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Disambiguation Across the Senses: The Role of Discovery-Based Interference

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Abstract

When asked to find the referent of a novel label, children typically select an object that they cannot already name (the “disambiguation effect”; Merriman & Bowman, 1998). However, when the task required cross-modal extension of a label, children did not show this effect (Scofield, Hernandez-Reif, & Keith, 2009). In Experiments 1 and 2, preschoolers learned a label for a visual object, then examined it and a novel object by touch. On the critical trials, children were asked to decide which tactile object was the referent of a novel label. Four-year-olds only showed the disambiguation effect if, prior to the label test, they had identified the tactile object that matched the visual training object. The results of Experiment 3 suggest that the 4-year-olds expected to be asked about the matching object, which interfered with their tendency to disambiguate. This discovery-based interference appears to attenuate the use of common word learning strategies.

Keywords: word learning; novel word mapping; mutual exclusivity; cross-modal perception; language learning strategies; attention; discovery

Introduction

Infants as young as 16 months tend to map novel labels onto novel, unnamed objects (Halberda, 2003; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1994). For example, if shown a familiar object (e.g., a cup) and an unfamiliar object (e.g., a garlic press) and asked to pick the “zav”, children typically choose the unfamiliar object. This tendency, dubbed the “disambiguation” effect (Merriman & Bowman, 1998), is robust by 2.5 years and has been central for advancing our understanding of early word-learning (Evey & Merriman, 1998; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Markman & Wachtel, 1988).

Interestingly, the disambiguation effect appears to be less robust when label extension is cross-modal. Scofield, Hernandez-Reif, and Keith (2009; Experiment 2) taught 2- to 5-year-olds a label for a visual object (e.g., “blicket”), which was then presented along with a novel object in the tactile modality (i.e., the objects could be touched but not seen). On some trials, children were asked which tactile object was the referent of the trained label (e.g., a “blicket”). On other trials, they were asked which tactile object was the referent of a novel label (e.g., a “tigg”). Previous research has demonstrated that even pre-linguistic infants were able to detect some visual-tactile shape matches (Hernandez-Reif & Bahrck, 2001; Gottfried, Rose, & Bridger, 1977;

Meltzoff & Borton, 1979; see Scofield et al., 2009, for a review). Therefore, Scofield et al. (09) argued that preschoolers should have little difficulty disambiguating across sensory modalities.

Children did not reliably select a novel tactile object, however. In fact, they selected the already-nameable tactile object more often than the novel one. This finding is surprising given the robust disambiguation effect in non-cross-modal contexts suggesting that other factors may interfere with this common word-learning strategy.

Some theories suggest that the disambiguation effect will only occur if a child retrieves a name for the familiar object and notes that it differs from the novel label he or she is asked to extend (Halberda, 2003, 2006; Grassmann, Schulze, & Tomasello, 2009; Markman & Wachtel, 1988; Merriman & Marazita, 1995). Thus, one explanation for not disambiguating in cross-modal contexts is that preschoolers failed to learn the initial object-label pairing.

To rule out this alternative explanation, Experiment 1 (modeled after Scofield et al., 2009; Experiment 2) incorporated stronger label training procedures and, in one condition, highly contrastive language to highlight the difference between the trained and novel labels. To foreshadow our results, children in Experiment 1 failed to show the disambiguation effect despite our manipulations. However, Experiment 1 yielded an unexpected finding that suggested an additional explanation for children’s performance. Some children selected the already-nameable tactile object even before they were asked to extend a label. This finding suggests that children may have anticipated being asked about this object.

This observation led us to propose the discovery-based interference hypothesis. Discovery of the cross-modal match may have evoked a desire or expectation to talk about it. Even infants show a tendency to point out the presence of a previously shared object (Liebal, Carpenter, and Tomasello, 2010; Moll, Richter, Carpenter, & Tomasello, 2008; Saylor & Ganea, 2007). Alternatively, discovery of the cross-modal match may have elicited a surprise reaction that interfered with children’s ability to follow the experimenter’s request. According to some theories, a common consequence of surprise is disruption of ongoing processes and reallocation of attention to the surprise-inducing stimulus (Roseman, 2013; Reisenzein, 2000). Any of these factors could have disrupted the processes necessary for disambiguation. The goal of Experiment 2 was to determine whether eliminating

discovery-based interference would improve performance. Finally, Experiment 3 provides further evidence that a strong expectation to be asked about the match may have attenuated children's tendency to disambiguate across the senses.

Experiment 1

Participants

The basic condition consisted of 11 3-year-olds ($M = 43$ months, range = 36-47 months; five boys) and 13 4-year-olds ($M = 56$ months, range = 52-59 months; seven boys). The contrastive condition consisted of 15 3-year-olds ($M = 43$ months, range = 38-47 months; seven boys) and 17 4-year-olds ($M = 54$ months, range = 48-58 months; nine boys). An additional seven children were excluded from data analysis due to failure to follow directions. All of the children were recruited from preschools in middle- to upper-class regions of Northeast Ohio. Nearly all were Caucasian and all were monolingual speakers of English. Each child received a sticker for participating.

Materials

A white wooden box measuring 16 in X 17 in X 8.5 in was used. One side was open so the experimenter could transfer objects in and out of it, and the opposite side had two arm holes cut into it. These were 3 inches in diameter and had cotton sleeves attached to them. The side with the arm holes faced the child so he or she could put his or her arms inside the box without seeing inside (see Figure 1).

A different set of three unfamiliar objects (two of which were identical to each other) was used on each of four trials. These objects were small, easy to manipulate, and had names the children did not know (e.g., a plastic t-joint). Six nonsense words (e.g. zav, cobe, ferp) were used as either a trained or novel label. None of these words was used on more than one trial, and the order of trial type and novel labels was counterbalanced across all children.



Figure 1. Stimuli for the Cross-Modal Label Extension task in Experiments 1-3.

Procedure

The experimenter and child sat opposite of each other at a small table, and the experimental box was introduced. As a warm up, the child was asked to close his or her eyes while the experimenter placed a soft, foam ball inside the box. The child was then asked to place his or her arms through the arm holes, pick up the object, and answer three questions: "Is it hard or is it soft?", "Is it big or is it small?", and finally, "What is it?" Each child was provided feedback and shown the object afterward.

At the start of each of the four test trials, the experimenter showed the child a novel object and labeled it three times (e.g. "This is a zav. It's a zav. You're looking at a zav."). The child was prompted to repeat the name out loud. To ensure that the child had learned the label for the object well enough to retrieve it later, a distractor task that lasted approximately 5 s followed. The object was removed from sight and the child was asked to state how many fingers the experimenter held up. The child did this for two finger displays. The experimenter then placed the object back on top of the box and asked the child what it was called. If the child did not recall the label correctly, the experimenter labeled it herself and then repeated the whole procedure (beginning with, for example, "This is a zav. It's a zav. You're looking at a zav") until the child successfully recalled the label. If the child did not recall the label after three training and test cycles, the experimenter taught the name one more time and then proceeded to the cross-modal label test. Failure to meet this criterion was rare (10% of trials).

Once the child demonstrated an ability to retrieve the trained label, the training object was placed on top of the box so that it remained visible to the child. The experimenter instructed the child to close his or her eyes while she placed two objects inside of the box. One was identical to the training object (i.e. another "zav") while the other was a different object. The child was then instructed to open his or her eyes, place his or her hands through the sleeves, hold the objects that the experimenter placed in each hand, and then indicate which one was the referent of a label.

In the basic condition, the label request took the form: "Do you know what a ___ is? One of these is a ___. Which one is the ___?" On the two trained label trials, the trained label filled the blanks in the form. On the two novel label trials, a novel label filled these blanks. The form of the label request was nearly identical in the contrastive condition, except that on the two novel label trials, the first slot was filled by the trained label to highlight the contrast between it and the novel label (e.g., "Do you know what a zav is? One of these is a tigg. Which one is the tigg?"). In both conditions, the first and fourth trials involved trained label tests for half of the participants. For the other participants, the first and fourth trials involved novel label tests. Children indicated their response to the test questions by shaking, lifting, or extending one of the objects toward the experimenter. The objects remained hidden until after

children made their selection. Some children also made a confirming statement (i.e., “this one”) while making their selection. Minimal feedback was provided (e.g., “Ok.”)

Results

Performance on the trained label trials was excellent (M correct = 1.77, SD = .54; max = 2) and exceeded chance levels, $t(55) = 10.66$, $p < .01$. In contrast, performance on the novel label trials was at chance (M correct = 1.02, SD = .78; max = 2), $p > .05$. Because there were only three possible values for performance (0, 1, 2 correct), a log-linear analysis was conducted. Performance did not vary by age, condition, or age x condition, $ps > .10$ (see Figure 2).

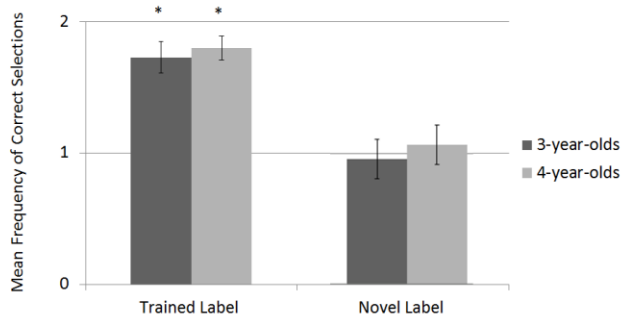


Figure 2: Experiment 1 Performance by Age and Trial Type.

Conclusions

After learning a label for a visual object, 3- and 4-year-olds extended that label to its tactile counterpart rather than to a novel object. When tested on a novel label, however, children chose both objects equally. Although our participants did not show a preference for the cross-modal match on these trials (as they did in Scofield et al., 2009), they still failed to show the disambiguation effect. Interestingly, several 4-year-olds selected the cross-modal match before they were asked to extend a label. This finding suggests that older children may have wanted or expected to talk about this object, which may have interfered with processing the experimenter’s request on the novel label trials.

In Experiment 2, this potential interference was eliminated by giving children an opportunity to inform the experimenter of their discovery of the cross-modal match. On every trial, children were asked to indicate which tactile object was the same as the visual object before they were asked to extend a label. The rest of the procedure was identical to Experiment 1. No 3-year-old spontaneously commented on the cross-modal match in Experiment 1. Therefore, only 4-year-olds were included in Experiment 2.

Experiment 2

Participants

Twenty-four 4-year-olds (M = 54 months; range = 49-59 months; 14 boys) were recruited from preschools similar to those sampled in Experiment 1. All of the children were monolingual speakers of English and nearly all were Caucasian. Each child received a sticker for participating.

Materials

The materials were identical to Experiment 1.

Procedure

The procedure was identical to Experiment 1 except every child was asked to identify the cross-modal match before being asked to select the referent of a label. That is, after recalling the visual training object’s label (e.g., “zav”) and placing their hands inside of the box, children were asked, “Which one is the same as that one [gazing at the visual training object on top of the box]?”. On some trials, children were then asked to extend the trained label (i.e., “Do you know what a zav is? One of these is a zav. Which one is the zav?”). On others, children were asked to extend a novel label (i.e., “Do you know what a tigg is? One of those is a tigg. Which one is the tigg?”).

Results

Four-year-olds’ performance on the trained label trials was excellent (M = 1.71, SD = .62; max = 2), exceeded chance, $t(23) = 5.56$, $p < .01$, and comparable to that of Experiment 1 (M for 4-year-olds = 1.80, SD = .48). Performance on the novel label trials also exceeded chance (M = 1.83, SD = .48; max = 2), $t(23) = 8.48$, $p < .01$. This pattern differs considerably from what was observed in Experiment 1 (see Figure 1). A 2 (Experiment) X 3 (trials correct: 2, 1, 0) Fisher’s Exact Probability test revealed that this difference in performance is unlikely to occur by chance ($p = .00068$).

Conclusions

Our results support the discovery-based interference hypothesis. In contrast to Experiment 1, 4-year-olds showed a strong tendency to disambiguate on the novel label trials. The only procedural difference was that, before being asked to extend a label, children in the current experiment were asked to identify the cross-modal match. This procedure was intended to control for possible interference resulting from discovery of the familiar, previously shared object. All children discovered the cross-modal match and then had a chance to communicate this discovery before the label test.

Although the results of Experiment 2 are consistent with the idea that 4-year-olds were influenced by discovery-based interference, the data do not tell us whether this interference was due to an expectation or desire to talk about the cross-modal match or simply surprise at discovering it. The purpose of Experiment 3 was to assess the presence of an expectation. That is, upon discovering the cross-modal match, will preschoolers report an expectation to talk about it? A strong expectation may shift attention to this object, leaving fewer resources available to process the experimenter’s request.

In a similar paradigm as Experiment 1 and 2, 3- and 4-year-olds were asked a series of questions about what they thought the experimenter might ask next. If children have an expectation to talk about the cross-modal match, they were expected to mention this object after at least one of the questions.

Experiment 3

Participants

Twenty-six 3-year-olds ($M = 42$ months; range = 36-47 months; 11 boys) and 26 4-year-olds ($M = 53$ months; range = 46-59 months; 16 boys) participated. All of the children were recruited from preschools in middle- to upper-class regions of Northeast Ohio. Nearly all were Caucasian and all were monolingual speakers of English. Each child received a sticker for participating.

Materials

The materials were identical to Experiment 1 except only one of the unfamiliar object sets was used.

Procedure

The procedure was identical to Experiment 1 except instead of asking children to indicate the referent of a label, children were given approximately 5 s to make any spontaneous comments about the objects. After these 5 s, children were asked a series of questions about what they thought the experimenter might ask next. These questions proceeded from general to specific (see Table 1). Any comments or actions indicating one of the objects was recorded.

Results

Table 1 shows how often children referenced the cross-modal match after each question. On average, 4-year-olds mentioned the match more often than 3-year-olds ($M = 1.81$, $SD = 1.13$ and $M = 1.04$, $SD = 1.00$, respectively; max = 4), $t(50) = -2.60$, $p = .01$. This shows that the older children had a stronger expectation that they would be asked about the match compared to the younger children.

Table 1: Number of Children Who Referenced the Cross-Modal Match After Each Prompt.

Prompts	3-year-olds	4-year-olds
<i>Spontaneous comments</i>	0	3
<i>“What do you think I’m going to ask you?”</i>	1	5
<i>“Which one do you think I’m going to ask you to pick?”</i>	13	19
<i>“Can you hand me one?”</i>	13	20

Discussion

An important question in language development is how children acquire new words. One common word-learning strategy is to assume that novel labels refer to novel, unnameable objects. This assumption helps children “disambiguate” in situations where the referent is ambiguous. However, children are less likely to use this otherwise robust strategy when extending object labels across sense modalities. We investigated the possibility that discovery-based interference, an expectation or desire to communicate their discovery of a previously shared object, disrupts disambiguation. Our results provide two novel findings.

First, strong label training procedures (i.e., training to production) increased the likelihood that children disambiguated. This finding is consistent with both the Mutual Exclusivity (Markman & Wachtel, 1988; Merriman & Bowman, 1989) and pragmatic accounts (Clark, 1990; Diesendruck & Markson, 2001; Gathercole, 1989) of word learning, which posit that children will only avoid mapping a novel label onto a familiar object if he or she can retrieve its known name. Preschoolers failed to disambiguate even with the stronger training procedures, however, suggesting that other factors influenced their behavior.

The second, and perhaps most intriguing, finding is the presence of discovery-based interference. Experiment 2 provided compelling evidence that the discovery of a cross-modal match appeared to trigger an expectation to talk about it, at least in 4-year-olds. Experiment 3 demonstrated that 4-year-olds, but not 3-year-olds, expected the Experimenter to ask them about the matching object rather than the novel one. To the best of our knowledge, the current studies are the first to demonstrate a task-specific expectation of this sort in young children.

We argue that this expectation influenced children’s tendency to disambiguate by shifting their attention to the cross-modal match and away from the experimenter’s request. With fewer resources available to fully comprehend the request, children’s ability to carry out essential processes necessary for successful disambiguation (i.e., retrieving the familiar object’s label and noting it mismatches the novel label) was disrupted.

Previous research has shown that infants will spontaneously inform an adult upon detecting an object that had been a focus of shared interest in a different context. In a study by Liebal, Carpenter, and Tomasello (2010), 18-month-olds played with a set of toys with one experimenter and a different set of toys with a second experimenter. Later, one of the experimenters led the infants to a room where there was a picture of each type of toy. The majority of infants spontaneously pointed towards the toy that they and the accompanying experimenter had played with earlier (see also Moll, Richter, Carpenter & Tomasello, 2008; Saylor & Ganea, 2007). Similarly, Liszkowski, Carpenter, and Tomasello (2007) found that 12-month-olds pointed more towards an event that an experimenter had previously

expressed interest in, even if the experimenter was already aware that it was occurring.

Based on the studies mentioned above, even infants show a tendency to point out the presence of a previously shared object. It is unclear, then, why the 4-year-olds reported a stronger expectation to talk about the cross-modal match in Experiment 3 than the 3-year-olds. Perhaps the 3-year-olds did not experience discovery-based interference because they lacked an expectation or desire to communicate about the match. They may have assumed that, because the experimenter had visual access to the tactile objects as well as the training object, she did not need to be informed of the cross-modal match.

Perhaps only children with a more advanced theory of mind (i.e., the 4-year-olds) may realize that the experimenter does not know that they have made this discovery, and so only these children may desire or expect to communicate about it. Research on children's understanding of teaching supports this possibility. For example, only after the fourth birthday do most children understand that teachers sometimes ask for information that they themselves already possess in order to determine if the learner also possesses it (Ziv, Solomon, & Frye, 2008). Perhaps 4-year-olds expected the experimenter to ask about the cross-modal match in order to determine whether the child had discovered it.

This finding seems counterintuitive. The results of the current studies suggest that older children may fail to show the disambiguation effect, a sophisticated word-learning strategy, when the context involves making a discovery. Instead, based on a strong pragmatic expectation, these children may adopt a different strategy that is arguably even more sophisticated, yet detrimental to their performance. Future research should investigate which factor(s) influence this expectation and whether different types of discoveries promote this expectation more than others.

It is important to note that typical tests of disambiguation (i.e., non-cross-modal ones) do not evoke discovery-based interference because children never make a discovery. For example, in some of these studies (e.g., Markman & Wachtel, 1989; Merriman & Bowman, 1989), no label was trained at the beginning of a trial; rather, an exemplar of a highly familiar label (e.g., a shoe) and a novel object were presented and the child was asked to select the referent of a novel label. So, at no point did participants discover that one of the choice objects matched the object they just learned a name for. In other studies (e.g., Diesendruck & Markson, 2001; Suanda & Namy, 2013), a label was first trained for an unfamiliar object, then the child was asked to decide whether this object or a novel object was the referent of a novel label. However, the training object remained in view throughout the trial, and thus, was never discovered again.

Our lab is currently investigating whether this interference is unique to a cross-modal context, or if it is more robust. For example, if children were to discover that one of two visual objects matches a visual object they just learned a name for, will this non cross-modal discovery

undermine their tendency to disambiguate? This prediction may only be supported if the experimenter's view of the choice objects is blocked. Otherwise, children may assume that the experimenter knows they have made the discovery, and would thus have no reason to communicate or expect to be asked about it. Future research will need to determine whether discovery-based interference is unique to word-learning, or if it affects performance on other types of tasks, as well.

Overall, the current studies demonstrate the complexity of language learning. Both lexical and pragmatic cues help young children decipher the meaning of new words. When pitted against one another, however, children sometimes follow a pragmatic cue even when it leads to an inaccurate response (Grassmann & Tomasello, 2010). Thus, under some conditions, pragmatics may attenuate the use and effectiveness of other word learning strategies. We are the first to provide evidence that the disambiguation effect, a common word-learning strategy, can be disrupted by an expectation to communicate about the discovery of a previously shared object.

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