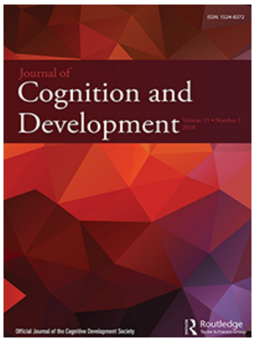

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The metacognitive disambiguation effect

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ABSTRACT

From an early age, children show a tendency to map novel labels onto unfamiliar rather than familiar kinds of objects. Accounts of this tendency have not addressed whether children develop a metacognitive representation of what they are doing. In 3 experiments (each N = 48), preschoolers received a test of the *metacognitive disambiguation effect*, which involved deciding whether the referent of a novel label was located in a bucket of things "I know" or bucket of things "I don't know." Most 4-year-olds passed this test, whereas most 3-year-olds did not. Children's performance was predicted by their ability to report whether various words and pseudowords were ones that they knew, even after age and vocabulary size were controlled. As children develop an awareness of their lexical knowledge/ignorance, they also develop a metacognitive representation of their tendency to map novel labels onto unfamiliar rather than familiar kinds.

A fundamental problem that children must solve whenever they hear a label is that of identifying its intended referent. Although a speaker's gaze and gesture can help children solve this problem, these cues are not always present. Even if these cues are present, children may not always detect them or find them to be precise enough to single out the referent. 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 (Yurovsky, Smith, & Yu, 2013), many of their object references occur outside of such goal-directed one-on-one interactions. In these other contexts, children's attention may focus on some object other than the intended referent of a label (Yu & Smith, 2013).

When speaker cues to the reference of a novel label are absent or unclear, children tend to select an unfamiliar rather than a familiar kind of object as the label's referent. Even children as young as 16 months old show this tendency (Halberda, 2003; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1994). Although this solution is not always correct (i.e., the intended referent could be an object that the child can already label), it is correct more often than not (Markman, 1984; Merriman, 1986). This solution, which Merriman and Bowman (1989) called the *disambiguation effect*, may play an important role in children's word learning.

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Researchers do not agree on why children show this effect. According to the mutual exclusivity account, children's default assumption is that the extension of one label will not overlap with the extension of another (Markman & Wachtel, 1989; Merriman & Marazita, 1995). According to this account, the effect depends on representing the known label for the familiar object as not matching the novel label and then rejecting the familiar object because of this mismatch. The account does not specify how the child makes this mismatch decision. It is most likely based on the child detecting the dissimilarity between a phonological representation of the label for the familiar object (e.g., "cup" for a cup) and a phonological representation of the novel label (e.g., "zav"; Jarvis, Merriman, Barnett, Hanba, & Van Haitsma, 2004; Merriman & Marazita, 1995). However, children might also detect a mismatch between *metacognitive representations* of the familiar object and the novel label. That is, they might note that the familiar object has a name "I know" whereas the novel label is a name "I don't know." Detection of the mismatch between *metacognitive representations* (codings of entities for whether or not they are known) may reinforce the decision to reject the familiar object as the referent of the novel label.

According to the pragmatic contrast account of the disambiguation effect, children expect speakers to be cooperative. One implication is that if a speaker wants to refer to something, the speaker will use a mutually known way of making this reference, if one exists (Clark, 1990; Diesendruck & Markson, 2001; V. C. Gathercole, 1989). For example, if the two potential referents of "zav" in a situation are a cup and an unfamiliar kind of object, the child will reason that if the speaker had wanted the cup, she would have asked for the "cup." 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 also leaves open the question of the types of representations that the child consults when deciding that the novel label mismatches the known label for the familiar object.

Not all accounts of the disambiguation effect can accommodate a possible role for metacognitive representations as readily. Various competitive activation accounts (McMurray, Horst, & Samuelson, 2012; Merriman, 1999; Regier, 2005), for example, have considered the effect to be an emergent property of the excitatory and inhibitory connections among representations. These connections formed from having heard various labels used for various objects in the past. Because of these connections, the presentation of a novel label simply causes a child's representation of a novel object to receive more activation than his or her representation of the familiar object. These accounts do not posit a process whereby the child decides that a representation of the novel label does not match a representation of the known label for the familiar object.

Based on the findings of research on children's judgment of their own lexical knowledge/ignorance, we proposed that an ability to make name mismatch decisions based on metacognitive representations develops during the preschool years. When asked to judge whether various words and pseudowords (e.g., *zav*) are words that they know, 2- and 3-year-olds often said that they knew the pseudowords, whereas 4-year-olds rarely made this mistake (Chaney, 1992; Merriman, Lipko, & Evey, 2008; Merriman & Schuster, 1991; Smith & Tager-Flusberg, 1982). A similar trend has been found with respect to children's tendency to report that they know names for unfamiliar kinds of objects (Marazita & Merriman, 2004; Merriman & Lipko, 2008; Merriman et al., 2008; Wall, Merriman, & Scofield, 2015). Because younger preschoolers often fail to identify novel labels and novel objects as ones they do not know, it is unlikely that they would represent the disambiguation problem as one in which they must choose between an object they know and an object they do not know as the referent for a label they do not know.

Merriman and Schuster (1991) found that 4-year-olds who tended to say, "No," when asked, "Do you know what a(n) [novel label, e.g., a zav] is?" mapped the label to an unfamiliar rather than familiar kind of object more frequently than 4-year-olds who tended to say, "Yes," or not respond to the question. Merriman and Bowman (1989) conducted several disambiguation studies in which every trial began with children being asked whether they knew the novel test label. Children who tended to say, "Yes," or not respond to the question still showed a significant disambiguation effect. However, Merriman and Bowman did not examine the relation between how often children answered the "do you know" question correctly and how often they mapped the novel label to the unfamiliar rather than the familiar object. We had access to these data and calculated these correlations. In the first two studies, the average correlation coefficient for the older preschoolers (Experiment 1, 4-year-olds, N = 12; Experiment 2, 3.5-year-olds, N = 16) was .48 (p = .008). In the third study, nearly every 4-year-old mapped the label onto the unfamiliar object on every trial, and so the correlation was not computed. In each of two studies by Wall et al. (2015), the accuracy of 3- and 4-year-olds' judgments of whether they knew names for various objects was found to predict the strength of their disambiguation effect in a cross-modal paradigm.

This consistent finding, that lexical knowledge judgment is positively associated with the strength of the disambiguation effect, suggests that once children have become capable of reporting their lexical knowledge/ignorance accurately, they might also show a purely metacognitive form of the disambiguation effect. That is, they might tend to map novel labels to novel rather than familiar objects even in a situation in which the only information available about the objects was whether or not they had known labels. The goal of the current investigation was to test this prediction.

Research on children's ability to justify the disambiguation effect has also been consistent with this prediction. In Merriman and Bowman (1989, Experiment 4), whenever children selected a novel object over a familiar object as the referent of the novel label, they were asked, "Why did you pick this object? How did you know that it was a [the novel label, e.g., zav]?" Merriman and Schuster (1991) conducted an analysis on how the children in the experiment responded to this probe. Children aged 2.5 years either did not respond or pointed out some property of the unfamiliar object. In contrast, many 4-year-olds pointed to the familiar object and said, "Because that one is a [familiar label, e.g., cup]." Moreover, the 4-year-olds who offered this justification showed a stronger tendency than the other 4-year-olds to have acknowledged their ignorance of the label before they were asked to map it. Marazita and Merriman (2004) extended this last result and found that 4-year-olds who tended to offer this justification also tended to respond accurately when asked whether various words and pseudowords were ones they knew and whether various objects were ones for which they knew names.

In the current investigation, we examined whether 3- and 4-year-olds might show a purely metacognitive disambiguation effect. The experimenter assisted the child in sorting objects into two buckets based on whether the objects had labels that the child knew. They put all the familiar objects into the "I know" bucket and all of the unfamiliar objects into the "I don't know" bucket. The experimenter then asked the child to recall the names of the objects in the "I know" bucket. Based on research on preschoolers' free-recall ability (Perlmutter & Myers, 1979; Perlmutter & Ricks, 1979; Perlmutter, Sophian, Mitchell, & Cavanaugh, 1981), we expected the children to recall at most only a few of these names. For any name that a child did recall, however, the experimenter removed its corresponding object from the bucket and then removed a similar number of objects from the "I don't know" bucket. This procedure ensured that children would be unlikely to spontaneously recall the names for any of the objects that remained in the buckets and that each bucket had the same number of objects. The experimenter then presented several trials in which he said that he had seen a "zav" (or some other pseudoword) in one of the buckets and asked the child to decide which bucket it was.

Children were credited with showing the metacognitive disambiguation effect if they chose the "I don't know" bucket more often than the "I know" bucket. Because they had failed to freely recall the names of any of the remaining objects in the "I know" bucket, it was unlikely that they would reject this bucket simply by noting the mismatch between the novel label and a name that they spontaneously recalled for one of the objects in this bucket. That is, it was unlikely that they could use phonological representations of the known labels that they might have retrieved for objects in the "I know" bucket to inform their decision.

Based on 4-year-olds' greater reflective awareness of their lexical knowledge (Marazita & Merriman, 2004; Merriman et al., 2008; Smith & Tager-Flusberg, 1982) and greater ability to justify the disambiguation effect (Marazita & Merriman, 2004), we predicted they would show a stronger metacognitive disambiguation effect than would 3-year-olds. More importantly, we predicted that the accuracy of children's judgments of whether various words were ones they knew would predict the strength of their metacognitive disambiguation effect, even after controlling for age and vocabulary knowledge.

The three experiments provided children with increasingly informative feedback about their performance in the metacognitive disambiguation task. In Experiment 1, after every trial, the experimenter simply accepted whatever choice the child had made. In Experiment 2, the experimenter responded to each choice by indicating whether it was correct. In Experiment 3, the experimenter not only responded this way, but took an object from the "I don't know" bucket and indicated that it was the zav (or whatever the novel label had been) and then took an object from the "I know" bucket and identified it by its familiar label.

Experiment 1

Method

Participants

Twenty-four 3-year-olds (M_{age} = 3;7, range = 3;0–3;11; 12 boys) and 24 4-year-olds (M_{age} = 4;6, range = 4;0–4;11; 12 boys) participated. Five other children were excluded due to a general failure to follow directions on the tasks. One child followed directions on all but the word knowledge judgment task. Her data for the other tasks were included in analyses. The children 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) and eight objects that preschoolers were unlikely to be able to name (steel nutcracker, pipe cutter, whisk, egg slicer, staple remover, hose connector, cleat wrench, tomato corer). Two 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 1). The Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was also used.

Procedures

The experimenter and the child sat at a small table in a quiet room at the child's preschool. After establishing rapport, the experimenter administered the metacognitive disambiguation task, word knowledge judgment task, and the PPVT-4. The order of the first two tasks was counterbalanced; the PPVT-4 was always last. The session lasted approximately 25 min.

Figure 1. Buckets used in the metacognitive disambiguation task.

Metacognitive disambiguation. The buckets were placed in front of the child. The left–right position of the buckets was counterbalanced across participants within each age group. After telling the child that they were going to play a game, the experimenter pointed to the pictures on the front of the buckets and 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." All the objects were presented one at a time. For each object, 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's not what that's 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 (known or unknown) never occurred more than three times in a row. Two random orders were used. Order was counterbalanced across participants within each age group.

Whenever a child chose the appropriate bucket, the experimenter put the object in the bucket, while saying, "So that goes in the 'I know'/'I don't know' bucket." Twenty-two 4-year-olds and 17 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.

A four-trial distractor task was administered to clear the children's working memory of the labels that they had just uttered. On each trial of the distractor task, the child was asked to report the number of fingers that the experimenter held up. The experimenter then 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. (Looking at the 'I know' bucket) Can you remember any of the things in here? These were the ones you know." Children recalled very few objects, although 4-year-olds recalled more than 3-year-olds (M = 1.67 and 0.83, respectively), $t(46) = 3.43$, $p = .001$. No child recalled more than three objects. Whenever a child recalled an object, the experimenter said, "OK, let's get rid of that one (removing it from the 'I know' bucket). And since we are taking one of out of that bucket, let's take one out of this bucket too (removing a randomly selected object from the 'I don't know' bucket)."

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 metacognitive disambiguation test. He said, "OK, so now we have (e.g., five) things in this bucket and the same number in that 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 the target words were nonsense words (*blicket, zav, tigg*, and *mido*), except for the target word on the third trial, 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. Although 17 children recalled the familiar label that had been tested in the third trial (i.e., *block*), only 2 children recalled any other object in the buckets. Finally, to see whether children could justify 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 10 words. Five were familiar words (*shoe, dog, truck, chair, house*), and 5 were nonsense words (*hust, mave, gock, prad, blim*). See Hartin, Stevenson, and Merriman (2016) for further details about the procedures involved in this task.

Results

Metacognitive disambiguation

Four-year-olds’ mean number of correct responses on the novel-label trials (M = 3.33 out of 4, SD = 0.64) was significantly greater than that of 3-year-olds (M = 2.29, SD = 0.46), $t(46) = 6.47$, $p < .001$, $d = 1.87$. Although the 3-year-olds’ mean number exceeded chance, $t(23) = 3.08$, $p = .005$, the majority of children in this age group (17 of 24) made only two correct selections. Sixteen showed a consistent switching pattern. From both the first to the second novel-label trial and from the third to the fourth novel-label trial, they changed the bucket that they selected. So, if they chose correctly on one trial, they chose incorrectly on the next trial, and vice versa. In contrast, only two 4-year-olds showed this pattern.

Table 1 summarizes the number of children who responded correctly (score = 1) or incorrectly (score = 0) on each trial. It also summarizes the number of children who made zero, one, or two correct responses on the first two and final two novel-label trials. The first trial is of special significance because it could not be affected by either a switching bias or a reaction to how the experimenter had responded to a previous selection. On the first trial, 3-year-olds performed no better than chance (12 of 24 correct), whereas nearly every 4-year-old chose correctly (21 of 24), $\chi^2(1, N = 48) = 7.85$, $p < .01$, $\Phi = .40$.

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

	3-year-olds			4-year-olds		
Trial	0	1	2	0	1	2
First Novel	12	12	__	3	21	__
Second Novel	11	13	__	10	14	__
Total	1	21	2	0	13	11
Familiar	1	23	__	0	24	__
Third Novel	5	19	__	1	23	__
Fourth Novel	13	11	__	3	21	__
Total	0	18	6	0	4	20

On the second trial, which was also a novel-label trial, neither age group showed a significant tendency to select the “I don’t know” bucket. On this trial, nearly every 3-year-old selected whichever bucket they had not selected in the previous trial. Among 4-year-olds, about as many switched (13) as selected the same bucket again (11). The number of 4-year-olds who choose correctly on both trials (11) was significantly above chance (6), χ^2 (1, N = 24) = 5.56, $p < .02$.

On the lone familiar-label trial, which occurred next, nearly every child chose the “I know” bucket. On the next trial, which was the third novel-label trial, nearly every child also chose correctly. Success on this trial was 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. On the final novel-label trial, 13 of the 19 3-year-olds who had selected correctly on the third novel-label trial switched to the incorrect “I know” bucket. The 5 3-year-olds who had not selected correctly on the third novel-label trial switched to the correct “I don’t know” bucket. In contrast, nearly every 4-year-old who chose correctly on the third novel-label trial also chose correctly on the final novel-label trial.

After the final trial, the children were asked to justify their choice of the “I don’t know” bucket for one of the novel labels. Most either did not respond or gave an uninformative answer (e.g., “Because I’m smart”). Only five children mentioned not knowing the label or the answer (e.g., “Because I didn’t know blicket”).

Test intercorrelations

Table 2 summarizes performance on the other tests. Four-year-olds outperformed 3-year-olds on both word knowledge judgement, $t(31.07) = 12.13$, $p < .001$, and PPVT-4 (scores are not standardized by age), $t(46) = 5.52$, $p < .001$.

Table 2. Mean scores (*SD*) on tests in Experiment 1, Experiment 2, and Experiment 3.

Test	3-Year-Olds	4-Year-Olds
Experiment 1		
Word Knowledge Judgment[a]	0.57 (0.15)	0.97 (0.06)
PPVT-4[b]	62 (12)	82 (13)
Experiment 2		
Word Knowledge Judgment[a]	0.71 (0.22)	0.93 (0.12)
PPVT-4[b]	61 (11)	79 (12)
Experiment 3		
Word Knowledge Judgment[a]	0 .69 (0.19)	0.91 (0.14)
PPVT-4[b]	58 (7)	76 (9)

Note. PPVT-4 = Peabody Picture Vocabulary Test-Fourth Edition. [a] Proportion of judgments correct. [b] Raw score.

Table 3. Test intercorrelations in each experiment.

	Experiment 1			Experiment 2			Experiment 3		
	1	2	3	1	2	3	1	2	3
1. Age (months)	—	.80**	.76**	—	.65**	.66**	—	.61**	.84**
2. Word Knowledge Judgment		—	.72**		—	.58**		—	.56**
3. PPVT-4			—			—			—
4. Metacognitive Disambiguation: Overall	.68**	.73**	.82*	.57**	.56**	.31*	.56**	.56**	.43**
First Trial	.33*	.45**	.40**	.32*	.51**	.15	.31*	.33*	.36*
Second Trial	.09	.03	.21	.20	.12	.10	.22	.07	.12
Third Trial	.30*	.34*	.36*	.34*	.29*	.25	.45*	.38**	.30*
Fourth Trial	.36*	.38**	.41*	.50**	.41**	.27	0.14	.36**	.08

Note. PPVT-4 = Peabody Picture Vocabulary Test-Fourth Edition. *df* = 45 for Experiments 1 and 3; *df* = 43 for Experiment 2.
**two-tailed $p < .01$.
*two-tailed $p < .05$.

Table 3 summarizes intercorrelations for age (in months), word knowledge judgment, vocabulary size, and metacognitive disambiguation. All these measures were strongly correlated with one another. As predicted, word knowledge judgment was positively associated with metacognitive disambiguation. Although both age and vocabulary size were also associated with metacognitive disambiguation, a significant association between word knowledge judgment and metacognitive disambiguation remained after controlling for these other variables, partial $r(43) = .31$, $p = .036$. Vocabulary size was also associated with metacognitive disambiguation after controlling for age and word knowledge judgment, partial $r(43) = .59$, $p < .001$.

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 trial in which correct selection was not correlated with any of the other measures. When performance on this trial was excluded, the association between metacognitive disambiguation and word knowledge judgment after controlling for age and vocabulary size, partial $r(43) = .57$, $p < .001$, was as strong as the association between metacognitive disambiguation and vocabulary size after controlling for age and word knowledge judgment, partial $r(43) = .60$, $p < .001$.

Discussion

As predicted, most 4-year-olds showed the metacognitive disambiguation effect and most 3-year-olds did not. More importantly, the accuracy of children's word knowledge judgments predicted the strength of this effect, even after age and vocabulary size were statistically controlled. These findings are consistent with our proposal that as children develop a reflective awareness of their lexical knowledge/ignorance, they become capable of solving a purely metacognitive form of the disambiguation problem.

On back-to-back novel-label trials, most 3-year-olds and some 4-year-olds showed a tendency to choose whichever bucket they had not selected on the previous trial. This switching tendency cannot account for the age difference in performance on the very first novel-label trial or the positive correlation between performance on this trial and lexical knowledge judgment. However, some children's switching tendency may have prevented them from showing learning from exposure to multiple examples of the metacognitive disambiguation problem or the opportunity to contrast the familiar-label trial with the novel-label trials.

Switching may have been a reaction to the experimenter's feedback. On every trial, regardless of the bucket that the child had chosen, the experimenter responded by simply saying, "OK" or "Good." Children may have interpreted this lack of a strong confirmation as indicating that they might have picked the wrong bucket, and so they switched to the other bucket on the next trial. Another possibility is that switching reflected an expectation that children have when repeatedly asked to choose from a fixed set of options (e.g., as in some guessing games). They may have a bias, whether instinctive or learned, to expect the correct choice to change from request to request.

Neither age group showed a switching pattern on the familiar-label test trial. Even among those 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." Whatever the cause of the switching tendency on novel-label trials, it was not strong enough to lead children astray when mapping a familiar label. Note that children would not need to use metacognitive representations to map this label correctly. When asked which bucket contained "a 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 label "block" because this label was presented by the experimenter. They only had to recall having seen a block placed in the "I know" bucket when asked to find "a block."

Experiment 2

Experiment 2 replicated the procedures of Experiment 1, but with one change. In the metacognitive disambiguation task, children were told after every trial whether they had chosen correctly. Because the first novel-label trial was the same as in Experiment 1, we predicted that the findings for that trial would replicate. Regarding subsequent trials, if the switching tendency of Experiment 1 was caused by the experimenter's uninformative feedback, then the more informative feedback of the current experiment should have reduced this tendency. Those children who were unsure or who guessed on the first trial in the current experiment might even have learned from the feedback to select the "I don't know" bucket on novel-label trials. On the other hand, if these children did not understand the basis for the feedback (i.e., why the "I don't know" bucket was correct) or if their switching tendency was too strong, then their performance would not improve.

If children's switching tendency in Experiment 1 was due to their belief that the correct response in a game that involves choosing from a fixed set of options tends to change from one turn to the next, then children in Experiment 2 might have shown a switching tendency of a different kind. It would now involve switching away from whichever bucket they were told had been correct on the previous trial. In cases where they had picked this bucket, they would switch to the other bucket. In cases where they had picked the other bucket, they would pick it again on the next trial, believing that it would now be the correct choice.

Method

Participants

Twenty-four 3-year-olds (M_{age} = 3;6, range = 3;0–3;11; 11 boys) and 24 4-year-olds (M_{age} = 4;6, range = 4;0–4;11; 11 boys) participated. An additional child was excluded for not following directions. Three children followed directions on all but the word knowledge judgment task. Their data for the other tasks were included in the analyses. The characteristics of the sample (i.e., geographic location, ethnicity, monolingual) were the same as in Experiment 1.

Materials and procedure

The materials and procedure were the same as in Experiment 1 except for the feedback provided after every trial in the metacognitive disambiguation task. Whenever the child chose correctly, the experimenter said, "Yes, you're right!" Whenever the child chose incorrectly, the experimenter said, "Nope, it's actually in this one (pointing to the correct bucket)."

During the preparation phase of the metacognitive disambiguation task, in which the experimenter asked the children to place objects in the buckets based on whether they knew names for them, 22 4-year-olds and 10 3-year-olds chose the appropriate bucket for every object. As in Experiment 1, no child made more than two placement errors. Also as in Experiment 1, children recalled very few of the objects in the "I know" bucket, although 4-year-olds recalled more than 3-year-olds (M = 1.83 and 1.17, respectively), $t(46) = 2.29$, $p < .05$. No children recalled more than three objects. At the end of the disambiguation test, few children ($N = 5$) recalled the name of any object in the "I know" bucket other than the block.

Results

Metacognitive disambiguation

Four-year-olds' mean number of correct responses on novel-label trials ($M = 3.04$, $SD = 0.81$) was significantly greater than that of 3-year-olds ($M = 1.92$, $SD = 1.06$), $t(46) = 4.14$, $p < .001$, $d = 1.19$. Only the 4-year-olds' mean differed from chance, $t(23) = 6.33$, $p < .001$. There was no evidence that provision of corrective feedback improved performance. The mean number of correct selections on novel-label trials was actually lower than in Experiment 1, $F(1, 92) = 4.45$, $p = .038$, partial $\eta^2 = .05$. The age difference in the mean number of correct selections, $F(1, 92) = 28.17$, $p < .001$, partial $\eta^2 = .34$, was just as large in Experiment 2 (1.12) as in Experiment 1 (1.04).

Table 4 shows trial-by-trial performance. Just as in Experiment 1, fewer 3-year-olds than 4-year-olds chose correctly on the first trial, $\chi^2(1, N = 48) = 5.33$, $p < .05$. The overall number of children who chose correctly on this trial was somewhat lower than in Experiment 1, but this difference was not significant, $\chi^2(1, N = 96) = 3.50$, $p = .061$. Just as in Experiment 1, neither age group performed well on the second novel-label trial.

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

	3-year-olds			4-year-olds		
Trial	0	1	2	0	1	2
First Novel	16	8	—	8	16	—
Second Novel	15	9	—	13	11	—
Total	11	9	4	5	11	8
Familiar	3	21	—	1	23	—
Third Novel	8	16	—	1	23	—
Fourth Novel	11	13	—	1	23	—
Total	4	11	9	0	2	22

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, only 9 of 24 made this switch, $\chi^2(1, N = 48) = 12.80$, $p < .001$. Regarding those 3-year-olds who did not switch, 11 continued to select the incorrect "I know" bucket. In Experiment 1, only 1 3-year-old showed this pattern. Among 4-year-olds, the number of children who switched responses on the second trial (11) was similar to the number of children 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 chose the "I don't know" bucket on the novel-label trial that followed it. Also as in Experiment 1, nearly every 4-year-old chose this bucket again on the final trial. Among the 3-year-olds, 13 children made the same choice on the final trial as they had on the preceding trial, usually choosing the "I don't know" bucket each time. In Experiment 1, fewer 3-year-olds (6) had shown a nonswitching pattern on these trials, $\chi^2(1, N = 48) = 4.27$, $p < .05$. Finally, as in Experiment 1, when asked to justify choosing the "I don't know" bucket for a novel label, only a small number ($N = 4$) made reference to their ignorance of the label or the answer.

Test intercorrelations

As in Experiment 1, 4-year-olds outperformed 3-year-olds on both word knowledge judgment, $t(30.85) = 4.26$, $p < .001$, and PPVT-4 (scores not standardized by age), $t(46) = 5.24$, $p < .001$ (see Table 2). Age (in months) and the three tests were strongly intercorrelated (see Table 3). Critically, as in Experiment 1, the association between word knowledge judgment and metacognitive disambiguation was significant even after controlling for age and vocabulary size, partial $r(41) = .35$, $p = .023$. In contrast to Experiment 1, there was no evidence that vocabulary size was associated with metacognitive disambiguation after controlling for age and word knowledge judgment, partial $r(41) = -.19$, $p = .21$.

Just as in Experiment 1, the second trial of the metacognitive disambiguation task was the only novel-label trial in which selection of the correct bucket was not correlated with any other measure. Also just as in Experiment 1, when performance on this trial was excluded, the association between the number of metacognitive disambiguation trials that were correct and word knowledge judgment was significant even after age and vocabulary size were controlled, partial $r(41) = .37$, $p = .015$. In contrast to Experiment 1, the association between this measure of metacognitive disambiguation and vocabulary size was not significant after age and word knowledge judgment were controlled, partial $r(41) = -.18$, $p = .26$.

Discussion

The main results of Experiment 1 were replicated. Most 4-year-olds showed a metacognitive disambiguation effect and most 3-year-olds did not. The accuracy of children's word knowledge judgment predicted the strength of their metacognitive disambiguation effect, even after age and vocabulary size were controlled. Results did not support the proposal that 3-year-olds might perform better in the later trials of the metacognitive disambiguation task if they were told after every trial whether they had made the correct choice.

Fewer 3-year-olds switched selections from one novel-label trial to the next, compared with Experiment 1. However, in both experiments, they behaved as if they expected the bucket that had been correct on one novel-label trial to be incorrect on the next novel-label trial. In Experiment 1, where uninformative feedback was provided, the children who decided to select the "I know" bucket on a novel-label trial likely believed that this choice had been correct or at least did not believe that it had been incorrect, and therefore, they switched to the other bucket on the next novel-label trial. In Experiment 2, children who selected the "I know" bucket on a novel-label trial learned from the feedback that it had been the wrong choice, and so they tended to pick it again on the next trial believing that it would now be the correct choice.

Just as in Experiment 1, performance on the second trial of the metacognitive disambiguation task was not correlated with word knowledge judgment. The replication of this result means that some of the children who performed well on the word knowledge judgment task *and* who selected correctly on the first trial nevertheless switched to the incorrect "I know" bucket on the second trial. Although it is likely that their responses on the first trial were based on the use of metacognitive representations, their expectation that the correct choice would switch to the other bucket appears to have interfered with their use of metacognitive representations on the next trial.

There was no evidence that a switching bias had any influence over the more metacognitively advanced children on the final two trials. This same finding was obtained in Experiment 1, suggesting that these children's performance on these final trials was not affected by whether the experimenter provided informative feedback during the task. The contrast between the familiar-label mapping problem of the third trial and the novel-label mapping problems may have strengthened these children's tendency to use metacognitive representations to guide their choices on the final trial rather than follow a switching strategy.

Experiment 3 was conducted to see whether providing even more informative feedback might teach children to expect the referent of a novel label to be an object "I don't know" rather than an object "I know." If such teaching occurred, then unlike in Experiments 1 and 2, 4-year-olds might have shown significant disambiguation on the second novel-label trial and 3-year-olds might have shown it on the second and/or fourth novel-label trials. In Experiment 3, after every novel-label trial, the experimenter not only told children whether they had chosen correctly, but also removed one of the unfamiliar objects from the "I don't know" bucket and identified it as the correct exemplar and then removed a familiar object from the "I know" bucket and identified it by its familiar label.

Experiment 3

Method

Participants

Twenty-four 3-year-olds (M_{age} = 3;7, range = 3;3–3;11; 12 boys) and 24 4-year-olds (M_{age} = 4;7, range = 4;0–4;11; 14 boys) participated. One child followed directions on all but the word knowledge judgment task. Her data for the other tasks were included in analyses. The characteristics of the sample were the same as in Experiments 1 and 2.

Materials and procedure

The materials and procedure were the same as in Experiment 2 except for the feedback in the metacognitive disambiguation task. Whenever the child chose the "I don't know" bucket on a novel-label trial, the experimenter said, "Yes, you're right. OK, let's take it out." He then removed an unfamiliar object from the bucket, saying, "This is the [novel label]." He then said, "Let's take one out of the 'I know' bucket too." After removing a familiar object from it, he said, "This is the [the familiar object's label]." The experimenter then placed both objects out of view. Whenever the child selected the "I know" bucket on a novel-label trial, the experimenter followed the same procedure except that he first said, "Nope, it's actually in this one (pointing to the 'I don't know' bucket)." The experimenter followed a similar procedure for the familiar-label trial. After indicating whether the child's choice was correct, he removed the familiar object and said, "This is the block." He said, "Now let's take one out of the 'I don't know' bucket too." The experimenter removed an unfamiliar object from the other bucket and said, "And this is a pilson."

During the preparation phase, in which the experimenter asked children to place the objects into the two buckets, 19 4-year-olds and 16 3-year-olds made no errors. No child made more than two errors. Also as in the other experiments, children recalled very few of the objects in the "I know" bucket (M = 1.13 and 1.54 for 3- and 4-year-olds, respectively), $t(46) = 1.62$, $p = .11$. No child recalled more than three objects.

Results

Metacognitive disambiguation

Four-year-olds' mean number of correct responses on novel-label trials ($M = 3.33$, $SD = 0.87$) was greater than that of 3-year-olds ($M = 2.38$, $SD = 0.71$), $t(46) = 4.18$, $p < .001$, $d = 1.21$. Although the 3-year-olds' mean number exceeded chance, $t(23) = 2.58$, $p = .017$, the majority in this age group (14 of 24) made two or fewer correct selections.

As in the previous experiments, the number of 3-year-olds who chose correctly on the first novel-label trial was near chance, whereas the number of 4-year-olds who did so exceeded chance, $\chi^2(1, N = 24) = 5.04$, $p = .025$ (see Table 5). This age difference was significant, $\chi^2(1, N = 48) = 4.27$, $p = .039$. On the second novel-label trial, the number of 3-year-olds who chose correctly was near chance, whereas the number of 4-year-olds who did so exceeded chance (two-tailed $p = .008$). In the previous experiments, neither age group had differed from chance on this trial. The age difference on this trial in the current experiment was not statistically significant, however, $\chi^2(1, N = 48) = 3.38$, $p = .066$.

As in Experiment 1 but in contrast to Experiment 2, a significant number of 3-year-olds (18) switched in the second trial to whichever bucket they had not selected on the first trial (two-tailed $p = .024$). Also, as in Experiment 1 but in contrast to Experiment 2, the number of 4-year-olds who chose correctly on both the first and second trials (15)

Table 5. Number of correct responses on the metacognitive disambiguation task in Experiment 3.

	3-year-olds			4-year-olds		
Trial	0	1	2	0	1	3
First Novel	13	11	—	6	18	—
Second Novel	11	13	—	5	19	—
Total	3	18	3	2	7	15
Familiar	2	22	—	0	24	—
Third Novel	9	15	—	1	23	—
Fourth Novel	6	18	—	4	20	—
Total	1	13	10	1	3	20

exceeded the number that would be expected by chance (6), $\chi^2(1, N = 24) = 16.05$, $p < .001$. The current experiment was the only one in which the majority of 4-year-olds chose correctly on both the first and second trials.

As in the previous two experiments, nearly every child chose the "I know" bucket on the familiar-label trial and the majority chose the "I don't know" bucket on the novel-label trial that followed it. As in the previous experiments, the majority of 4-year-olds (20) chose this bucket again on the final novel-label trial. Among the 3-year-olds, 10 of the 15 who chose this bucket on the third trial chose it again on the final trial and 8 of the 9 who chose the "I know" bucket on the third trial switched to the "I don't know" bucket on the final trial. Thus, 18 3-year-olds chose correctly on the final trial, which was significantly greater than chance, $\chi^2(1, N = 24) = 5.04$, $p = .025$.

Regarding the final three novel-label trials, which were the only ones that could be affected by feedback, the number of correct selections in the current experiment ($M = 2.25$) was not significantly different from the number of correct selections in Experiment 2 ($M = 1.98$), $t(94) = 1.72$, $p = .089$, or Experiment 1 ($M = 2.10$), $t(94) = 0.96$, $p = .34$. As in the previous experiments, when asked why they had selected the "I don't know" bucket for one of the novel labels, all but a few ($N = 3$) either did not respond or gave an uninformative answer.

Test intercorrelations

Four-year-olds outperformed 3-year-olds on both word knowledge judgment, $t(40.88) = 4.45$, $p < .001$, and the PPVT-4, $t(46) = 7.43$, $p < .001$ (see Table 2). The three tests were again strongly correlated with age as well as with one another (see Table 3). As in the previous experiments, word knowledge judgment was associated with metacognitive disambiguation even after controlling for age and vocabulary size, partial $r(43) = .34$, $p = .021$. There was no evidence of an association between vocabulary size and metacognitive disambiguation after controlling for age and word knowledge judgment, partial $r(43) = -.12$, $p = .44$.

Once again, the second trial of the metacognitive disambiguation task was the only one in which a correct selection was not associated with any other measure. When performance on this trial was excluded, word knowledge judgment predicted metacognitive disambiguation after controlling for age and vocabulary size, partial $r(43) = .42$, $p = .004$.

Discussion

The main findings of the previous experiments were replicated. More 4-year-olds than 3-year-olds showed the metacognitive disambiguation effect. The accuracy of children's word knowledge judgment predicted the strength of the effect even after age and vocabulary size were statistically controlled.

There was evidence that the more informative feedback of the current experiment may have increased the strength of the metacognitive disambiguation effect. For 4-year-olds, the improvement was limited to the second trial; the disambiguation effect was at ceiling on the third and fourth novel-label trials in every experiment. For the 3-year-olds, the improvement was limited to the fourth novel-label trial. Because the feedback paired each type of label (novel and familiar) with its corresponding kind of object (unfamiliar and familiar) and corresponding bucket ("I don't know" and "I know"), some of the children may have learned from this feedback to expect that a novel label would denote an object "I don't know" rather than an object "I know." However, it is important to note that about half the 3-year-olds who chose the "I don't know" bucket on the final trial had chosen the "I know" bucket in the preceding novel-label trial. These children may have just chosen correctly in the final trial because they were following a switching strategy. The majority of 3-year-olds (14 of 24) made at least one error in the final two trials.

General discussion

In every experiment, more 4-year-olds than 3-year-olds showed the metacognitive disambiguation effect. Also, in every experiment, our prediction that word knowledge judgment would account for variance in the strength of this effect, even after age and vocabulary size were statistically controlled, was confirmed. These results support our claim that as children develop a reflective awareness of their lexical knowledge/ignorance, they also develop a metacognitive representation of their tendency to map novel labels onto unfamiliar rather than familiar kinds.

Regarding 3-year-olds, we must be careful not to conclude the null hypothesis. It is possible that something about our procedure interfered with the expression of the metacognitive disambiguation effect in this group. One cannot argue, however, that these children had no understanding of how the objects in the "I know" bucket differed from those in the "I don't know" bucket. During the preparation phase, they correctly sorted the objects into the two buckets. Although they showed a switching tendency on consecutive test trials, which could have interfered with their using metacognitive representations, they did not tend to select the "I don't know" bucket over the "I know" bucket in the very first trial in any experiment.

There was evidence that a minority of 3-year-olds learned to produce the metacognitive disambiguation effect by the final two novel-label trials, despite the possible interfering effect of a switching expectation. In the three experiments combined, 25 3-year-olds chose correctly on both of these trials, whereas only 5 chose incorrectly on both of them. (The remaining 42 chose one of two correctly.) The chi-square for the observed distribution of these two extreme scores (2 and 0), given both are equally probable by chance, was 12.04 (p = .0005). It is much more likely that about 25% of 3-year-olds in the population would show the metacognitive disambiguation effect on the final two trials than that none would or that a majority would. Calculation of Bayes factors (cf. Dienes, 2014) for comparisons of these possibilities provided strong support in favor of the 25% hypothesis (Bs > 1,000).

Perhaps many of the 3-year-olds thought too much about how they could neither see the objects in the buckets nor recall the name of any of the objects. They may have been so preoccupied by these concerns that they did not consider how the metacognitive difference between the two sets of objects might guide their choices. Perhaps some were reluctant to select the "I don't know" bucket because they were concerned that the experimenter might take this selection to mean that they did not know the answer. However, even if there were some validity to these proposals, most in this age group have at best a weak metacognitive awareness that novel labels are more likely to denote kinds of objects that they do not know than kinds that they do know.

Would it be possible to teach a majority of 3-year-olds to produce the metacognitive disambiguation effect? There was suggestive evidence for this possibility in Experiment 3. This experiment was the only experiment in which children received feedback that paired each type of label (novel and familiar) with its corresponding kind of object (unfamiliar and familiar) and corresponding bucket ("I don't know" and "I know"). And it was the only experiment in which the number of 3-year-olds who selected the "I don't know" bucket in the final novel-label trial was significantly greater than chance. However, many may have chosen correctly in this trial only because they were following a switching strategy.

Regarding 4-year-olds, although we demonstrated that the majority can use metacognitive representations in this manner, we do not know whether children this age or older ever use such representations when solving more typical disambiguation problems (i.e., ones where the objects are visible). There has been correlational evidence that is consistent with this possibility. Among preschoolers, accuracy of lexical knowledge judgment has been found to be associated with the strength of the disambiguation effect in the standard paradigm (Merriman & Bowman, 1989; Merriman & Schuster, 1991) and in a cross-modal paradigm (Wall et al., 2015). However, this correlation could just reflect the causal impact of some third variable on the development of both lexical knowledge judgment and the disambiguation effect. For example, preschoolers' phonological working memory (S. E. Gathercole, 1995) is positively correlated with the accuracy of their word knowledge judgment (Merriman & Lipko, 2008; Merriman et al., 2008). It might also be correlated with the strength of the disambiguation effect, although we know of no studies that have examined this relation.

In every experiment, very few children could explain why they had decided that the referent of a novel label was in the "I don't know" bucket. Thus, at the age at which children show that they are capable of reasoning that a novel label is more likely to refer to an object "I don't know" than an object "I know," most appear to be unaware that they are reasoning in this manner.

It will be important to examine whether experimental manipulations that affect the availability of metacognitive representations have an impact on the standard disambiguation effect. The implications of such findings would be greatest for competitive activation accounts of the disambiguation effect (McMurray et al., 2012; Merriman, 1999; Regier, 2005). These accounts would need to grant a role for processes that are quite different in kind from the activation of connections between (nonmetacognitive) representations of words and objects. In contrast, the mutual exclusivity (Markman, 1984; Merriman & Marazita, 1995) and pragmatic contrast accounts (Clark, 1990; Diesendruck & Markson, 2001; V. C. Gathercole, 1989) would not need to change their central process, which is that of deciding whether the representation of the novel label matches or mismatches representations of each of the choice objects. However, these accounts would have to acknowledge that these decisions sometimes involve comparing metacognitive representations.

Perhaps a proponent of a competitive activation account might argue that representations of the names of one or more objects in the "I know" bucket were activated in the children when they looked at the bucket and thought about what was in there, even though the children could not recall the names. By this account, this increase in activation would have to be large enough for the objects hidden in that bucket to receive substantially less activation from the novel label than the objects hidden in the "I don't know" bucket. There is one piece of evidence against this proposal. Grassmann, Schulze, and Tomasello (2015) found that preschoolers did not show the standard disambiguation effect when they could recognize but not recall the names of the familiar choice objects. For example, they were able to pick out a microphone from a set of objects when asked for "the microphone" (in German) but were not able to produce this name when asked what the microphone was called. In the disambiguation task, where the objects were visible, the children did not tend to reject the microphone in favor of an unfamiliar kind as the exemplar of a novel label. If anything, a visible familiar object with a difficult-to-recall familiar name should activate the representation of its name more than hidden objects whose names cannot be freely recalled activate their names. Yet, whatever activation of familiar names may have occurred in the former case, it was not sufficient to cause the disambiguation effect. So whatever activation of familiar names may have occurred in our task, it was unlikely to have been sufficient to cause the (metacognitive) disambiguation effect.

Our main findings are consistent with evidence that both reflective awareness of one's lexical knowledge (Chaney, 1992; Marazita & Merriman, 2004; Merriman et al., 2008; Smith & Tager-Flusberg, 1982) and the ability to justify the standard disambiguation effect (Marazita & Merriman, 2004; Merriman & Schuster, 1991) develop during the preschool years. Our findings are also consistent with the substantial increase that occurs during this period in how often children use *know* and *think* to make genuine references to belief states (Bartsch & Wellman, 1995; Hughes & Dunn, 1998; Moore, Furrow, Chiasson, & Patriquin, 1994).

Other advances in children's understanding of knowledge also occur during this period. They come to grasp important conceptual differences between "knowing (that)" and "thinking (that)," such as in truth conditions (Johnson & Maratsos, 1977) and expressed certainty (Cherney, 2003; Moore, Bryant, & Furrow, 1989). They begin to understand how different sensory experiences of the same stimulus (e.g., looking vs. touching) cause one to acquire different kinds of knowledge about it (O'Neill, Astington, & Flavell, 1992). An important project for future research will be to examine whether these developments are related to the development of an understanding that novel labels tend to denote objects "I don't know" rather than objects "I know."

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