

Out of the Mouths of Babes: The effect of source on 20-month-olds' Use of Mutual Exclusivity

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Abstract

One account of word learning suggests that children learn that words are unique as labels among perceptual signals because of the way they tend to systematically co-occur with categories of objects. Twenty-month-olds' use of mutual exclusivity with different types of labels emanating from different sources was investigated in order to evaluate this account. Specifically, words and animal sounds were investigated. Results showed that children applied mutual exclusivity to both words and animal sounds produced by mouths, but not to words or animal sounds produced by noisemakers. This suggests the importance of including the regularities of social context and pragmatics to the associationist account of word learning.

Introduction

By the time children are two years old, most have gained a large vocabulary of words, mostly made up of nouns that refer to objects in their world (Goldin-Meadow, Seligman, & Gelman, 1976). But how they do this is still somewhat of a mystery. In order for children to learn a novel word for a novel object they must first recognize the signal as a linguistic signal (word) rather than an arbitrary non-linguistic signal (sounds and hand gestures). For instance, when a parent points to a dog while at the same time naming it as a dog, and maybe imitating a barking sound, how does the child know that the word is what the parent means to use to label the dog? How does the child know that the non-linguistic signals (pointing gesture and animal sound) are not referring to the dog? In this paper, we address this question by asking in which situations children treat different types of signals produced by different sources as labels for categories; in particular animal categories.

Development of Word Form Associations

The special status of auditory signals may begin early in development. Robinson and Sloutsky (2004) found that auditory signals overshadow visual information in 8-month-olds. A distinction between linguistic and non-linguistic sounds and their effect on attention to objects emerges at around that time too. Although both linguistic and non-linguistic sounds, seem to encourage 9-month-old infants to attend to objects, only linguistic, but not non-linguistic

sounds, facilitate categorization (Balaban & Waxman, 1997) and individuation of objects at this age (Xu, 2002).

The preference for linguistic sounds as labels for object categories appears later in development. Early on in language acquisition, children will accept both linguistic and non-linguistic signals as labels for novel objects that they encounter (Namy, 2001; Namy & Waxman, 1998, 2002; Woodward & Hoyne, 1999). But as children get older they begin to accept only words as possible labels for categories.

In one study, Woodward and Hoyne (1999) tested whether 13-month-olds would accept linguistic sounds (words) produced by the experimenter and non-linguistic sounds (squeaks and beeps) produced by a noisemaker as labels for objects in a forced-choice task. Both a training session and a test procedure were included during which children were presented with novel objects and novel words and sounds in a joint-attention setting. Throughout the training procedure, children were shown a novel target object that was paired with either a novel word or a novel sound. A second distracter object was also presented but not labeled. The test trials consisted of asking the children to "Get the <label>", the label being the original novel word or sound presented during the training session, and giving them the target object and the distracter object to choose from. In a separate control condition children were simply asked to "get one." Results showed that the 13-month-olds chose the target object more often than chance for both the sound and word conditions but not the control condition. Thus, at 13-months of age children accepted both words produced by an experimenter and sounds coming from a noisemaker as labels for objects.

Similar studies by Namy and Waxman (1998, 2002) have also shown that at 18-months of age children will accept gestures in addition to words as labels for objects. Furthermore, it has been suggested that at this very young age children's word learning encompasses many different types of signals including not only words, sounds and gestures, but possibly even pictograms (Namy, 2001).

Later on in development, the type of signals that are accepted as labels for object categories becomes more constrained. In a separate condition conducted by Woodward and Hoyne (1999), 20-month-old children accepted words but not non-linguistic sounds as labels. Likewise, in a simi-

lar study, by 26-months of age children preferred words over gestures as labels for objects (Namy & Waxman, 1998). Thus, it seems that sometime between 13-months of age and 20-months of age children begin to accept only words as labels and reject other non-linguistic sounds and gestures as referring to objects.

The Associational Account

Yet the same question still remains. How do children learn that words are privileged as labels for objects? As suggested by the evidence reviewed, children's understanding that words are unique among perceptual signals is not necessarily present before word learning begins. It may instead all be part of the same learning process. One explanation holds that as children begin to learn words for categories of objects in their environment, they begin to attend to the properties of objects that make up coherent categories (Smith et al., 2002). For example, children might learn that all small round objects are called balls. This in turn trains up their attentional mechanism to focus on shape as a way of categorizing objects. Thus, word learning influences what children attend to and, in return, this attentional mechanism allows children to acquire novel words for objects by focusing on the salient properties of objects (i.e. shape). Whatever signals tend to co-occur with categories in a systematic way will most likely be taken as labels for those categories. In other words, simply attending to the perceptual features that define categories and attending to what co-occurs with those categories allows children to learn which types of signals tend to be good as labels for objects.

During the word learning process, words seem to be unique in two aspects. First, words tend to point to objects in the world in a systematic way (Colunga & Smith, 2002). For example, the word "ball" seems to only co-occur with objects that are of a similarly round shape. On the contrary, "ball" does not occur with long thin objects, which tend to alternately co-occur with the label "bat". In this way, children learn that words, and not non-linguistic sounds, occur in a systematic fashion with objects. They also learn that the relationship between objects and words tends to be based on shape; that objects with the same shape tend to be called by the same name (Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). What makes words unique is that they can carve up the world in a systematic fashion and make the world more predictable. Because of words, children focus their attention on certain aspects of the environment like shape.

Second, because words focus children's attention on specific aspects of objects, words become especially good at facilitating categorization of objects and facilitating the individuation of objects. In a study by Xu, Cote, and Baker (2005) children were shown a box while an experimenter pretended to label either one or two objects inside the box. After one object was removed from the box, the children were then allowed to search in the box. There was significantly more searching for the two-word trials than the one-word trials owing, presumably, to the fact that children,

upon hearing two different labels, expected there to be two different objects in the box. On the other hand, hearing only one label would signify that only one object was in the box. In this way words facilitate the individuation of objects into separate and discrete entities.

In order to investigate this perceptual or associational account of word learning, we asked in what situations children will accept different types of linguistic situations as labels. The associational account suggests that as they age children begin to accept anything that systematically co-occurs with object categories. Therefore, because words are spoken and are almost always produced by the mouth, children should come to associate the property of being produced by the mouth as an important property of a label. In addition, children should expect signals produced by other sources, such as a small noisemaker, to not be good as a label. Accordingly, when children are presented with animal toys from animal categories and given words or animal sounds as possible labels, they should take animal sounds, as well as words, as labels for the animal toys.

In contrast, children should accept words as labels only when they are produced by the mouth, but not when they come from the noisemaker, as words coming from noisemakers are not consistent with the way things correlate in the environment. However, animal sounds may still be taken as labels for objects, even when coming from a noisemaker, as animal sounds tend not to specifically correlate with things produced by the mouth.

Colunga and Smith (2002) tested this prediction by asking 20- to 26-month old children to choose between a distracter and a target object; the target being a novel animal toy that was previously paired with a novel word, animal sound, or arbitrary sound that emanated from the mouth or a noisemaker (Colunga & Smith, 2002). Results showed that anything, word or sound, emanating from the mouth was considered a label for the novel animal toy. In addition, the animal sounds, which are often associated with animals, were always taken as labels regardless of the source of the sound. Both of these results fit with the predictions laid out by the associational account. In particular, the signals that were mapped to the novel animal toys fit well with the way the world is organized. Animal sounds, which are highly correlated with animal categories in everyday life, were always taken as labels. Words, on the other hand, which only correlate with animal categories when produced by a mouth, were only taken as labels when produced by the experimenter.

Colunga and Smith's results suggest that linguistic and non-linguistic sounds will be accepted as labels for different kinds of categories insofar as they correlate with the different kinds of categories. One question that remains, however, is whether for children this age the relationship between words and animal categories is qualitatively just like the relationship between animal sounds and animal categories? It is possible that in this task children are taking the words as referring to categories, but the animal sounds are merely

associated with the animals and not really bearing any symbolic status.

Study Overview

One way to figure this out is to see if these non-linguistic signals behave like words do in other tasks. The current study asked whether children would continue to treat animal sounds like words in a mutual exclusivity task. Mutual exclusivity refers to the fact that children seem to assume that each object is given only one label (Markman & Wachtel, 1988). This assumption comes in handy when trying to learn a novel word. For example, if there is a cup and an unknown gadget on a table, and mom points in the general direction of the table and tells the child “There’s your blicket”, the child can infer that since the cup is called “cup”, the unlabeled gadget must be the wicket. In that sense, the mutual exclusivity task appears to be a more inferential task, and thus, perhaps a more stringent test of the referential status of a label. To test mutual exclusivity we used a task previously shown to work with infants as young as 16 months of age. In this task, in each trial the infant is presented with a choice of a familiar object and a bucket, which has previously been shown to contain an object unseen by the child. There are three kinds of trials. In familiar trials, children are asked to get the familiar object; in the baseline trials, children are asked to “get one”; in novel trials, children are asked to get the novel toy hidden in the bucket and whose name the child has never heard before. Children are said to be applying mutual exclusivity if they choose the bucket more often in the novel trials than in the baseline trials, and the familiar outside toy more often in the familiar trials than in the baseline trials.

Thus, in the current study a mutual exclusivity task was conducted with 20-month-old children, an age at which children have shown to apply the mutual exclusivity constraint to words (Markman, Wasow, & Hansen, 2003), and to associate both animal sounds and words to animal categories in a novel word learning task (Colunga & Smith, 2002). Infants were tested with two kinds of labels – words and animal sounds. The stimuli used all consisted of familiar and unfamiliar realistic toy animals, and the labels used were their real names or recordings of the sounds the animals made. If, as suggested by Colunga and Smith (2002) animal names and animal sounds work equally well as labels for animal categories for children at this age, then we would expect children to use mutual exclusivity with either kind of label. However, if animal sounds are just associations, children might do mutual exclusivity with the animal names but not the animal sounds. Additionally, the two kinds of labels were produced by one of two sources – spoken by the experimenter or produced by a mini-recorder.

Method

Subjects

Forty-eight 20-month-old children, including 22 females and 26 males, with a mean age of 20.54 months (Range = 18.69 months to 22.82 months) participated in the project.

Design

A mixed design with two between subject variables and one within subject variable was used. The within subject variable consisted of three different trial types (familiar, novel, and no label) and tested the child’s use of mutual exclusivity. The two between subjects variables created four conditions which varied by source (mouth versus noisemaker) and type of label (words versus animal sounds). Children were randomly placed into one of the four conditions to avoid effects due to vocabulary or language ability differences.

In each of nine trials children were presented with two animals, one on the inside of an opaque bucket and the other on the outside of the bucket. In the familiar trials, the animal on the outside of the bucket was familiar to the child as reported by the parent. The children were then asked to “get” this familiar animal with the specific label for the animal being the name of the animal (word) or the sound the animal made (animal sound). The label was produced either by the experimenter in the mouth condition, or by a small hand-held playback recorder in the noisemaker condition. The second trial type, the novel trials, consisted of a familiar animal on the outside of the bucket and a novel animal on the inside of the bucket. The child was then asked, to “get” the novel animal on the inside of the bucket. Again, according to which condition they were in, the label used to ask for this animal was either a word or an animal sound and was either produced by the mouth or a noisemaker. Finally, the third trial type, the no label trials, consisted of simply asking the child to “get one” or to “pick one” as a baseline condition.

Stimuli

Materials consisted of small familiar and novel animal toys (e.g. a dog and cat for familiar animal toys and a Pteranodon and jellyfish as novel animal toys), a small opaque bucket and a vocabulary form that was used to ask parents to report which of the animal toys were familiar and novel to the child and for which animals the child knew the sounds that the animals make. Some animals do not make obvious noises, and thus, these animals were simply skipped over on the form. Parents were also asked whether children had any alternative names for any of the animals such as “doggie” instead of “dog.” The parents’ answers on this form were used to determine which animals were used in each of the previously mentioned trial types.

The experiment was set up according to the children’s previous knowledge and was different for each child. It was expected that this would make the task easier for the children as they did not have to learn any new labels to complete the task. For each child, six clearly familiar animals, three clearly novel animals and nine distracter (novel or familiar) animals were used. There were also several animals that were not used due to the surplus of animals on hand to ensure that enough familiar and novel animals would be available for each child. The words used in the experiment were simply the names of the animals. The animal noises used were the animal noises normally associ-

ated with the animals. Animals for which there was no specific sound available were simply used as distracters.

For the mouth conditions, the experimenter produced the word and animal noises. Every attempt was made for the animal noises to sound like real animal noises that could be made by a real animal rather than sounds that were more like words such as “bark.”

For the noisemaker conditions, the words and animal noises were recorded onto small 10-second recorders (here called noisemakers) that played back the words and sounds with one button press. In order to be less distracting, the noisemakers were put into small black cloth holders. The words recorded onto the noisemakers were simply spoken by the experimenters whereas the animal noises recorded onto the noisemakers were real animal noises obtained on the internet.

Procedure

After children and parents were welcomed into the lab waiting room, parents completed consent forms and the vocabulary form. During this time the experimenter played with the child in order to make them more comfortable with their surroundings and, hopefully, make them more relaxed with the experimenter.

Following this, the children, with their parents, were escorted to a plain lab room consisting of a table with one chair on one side and two chairs on the other side. A video camera was also present and set up behind the table in order to videotape the entire procedure in case questions arose. The children either sat on their parents’ lap across the table from the experimenter or in their own chair with their parents next to them.

There were two phases to the experiment; the familiarization phase and the testing phase. The familiarization phase was to orient the child to the task and get them accustomed to pointing to and choosing objects that were hidden inside a bucket. There were four familiarization trials in which the child saw the experimenter place a ball, a large paperclip, a crayon, and a small kaleidoscope toy inside the bucket. The experimenter then shook the bucket to further indicate that there was something inside. The experimenter asked the child to retrieve the toy by asking them to “find the” object or “get the” object. All toys were simply referred to by their names. If after the four trials the child was still reluctant to point to or retrieve the objects the four trials were repeated. In addition, parents were allowed to comment and help their child during this phase.

Every attempt was made to use the same intonation of quality of voice across conditions and trial types. Each type of label was used with a sentence and was used in such a way that the sentence flowed naturally. In addition, experimenters looked directly at the child when asking for an object so as not to indicate either object, possibly biasing the child’s choice.

Throughout the testing phase one animal was placed in the bucket out of sight of the child. Both the bucket with the animal inside and a separate animal outside the bucket

were then presented to the child. Again, the experimenter shook the bucket so that it was obvious that a toy was hidden inside. The bucket and animal were placed on the table near the experimenter so that each was equally distant from the child and each was on a separate side of the child. The sides that the bucket and lone animal were placed on were random with the added conditions that they could not be placed on the same side more than three times in a row and that they could not be placed on the same side more than five out of the nine trials.

Once the experimenter had the child’s attention, the child was asked to “get the <label>?” according to the condition that they were in. Only the last word of this phrase was different. The beginning of each phrase was always the same and presented as words produced by the mouth. If the child did not readily choose an animal, the bucket and the lone animal were pushed forward toward the child and the child was then asked “Can you get the <label>?” While several children required that we progress to this stage, it was rare that they did not respond at this point

Results

The number of times each child choose the bucket for each of the three trial types was recorded and submitted to a 2 (source) X 2 (label) X 3 (trial type) ANOVA, as shown in Figure 1. Only instances in which the child clearly chose one of the two animals was analyzed. There was a significant main effect of trial type ($F(1,88) = 8.83, p < .001$) such that, according to subsequent planned comparisons, there were significantly fewer bucket picks in the familiar condition ($M = .44, SE = .12$) than in the novel condition ($M = .79, SE = .14$) ($p < .001$) and the no label condition ($M = 1.08, SE = .17$) ($p = .02$). No other main effects were significant.

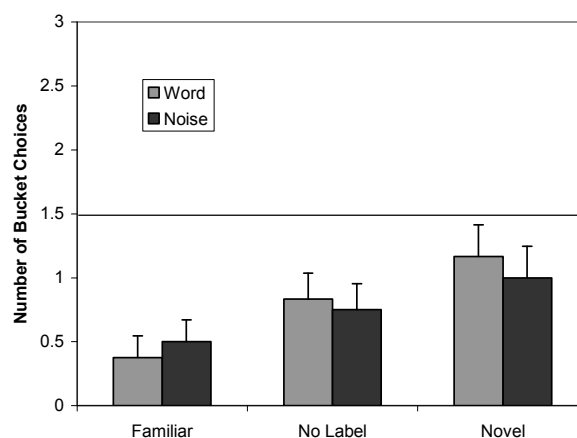


Figure 1: Mean number of times the children chose the bucket over the outside animal according to type of source and trial type.

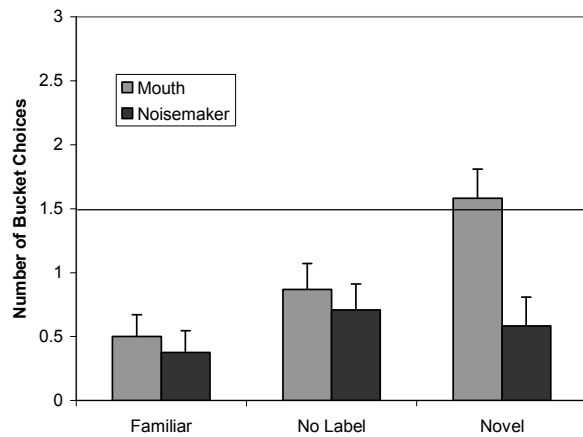


Figure 2: Mean number of times the children chose the bucket over the outside animal according to type of label and trial type.

However, when looking at only the mouth conditions, where subsequent analyses show that most of the effect occurred, the novel and no label conditions were significantly different ($t(23)=2.66, p=.01$). There was also a significant two-way interaction between source and trial type (as shown in Figure 2) ($F(2,88) = 5.14, p<.01$). Children chose the bucket significantly more often in the mouth condition than the recorder condition for the novel trial type only. There were no other significant interactions.

A chi-square analysis was also run to investigate any differences in the number of children that used the mutual exclusivity constraint between conditions. Children whose difference score was a two or three (meaning that they chose the bucket two or three times more in the novel condition than the familiar condition) were considered as having adhered to the mutual exclusivity constraint. Those whose difference score was a zero or one (meaning that they only chose the bucket in the novel condition one time more than the familiar condition or that there was no preference for the bucket in the novel condition at all) were considered as having not adhered to mutual exclusivity. A chi-square comparing the number of kids who adhered to mutual exclusivity in the word versus noise conditions showed no difference ($\chi^2 = 0.137, p=0.712$). However, there was a significant difference between the number of kids adhering to mutual exclusivity in the mouth versus the recorder conditions ($\chi^2 = 11.077, p<.01$), such that more children in the mouth condition were doing ME ($n=9$) than in the recorder condition ($n=0$). Thus, there was an effect of source, but no effect of label. These results are consistent with the results of the ANOVA test.

Overall, these results suggest that children will treat both words and animal sounds in the mouth condition as labels for animal categories, but not words or animal sounds coming from noisemakers as labels for the same category. Another way of looking at this is that words and animal sounds were only treated as labels when produced by a mouth.

Discussion

Previous research has shown that, at least in some situations, words and animal sounds are treated similarly as labels (Colunga & Smith, 2002). Specifically, in the previously mentioned association task, 20- to 26-month-old children took both words and animal sounds produced by the mouth as labels for novel animal categories. In addition, animal sounds, but not words, were taken as labels when coming from noisemakers. However, similar behavior does not necessarily imply similar mechanism. Although children appear to be treating anything produced by the mouth as labels and anything associated with a category as a label, what is the underlying mechanism that relates these signals to the category of objects?

The question proposed at the outset of this study was whether or not the relationship between words and animal categories is the same as the relationship between animal sounds and animal categories. That is, for 20-month-olds, are both words and animal sounds referring to animal categories? Or are these two relationships both based on association? Or is one type of label taken as referential and the other as associational?

Results from the current study begin to answer this question. Words and animal sounds are indeed treated similarly. Therefore, words do not appear to be special. Children apply the mutual exclusivity principle to both types of labels when they are produced by the experimenter's mouth, but fail to do so when either type of label is produced by a noisemaker. Thus, so far the evidence suggest that the kind of link formed between words and animal categories and between animal sounds and animal categories is of the same kind – both types of labels are readily associated with categories and children readily apply the mutual exclusivity constraint to both types of labels. Furthermore, the evidence presented here suggests that at least by this age, it is not words that are special, but mouths. In other words, the type of label does not seem to matter; what seems to matter is the source – that the source is a person. There seems to be something inherently special about people when it comes to determining what types of signals can be used as a label.

Previous research is consistent with the trend for children to treat anything produced by the mouth, and nothing produced by a noisemaker, as a label. In one preferential-looking paradigm study, labeling novel objects with words lead 15-month-olds to only categorize the objects when the source was the mouth and not a noisemaker (Fulkerson & Haaf, 2003). Results from the current study, while with slightly older children, are clearly consistent with these results. In both cases, children treated words and labels as objects only when produced by the mouth.

So why do infants fail to apply the mutual exclusivity constraint to either words or animal sounds when the labels are produced by the noisemaker? One explanation is that the presence of an extra unfamiliar but interesting object during the task is distracting or disturbing for young children, thus children perform poorly in the task. It is possible that given this strange scenario, children prefer the go with the familiar

toy and avoid the bucket. However, it is important to note that children did not pick the familiar toy more often in the familiar and no label trials in the noisemaker than in the mouth condition, but rather the main difference is in the novel trial. Another possibility is that children fail to apply the mutual exclusivity constraint in the noisemaker condition because naming situations require a person to do the naming. This constraint could come from learning that people are the ones doing the naming, or it could be based on an earlier and more basic preference to attend to people's actions.

Indeed, previous research has suggested that social context and pragmatics are important when it comes to determining what types of signals are good as labels. Through a forced-choice task, Namy and Waxman (2000) showed that gestures were taken as labels by 17-month-olds regardless of whether they were presented within a naming phrase or alone. However, words were only taken as labels when presented within a labeling phrase. Again, this is further support for the idea that there is something inherent in the social or pragmatic situation that focuses children on signals produced by the mouth as labels for objects. Research with 3-year-olds has also shown the importance of pragmatics in the application of the mutual exclusivity constraint (Diesendruck & Markson, 2001).

Conclusion

The current data show that 20-month-old children will treat anything systematically co-occurring with a particular category and produced by the mouth as a label. Specifically, 20-month-old children applied the mutual exclusivity constraint to both words and animal sounds produced by the mouth for animal categories. On the contrary, nothing produced by a noisemaker was treated as a label. These results are consistent with an associative learning account of word learning, but importantly highlight the necessity of including the correlations of social context and pragmatics into the associationist account.

References

- Balaban, M. T., & Waxman, S. R. (1997). Do words facilitate object categorization in 9-month-old infants? *Journal of Experimental Child Psychology*, 64, 3-26.
- Booth, A. E., & Waxman, S. (2002). Word learning is 'smart': Evidence that conceptual information affects preschoolers' extension of novel words. *Cognition*, 84, B11-B22.
- Colunga, E., & Smith, L. B. (2002). *What makes a word?* Paper presented at the Proceedings of the Annual Conference of the Cognitive Science Society.
- Diesendruck, G. & Markson, L. (2001). Children's avoidance of lexical overlap: A pragmatic account. *Developmental Psychology*, 37(5), 630-641.
- Fulkerson, A. L., & Haaf, R. A. (2003). The influence of labels, non-labeling sounds, and source of auditory input on 9- and 15-month-olds' object categorization. *Infancy*, 4, 349-369.
- Goldin-Meadow, S., Seligman, M., & Gelman, R. (1976). Language in the two-year old. *Cognition*, 4, 189-202.
- Markman, E. M., & Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology*, 20, 121-157.
- Markman, E. M., Wasow, J. L., & Hansen, M. B. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology*, 47, 241-275.
- Namy, L. L. (2001). What's in a name it isn't a word? 17-month-olds' mapping of nonverbal symbols to object categories. *Infancy*, 2, 73-86.
- Namy, L. L., & Waxman, S. R. (1998). Words and gestures: Infants' interpretations of different forms of symbolic reference. *Child Development*, 69, 295-308.
- Namy, L. L., & Waxman, S. R. (2000). Naming and exclaiming: Infants' sensitivity to naming contexts. *Journal of Cognition and Development*, 1, 405-428.
- Namy, L. L., & Waxman, S. R. (2002). Patterns of spontaneous production of novel words and gestures within an experimental setting in children ages 1;6 and 2;2. *Journal of Child Language*, 29, 911-921.
- Robinson, C. W., & Sloutsky, V. M. (2004). Auditory dominance and its change in the course of development. *Child Development*, 75(5), 1387-1401.
- Smith, L. B., Jones, S. S., Landau, B., Gershkoff-Stowe, L., & Samuelson, L. (2002). Object name learning provides on-the-job training for attention. *Psychological Science*, 13, 13-19.
- Woodward, A. L., & Hoyne, K. L. (1999). Infants' learning about words and sounds in relation to objects. *Child Development*, 70, 65-77.
- Xu, F. (2005). Categories, kinds, and object individuation in infancy. In L. Gershkoff-Stowe & D. Rakison (Eds.), *Building object categories in developmental time: Papers from the 32nd Carnegie symposium on cognition* (pp. 63-89). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Xu, F., Cote, M., & Baker, A. (2005). Labeling guides object individuation in 12-month-old infants. *Psychological Science*, 16, 372-377.