a[n] X") or whether non-label speech was applied ("Look what's here"). The authors interpreted this as an indication that children were organizing the basic level categories during familiarization in a manner independent of how language was applied. When objects in the familiarization phase were of different basic level categories, but formed a global category, children showed a preference for the out of category test object only when a label was applied during familiarization. Thus,

labeling was shown to help organize objects into global categories for children who are just entering into word learning. Furthermore, the fact that children formed categories only when labels were applied suggests that they were beginning to distinguish some linguistic stimuli for use in categorization. An important issue that needed to be dealt with, however, was the extended age rage of participants in this study. Quite a bit of language development occurs between 9 and 20 months. It could be that the older children were driving all of the interesting results.

In another study, Waxman and Markow (1995) tested a more restricted age range (11-13.7 months) to deal with this issue. In addition, they added an "adjective condition" in which the label was presented in an adjectival syntactic frame ("look at the X-ish one"). Using a vocabulary checklist filled out by parents, Waxman and Markow divided children into a high vocabulary and a low vocabulary group (defined by a median split on number of words in children's productive vocabulary). They then compared the label-based categorization of high-vocabulary children and low-vocabulary children. During basic level trials, children with high vocabulary measures displayed a novelty preference in both the adjective and noun conditions, but not the no-label condition. Note that this is different than what Waxman and Markow found in the earlier study, in which infants categorized in the non-label condition. During global category trials, high vocabulary children showed a novelty preference only in the noun condition. Low vocabulary children behaved very differently during the test phase. During basic-level trials, these children showed a novelty preference in the adjective and no-label conditions, but not the noun condition. During global category trials, these children showed no novelty preference in any of the three conditions. These studies provide further evidence that there may be a link between labeling and categorization. It also suggests a link between the size of a child's vocabulary and the relationship between words and categories.

Waxman and Markow do provide a useful warning concerning this interpretation of their findings. Though they found evidence for a relationship between label-based categorization behavior and vocabulary size, causal conclusions cannot be drawn between the two. Whether categorization ability facilitates vocabulary growth or vice versa is not answerable using these data.

The potential for different effects of labels on categorization at different levels of category was also studied by Fulkerson and Haaf (2003), who investigated this label/categorization relationship in a group of 9- and 15- month olds. In addition, they also investigated the influence of social and contiguity cues. The authors tested to see if the phenomenon is exclusive to words used as labels, and to human labelers. They used an object examining procedure that consisted of a 6 trial familiarization phase immediately followed by a 2 trial test phase. During familiarization, children were handed 3 objects (one at a time) from either the same basic-level or global-level category. After the infant focused his or her attention on an object, the experimenter proceeded with a labeling event. Infants were either exposed to a label condition, in which a labeling phrase was presented or were exposed to a non-labeling condition in which repetitive mouth sounds were presented. Half of these children were presented with the auditory stimulus by a real person, half by an electronic speaker. Some children were exposed to a control condition in which no sounds were presented. The auditory stimulus was repeated 10 seconds into the 30-second trial. The test phase consisted of exposure to a within category exemplar during one trial, and an out-of-category exemplar on the other trial. No auditory stimulus was presented during the test phase. The dependent measure was the amount of time a child spent looking at the novel out of category object versus the within category object, with or without touching. All presentation conditions at both ages led to basic-level categorization behavior (more time spent looking at the out of

category object) at both age levels. There were, however, important differences between conditions concerning global categorization behaviors. At both 9- and 15-months of age, global categorization occurred only following labeling events (not following non-sound, or non-label events). At 15 months of age, global categorization behavior only followed familiarization to human labelers. There was no global categorization at 15 months of age following familiarization to machine labelers. In these studies, the categorization effect was specific to label conditions for both 9 and 15 month olds. Unlike Balaban and Waxman (1997), the complex acoustic stimulus did not lead to categorization. In all, the results of Fulkerson and Haaf suggest that the influence of language is general at 9 months of age, and becomes more specific later, narrowing to language presented by humans by 15 months.

The Uniqueness of Speech

The possibility that language related behavior is general to a range of acoustic stimuli carries important implications. Behavior specific to linguistic stimuli would be an indicator of a specialized system of representation. Furthermore, if infants' label-related behavior is reflected in situations in which non-linguistic stimuli are used in place of linguistic, this would suggest that the specialized system of representation used by adults (language proper) grows out of more general processes. If, however, infant behavior in response to linguistic stimuli is different than behavior in response to non-linguistic stimuli, then it is possible that an isolated system of representation develops in parallel to similar domain general processes.

Researchers using both familiarization procedures and intermodal matching procedures have tested whether or not words play a special role in stimulus processing, or if whatever role they do play would be played by any acoustic stimulus. We've already seen that Balaban and Waxman (1997) claim the categorization effect they found for

words and word-like stimuli was not found with the simple tones. They use this to argue that words do serve a special role in focusing infants' attention to commonalities in a set of objects. Others, however, have found a categorization effect for non-linguistic stimuli. Roberts, using procedures very similar to Balaban and Waxman found such an effect when music was presented in place of labels. In conjunction with the Balaban and Waxman results, this suggests that perhaps the effect of labels is the same as that of any sufficiently complex acoustic stimulus.

Other investigations have suggested an important developmental change in the effect of labels and non-linguistic stimuli. Woodward and Hoyne (1999) trained 13-month old infants on 9 exposures to either a novel word-object pairing or a sound-object pairing. Labeling was produced in a natural setting wherein the child handled the object. The experimenter produced the label or the sound only when the child's attention was focused on the object. The label or sound was produced in a labeling context, "Look, it's a toma. See? A toma. That's the toma." Or "Look at this. [Squeek]. Yeah, see it? [squeek]. Wow, look! [squeek]" The child was then introduced to what in test would be the distracter object. The experimenter talked about the object (without labeling), and drew the child's attention to it, as was done with the target object. This was repeated three times. A second experimenter who was blind to the training condition then conducted a test procedure. Test trials were embedded in natural play, and individual test trials were not initiated if the child was distracted by other toys. Half of the children in each condition (word and noise) were given label event test trials, and the other half were given preference trials. In each test trial, children were presented with the target and distracter objects in a tray and were asked, "Can you get the toma?" (word condition) or "Can you get me one of these?" (noise condition). Note that the noises were not presented within a labeling phrase. Children were given 3 trials involving the same

objects seen in the familiarization phase, and 3 trials involving novel exemplars from the same category as the familiarization objects. In both the word and noise conditions, children were more likely to choose the target object during the experimental tests than they were during the control tests. Furthermore, in both word and noise conditions, children chose the target object more often than would be predicted by chance.

In a second study, Woodward and Hoyne (1999) tested children at 13 and 20 months of age in a procedure very similar to the first study. All children in this study were exposed to a non-language noise during the label event, rather than a true label. Thirteen month olds, as in the first study, chose the target object at above chance levels on both familiar and generalization test trials. Twenty month olds, on the other hand, did not choose the target object at above chance levels on either test trial type. Taken as a whole, these studies show that children at 13 months of age will accept either a word or a non-language sound as a reliable associate (label) for an object, but 20 month olds will not accept a non-language sound as such.

As the authors point out, the preponderance of word learning cues (social and otherwise) in the training phase of the study makes it hard to distinguish how children at 13 months of age were learning the noise/object associations. They discuss the possibility that the 13 month olds understood the non-language noise symbolically as a separate issue, stating that not enough is known about infants' capacity in this regard to come to a conclusion about the children in their own study. Woodward and Hoyne discuss several possibilities for why the 20 month olds in their study did not learn the association between noises and objects. First, children at this age might have learned something about the special nature of words, and adopted an understanding that non-word noises do not constitute labels. Second, children might not have accepted the noises as labels simply because the noises were presented outside of syntactic units.

Auditory Overshadowing

Others argue that visual processing is actually inhibited, rather than facilitated. The discussion has implications for interpretation of behavior that are linked to the Hunter and Ames model. The facilitation of categorization by labels described above is an important hypothesis. If present, it represents a powerful link between linguistic and cognitive systems that perhaps exists before either system is significantly developed, affecting the development of both systems. Not surprisingly, though, all researchers do not agree that for young infants the presence of labels will facilitate categorization. Others argue that what appears to be categorization behavior is in reality something completely different. Robinson and Sloutsky (2004) argue that the categorization effect of labels is caused not by attention being focused on commonalities among objects, but by an overshadowing by acoustic stimuli of visual stimuli. In effect, for young infants, suitably complex acoustic stimuli such as labels should draw attention away from visual processing, such that attentional resources are drawn away from visual processing, resulting in an inability to discriminate similar stimuli. The resulting behavior merely mimics categorization. The authors presented word-object pairs to 8- and 16-month old infants in a train-test-train-test procedure. This procedure consisted of 10 familiarization trials, 2 test trials, 3 more familiarization trials, and 2 final test trials. Test trials consisted of 1 trial in which both the visual and auditory component of the familiarization stimulus changed, 1 trial in which only the visual component changed, 1 trial in which only the auditory component changed, and one trial in which neither component changed. Only those infants that exhibited a novelty preference were included in the results, which showed that 16-month-old infants recovered attention to every change trial, but 8-month-old infants recovered attention only when the auditory component changed. Eight month olds did not recover attention when the visual component alone was changed.

Importantly, the authors report elsewhere (Robinson and Sloutsky, in press) that the visual stimuli used here are discriminable by 8-month-old infants when the stimuli are presented without an auditory component.

In a second study, Robinson and Sloutsky (2004) familiarized participants to the acoustic component of the stimuli before proceeding with the actual experiment. The same acoustic stimuli that they used here (a noise) led to what the authors termed "overshadowing" in a different study (Robinson and Sloutsky, in press), in which 16 month olds did not recover attention to the visual change. With the familiarization performed in the 2004 experiment, however, 16-month-olds did recover attention. The authors argue that, for 16-month-old infants, prior experience with the acoustic stimuli made a difference in their processing of the visual-acoustic pairs. They further speculate that something similar may occur for verbal labels. Infants may have a familiarity with labels as a "class" of stimuli, leading to less attentional drain and a greater ability to process stimuli in other domains, including visual. The familiarization performed in Robinson and Sloutsky (2004) may not have been the most ecologically valid approach that they could have taken. The authors presented only 10 exposures to the acoustic stimulus for pretest familiarization, and then gave a short break before the actual experiment. The possibility of an effect of previous experience with stimuli, though, remains intriguing.

There are some issues in the Robinson and Sloutsky studies that are worth discussing. In the 2004 study, for example, the visual stimuli, though novel, were composed of basic shapes which could very well have been familiar to the infants before those infants entered into the testing situation. As discussed earlier, this may have something to do with how the children processed the stimuli. Furthermore, the authors presented the visual stimuli for only 1 second at a time. This was most likely done in an

attempt to equate presentation time for the auditory and visual components. This time frame is not a natural frame for visual processing, however, so generalizability may be limited. In the same way, if the acoustic stimulus had been stretched out from 1 second to the entire trial, infants might have been more likely to discount the acoustic information. The lack of recovery of attention to the visual change by the 8 month olds might have been a quirk of the design, rather than general attentional processes. Despite these issues, the attentional competition hypothesis presented by Robinson and Sloutsky is an interesting rationale for the categorization-like behavior reported in the other studies.

The Role of Social Cues in the Development of Reference

The role of social influence discussed by Woodward and Hoyne, and designed into the studies of Hollich, et al. is an important and debated issue in this area of developmental research. Baldwin and her colleagues have argued that social cues are a necessary factor in word learning, from early in infancy (Baldwin, 1991, 1993a, 1993b; Baldwin & Moses, 2001, Baldwin, et al., 1996). If true, this hypothesis has some very hefty implications for word learning studies that try to isolate the associative or representative aspects of word learning, and test for those behaviors in the absence of social influence. If Baldwin's hypothesis is correct, then those studies are doomed to failure!

In one well-known study, Baldwin and her colleagues tested children's use of social cues as a tool for word learning. Baldwin, et al. (1996) tested children 15- and 18-20 months old in two separate labeling situations. In one situation, an experimenter sitting in the same room as the child labeled objects, such that social cues of indication were available. In the other situation, someone outside of the room labeled objects, such that social cues were unavailable to the child. Furthermore, the labeler in this second

situation was known to be involved in a telephone conversation, and a second experimenter sat in the room with the child, interacting with the child, but not labeling the objects. Fifteen-month-old children did not show signs of learning the label in either condition, while 18-20 month olds did show signs of label learning, but only in the condition in which social cues were available. The lack of results with 15 month olds seems at odds with results by others using both habituation / novelty (Werker, et al., 1998) preferences and preferential looking (Schafer & Plunkett, 1998) to teach words to children as young as 14 months of age.

Several researchers (including Fulkerson and Haaf, described above) have uncovered evidence of a developmental change in infants' reliance on social cues for word learning. Hollich, et al. (2000) used a preferential looking procedure to test predictions made by their model for children from 12 to 24 months of age. In order to make the procedure usable with children at such a wide range of age, they used real objects, and labeled using a linguistic frame, such as "[Child's name], look at the MODI," where "MODI" was the novel word to be learned. They used objects that were physically interesting and objects that were physically boring, and counterbalanced that with social cues (eye gaze). During the familiarization phase, both objects were presented to the child, and eye gaze was directed at either the boring or the interesting object. In a series of studies, they showed that 10-month olds will associate a label with the interesting object regardless of direction of eye gaze, 12-month-olds will learn a new label only when eye gaze is directed at the interesting object, and 19- and 24-month olds will associate the label with whatever object to which eye gaze is directed. Children begin with a primitive principle of reference, relying on association and perceptual salience to map words to objects.

This seems to be in agreement with Fulkerson and Haaf (2003) who found a facilitation of categorization at the global level occurred for 12 month olds when the labels were delivered by electronic speaker or by a human labeler, but for 15 month olds only when a human labeler delivered labels.

So while it is true that as infants move into toddler hood, they come to increasingly value social cues for word learning, it is also true that social cues are not necessary for the older infants, and are probably not very useful for the younger infants. That being so, the practice of isolating associative and representational aspects of word learning from social influence should still be useful.

QUESTIONS OF INTEREST

Is it Possible to Empirically Distinguish Between Familiarity-Novelty Processing and Intermodal Matching?

An answer to this question would go a long way towards testing the development for the development of symbolic reference. The novelty preference curve is one of simple stimulus processing. Many studies have shown that infants will follow the trend from familiarity to novelty preference in regards to association between components of a stimulus. On the other hand, if symbolic reference drives intermodal matching then infants would direct their attention toward a trained label-object pair, and away from a novel pairing. If symbolic reference develops sometime during late infancy, then we should be able to detect the development by noting when infants switch from novelty preference curves to behavior driven by reference.

When Can Infants Assign a Label to a Category of Objects?

Thus far, well controlled, looking-time studies of infant word learning have been constrained to the association of labels with single objects by infants as young as 14

months of age (Schafer & Plunkett, 1999; Werker et al., 1998). While this is an important advance, allowing for study of many related phenomena, there are still many real-world phenomena that remain unstudied in the laboratory. In natural language use, many (if not most) labels are applied to categories, whether that be categories of objects, motions, spatial relations, or qualities. In natural development, infants use labels for such categories as early as 12 months of age, and are quite proficient by 18 months. To be able to investigate this behavior in the laboratory would open up many more avenues of research.

Is the Facilitation of Categorization a Chimera Created by Overshadowing?

The auditory dominance effect cited by Robinson and Sloutsky (2004) remains an intriguing explanation for the facilitation of categorization reported by Waxman (2003) and Robinson and Jacob (1991). More evidence must be collected with proper comparisons to categorization performance in silence before the auditory dominance hypothesis is completely disproved.

When is Speech Special?

Yet another question, opened up by recent research into language development, but not yet settled concerns language as a special system of symbolic communication. At some point in development, linguistic signals are processed differently than other, non-language sounds. Knowing when and how this systematic division occurs may help to answer questions concerning the nativism and modularity of linguistic (and more generally symbolic) processing. Of course, part and parcel with this question is the experimental question of proper control. A more precise wording of the question would be, when is a linguistic stimulus processed differently than X, where X is some non-linguistic comparison. Such a stimulus may be as acoustically different from language as

white noise or a simple sine wave. It might also be a comparison between stimuli very similar in nature, such as familiar v. non-familiar language. Ultimately, the continuum from linguistic to very non-linguistic could potentially be divided into an infinite number of possible comparisons, corresponding to testable hypotheses.

A Method by Which to Test Some Questions

Given the possible ambiguity in predictions made for referential looking and novelty preference based hypotheses, it would be useful to use a method that makes it possible to track looking behavior across time. Such a method was used recently by Roder et al. (2000) in a test of the Hunter and Ames (1988) model of novelty preference. Their method was, in effect, an extended set of preferential looking trials. Their goal was to present enough trials to each infant so that they might detect when and if an individual infant moves out of a familiarity phase into a novelty preference. One of the items in each trial remained familiar, the other changed on every trial. By noting at what point individual infants consistently preferred the novel object, they were able to analyze familiarity and novelty preference curves at an individual level. They found that infants exposed to faces or common objects as stimuli, but not children shown kaleidoscope patterns, reliably displayed a familiarity preference before switching to a novelty preference. Infants did not, however, display a period of no preference between familiarity and novelty preferences. This basic procedure of extended preferential looking trials is a direct descendant of (and an improvement on) Fanz's (1964) early design. It allows for a sensitive tracking of looking behavior across time, and forms the basis of the studies proposed below.

If, when presented with a label during a procedure such as that used by Roder et al (2000), infants learn to associate the label with the stimulus that is presented in correlation with the label (the constant object), then the method would provide a manner

in which the above questions may be tested. If infants make such an association, then processes of referential preference and novelty seeking would be in competition, and clearly distinguishable. Greater looking toward novelty would indicate novelty preference. Greater looking toward the constant object would indicate preferential looking. To the extent that preferential looking occurs after the point of expected novelty preference, occurs in relation to a constant category, and occurs uniquely in the presence of labels (rather than some non-linguistic control), then the preferential looking will be indicative of referential behavior, category extension, and the systematic nature of linguistic stimuli. With proper controls, we will be able to test whether categorization is facilitated or hindered.

Chapter 2: Study 1

INTRODUCTION

Study 1 was designed as a test of several of the questions listed above, and was performed with 13-month-olds, who are less likely to behave referentially. A separate study was performed with 18-month-olds, who are more likely to exhibit reference related behavior. That study is described as Study 2, below. In service of this investigation, there are several specific hypotheses that will be tested. First is a methodological issue related to the prediction by Hollich, et al (1998) that referential matching will always result in preference for the visual stimulus that matches the auditory stimulus. As discussed above, the Hunter and Ames model predicts just the opposite for looking behavior after extended exposure to a word-object pair. An adaptation of the extended preferential looking design used by Roder, et al. (2000) was used in Study 1 to test these hypotheses. Infants were exposed to an extended number of preferential looking trials while labels are played in the background. This allowed for tracking of preference for familiar and novel objects across trials, and comparing the progression of these preferences across acoustic conditions. This design also allowed for testing of two other hypotheses. One is the hypothesis that speech is special. This hypothesis was tested by comparing looking behavior in conditions in which object pairs are presented with labels to conditions in which objects are presented with non-speech noises. A third hypothesis is related to Sloutsky's overshadowing hypothesis, predicting effects of a lack of processing across a category of objects. The specific hypotheses are listed below:

Reference

Hollich et al. (1998) make the claim that when infants can form a referential match between a label and a visual stimulus, they will spend more time looking at the matching visual stimulus than another visual stimulus when presented with the linguistic stimulus. Specifically, this hypothesis leads to the prediction that infants will not develop a novelty preference in the procedure described below. A general intermodal matching hypothesis, in contrast, leads to the prediction that infants will form a match between the common visual stimulus and any common auditory stimulus, leading to looking towards that visual stimulus for some time longer than would be expected without auditory stimuli. A "speech is special" approach would further hypothesize that this lengthened familiarity phase will last longer during a labeling condition than a noise condition.

Facilitation of Categorization

Even if infants do not form an association between the auditory and visual stimuli, such that true referential matching might occur, it may be the case that the auditory stimuli still have an effect on the processing of the visual stimuli. There may be a facilitation of categorization that occurs, shifting the switch from familiarity to novelty preference quicker in the acoustic conditions than in the silence condition. Again, we can draw a distinction between the speech is special hypothesis which predicts that this would happen with speech, but not non-speech noise, and the general hypothesis that this would happen in the presence of any acoustic stimuli.

Overshadowing

There are two possible predictions to be made from the standpoint of overshadowing. Most consistent with predictions by Sloutsky (2004, in press), if acoustic overshadowing has a significant effect on visual processing, then infants may

simply fail at the visual novelty-seeking task, and develop no preference whatsoever. This should be more pronounced in a non-familiar sound condition than in a label condition. A second prediction, less consistent with Sloutsky (but perhaps more consistent with a resource sharing view of Stager and Werker (1997)) involves the redirection of attentional resources away from visual processing and toward label assignment. In this case, infants may not develop a preference in the label condition, but still would in the non-familiar noise condition.

METHOD

Participants

Sixty-eight 13-month-old infants from primarily English speaking households were tested. Of those, 10 were excluded due to fussiness, 1 for experimenter error, 2 for parental interference, and 2 for not being full term. The final sample consisted of 29 males and 24 females ranging in age from 12.5 months to 13.5. They were given a small gift (a t-shirt, bib, or sippy-cup) in appreciation for their time and effort.

Stimuli and Materials

Visual stimuli were constructed from photographs of objects downloaded from the World Wide Web. A total of 42 photographs were retrieved for the study. Five exemplars for each of 5 target categories were retrieved, and an additional 17 photographs, each from a separate category were also used. The 5 target categories for which 5 different tokens were retrieved were: fire sprinklers, helicopters, penguins, scissors, and tape dispensers. The 17 additional distracter categories for which only one token was retrieved were: banjo, bat, gourd, guitar, gumball machine, microscope, saddle, seashell, snorkel, squid, stapler, starfish, swimming fin, teapot, violin, whistle, and windmill. See Figure 1 for example photographs. For each photograph, the object of

interest was cut, resized to 4.5 inches along its longest axis, and pasted onto a neutral gray background. QuickTime movie-making software was used to animate the images such that they moved slowly up and down at a rate of 5 cm per second along a 10 cm vertical path.

Figure 1: Depicted are four example paired-comparison trials. Items on the left are always drawn from the same category (here, fire-sprinklers). Items on the right are always drawn from a different category. Side of presentation was randomized between subjects. Infants in Studies 1 and 2 viewed 20 such paired comparison trials.

Two separate audio stimuli were also constructed. In the label stimulus, 4 tokens of the nonsense word "Lif" were recorded by a female speaker in an infant directed voice. The length of tokens ranged from .89 to 1.02 seconds. Inter-token intervals of silence ranged from 1.17 – 1.59 seconds. An equivalent non-language stimulus was also constructed. This was constructed from 4 tokens of the "Boing" audio file from the Kaboom!Factory sound editing software package. Tokens of this sound were modified such that the length of tokens ranged from .98 - 1.47 sec, and were concatenated into a single file with an inter-token interval of silence ranging from 1.02 to 1.59 seconds.

Images were displayed on two separate video monitors, each measuring 38 cm in diagonal. A third video monitor, measuring 10 cm in diagonal was used for attention getting. It was situated between the other two monitors, and played a video of a green looming circle accompanied by a bell sound. From a separate control room, experimenters used a Macintosh computer running Habit software (Cohen, Atkinson, & Chaput, 2000) to present the attention getter, present stimuli, and record infant looking time. Infant looking behavior was observed via closed circuit video, and recorded onto DVD.

Design and Procedure

Design

The experiment was designed as a series of 20 8-second paired comparison trials (Fig. 1). Each infant was randomly assigned 1 of 5 categories that would serve as the target category for that infant. Each trial consisted of one of the 5 exemplars of the target category paired with a novel stimulus object. Infants did not see the same novel object twice. Side of presentation of the target category was constant for each infant and randomized between infants. Presentation of exemplars for the target category was

randomized within block, such that an infant would see all 5 exemplars in random order before any were repeated.

Each infant was also randomly assigned to 1 of 3 acoustic conditions. In the label condition, infants were presented with the label acoustic stimulus during each paired comparison trial. In the boing condition, infants were presented with the non-language acoustic stimulus during each trial. In the silent condition, infants observed all 20 paired comparison trials in silence.

Procedure

Each infant sat on a parent's lap, approximately 40cm away from a small computer monitor on which the attention-getter was displayed. Two larger monitors were situated one on each side of the smaller (approximately 38 cm apart) and were used to present stimuli. Between the 2 larger monitors was a speaker for presentation of the auditory stimuli. Each trial began with the presentation of the attention-getter. When the infant looked forward, the experimenter pressed a single button to stop the attention-getter and to present the stimuli. The stimuli appeared simultaneously on the larger monitors, and moved up and down in unison at a rate of 5 cm per second. The experimenter measured infant looking behavior with separate keys for right looks and left looks. Stimuli remained on screen for 8 seconds, at which point the visual stimuli disappeared, the auditory stimuli stopped, and the attention-getter returned to the small video screen. This procedure was repeated for 20 trials.

RESULTS

Data Reduction

Independent trials were considered to be complete if the infant attended to both objects during the 8 seconds of presentation. Infants failing to complete more than 80%

of the trials (16 trials) were removed from the analysis. Twenty infants were removed under this criterion. They did not differ from the others by age, sex, or by condition in which they participated. Data for the remaining 33 infants are analyzed below.

Description of dependent measure

The remaining trials were then averaged into 5 blocks of 4 trials each. The dependent measure was then calculated as the preference to look toward the novel object during a given block of trials. This was calculated by dividing the amount of time an infant spent looking to the novel object during a block of trials by the total looking time to the novel and constant objects for that block.

Preliminary within-subjects ANOVAs were run to test for effects of sex, stimulus, and side of presentation across blocks of trials. There were no significant differences found for sex or side of presentation. Further analyses were collapsed across groups. There was a significant effect of side of preference ($f(1, 31) = 8.6$, $p = .006$). Novelty preference was greater when the constant stimulus was presented on the left ($m = .64$, $sd = .14$) than when it was presented on the right ($m = .55$, $sd = .14$), suggesting that infants tended to look toward the monitor on the right more than the monitor on the left. Individual t-tests showed that novelty preference was significantly above chance across conditions when the constant stimulus was presented on the left ($t(84) = 8.90$, $p < .0001$) and when the constant stimulus was presented on the right ($t(79) = 3.24$, $p = .002$). This difference in side preference is between very strong novelty preferences, doesn't show up in any of the other 3 studies, and is not of theoretical focus. Therefore, it was not further analyzed. Remaining analyses collapsed across side of presentation.

Primary analysis

In order to determine if sound condition had an effect on novelty preference across the five blocks of trials, the data were then subjected to a 3 (sound: between) X 5 (blocks: within) ANOVA. This analysis yielded a marginally significant effect for block ($f(4, 120) = 2.36$, $p = .06$). There was no main effect for sound condition ($F(2, 30) = .09$, $p = .91$), and no interaction between the two factors ($F(8, 120) = .75$, $p = .65$).

Fisher's PLSD was run to test for differences across the blocks of trials. The novelty preference in Block 1 was significantly lower than novelty preference in Block 2 ($p < .01$), Block 3 ($p = .03$), and Block 4 ($p = .01$), and was marginally lower than Block 5 ($p = .067$). This suggests that a novelty preference developed early, and remained high throughout the remaining trials.

Table 1: Mean Novelty Preference in Study 1 by Trail Block

	Silent			Boing			Label		
Trial Block	M	t	p	M	t	p	M	t	p
Total	.60	5.16	.0001	.60	4.56	.0001	.59	4.72	.0001
1	.55	1.37	.20	.52	0.80	.45	.54	1.13	.28
2	.63	4.12	.002	.61	2.10	.07	.62	2.91	.01
3	.63	2.41	.04	.59	1.24	.25	.60	3.03	.01
4	.59	1.91	.09	.63	3.42	.01	.63	3.43	.001
5	.60	2.10	.07	.65	3.23	.01	.54	0.80	.44

Finally, t-tests were run to test whether novelty preference was significantly above chance for individual blocks of trials. These results are presented in Table 1. As a whole, collapsing sound conditions and trials, novelty preference was significantly above chance. Collapsing across all blocks of trials, each of the three groups exhibited significant novelty preference. Finally, novelty preference in the label condition was significantly above chance in Block 2, Block 3, and Block 4. Novelty preference in the

boing condition was significantly above chance in Blocks 4 and 5. In the silent condition, novelty preference was significantly above chance in Block 2 and Block 3. Block 2 of the boing condition and Blocks 4 and 5 of the silent condition were marginally above chance.

DISCUSSION

The 13-months-olds in Study 1 exhibited a novelty preference in all 3 sound conditions. This can be considered a replication of the basic finding of Roder et al. (2000), and an extension of the novelty preference finding to a category situation. There were not differences between groups. There was no evidence of referential behavior, of facilitation of categorization, or of acoustic overshadowing, or of any unique effect of labels. The lack of observed differences between groups is not entirely unexpected. At 13 months of age, infants are younger than those who reliably associate a label with an object in an experimental situation (Werker, et al., 1998). Though several labs have shown an effect of facilitation of categorization for infants as young as 9 months (Balaban & Waxman, 1997) and infants aged 15 months (Roberts & Jacob, 1991), the methodologies used in those studies were considerably more simple than the one used here. Those laboratories presented infants with a single picture at a time during the familiarization phase, and there was not a novel object presented during the familiarization phase as a competing stimulus. It could be that the task here is simply too complex to register an effect for infants of this age. Eighteen month olds were tested under the same experimental design in Study 2.

Chapter 3: Study 2

INTRODUCTION

Study 2 was performed with 18-month-olds. Infants of this age are older than the age at which infants reliably associate labels and objects in laboratory settings (Werker et al., 1998; Schafer & Plunkett, 1998). Infants of this age are also beginning a more rapid rate of word learning (Bates, Dale, and Thal, 1995), and differentiate between labels and non-label sounds in word learning tasks (Woodward & Hoyne, 1999). We expect infants in Study 2 to form an association between labels and the constant category, not to make that association with non-language sound, and to display that learning with looking behavior that is different across conditions. However, specific hypotheses relating to facilitation of categorization and overshadowing remain as described above.

METHOD

Participants

Fifty-eight 18-month-old infants from primarily English speaking households were tested. Of those, 8 were excluded due to fussiness, 1 for experimenter error, and 3 or for not being full term. The final sample consisted of 22 females and 24 males ranging in age from 12.5 months to 13.5 months. They were given a small gift (a t-shirt) in appreciation for their time and effort.

Stimuli and Materials

Stimuli and Materials were the same as those used in Experiment 1.

Procedure

The procedure was the same as that used in Experiment 1.

RESULTS

Data Reduction

Independent trials were considered to be complete if the infant attended to both objects during the 8 seconds of presentation. Infants failing to complete more than 80% of the trials (16 trials) were removed from the analysis. Data for 14 infants were removed under this criterion. They did not differ from the others by age, sex, or by condition in which they participated. Data for the remaining 32 infants are analyzed below.

Description of dependent measure

The remaining trials were then grouped into 5 blocks of 4 trials each. The dependent measure was then calculated as the preference to look toward the novel object during a given block of trials. This was calculated by dividing the total looking time to the novel object for a given block by the sum of the looking times to the novel and constant objects for that block.

Preliminary ANOVAs were run to test for effects of sex, stimulus, and side of presentation. There were no significant differences found for sex, stimulus, or side. Further analyses collapsed across these groups.

Primary Analysis

In order to determine if sound condition had an effect on novelty preference across the five blocks of trials, the data were then subject to a 3 (sound: between) X 5 (blocks: within) ANOVA. This analysis yielded a significant main effect for block ($F(4, 116) = 3.14$, $p = .02$), suggesting that on the whole, infants developed a preference to look at the novel object as trials progressed. The analysis also yielded a significant effect for sound condition ($F(2, 29) = 3.27$, $p = .05$), suggesting that the preference was

stronger for the sound and silence conditions than the label condition. There was, however, no significant interaction between the two factors ($F(8, 116) = .50$, $p = .72$).

Fisher's PLSD post hoc analyses were then run to explore the main effects of Sound and Trial Block. Novelty preference was significantly lower in the label condition than in the silent condition ($p = .02$). Novelty preference for the boing condition was perhaps marginally higher than the label condition ($p = .08$), and not different from the Silence condition ($p = .48$).

Table 2: Mean Novelty Preference in Study 2 by Trial Block

	Silent			Boing			Label		
Trial Block	M	t	p	M	t	p	M	t	p
Total	.59	4.18	.0001	.56	3.49	.001	.49	-0.74	.46
1	.54	0.87	.41	.51	0.38	.71	.42	-2.06	.06
2	.64	4.00	.003	.53	0.48	.64	.49	-0.35	.74
3	.57	1.07	.31	.56	1.73	.11	.51	0.22	.83
4	.61	2.12	.06	.57	2.03	.07	.48	-0.45	.66
5	.61	2.21	.05	.64	4.89	.0006	.53	0.56	.59

Finally, to track novelty preference across the blocks of trials, t-tests were run to compare looking behavior to chance. The results of these are presented in Table 2. Across sound conditions and trials, infants exhibited a significant novelty preference $t(159) = 3.93$, $p < .01$). Collapsing only across trials, the silent and boing conditions exhibited a novelty preference significantly different from chance ($t(49) = 4.184$, $p < .01$ and $t(54) = 3.49$, $p < .01$, respectively). Infants in the label condition did not ($t(54) = -.79$, $p = .46$). Finally, t-tests revealed significant novelty preference within several trial blocks. These include Block 2 of the silent condition ($t(9) = 4.00$, $p < .01$), Block 5 of the silent condition ($t(9) = 2.21$, $p = .05$) and Block 5 of the boing condition ($t(10) = 4.89$, $p < .01$). Block 4 of the silent and boing conditions were marginally above .5 (t (9)

= 2.12, p = .06 and t (10) = 2.03, p = .07, respectively). None of the blocks of trials in the label condition were significantly above chance, though novelty preference in Block 1 of the label condition was marginally below chance (t (10) = -2.09, p = .06). These suggest that a novelty preference developed relatively late in the 20 trials for infants in the silent and boing conditions, but that no novelty preference developed in the label condition.

DISCUSSION

In Experiments 1 and 2, the only infants who did not form a preference to look toward the novel object were the 18-month-olds who listened to the label stimuli. Thus, clearly, there is a difference in how 18-month-olds process visual categories in the presence of labels that is not simply attributable to general auditory stimulation. Furthermore, this difference develops between 13 and 18 months of age. The nature of that difference, however, remains unclear. The 18-month-olds who listened to label stimuli did not develop a strong preference at all during the 20 paired presentation trials. Two possible reasons for this null result are discussed here.

It may be that for 18 month olds, processing labels demands attention/cognitive resources that might otherwise be directed toward the visual processing task. In this case, infants are not processing the visual stimuli, and the null result stems from truly random looking behavior. In relation to this possibility, it is notable that the novelty preference in the silent condition develops more quickly than in the sound condition (Block 2 versus Block 4 or 5). A description of the development of novelty preference across the silent, sound, and label conditions might read: early, later, and not at all. This explanation is similar to, but not consistent with the auditory dominance hypothesis of Robinson and Sloutsky. Those authors would predict a later developing preference for conditions that include acoustic stimuli than for a silent condition. They would, however, predict that language, as a familiar class of acoustic stimuli, would have less of an overshadowing

effect than would unfamiliar sound stimuli. The results of Study 2 were just the opposite, with a greater effect for language than for unfamiliar sound. The results of Study 2 might indicate behavior more akin to a "cognitive dominance" effect, in which attention is demanded by a labeling process, and removed from the sensory processing. A similar story was told by Stager and Werker (1997), who found that infants of this age were less likely to discriminate fine contrasts in auditory stimuli in a labeling situation. An argument parallel to Stager and Werker might posit that the lack of novelty preference results from a failed attempt to assign the label to a visual stimulus. In this case, attentional resources are dominated not by acoustic processing per se, but by the attempt at referential assignment, leading to an inability to properly identify what would be the acoustic and (in this case) visual components of that assignment.

A second explanation might be more consistent with the referential matching hypothesis of Hollich and others. It may be that the null results result from a balance between referential looking (which would appear in this design as familiarity preference) and novelty seeking (which would appear as a preference for novelty). Such a situation would result in two effects, appearing as familiarity and novelty preference that effectively cancel each other out. This would indicate two separate cognitive processes, reference seeking and novelty seeking, that are affecting infant looking behavior. It should be noted that the strong hypothesis posited by Hollich predicts that the reference seeking behavior should always dominate any preference for novelty, which clearly would not be the case here. A weaker version, however, in which reference seeking should always exhibit an effect despite novelty preference, still needs to be tested.

One way to explore these two possibilities is to reduce the demands of visual processing by repeatedly presenting a single object paired with novel objects, rather than various category members paired with novel objects. In this way, because infants do not

have to generalize across a set of exemplars, label assignment should be easier. Because variation with the "constant" stimulus is reduced, relative to the novelty, detection of novelty should also be reduced. If there is a competitive process between referential matching and novelty seeking, then by reducing the demands of both, one of the tasks may more easily dominate.

Chapter 4: Study 3

INTRODUCTION

Study 3 tested the prediction made by Hollich et al. (1998) that label assignment would dominate infant looking behavior, and overrides any preference for novelty. This was accomplished by greatly simplifying both the novelty preference and referential assignment tasks within the same procedure. In Studies 1 and 2, different exemplars of a category were paired with novel items in order to test whether the presence of labels would affect infants' preference for novelty. In Study 3, infants were presented with a single exemplar of a category repeatedly paired with novel exemplars from different categories. If infants were attempting to make a label assignment in Studies 1 and 2, but were unable to reliably do so due to the complexity of the target category, then this task should be easier since they would not have to generalize a label across a category of items. Note that the same manipulation will make the detection of novelty much easier as well.

Hypotheses

A preference in either direction would rule out the overshadowing explanation of Robinson and Sloutsky (2004) described above. Robinson and Sloutsky's overshadowing hypothesis rests on the notion that because of a loss of visual stimulus discrimination, infants will treat a category of objects as if it is a single object when listening to acoustic stimuli. If infants develop a preference in Study 3, then that implies that they are processing the single stimulus differently than they did the category of objects in Study 2.

METHOD

Participants

Twenty-two 18 month old infants from primarily English-speaking households were tested. Of those, 4 were excluded due to fussiness. The final sample consisted of 12 males and 7 females ranging in age from 17.5 to 18.5 months of age. They were given a small gift (a t-shirt) in appreciation for their time and effort.

Design and Materials

The design and materials were the same as were used in Experiments 1, with two exceptions. First, instead of presenting 5 exemplars of a target category, one exemplar was chosen and repeatedly paired with different novel objects. In this way, each participant viewed on one monitor the same picture on each of 20 trials, and on another monitor, a different object on every trial. Second, because we were interested in exploring the lack of preference by 18 month olds in the label condition, all infants in Experiment 3 were presented with label stimuli.

Procedure

The procedure was the same as in Experiments 1 and 2

RESULTS

Data Reduction

Independent trials were considered to be complete if the infant attended to both objects during the 8 seconds of presentation. Infants failing to complete more than 80% of the trials (16 trials) were removed from the analysis. Nine infants were removed under this criterion. They did not differ from the others by age, sex, or by condition in which they participated. Data for the remaining 9 are analyzed below.

Description of dependent measure

Looking time for the remaining trials were then averaged into 5 blocks of 4 trials each. The dependent measure was the preference to look toward the novel object during a given block of trials. This was calculated by dividing the total looking time to the novel object for a given block by the sum of the looking times to the novel and constant objects for that block.

Preliminary ANOVAs were run to test for effects of sex, stimulus, and side of presentation. There were no significant differences found for sex, stimulus, or side of presentation. Further analyses collapsed across these groups.

Primary Analysis

In order to determine whether infants would develop a novelty preference in the presence of labels, a repeated measure ANOVA was run on novelty preference across blocks. This analysis yielded a significant main effect for Block ($F(4, 36) = 4.07$, $p < .01$), suggesting that infants developed a preference to look at the novel object as trials progressed.

Fisher's PLSD was run to determine differences in novelty preference across blocks of trials. Block 5 was significantly higher than Block 1 ($p < .05$), Block 2 ($p = .03$), Block 3 ($p < .01$), and Block 4 ($p = .02$), suggesting that infants developed a novelty preference as trials progressed. Block 4, though significantly different from chance, was not significantly different from Blocks 1, 2, or 3.

Table 3: Mean Novelty Preference Scores in Study 3.

Trial Block	M	t	P
Total	.60	4.62	< .0001
1	.52	0.53	.61
2	.60	1.70	.12
3	.54	0.77	.46
4	.59	5.24	.0005
5	.74	7.24	< .0001

To track novelty preference across the blocks of trials, t-tests were run to compare looking behavior to chance. The results of these are presented in Table 3. Novelty preference collapsed across blocks was significantly above chance ($t(49) = 4.56$, $p < .01$). Novelty preference for blocks 4 and 5 were significantly higher than chance ($t(9) = 5.24$, $p < .01$ and $t(9) = 7.24$, $p < .01$, respectively).

DISCUSSION

Infants in Study 3 developed a novelty preference in the presence of labels. Without the context of Study 2, these data would carry very little implication, except perhaps that the novelty seeking behavior in this study was stronger than any referential behavior that might also be taking place. Considered in conjunction with results from the label condition of Study 2, however, several conclusions can be reached. The 18-month-olds in the label condition of Study 2 failed to develop a novelty preference when the familiar stimuli constituted a category. The novelty preference developed by infants of the same age in Study 3 was developed in response to familiar stimuli that constituted a repetition of the same stimulus. Infants were processing the category of objects differently than the single object. This suggests that the null result of Study 2 was not a result of stimulus generalization caused by Robinson and Sloutsky's (2004) acoustic overshadowing.

There are still two possibilities, though, for the difference in novelty preference profiles between the infants in the label condition of Study 2 and those in Study 3. It could be that infants were attempting to apply the label to the set of objects, but were unable to fully process the stimuli due to the complexity of the situation. This explanation may be consistent with that given by Stager and Werker (1997). A second possibility is that infants were successfully associating the label to the constant stimulus, but that any tendency for referential behavior was in direct competition with a tendency to seek novelty in the situation. When the tasks were simplified in Study 3, novelty seeking dominated, and resulted in a novelty preference. Study 4 was designed to test whether or not infants could successfully make a label-category association in this paradigm.

Chapter 5: Study 4

INTRODUCTION

Study 4 was designed as a test of whether infants would associate labels with object categories in this extended preferential looking paradigm, and whether they might exhibit a referential preference after a point at which one might expect a novelty preference. In order to perform this test, the design used in the previous studies was adjusted to make use of the type of reference test used by Schafer and Plunkett (1998). Similar to the previous 3 studies, infants were first presented with a set of preferential looking trials in which one side remained more familiar than the other. However, the more familiar side consisted of 2 different object categories, each presented in conjunction with a different label. The other side was novel on every trial. After this training phase, objects from both familiar categories were presented at the same time, and one of the labels was presented. Looking toward the matching object would signify referential behavior.

METHOD

Participants

Sixteen 18-month-old infants from primarily English speaking households were tested. Of those, 1 was excluded due to fussiness and 3 for not being full term. The final sample consisted of 7 females and 5 males ranging in age from 17.5 months to 18.5 months. They were given a small gift (a t-shirt) in appreciation for their time and effort.

Design and Materials

Visual stimuli were the same as those used in Study 1. In addition to the "Lif" label stimulus from Study 1, a second label stimulus was constructed, containing 4 tokens

of the label “Neem”. Tokens in this stimulus file ranged from .7 seconds to .9 seconds. Inter-token intervals of silence ranged from 1.5 seconds to 1.65 seconds.

The design of Study 4 consisted of 2 phases. In a label-training phase, infants were exposed to 20 paired comparison trials in which they were trained on 2 label-category pairings. In each trial, infants viewed 1 exemplar from 1 of 2 target categories paired with a distracter object. Presentation of both target categories remained on the same side throughout the training phase. Presentation of target categories was also blocked across category, such that infants never saw more than 2 in a row of either category, and was also blocked within category, such that infants saw all 5 exemplars of each category before seeing any target exemplar a second time. Infants never saw the same distracter object twice. Presentation of target categories was correlated with presentation of audio stimuli. In this way, every presentation of a given target category was paired with the “Lif” label stimulus, and every presentation of the other target category was paired with the “Neem” label stimulus. Stimuli were constructed such that infants viewed as target categories sprinklers paired with “Neem” and tape dispensers paired with “Lif” fire or scissors paired with “Neem” and helicopters paired with “Lif.”

A 4 trial test phase followed the training phase. In the test phase, both target categories were presented simultaneously, one on each of the 38 cm monitors, along with one of the label stimuli. As in the training phase, the objects moved up and down at a rate of 5 cm per second, and each trial lasted 8 seconds. A single, familiar exemplar of each target category was used throughout the test phase. Each target category was presented twice on the left, and twice on the right. Type of label stimulus was counterbalanced with side-of-presentation, such that “Lif” was presented once when its associated visual stimulus was on the left, and once when the associated visual stimulus was on the right. The 4 test trials were presented in random order.

Procedure

The 24 trials were presented using the same procedure as in Study 1, with the exceptions noted above.

RESULTS

Data Reduction

Independent trials were considered to be complete if the infant attended to both objects during the 8 seconds of presentation. Infants failing to complete more than 80% of the trials (16 trials) were removed from the analysis. One infant was removed under this criterion. This left data for 10 infants in the dataset.

Description of dependent measure

Looking time for the 20 trials were then averaged into 5 blocks of 4 trials each. The dependent measure for the initial 20 preference trials was the preference to look toward the novel object during a given block of trials. This was calculated by dividing the total looking time to the novel object for a given block by the sum of the looking times to the novel and constant objects for that block.

Preliminary within-subjects ANOVAs were run to test for effects of sex, stimulus, and side of presentation. There were no significant differences found for sex or side of presentation. Further analyses collapsed across these groups. There was a significant interaction between stimulus and trial block ($F(4, 36) = 5.54$, $p = .001$). This interaction seemed to be driven by greater looking to novelty during trial blocks 4 and 5 when tape dispensers and fire sprinklers were the target categories ($M = .65$, $sd = .09$ and $M = .65$, $sd = .12$) than when scissors and helicopters were the target categories ($M = .40$, $sd = .16$ and $M = .43$, $sd = .25$). However, there were almost twice as many infants who viewed tape dispensers and fire sprinklers ($n = 7$) than viewed scissors and helicopters ($n = 4$),

making further analyses within each group unfeasible. The analyses below collapse across these two groups.

Primary Analysis

Training Trials

In order to determine whether infants would develop a novelty preference in the presence of labels, a repeated measure ANOVA was run on novelty preference across blocks. This analysis yielded no significant effect of block ($F(4, 40) = .73$, $p = .59$), suggesting that any novelty preference for the group of infants did not change significantly as trials progressed.

To test whether any novelty preference might be greater than chance, t-tests were run on novelty preference for each of the 5 blocks of training trials. These results are displayed in Table 4. Though novelty preference across all trials was significantly above chance ($t(54) = 2.45$, $p = .02$), preference for any individual block was not above chance.

Test Trials

The 4-trial test phase was collapsed into a single preference score by the same method that was used for the training phase. Because neither object shown in test was truly novel, the test trials were treated as target and distracter objects. The target object for a given test trial was the object that had been paired during training with the label that was presented on that trial. Looking time was averaged across the block of 4 test trials for both target and distracter objects. A target preference score was calculated as average looking time to the target object divided by the sum of average looking times to the target and distracters. These data are displayed in Table 4. A single-sample t-test was used to test whether looking time toward the target object was significantly greater than chance. It was ($t(9) = 2.57$, $p = .03$).

Table 4: Mean Novelty and Target Preference Scores in Study 4.

Familiarization Phase; Preference for Novel Object

Trial Block	M	t	p
Total	.55	2.45	.02
1	.56	1.52	.16
2	.50	-0.05	.96
3	.57	1.87	.09
4	.56	1.21	.26
5	.57	1.19	.26

Test Phase: Preference for Target

	M	t	p
Test	.56	2.57	.03

DISCUSSION

The goal of Study 4 was to test whether infants would be able to associate labels with a category of objects in the context of the testing situation used in Studies 1-3, and whether or not they would behave referentially if they did. In the test phase, infants looked longer toward an exemplar from the category of objects that had been previously associated with the label that was presented. This is clear evidence that the infants had learned the label-category associations, and by our operational definition, is referential behavior. Furthermore, infants learned these associations despite spending more time during the training phase looking toward the novel distracter objects than to the increasingly familiar target categories.

Chapter 6: General Discussion

The primary goal of the research was to test whether processes of novelty preference and referential behavior might be separable in infant word learners. Secondary goals included testing whether infants might associate a label for a category of objects in an experimental paradigm, to test whether labels might help or hinder categorization, and to test whether effects of labels might be unique.

These studies were able to successfully distinguish between referential and novelty processes. Specifically, Study 4 provided evidence of referential behavior that is not explainable by simple novelty processing. The evidence for this was preferential looking toward a target object in the presence of a label. This finding constitutes 2 new advances in the study of infant word learning. First, the preference was exhibited at a moment in processing in which a novelty preference would otherwise be expected. This is evidence directly supporting the hypothesis by Hollich et al (1998) for referential behavior. Second, the label association was made with a member of a category that had been trained with the label. Other early word learning studies using passive looking have trained an association between a label and a single object (Schafer & Plunkett, 1998; Werker et al, 1998). It should be noted that study 4 is not a category extension study, in which referential behavior would be tested with a novel category member. Such a study would have provided stronger evidence of the application of a label to a category, but this study is a first step.

A second goal of the study was to determine whether labels might help or hinder categorization. The study did not yield very good evidence in favor of either of the hypotheses. The 13-month-olds in Study 1 behaved similarly in all three sound conditions (they developed a novelty preference). Though the 18-month-olds in the label

condition of Study 1 did behave differently than 18-month-olds in the other conditions, the difference in groups is not clearly interpretable as an effect of categorization. A clear effect would have been a preference that developed more quickly or more slowly than the novelty preference that developed in the silent condition. Equal looking to both types of stimuli might have resulted from a lack of visual processing in the label condition: an effect consistent with the Robinson and Sloutsky (2004) hypothesis of Overshadowing. Equal looking to both familiar and novel sides might also have resulted from systematic factors: infants may have been looking toward what they determined was the referent for the label and looking for novelty in their environment. The results of Studies 3 and 4 suggest that separate referential and novelty preference looking behaviors explain the null result in Study 2, rather than overshadowing. The results of Study 3 show that infants behave differently in the label situation in response to a single object than in response to a category, suggesting that the null result was not due to Overshadowing. It is likely that the results of Study 3 reveal a novelty preference that existed in Study 2, but was hindered by the complexity of the familiar category. That this happened in the label condition suggests a special role for linguistic stimuli, and is perhaps consistent with the hypotheses of Stager and Werker (1997). In Study 4, infants exhibited evidence of label assignment in a similar paradigm suggesting that they may have been assigning labels to the objects in Studies 2 and 3. Thus, though we found evidence relating to some of the issues involved in the facilitation or hindrance of categorization, we found no direct evidence for or against those hypotheses.

It may have been that the design used in these studies was too complex, and not sensitive enough to pick up on an acceleration or deceleration in the development of novelty preference. These studies used photographs of real objects, and included all the (visual) complexity that one might find therein. Other studies on the facilitation and

hindrance of categorization have used simpler visual stimuli, such as line drawings (Balaban & Waxman, 1997), simple monochromatic toys (Waxman & Markov, 1995), or simple geometric shapes (Robinson & Sloutsky, 2004). Those studies also present training stimuli one at a time, without a distracter object present. These issues of complexity may have contributed to a higher level of variability that prohibited measurement fine enough to capture variation in category development.

One point of interest, possibly related to the issue of categorization, is the difference in novelty preference profiles among the three groups of 18-months-olds tested in the label conditions. Infants in Study 2 developed no preference when there was within-category variation in the constant stimuli. However, infants showed evidence of a novelty preference in both Studies 3 and 4, when the situation was simplified by eliminating variation within the familiar stimulus (Study 3) and when it was made more complex by increasing variation across 2 categories in the familiar stimulus (Study 4). A simple visual processing hypothesis would predict an increase in novelty preference with simpler stimuli, but no change or a reduction in novelty preference with more complex stimuli. Though the evidence here provides no clear answer as to why novelty preference did not vary directly with stimulus complexity, it is worth some speculation.

The simplest explanation for the difference in novelty preference profiles is that any preference exhibited in Study 4 was a chance occurrence. The evidence for the preference was relatively weak, showing up only across all 5 blocks of training trials, but not within any single block. This explanation, though, is a stretch, given that mean preference for each block was .5 or above, and that the probability that the preference across blocks was a chance occurrence was quite low. Another possibility is that the method of stimulus presentation in Study 4 was so complex that infants were prompted

into a search behavior. Infants may have been searching for a familiar object when they noticed a category change on the side in which familiar objects were presented.

A third possibility is that the labels presented in Study 4 actually made the 2-category task easier than the 1 category task of Study 2. 1n Study 4, the only difference between trials other than the change in labels was the change in object categories. The ability to coordinate these two changes may have made identification of both target categories easier, allowing novelty preference to have an effect above and beyond the label assignment task (in the same way novelty preference dominated in Study 3).

A final goal of the study was to determine whether any label related behavior is unique to language, or might be general to all similarly complex acoustic stimuli. Studies 1 and 2 provided evidence that in the task presented to infants here, labels played a unique role in infant looking behavior. The results of Study 4 suggest that this might be that 18 month olds are attaching labels to objects, but not sounds. Further testing will be needed to test whether 18 month olds would attach 2 different non-language sounds to two visual categories the way they attached labels in Study 4. The difference in behavior between the label and non-label sound conditions in Study 2 constitute some evidence that by 18 months, label effects are being constrained to a limited set of acoustic stimuli, indicative of the feature of the systematicity in our list of referential behaviors and mechanisms described in the introduction. Given these results, and those of Woodward and Hoyne (1999), I would expect that infants in this future study would not assign non-linguistic noises to objects.

This dissertation was framed in a discussion of the development of symbolic reference. An investigation of language was chosen as a doorway into this discussion because language is ubiquitous, and its development is relatively well mapped. In light of this framework, one might be tempted to ask whether the results of the 4 studies

presented provide evidence for the development of a general symbolic mechanism between the ages of 13 and 18 months. Do these two ages straddle a more precise moment in which a domain general mechanism of symbolic reference comes "online?" This question, however, might be too simple to provide a proper answer. A thorough theoretical bridge between linguistic function and a more general symbolic reference would necessitate a more complex presentation of the issue than the simple offline/online viewpoint framed by that question.

One issue that is hopefully evidenced by the results of the studies presented here (if not clearly expressed in the dissertation) is that the infant mind is complex, inhabited by multiple interacting systems that sometimes share resources while providing entirely different services to the infant. In the studies presented here, auditory and visual input are shared by systems whose tasks are novelty seeking and referential assignment. These systems deal with the same set of input and are saddled with essentially parallel tasks of determining which aspects of that input are particularly useful for the services that each system provides. A proper bridge between the specific area of language development and the more general investigation of the development of symbolic reference would keep this complexity firmly in hand, investigating similarity and difference between language and other domains.

There are a number of factors that set language apart from other modalities of symbolic reference. As discussed earlier, similarity in a dual representation can be a hindrance for young symbol users (DeLoache, 2002, 2004). It may be that the perceptual distance between labels and referents and the relatively low salience of labels provide a distinct advantage for the labeling system. The social nature of language use also creates a context in which the development of a symbolic function may proceed somewhat differently than it would outside of language. The social importance of language creates

a host of contextual factors that set label learning apart from other, less social domains. Label use then, is more common, more salient, and more closely tied to all sorts of learning systems than is say, the symbolism behind traffic signs. In this respect, it should not be a surprise that infants master the symbolic nature of labels before the symbolic nature of traffic signals.

Along with these differences, there is a basic, at least functional, similarity between the symbolic reference of language and that of other modalities. The similarity was outlined in the introduction, and might be describable by features such as indication, decontextualization, and systematicity. A proper program of research would encapsulate and control these differences and similarities as factors and measures. From such an approach, we might be better able to determine whether the mechanisms underlying the symbol system in language are shared across domains, are common across domains, or merely result in a superficial functional similarity across domains. One would also be in a better position to describe the structure of such mechanisms, and to describe factors that determine the developmental nature of symbol use across domains.

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