The Metacognitive Disambiguation Effect

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by

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Introduction

For young children, learning novel words is a task as daunting as it is necessary. Children are often faced with the challenge of determining the intended referent of a novel label, and they use strategies to help solve this problem from an early age. For example, consider the situation in which a child hears a novel noun in the presence of two objects, one of which is familiar and the other unfamiliar, and is not sure which one the speaker intends the word to denote. Even children as young as 16 months old tend to make the more rational choice in this situation, which is to pick the unfamiliar object (Halberda, 2003; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1994). Although some novel nouns are names for things that the child can already name, it is more likely that a novel noun that is introduced without any additional cues will denote an object that the child cannot already name (Markman, 1984; Merriman, 1986). This strategy for resolving the ambiguous reference of a novel word, which Merriman and Bowman (1989) called the “disambiguation effect,” may play an important role in children’s word learning.

The example just described is the simplest version of the problem of disambiguating the reference of a novel word. Children often encounter numerous visible objects, many of which are plausible referents. The intended referent in these settings is not always clear. In one study, even adults watching videos of parents with their infants were unable to use the parent’s eye gaze and other cues to guess the word that the parent had used to refer to something in the setting (Medina, Snedeker, Trueswell, & Gleitman, 2011). Although parents and teachers can establish and maintain children’s attention to an object of discourse, many of their object references occur outside of such goal-directed one-on-one interactions. In these other contexts, children’s

attention may well be drawn to some object other than the one that a speaker is talking about (Yu & Smith, 2013).

According to the Mutual Exclusivity account of the disambiguation effect, children's default assumption is that a pair of labels will not have exemplars in common (Markman & Wachtel, 1989; Merriman & Marazita, 1995). Although they may abandon this assumption for a specific pair of labels if they receive evidence that each label can be applied to the same thing, no such evidence is presented in the standard test of the disambiguation effect. So a child who is shown a familiar, nameable object (e.g., cup) and an unfamiliar, as-yet-un-nameable object (e.g., garlic press) and asked which is a "zav" tends to choose the unfamiliar object. According to this account, the effect depends on the child representing the familiar object as having a name that does not match the novel name, and rejecting the familiar object because of this mismatch.

The Mutual Exclusivity account does not specify how the child makes this name mismatch decision. Merriman and colleagues (Marazita & Merriman, 2004; Wall, Merriman, & Scofield, 2015) have proposed that younger children may have to retrieve a phonological representation of the familiar object's name and compare it to a phonological representation of the novel name, whereas older children may be able to use an alternative strategy of simply noting that the familiar object has a name "I know" and the novel name is not a name "I know." That is, only older children may be able to make the name mismatch decision based on a comparison of *metacognitive representations* of the names and objects involved.

According to the alternative Pragmatic Contrast account of the disambiguation effect, children expect speakers to be cooperative, which means that if a speaker wanted to refer to something, the speaker would use a mutually known way of making this reference, if one exists (Diesendruck & Markson, 2001; Clark, 1990; Gathercole, 1989). For example, a child who

hears “zav” assumes that if the speaker had wanted the cup, he would have asked for the “cup.” Because the speaker used some other word, the child infers that the speaker must want the other object. This account is similar to the Mutual Exclusivity account in identifying rejection of the “already-nameable” object as critical to the disambiguation effect (Halberda, 2003; 2006). It is also similar to the Mutual Exclusivity account in leaving open how the mismatch between the novel label and the known label for the familiar object is made. Children could very well use metacognitive representations (e.g., ones that represent the names or objects as known/not known) in that the speaker’s label did not match the mutually known label for the familiar object.

Not all accounts of the disambiguation effect leave open the possibility of a role for metacognitive representations in the effect. Various competitive activation accounts (McMurray, Horst, & Samuelson, 2012; Merriman, 1999; Regier, 2005), for example, consider the effect to be an emergent property of the excitatory and inhibitory connections among representations. These connections have formed as a result of having heard various names used for various objects in the past. Because of these connections, the presentation of a novel name simply causes a child’s representation of a novel object to receive more activation than his or her representation of the familiar object. No process of comparing a representation of the novel name to a representation of the name for the familiar object is posited in these accounts.

The proposal that only older children may make name mismatch decisions based on a comparison of metacognitive representations is consistent with findings regarding the development of lexical knowledge judgment in early childhood. When asked to say whether or not various objects have known names, 4-year-olds nearly always respond correctly, whereas younger children often report knowing the names for unfamiliar kinds of objects (Marazita & Merriman, 2004; Merriman, Lipko, & Evey, 2008). A similar developmental trend has been

found with respect to children's judgments of whether various words are ones they know (Chaney, 1992; Merriman & Schuster, 1991; Merriman et al., 2008; Smith & Tager-Flusberg, 1982).

Merriman and Schuster (1991) also found that among 4-year-olds, frequency of responding, "No," when asked, "Do you know what [some novel label, e.g., a zav] is?" was positively correlated with frequency of selecting an unfamiliar rather than a familiar kind as an exemplar of the label (i.e., the strength of the disambiguation effect). Merriman and Bowman (1989) also included these two measures (frequency of acknowledging one's ignorance of a novel label's meaning and frequency of mapping a novel label onto an unfamiliar rather than a familiar object) in three experiments, but did not report the correlation between them. I had access to these data and found that in their first two experiments, the average correlation in the older preschoolers (4-year-olds, $N = 12$ and 3 ½-year-olds, $N = 16$, respectively) was .48, $p = .008$. In the third experiment, the correlation could not be computed because 4-year-olds' frequency of mapping a novel label onto an unfamiliar object was at ceiling. As children develop a metacognitive awareness of their lexical knowledge/ignorance, they may come to represent the disambiguation problem as one in which they must decide whether an object "I know" or an object "I don't know" is the referent of a label "I don't know." This way of representing the problem may further strengthen their tendency to select the latter object as the referent of the novel label.

In the final experiment reported by Merriman and Bowman (1989), children were asked to justify their solution to the disambiguation problem. Whenever they selected an unfamiliar object over a familiar one as the referent of the novel label, the tester asked them, "Why did you pick this object? How did you know that it was a [the novel label, e.g., zav]?" Merriman and

Schuster (1991) reported an analysis of the children's responses to this probe. Whereas 2 ½-year-olds tended to either not answer the question or point out some property of the unfamiliar object, many 4-year-olds tended to point to the familiar object and say, "Because that one is a [familiar label, e.g., cup]." Moreover, among the 4-year-olds, those who gave this response the most frequently also showed the strongest tendency to acknowledge their ignorance of the novel label (before they had been asked to map it).

Marazita and Merriman (2004) extended this last result. They found that 4-year-olds' tendency to offer this justification for mapping novel labels onto unfamiliar rather than familiar objects was positively associated with two measures of awareness of lexical knowledge. For one measure, the child had to answer "Yes" or "No" when asked, "Do you know what a _____ is?" regarding various words that were either highly familiar or completely made-up. For the other, the child had to answer "Yes" or "No" when asked, "Do you know what this is called?" regarding various objects that were either familiar or unfamiliar kinds. These results lend further support to the claim that as children become aware of what they know and what they do not know, they become aware that their solution to the disambiguation problem involves rejecting one of the objects because it has a known name that does not match the novel label they have been asked to map.

The goal of the current investigation was to examine whether 3- and 4-year-olds would show the disambiguation effect in a task where the effect depended on using metacognitive representations of the objects involved. The children first sorted familiar and unfamiliar objects into a bucket for "things I know" and a bucket for "things I don't know." They were then asked to recall the names of the objects in the "I know" bucket, and for any name that they recalled, the corresponding object was removed from the bucket. The children then received several trials in

which they had to decide which bucket contained the referent of a novel label. To counteract any aversion the children might have to selecting the same bucket on every trial, one trial was included in the middle of the test in which they were asked to decide which bucket contained the referent of a familiar label.

In order to succeed in this “metacognitive disambiguation” task, children had to rely on metacognitive representations of the objects, specifically, on representations of them as either ones “I know” or ones “I don’t know.” Because they could not recall the names of the objects in the “I know” bucket, they could not reject the objects in the “I know” bucket based simply on the mismatch between the novel label and a name that they retrieved for one of the objects in the bucket. That is, they could not use non-metacognitive representations of the objects in the “I know” bucket to inform their decision.

We predicted that older children would be more likely than younger ones to show the metacognitive disambiguation effect. This prediction was based on the increase during early childhood in both reflective awareness of lexical knowledge (Marazita & Merriman, 2004; Merriman, Lipko, & Evey, 2008; Smith & Tager-Flusberg, 1982) and in the tendency to justify selections in the standard disambiguation effect by noting that the rejected object has a name that mismatches the novel label (Marazita & Merriman, 2004). For similar reasons, we predicted that children’s performance on a lexical knowledge judgment task would predict whether they showed the metacognitive disambiguation effect, even after controlling for age and vocabulary knowledge.

Experiment 1

Method

Participants. Twenty-four 3-year-olds ($M = 43$ months, range = 36-47 months; twelve boys) and 24 4-year-olds ($M = 56$ months, range = 48-59 months; twelve boys) participated. Five other children were excluded due to failure to follow directions. All were recruited from middle-class regions of northeast Ohio and eastern Pennsylvania. Nearly all were Caucasian, and all were monolingual speakers of English. Each child received a sticker for participating.

Materials. The metacognitive disambiguation task included eight familiar objects (ball, flower, rubber duck, cup, block, watch, scissors, pencil) (see Figure 1) and eight objects that preschoolers were unlikely to be able to name (steel nutcracker, clamp, whisk, egg slicer, staple remover, hose connector, cleat wrench, tomato corer) (see Figure 2). Two identical opaque buckets were also used. Attached to the front of one bucket was a picture of a girl smiling and raising her hand. Attached to the front of the other bucket was a picture of a girl shrugging her shoulders (see Figure 3). The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was also used.

Procedures. The experimenter sat opposite the child at a small table in a quiet room at the child's preschool. After the child colored with the experimenter for 5 minutes, the child completed the metacognitive disambiguation task, the word knowledge judgment task, and the PPVT-4. Order of the metacognitive disambiguation and word knowledge judgment tasks was counterbalanced, and the PPVT-4 was always administered last. The session lasted approximately 25 minutes.

Metacognitive disambiguation. The preparation phase for this task involved getting the child to place all of the objects in their appropriate bucket. The buckets were placed in front of

the child and the child was told that he or she was going to play a game. The left-right position of the buckets was counterbalanced across participants. Pointing to the pictures on the front of the buckets, the experimenter asked, “Which one of these girls looks like she knows the answer? And which one of these girls looks like she doesn’t know the answer?” Every child answered correctly.

The experimenter said, “This one (pointing at the bucket with the knowing girl) is the ‘I-know’ bucket and that one (pointing at the other bucket) is the ‘I-don’t-know’ bucket. I am going to show you some things. If you know what it is called, put it in the ‘I-know’ bucket. If you don’t know what it is called, put it in the ‘I-don’t-know’ bucket.” The child was then shown the objects one at a time. For each one, the child was asked, “What is this?” If the child named it correctly, the experimenter said, “Since you know the name for that one, which bucket does it go in?” If the child could not name it, the experimenter said, “Since you don’t know the name for that thing, which bucket does it go in?” Occasionally, the child called an object by an incorrect name (e.g., calling a staple remover a “pincher”). In these cases, the experimenter said, “No, that is not what that is called. Since you don’t know the name for that thing, which bucket does it go in?” Objects were presented in an order that was random except that the same type never occurred more than three times in a row. Two random orders were used, and order type was counterbalanced across participants.

Whenever a child chose the appropriate bucket, the experimenter put the object in the bucket, saying, “So that goes in the ‘I-know’/‘I-don’t-know’ bucket.” Twenty-two 4-year-olds and seventeen 3-year-olds chose the appropriate bucket for every object. No child made more than two errors. Whenever a child erred the experimenter said, “No, this is something we

do/don't know the name for, so it goes in the other bucket," and placed it in the appropriate bucket.

To clear the names of the objects from the child's working memory, a four-trial distractor task was administered. On each trial, the child was asked to report the number of fingers that the experimenter held up.

The experimenter said, "So this bucket (pointing at the 'I-know' bucket) has all the things you know. And this bucket (pointing at the other bucket) has all the things you don't know." The experimenter then looked at the "I-know" bucket and asked, "Can you remember any of the things in here? These were the ones you know." The children recalled very few objects, although 4-year-olds recalled more than 3-year-olds, $M = 1.67$ and $.83$, respectively, $t(46) = -3.43$, $p = .001$. Whenever a child recalled an object, the experimenter said, "OK, let's get rid of that one (removing the object from the "I-know" box and placing it out of view). And since we are taking one out of this bucket, let's take one out of this bucket too." The experimenter randomly selected an object from the "I-don't know" bucket and placed it out of view.

Once a child indicated that he or she could not recall any more of the objects in the "I-know" bucket, the experimenter administered the test phase of the metacognitive disambiguation task. The experimenter told the child, "Ok, so now we have (e.g., six) things in this bucket (the 'I-know' bucket) and same number in that bucket (the 'I-don't know' - bucket). Now remember, this bucket (the 'I-know' bucket) has the things you know the names for and this bucket (the 'I-don't know' bucket) has the things you don't know the names for."

The experimenter then administered five trials, each time saying, "OK, when I was looking in these buckets, I noticed there's a [target word] in one of them. Which one do you think that would be?" All of the target words were nonsense words (*blicket*, *zav*, *tigg*, and *mido*),

except for the third target word, which was the name of one of the objects that was actually in the “I-know” bucket (e.g., *block*). This trial was included in case some children might doubt that the same bucket would always be the correct answer to the experimenter’s questions

After the final disambiguation test trial, the child was again asked if he or she could remember any of the objects in the “I-know” bucket. This procedure was followed to verify that children could not recall the names of any of the objects in this bucket. Finally, to see if children could offer a justification for a correct bucket selection, the experimenter looked inside the “I-don’t-know” bucket and said, “You said the *zav* [or whatever had been the first novel target word for which they had selected the I-don’t-know-bucket] would be in this bucket. Why did you say that? Why did you pick this bucket?”

Word knowledge judgment. The child was told, “I’m going to play a Yes-No game with you. I’m going to say some words. Listen carefully because some of the words are ones that you know and some are ones that you don’t know. I’m going to say a word, and then I’m going to ask you whether you know it. Just say ‘Yes’ or ‘No.’ Let me show you how to play.” The experimenter then provided some brief instructions. “The first word is *book*. Do you know what a *book* is? Say, ‘Yes.’ *Book* is a word that you know. You’ve heard that word before. You know what a *book* is. Are you ready for another one? The next word is *zimbiddy*. Do you know what a *zimbiddy* is? Say, ‘No.’ *Zimbiddy* is not a word that you know. It’s a made-up word. You’ve never heard that word before. There is no such thing as a *zimbiddy*.” The word knowledge judgment task followed. The child was asked, “Do you know what a _____ is?” regarding ten words. Five were familiar words (*shoe, dog, truck, chair, house*) and five were nonsense words (*hust, mave, gock, prad, blim*). Order of presentation was random, except that words of the same

type never occurred more than twice in a row. The experimenter responded to the child's answers with mild acceptance (e.g., "OK" or "Good").

After the final judgment trial, the child was asked about any nonsense word that he or she mistakenly identified as known. For example, a child who had indicated knowing what a *blim* was asked, "What is a *blim*? Can you tell me anything about it?" This query was intended to confirm that the child had not misperceived the word as some familiar word (e.g., *blim* as *blimp*). Children typically responded to these queries with silence, by saying "I don't know", or by producing a word or description that bore no relation to a potential misperception of the nonsense word (e.g. for *blim*, "that means when you get mean.") There were two instances of a potential misperception. The nonsense word in each instance was not counted in determining the proportion of nonsense words that the responding child had judged correctly (i.e., as ones they did not know).

Results

Metacognitive Disambiguation. Table 1 presents a summary of children's performance on each trial. The correct response on unfamiliar label trials was to select the "I don't know" bucket and the correct response on the one familiar label trial was to select the "I know" bucket.

The very first trial, which involved an unfamiliar label, was of particular importance because it was the only one that was not subject to a potential carryover effect from other trials. Three-year-olds performed no better than chance on this trial (12 of 24), whereas nearly every 4-year-old chose correctly (21 of 24), $\chi^2(1, N=48) = 7.85, p < .01$. On the second trial, which was also an unfamiliar label trial, neither 3-year-olds (13 of 24) nor 4-year-olds (14 of 24) showed a

significant tendency to select the “I don’t know” bucket. On this trial, nearly every 3-year-old (21 of 24) selected whichever bucket they had not selected on the previous trial, so that only two

3-year-olds chose correctly on each of the first two trials. Among 4-year-olds, about as many switched (13) as selected the same bucket again (11). Every 4-year-old who showed the latter pattern selected correctly on both trials. The total number of children who choose correctly on both trials was significantly above chance in 4-year-olds, $\chi^2 (1, N=24) = 5.56, p < .02$. In contrast, the total number of 3-year-olds who chose correctly on both trials (2) was below chance, but was not significantly different from chance, $\chi^2 (1, N=24) = 3.55, p = .06$

On the lone familiar label trial, which occurred next, every child except one 3-year-old correctly chose the “I know” bucket. On the unfamiliar trial that followed, nearly every child also chose correctly (19 3-year-olds and 23 4-year-olds). Their performance on this trial is difficult to interpret, however, because it could have reflected a simple bias to switch away from the bucket selected on the previous trial, which was the “I know” bucket for all but one child. Three-year-olds’ selections on the next and final unfamiliar label trial were consistent with this possibility. Thirteen of the 19 who had selected correctly on the previous trial switched to the incorrect “I know” bucket on this trial. Also, the five 3-year-olds who had not selected correctly on the previous trial now switched to the correct “I don’t know” bucket. In contrast, nearly every 4-year-old who chose correctly on the previous trial also chose correctly on the final unfamiliar label (20 of 23), $\chi^2 (1, N=23) = 17, p < .01$

Although 3-year-olds’ mean number of correct selections on unfamiliar label trials (2.29, $SD = .46$) exceeded chance, $t (23) = 3.08, p = .005$, the majority of them (17 of 24) made only 2 correct selections. Sixteen of these 17 showed the switching pattern on both the first two and final two unfamiliar label trials. In contrast, only two 4-year-olds showed this consistent switching pattern. The rest chose correctly on either three (12) or four (10) unfamiliar trials.

Four-year-olds' mean number of correct selections on unfamiliar trials (3.33, $SD = .64$) was significantly greater than that of the 3-year-olds, $t(46) = 6.47, p < .001, d = 1.87$.

Test Intercorrelations. The top section of Table 2 summarizes children's performance on the word knowledge judgment test and the PPVT-4. Four-year-olds outperformed 3-year-olds on both (for word knowledge, $t(39.76) = 10.59, p < .001$; for vocabulary size (scores are not standardized by age), $t(46) = 5.52, p < .001$.)

The top section of Table 3 summarizes the intercorrelations among metacognitive disambiguation (total number of correct responses), word knowledge judgment, and vocabulary size, as well as the correlation of each test with age in months. All three tests were strongly correlated with age and with one another. As predicted, word knowledge judgment was positively associated with metacognitive disambiguation. However, both age in months and vocabulary were also positively associated with metacognitive disambiguation. When age and vocabulary size were statistically controlled, there was no evidence of an association between word knowledge judgment and metacognitive disambiguation, partial $r(44) = .21, p = .169$. In contrast, vocabulary was associated with metacognitive disambiguation even after controlling for age and word knowledge judgment, partial $r(44) = .54, p < .001$.

This last result suggests that vocabulary size or verbal intelligence, rather than the specific ability to judge whether or not various words are known, accounts for individual differences in metacognitive disambiguation. However, the tendency for even some of the more advanced children to switch from the correct to the incorrect choice on the second trial of the metacognitive disambiguation test may have attenuated the relation between word knowledge judgment and metacognitive disambiguation. The lower section of Table 3 shows point-biserial correlations between correct selections on each trial of the metacognitive disambiguation task

and age in months, word knowledge judgment, and vocabulary size. The second trial stands out as the only one in which correct selection was not correlated with any of the other measures. When performance on this trial is excluded, total number of (other) metacognitive disambiguation trials correct is correlated with word knowledge judgment even after age and vocabulary size are statically controlled, partial $r(44) = .29, p = .047$. This score was also correlated with vocabulary size, after age in months and word knowledge judgment were controlled, partial $r(44) = .34, p = .019$.

Discussion

As predicted, the majority of 4-year-olds showed the metacognitive disambiguation effect, whereas the majority of 3-year-olds performed at chance. This finding is consistent with increases found over this age range in the accuracy of lexical knowledge judgments (Chaney, 1992; Marazita & Merriman, 2004; Merriman et al., 2008; Smith & Tager-Flusberg, 1982) and in the tendency to justify the standard disambiguation effect by noting the mismatch between the novel label and the known name for the rejected object (Marazita & Merriman, 2004).

Interestingly, most of the 3-year-olds, and many of the 4-year-olds, showed a tendency to choose whichever bucket they had not selected on the previous trial. The 3-year-olds tended to exhibit this switching pattern from the first to the second trial as well as from the third to the final trial, whereas the 4-year-olds, if they exhibited it at all, tended to show it only over the first two trials. One possible explanation for this switching is that it was a reaction to the feedback that the children received from the experimenter. On every trial, regardless of the bucket that the child had chosen, the experimenter responded with mild acceptance, saying, “OK” or “Good.”

Children may have interpreted this somewhat lukewarm reaction as an indication that they had picked the wrong bucket, and so they switched to the other bucket on the next trial. Another

possibility is that the switching pattern is based on an expectation that children formed from situations in which they have been repeatedly asked to choose from a fixed set of choices (e.g., as in guessing games). Children may have learned that in these situations the correct choice usually changes from request to request rather than staying the same.

We predicted that performance on the word knowledge judgment task would be positively associated with the tendency to select the “I don’t know” bucket in the metacognitive disambiguation task, even after age and vocabulary size were statistically controlled. This prediction was upheld for every trial of the metacognitive disambiguation task, except the trial that showed the strongest response-switching tendency (the second trial). Crucially, the prediction was upheld for the very first trial, which is the only one that cannot be influenced by a response-switching tendency. The evidence in favor of our prediction lends further support to the claim that successful performance in our metacognitive disambiguation task requires having a reflective awareness of one’s lexical knowledge/ignorance.

Vocabulary size also predicted performance on the metacognitive disambiguation task – excluding the second trial – after the other predictors (age and word knowledge judgment) were statistically controlled. This finding may be evidence that verbal intelligence also promotes the metacognitive disambiguation effect. It is quite possible that only the preschoolers who are more skilled in verbal reasoning derive the logical conclusion that because the “I know” bucket only contains things “I know” and the test word is not a name “I know”, the exemplar of the test word must be in the “I don’t know” bucket.

Neither age group showed a switching pattern on the familiar name test trial that intervened between the second and third novel name trials. Even among the children who had just selected the “I know” bucket on the previous trial, the vast majority selected this bucket

again when asked which one contained “a block.” So whatever the mechanisms are that underlie the switching pattern on novel name trials, they are not strong enough to counteract children’s tendency to select the correct bucket for the familiar name.

Note that children do not need to consult metacognitive representations of names to select correctly on the familiar name trial. When asked which bucket contained the block, a child may have chosen the “I know” bucket simply because he or she retrieved a specific memory of having seen the block placed in that bucket. They did not have to recall the name “block” because it was presented by the experimenter; they only had to recall having seen a block placed in the “I know” bucket. Although it is possible that some children did consider metacognitive representations of names on the familiar name trial, their success on this trial is not by itself definitive evidence that any of them did so.

Neither of these explanations for the tendency of some children to switch the bucket that they chose from one novel name trial to the next can account for the chance level of responding that the 3-year-olds showed on the very first test trial. Nor can they account for the significant preference for the “I don’t know” bucket (i.e., the metacognitive disambiguation effect) that 4-year-olds showed on the very first trial. However, they could explain why some who may have chosen correctly on the first trial and/or the third trial (possibly based on metacognitive representations) did not maintain this response on the trial that immediately followed. So it is possible that the current paradigm underestimates some children’s ability to show a disambiguation effect that is based solely on metacognitive representations.

Another possible contributor to the poor performance of children on the second trial is that something about the specific test word used on that trial promoted the tendency to pick the

“I know” bucket. Every child who participated in Experiment 1 heard the test words in the same order, and so heard the same test word on the second trial.

Experiment 2 was an attempt to replicate Experiment 1, but with two changes in procedure. First, more than one order of test words was used in the metacognitive disambiguation task. Second, children were told after every trial in this task whether they had made the correct choice. If the response-switching tendency of the children in Experiment 1 was due to the experimenter’s lukewarm reaction to their choices, then the children in Experiment 2 should not show a response-switching tendency. However, if the response-switching tendency of the children in Experiment 1 was due to belief that the correct response when playing a game tends to change from one turn to the next, then children in Experiment 2 might still show a switching tendency. However, it would be a tendency to switch away from whichever bucket they were told had been the correct choice on the trial. So, in cases where they had picked this bucket, they would switch to the other bucket. However, in cases where they had picked the other bucket (i.e., the wrong bucket), they would also pick this same bucket on the next trial, believing that it would now be the correct choice.

Experiment 2

Method

Participants. Twenty-four 3-year-olds ($M = 42$ months, range = 36-47 months; eleven boys) and 24 4-year-olds ($M = 54$ months, range = 48-59 months; eleven boys) participated. An additional child was excluded from analysis due to failure to follow directions. The children were recruited from the same regions of northeast Ohio as were sampled in Experiment 1. Nearly all were Caucasian, and all were monolingual speakers of English. Each child received a sticker for participating.

Materials and procedure. The materials and procedure were the same as in Experiment 1 except for changes to the metacognitive disambiguation task test trials. In Experiment 1, children were given only mild acceptance after their response on each test trial. In the current experiment, children were given corrective feedback after each trial. If the child chose the correct bucket, the experimenter said, “Yes, you’re right!” before beginning the next trial. If the child chose incorrectly, the experimenter instead said, “Nope, it’s actually in this one (pointing to the correct bucket)” before moving on to the next trial.

The other change to the procedure involved the administration of novel words on test trials. Whereas in Experiment 1 each child was administered the test trials in the same order (*blicket*, *zav*, *block*, *tigg*, and *mido*), this order varied according to condition. In the original condition, the experimenter followed the original order. In the reverse condition, the experimenter instead followed the reverse order (*mido*, *tigg*, *block*, *zav*, and *blicket*). The order of test trials was counterbalanced across participants.

In the preparation phase of the metacognitive disambiguation task, twenty-two 4-year-olds and ten 3-year-olds chose the appropriate bucket for every object. As in Experiment 1, no

child made more than two placement errors. Additionally, as in Experiment 1, the children recalled very few of the objects that had been placed in the “I know” bucket during the preparation phase, although 4-year-olds recalled more than 3-year-olds: $M = 1.83$ and 1.17 , respectively, $t(46) = -2.29$, $p < .05$. Once again, the order of the metacognitive disambiguation and word knowledge judgment tasks was counterbalanced, and the PPVT-4 was always administered last.

Results

Metacognitive Disambiguation. Table 4 shows children’s performance on each trial. Just as in Experiment 1, fewer 3-year-olds (8 of 24) than 4-year-olds (16 of 24) chose the “I don’t know” bucket as containing the referent of the unfamiliar label on the first trial, $\chi^2(1, N=48) = 5.33$, $p < .05$. The number who made this correct choice was somewhat lower than in Experiment 2, but this difference was not significant, $\chi^2(1, N=96) = 3.50$, $p = .07$. Just as in Experiment 1, neither age group performed well on the second unfamiliar label trial (3-year-olds: 9 of 24 correct; 4-year-olds: 11 of 24 correct). However, in contrast to Experiment 1, in which nearly every 3-year-old switched to whichever bucket they had not selected on the first trial, 15 of 24 3-year-olds picked the same bucket they had selected on the first trial, $\chi^2(1, N=48) = 12.80$, $p < .001$. Most of these instances (11 of 15) involved continuing to make the error of selecting the “I know” bucket. Among 4-year-olds, the number who switched responses on the second trial (11 of 24) was similar to the number who did so in Experiment 1 (13).

As in Experiment 1, nearly every child chose the “I know” bucket on the familiar label trial and the majority (16 of 24 3-year-olds and 23 of 24 4-year-olds) chose the “I don’t know”

bucket on the unfamiliar label trial that followed it. Also, as in Experiment 1, nearly every 4-year-old chose this bucket again on the final unfamiliar label trial. Among the 3-year-olds,

however, more children made the same choice on this final trial as they had made on the preceding trial than showed this pattern in Experiment 1 (13 of 24 vs. 6 of 24 in Experiment 2), $\chi^2(1, N=48) = 4.27, p < .05$. Most of these instances (9 of 13) involved continuing to correctly choose the “I don’t know” bucket.

There was no evidence that provision of corrective feedback improved the performance of either age group. Mean number of correct selections on unfamiliar label trials was actually somewhat lower than in Experiment 1 for both 3-year-olds (1.92 vs. 2.29) and 4-year-olds (3.04 vs. 3.30), although neither of these differences was significant, $t(31.52) = 1.59, p = .12$, and $t(46) = 1.39, p = .17$, respectively. The age difference in mean number of correct selections was just as large in Experiment 2 (1.12) as in Experiment 1 (1.04). The only robust difference between the results of the two experiments is that fewer 3-year-olds in Experiment 2 than in Experiment 1 showed a tendency to switch choices from one unfamiliar label trial to the next.

Test Intercorrelations. The lower section of Table 2 summarizes children’s performance on the word knowledge judgment test and the PPVT-4. Once again four-year-olds outperformed 3-year-olds on both tasks (for word knowledge, $t(37.12) = 4.86, p < .001$; for vocabulary size (scores not standardized by age), $t(46) = 5.24, p < .001$.)

The top section of Table 5 summarizes the intercorrelations among metacognitive disambiguation, word knowledge judgment, and vocabulary size, as well as the correlation of each test with age in months. Just as in Experiment 1, all three tests were strongly correlated with age and with one another. In contrast to Experiment 1, however, there was evidence of an association between word knowledge judgment and overall metacognitive disambiguation after controlling for age and vocabulary size, partial $r(44) = .35, p < .02$. Also, in contrast to Experiment 1, there was no evidence of an association between vocabulary size and

metacognitive disambiguation after controlling for age and word knowledge judgment, partial $r(44) = -.16, p = .28$.

The lower section of Table 5 shows correlations between correct selections on each trial of the metacognitive disambiguation task and age in months, word knowledge judgment, and vocabulary size. Just as in Experiment 1, the second trial is the only one in which selection of the correct bucket was not correlated with any other measure. When performance on this trial is excluded from analysis, the partial correlations do not differ from those found when all trials were included. The total number of (other) metacognitive disambiguation trials correct is correlated with word knowledge judgment even after age and vocabulary size are statistically controlled, partial $r(44) = .37, p < .02$, and there was no evidence of an association between this score and vocabulary size, after age in months and word knowledge judgment were controlled, partial $r(44) = -.17, p = .25$.

Discussion

The results of Experiment 1 were replicated. The majority of 4-year-olds showed a metacognitive disambiguation effect while the majority of 3-year-olds did not. Older children once again demonstrated an ability to produce the disambiguation effect in a situation in which they could not retrieve labels for any of the choice objects. The children who succeeded in this task are believed to have done so by comparing metacognitive representations. That is, they rejected the objects that they represented as ones “I know” as referents of a label “I don’t know” in favor of objects they represented as ones “I don’t know.”

The results provided no support for the suggestion that 3-year-olds' performance in the metacognitive disambiguation task in Experiment 1 was negatively affected by the experimenter's lukewarm, uninformative reaction to their choices. They performed just as

poorly in the current experiment, despite the experimenter telling them after every trial whether they had made the correct choice.

Compared to Experiment 1, 3-year-olds showed a weaker tendency to switch their selections from one unfamiliar label trial to the next and a stronger tendency to make two consecutive incorrect selections on unfamiliar label trials. This age group appears to be influenced by an expectation that whichever of two choices is correct on one trial will be incorrect on the next. In Experiment 1, where no feedback was provided, the children likely believed that the “I know” bucket that they had selected on an unfamiliar label trial was correct, or at least did not believe that it was incorrect, and therefore switched to the “I don’t know” bucket on the next unfamiliar label trial. In Experiment 2, children who selected the “I know” bucket for the unfamiliar label may have learned from the corrective feedback that this had been the wrong choice, and so picked it again on the next trial believing that it would now be the correct choice.

There was no evidence that providing feedback caused those children who responded correctly on the very first trial to perform any differently on the next trial than they had in Experiment 1. The proportion of these children who switched to the incorrect “I know” bucket on the second trial was no different in the two experiments, which is consistent with the notion that even among these children, some expect that the correct bucket on the second trial will be whichever bucket was not the correct one on the first trial. In both experiments, this switch expectation would lead those who had responded correctly on the first trial to select incorrectly on the second trial.

The association that was found in Experiment 1 between word knowledge judgment and successful performance on the very first trial of the metacognitive disambiguation task was

replicated in Experiment 2. In contrast to the results of the first experiment, however, receptive vocabulary size was not significantly associated with first trial performance. Because the procedure on the very first trial in this experiment was identical to that of the first trial in Experiment 1, this finding cannot be explained by the provision of corrective feedback. It may just reflect sampling error.

Just as in Experiment 1, performance on the second trial of the metacognitive disambiguation task was not correlated with word knowledge judgment. Regarding this finding in Experiment 1, I had argued that the attenuation in the correlation could be due to children's expectation that the correct response would switch from one trial to the next. The replication of the attenuation is evidence that it is primarily due to the negative influence of this switch expectation on those who selected correctly on the first trial. Because corrective feedback was provided, those who selected incorrectly on the first trial should also have tended to select incorrectly on the second trial. Thus, the responses of these children are unlikely to account for the attenuation in the correlation.

The attenuation must be due to the influence of the switch expectation among those who selected correctly on the first trial. Moreover, it must be due to those in this group who performed well on the test of word knowledge judgment; otherwise the correlation between word knowledge judgment and metacognitive disambiguation performance would not have declined from the first trial to the second trial. Although it is likely that these children used metacognitive representations to guide their correct responses on the first trial, the expectation that the other bucket would be correct on the next trial must have counteracted their tendency to use metacognitive representations to guide their choice on the next trial.

Just as in Experiment 1, word knowledge judgment was also correlated with metacognitive disambiguation on the final two trials, even after statistically controlling for receptive vocabulary and age. There was no evidence that the switch expectation had any influence over the more metacognitively advanced children on these final two trials. Corrective feedback is unlikely to account for this finding because the same finding was obtained in Experiment 1, where no corrective feedback was provided. The contrast between the familiar name mapping problem on the third trial and the novel name mapping trials that preceded and followed it may have strengthened these children's tendency to use metacognitive representations to guide their choices on the final two novel name mapping trials.

In contrast to Experiment 1, receptive vocabulary size was not correlated with metacognitive disambiguation on either of the final two trials, or with the first, third, and fourth trials combined, after controlling for age and word knowledge judgment. It is not clear why these particular results from Experiment 1 did not replicate. Sampling error may have been a contributing factor. These results in contrast to the consistent finding of a distinctive correlation between word knowledge judgment and metacognitive disambiguation across the two experiments. This consistent finding supports the hypothesis that a child's tendency to decide that a novel label denotes some object "I don't know" rather than some object "I know" depends on the child's ability to reflect on whether various words are ones "I know".

General Discussion

Very few 3-year-olds demonstrated an ability to map a novel label (e.g., “zav”) onto an unfamiliar, as-yet-un-nameable object (e.g., tomato corer) in a situation in which they could not retrieve labels for any potential referents, whereas the majority of 4-year-olds successfully resolved this ambiguity. While previous work has shown that even children as young as 16 months old succeed in the standard disambiguation paradigm (Halberda, 2003; Markman et al., 2003; Mervis & Bertrand, 1994), no previous research has studied the disambiguation effect in a task in which access to the labels of familiar objects is blocked. We propose that this age difference in metacognitive disambiguation can be explained by development of the ability to spontaneously represent objects, as well as labels, as known or unknown.

According to both the Mutual Exclusivity (Markman & Wachtel, 1989; Merriman & Marazita, 1995) and Pragmatic Contrast accounts (Clark, 1990; Diesendruck & Markson, 2001; Gathercole, 1989), in order for children to map a novel label onto an unfamiliar, as-yet-un-nameable object, they must reject the already-nameable object as a potential referent of that label (Halberda, 2003; 2006). Neither of these accounts are specific about the processes that occur in order to make a name mismatch decision. Previous work has suggested that as children get older they may rely less on a comparison of the phonological representation of a familiar object’s name to that of a novel name because they can spontaneously represent objects and labels as “ones I know” or “ones I do not know” (Marazita & Merriman, 2004; Wall et al., 2015).

Both of the current experiments provided support for this hypothesis. A significant age difference was evident in judgments of whether isolated words were known, which is consistent with findings from previous work on the development of lexical knowledge judgment (Chaney, 1992; Merriman et al., 2008; Smith & Tager-Flusberg, 1982). Furthermore, children’s accuracy

in word knowledge judgment was found to account for variance in three of four trials of metacognitive disambiguation, even after controlling for vocabulary size and age, in both experiments.

Some accounts of the standard disambiguation effect do not leave open the possibility that reasoning about the metacognitive representations of names may play a role. Models of competitive activation (McMurray et al., 2012; Merriman, 1999; Regier, 2005) suggest that the disambiguation effect simply occurs by way of connections formed between labels and objects resulting from a child's interaction with his or her world over time. These connections cause a child's representation of a novel label to generate more activation for an unfamiliar object than for a familiar one. These connectionist models could account for the age trend found in the standard disambiguation effect (Lewis & Frank, 2015; Merriman, Marazita, & Jarvis, 1995). Older children simply have more experience with names and objects, which could lead to stronger excitatory and inhibitory connections between representations. However, these models do not account for the age trend in the metacognitive disambiguation effect, nor the the positive correlation between the accuracy of word knowledge judgment and the strength of the metacognitive disambiguation effect.

Our proposal that a metacognitive representation of the disambiguation problem develops around four years of age is consistent with research showing advancements in many aspects of metacognition and theory of mind around the same age. There is substantial evidence that children do not begin to understand that different mental state terms (e.g., think, know, guess) denote varying levels of certainty until age four (Johnson & Wellman, 1980; Moore, Furrow, Chiasson, & Patriquin, 1994; Shatz, Wellman, & Silber, 1983). The development of mental language production and comprehension also coincides with the development of other theory of

mind achievements like the understanding of false belief (Gopnik & Astington, 1988; Wimmer & Perner, 1983). In addition to advancement in children's monitoring of certainty during the preschool years, there is evidence of significant development in their monitoring of uncertainty. Lyons and Ghetti (2011) found that older preschoolers were more confident in their correct responses and less confident in their incorrect responses than younger preschoolers were in tasks involving perceptual and lexical identification.

The development of metacognitive representations may also help explain the age-related increase in the strength of the standard disambiguation effect. While this effect has been demonstrated in children as young as sixteen months, there is substantial evidence that it increases in both strength and consistency as children get older. In a meta-analysis examining 20 peer-reviewed papers in children aged 16 to 61 months, the median correlation between the strength of the disambiguation effect and age was .54 (Lewis & Frank, 2015). Merriman and Schuster (1991) suggested that this relation is due to age-related increases in reflective awareness and theory of mind allow children to more quickly and efficiently recognize objects and labels as known or unknown.

It is possible that the non-metacognitive processes that have been proposed to account for the standard disambiguation effect by the leading accounts (e.g., retrieving the name of the familiar object and noting its mismatch with the novel label) become faster and more reliable with age. However, increased metacognitive awareness may also play a role in providing a quicker, more reliable route for the standard disambiguation effect to occur. Rather than relying on processes such as name retrieval and name mismatch detection, older children may be able to bypass them by spontaneously representing the epistemic status (known or unknown) of the novel label and the two choice objects. Our results are consistent with Merriman and Schuster's

(1991) proposal that the increase in strength of the disambiguation effect with age may at least be partly due to increases in theory of mind and metacognitive awareness.

Although we claim that the metacognitive disambiguation effect is a four-year-old achievement, some research does show that children as young as three-years-old can reflect on their own uncertainty and use that information to guide future behavior. Lyons and Ghetti (2013) found that when permitted to abstain from responding, three-year-olds gave significantly more accurate responses than inaccurate ones and were more likely to express higher confidence for accurate responses as compared to inaccurate ones. Another study found that three-year-old children were more likely to ask for help from an adult on questions for which they reported being less confident and less likely to seek help on the trials for which they reported high confidence (Coughlin, Hembacher, Lyons, & Ghetti, 2015).

It is possible that the younger children we tested were indeed aware of their own uncertainty in the task but failed to use this information to guide their behavior. A potential limitation of our method is that perhaps three-year-olds were not given enough training on which bucket contained the objects with known and which bucket contained the ones with unknown labels. Children might be surprised to hear a word they do not know (e.g., zav), and younger children might not be able to overcome this unexpected confusion and successfully complete the task until the later trials. Ghetti, Hembacher, and Coughlin (2013) propose that repeated exposure to uncertain situations may encourage reflection on one's own uncertainty. This would suggest that children's performance might improve as they complete more trials. Furthermore, the presence of a familiar label trial in our task may highlight the contrast between their certainty and uncertainty and cause them to realize that the presentation of a novel label brings about a different metacognitive experience than that of a familiar label. This might help explain why we

found young children to perform significantly better on the trials following the familiar label trial.

Another limitation of our method is that we only used one measure of lexical knowledge judgment. We used the word familiarity judgment task as our measure of awareness of lexical knowledge, but another task used to measure this awareness is the object nameability judgment task. In this task, children see familiar and unfamiliar objects and must provide a simple “yes” if it is an object they know and “no” if it is an object they do not know. Because success on our metacognitive disambiguation task depends on the representation of objects as well as labels, future research should examine the relationship between both measures of lexical knowledge judgment and metacognitive disambiguation. The combination of these measures may account for more variance in metacognitive disambiguation on all trials.

To more accurately assess three-year-olds’ understanding of the task, future studies might provide extensive training before administering the test trials. For example, one might advise these younger children that they are going to see a “zav” or a “blicket” and then ask them whether it is a word they know. Embedding this judgment of lexical knowledge in the task itself may help younger children to notice that a label they do not know should correspond with the bucket of objects they do not know.

Another potential future direction is to use eye-tracking to get a more complete depiction of the processes that are critical to succeeding in this task. The use of eye-tracking helped lead to the discovery that in a disambiguation task, children who happen to be looking at the unfamiliar object when a novel label is uttered will “double-check” and look back at the familiar object, rejecting it as a referent of the novel label (Halberda, 2006). While eye-tracking would not be used in our task to identify a pattern of label rejection, it could be helpful in determining

the process by which children conclude that a bucket contains the referent of a label that is uttered. One might predict that children with higher awareness of their knowledge would be more likely to look at the “I don’t know” bucket and continue looking there until they responded while those with lower awareness of their own knowledge might switch from one bucket to the other repeatedly, perhaps waiting for one of the buckets to evoke some sort of feeling of familiarity.

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Figure 1. Familiar objects to be sorted into buckets.

Figure 2. Unfamiliar objects to be sorted into buckets.

Figure 3. Buckets used to sort familiar and unfamiliar objects in the metacognitive disambiguation task.

Table 1. Number of correct responses on the metacognitive disambiguation task in Exp. 1.

TRIAL	3-YEAR-OLDS			4-YEAR-OLDS		
	0	1	2	0	1	2
1 st Unfam.	12	12	—	3	21	—
2 nd Unfam.	11	13	—	10	14	—
Total	1	21	2	0	13	11
Fam.	1	23	—	0	24	—
3 rd Unfam.	5	19	—	1	23	—
4 th Unfam.	13	11	—	3	21	—
Total	0	18	6	0	3	21

Table 2. Mean scores (SD) on tests in Exp. 1 and Exp. 2.

TEST	3-YEAR-OLDS	4-YEAR-OLDS
EXP. 1		
Word Knowledge Judgment ^a	.57 (.15)	.96 (.10)
PPVT-4 ^b	62 (12)	82 (13)
EXP. 2		
Word Knowledge Judgment ^a	.69 (.21)	.93 (.12)
PPVT-4 ^b	61 (11)	79 (12)

^a Proportion of judgments correct   ^b Raw score

Table 3. Test intercorrelations in Exp. 1.

	1	2	3	4
1. Metacognitive Disambiguation	--	.66**	.68**	.79**
2. Age (months)		--	.79**	.75**
3. Word Knowledge Judgment			--	.72**
4. PPVT – 4				--
Metacognitive Disambiguation: 1 st Trial	---	.33*	.43**	.40**
2 nd Trial	---	.09	.02	.20
3 rd Trial	---	.30*	.33**	.36**
4 th Trial	---	.36*	.36*	.40**

Notes – $df = 48$ for all correlations ** two-tailed $p < .01$ * two-tailed $p < .05$

Table 4. Number of correct responses on the metacognitive disambiguation task in Exp. 2.

TRIAL	3-YEAR-OLDS			4-YEAR-OLDS		
	0	1	2	0	1	2
1 st Unfam.	16	8	—	8	16	—
2 nd Unfam.	15	9	—	13	11	—
Total	11	9	4	5	11	8
Fam.	3	21	—	1	23	—
3 rd Unfam.	8	16	—	1	23	—
4 th Unfam.	11	13	—	1	23	—
Total	4	11	9	0	2	22

Table 5. Test intercorrelations in Exp. 2.

	1	2	3	4
1. Metacognitive Disambiguation	--	.61**	.60**	.40**
2. Age (months)		--	.69**	.70**
3. Word Knowledge Judgment			--	.64**
4. PPVT – 4				--
Metacognitive Disambiguation: 1 st Trial	---	.37*	.55**	.25
2 nd Trial	---	.25	.18	.18
3 rd Trial	---	.36*	.30*	.29*
4 th Trial	---	.48**	.39**	.25

Notes – $df = 48$ for all correlations ** two-tailed $p < .01$ * two-tailed $p < .05$