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The Disambiguation Prediction Effect

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ABSTRACT

Children tend to select a novel object rather than a familiar object when asked to identify the referent of a novel label. Current accounts of this so-called *disambiguation effect* do not address whether children have a general metacognitive representation of this way of determining the reference of novel labels. In two experiments (each $N = 48$), three- and four-year-olds received a prediction task that required such a representation. In the initial phase, children completed four disambiguation test trials that were presented as instances of the same “game.” In the next phase, they received four additional trials. These differed only in that before the label was presented, children were asked to predict which object “was going to be right.” On the first prediction trial, most four-year-olds predicted the novel object, whereas most three-year-olds did not. On subsequent trials, despite having received feedback regarding predictions, three-year-olds showed no tendency to begin to predict the novel object, whereas most four-year-olds continued to make this prediction. These findings add to the evidence that most children develop a general metacognitive representation of their tendency to map novel labels onto novel rather than familiar objects some time around their fourth birthday.

The disambiguation prediction effect

From an early age, children show many regularities in the way that they determine the reference and meaning of novel words (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989; Mayor & Plunkett, 2010; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). One regularity that has received considerable attention is the so-called *disambiguation effect*, or tendency to map novel labels onto novel rather than familiar objects (Markman & Wachtel, 1988; Merriman & Bowman, 1989). Even children as young as 16 months old show this effect (Halberda, 2003; Markman, Wasow, & Hansen, 2003; Mervis & Bertrand, 1994), and it is quite robust among children 2½ years or older (Evey & Merriman, 1998; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992).

The disambiguation effect may play an important role in everyday word learning. Although a child may be able to identify the intended referent of a novel label from a speaker’s gaze or gesture (Baldwin, 1993; Gliga & Csibra, 2009), these cues are not always present. Even when these cues are present, children may not always detect them or find them to be precise enough to single out the referent. Yurovsky, Smith, and Yu (2013, Exp. 1) found that in approximately half of the instances in which parents named an object while

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engaged in toy play with their toddler, the reference of the name was highly ambiguous. In these situations, children may tend to identify a novel rather than a familiar object as the referent of a novel label. Moreover, Jaswal and Hansen (2006) found that in some circumstances, even when a speaker gazed at or pointed toward a familiar object while using a novel label, preschoolers selected the novel object next to it as the label's referent (but see Grassmann & Tomasello, 2010).

Several explanations for the disambiguation effect have been proposed. According to the Mutual Exclusivity account, it results because children tend to assume that two labels will not have exemplars in common; they reject the familiar object because it already has a known label (Markman & Wachtel, 1988; Merriman & Marazita, 1995). Alternatively, according to the Pragmatic Contrast account (Clark, 1988; Diesendruck & Markson, 2001; Gathercole, 1989; Tomasello, 2000), the effect results because children expect speakers to be cooperative when referring to things. If some way of referring to an object is known by both the speaker and the children, they expect the speaker to use this expression to refer to it. So if the speaker uses some other expression, they infer that some other object must be the intended referent.

Although these accounts differ regarding the principle that children follow, both characterize children as rejecting the familiar object because they detect a mismatch between its known label and the novel label (Halberda, 2003, 2006). Neither account specifies how children make this label mismatch decision, however. It is likely based on comparing phonological representations of the labels (Jarvis, Merriman, Barnett, Hanba, & Van Haitsma, 2004; Marazita & Merriman, 2004; Merriman & Marazita, 1995; Wall, Merriman, & Scofield, 2015). For example, the child rejects a cup as a possible referent of *zav* because the child notes that the labels *cup* and *zav* do not match.

A third account of the disambiguation effect differs from the other two in that label retrieval is unnecessary and no comparison of label representations occurs. According to various competitive activation models, the disambiguation effect is the result of excitatory and inhibitory connections that have developed among representations (McMurray, Horst, & Samuelson, 2012; Merriman, 1999; Regier, 2005). The child selects the novel object as the referent for the novel label simply because the representation of the novel object receives more activation than the representation of the familiar object when the novel label is presented. This differential activation results because past experiences have strengthened the connection between the familiar object's representation and its associated name.

None of these accounts presupposes that children have a general metacognitive representation of the disambiguation effect. That is, none assumes that children represent cognitions or mental experiences that are common to all instances of the disambiguation effect. Children might abide by the Mutual Exclusivity principle, for example, if they have developed a habit of rejecting an object as the referent for a label whenever they retrieve a different label for the object. Likewise, children might abide by the Pragmatic Contrast principle if they have developed a habit of rejecting an object as the referent of a referring expression whenever they retrieve a different referring expression for the object. However, they may not represent these decisions as being choices of an object that is a novel kind (or object that does not have a known label/referring expression) over an object that is a familiar kind (or object that has a known label/referring expression). They might not even represent these decisions as based on noticing that one of the objects had a label/referring expression that did not match the one they were mapping. A child who rejects a cup in favor of a garlic press when asked, "Which

one is a zav?,” for example, might not reflect on the cognitions that compelled them to select the garlic press. Likewise, from the perspective of competitive activation models, a child may select the garlic press because it receives more activation from *zav* than the cup does but not reflect on what led them to select the garlic press.

Our concept of *general metacognitive representation* is similar to what Karmiloff-Smith (1986, 1992) refers to as a *representational redescription* of knowledge. By reflecting on the mental experiences involved in different instances of the same cognitive function, the child forms a more abstract representation of the cognitive function. According to Karmiloff-Smith, this redescription process causes knowledge that is embedded in cognitive processing to become explicit, that is, to become an object of thought itself. She also proposes that the first explicit representations that the child constructs for a cognitive function (E1 representations) are not available to conscious access or verbal report. Once children have used E1 representations enough for their use to become automatic, these representations are redescribed into ones that are accessible to conscious awareness and verbal report (E2 and E3 representations).

The current investigation examined the possibility that children’s tendency to map novel labels to novel objects is supported by general metacognitive representations. We hypothesized that this way of representing the disambiguation effect emerges with development. Specifically, we proposed that as children’s ability to reflect on their lexical knowledge develops, they develop a metacognitive representation of their tendency to map novel labels onto novel objects.

Over the preschool years, children become increasingly aware of what they know and what they do not know. By age four, most make accurate reports of their lexical knowledge. For example, when asked whether they know names for various familiar and unfamiliar kinds of objects, four-year-olds tend to respond correctly; in contrast, younger children often report knowing names for many of the unfamiliar kinds (Marazita & Merriman, 2004; Merriman, Lipko, & Evey, 2008). Likewise, when asked whether they know highly familiar words as well as made-up words, four-year-olds tend to respond correctly, whereas younger children often report knowing many of the made-up words (Chaney, 1992; Merriman et al., 2008; Merriman & Schuster, 1991; Smith & Tager-Flusberg, 1982).

Awareness of lexical knowledge is associated with a more robust disambiguation effect. In most studies, older children show a stronger effect than younger ones (Lewis & Frank, 2015; Merriman, Marazita, & Jarvis, 1995). The exceptions are studies in which corrective feedback is delivered after every trial (Marazita & Merriman, 2004) or the effect is put in conflict with a cue that favors the familiar object (e.g., the speaker pointing at the familiar object) (Gollek & Doherty, 2016; Grassmann & Tomasello, 2010; Scofield, Merriman, & Wall, 2018). Merriman and Schuster (1991) found that the four-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 object more frequently than the four-year-olds who tended to say “yes” or not respond to the question. Slocum and Merriman (2018) reported this same finding in analyses of data from two studies by Merriman and Bowman (1989). Also, in each of three experiments by Wall et al. (2015), three- and four-year-olds’ accuracy in judging whether they knew names for various objects predicted the strength of their disambiguation effect in a cross-modal paradigm.

Older preschoolers are also more likely than younger ones to provide an appropriate justification for the disambiguation effect. Merriman and Schuster (1991) found that when

2½-year-olds were asked why they had chosen the novel object as the referent of the novel label, they tended to either point to some feature of the novel object or not answer the question. In contrast, many four-year-olds responded by indicating that the familiar object had a different label (e.g., “because that one’s a cup.”) Among four-year-olds, the tendency to offer this justification has been found to be positively associated with the tendency to say “no” when asked whether they know the meaning of an unfamiliar word or the name for an unfamiliar object (Marazita & Merriman, 2004).

Slocum and Merriman (2018) examined children’s solutions to a purely metacognitive disambiguation problem. An experimenter first helped three- and four-year-olds sort objects according to familiarity, putting familiar ones into a bucket for things “I know” and unfamiliar ones into a bucket for things “I don’t know.” After sorting the objects, the children were asked to recall the objects in the “I know” bucket. The experimenter removed any object that they recalled from the bucket and removed the same number of objects from the “I don’t know” bucket. Finally, children received several trials in which they had to decide which bucket contained an exemplar of a novel label.

To succeed in this task, children most likely had to represent the novel labels as being names they did not know. Because they could not recall the labels of the objects in the “I know” bucket, it is unlikely that they would reject this bucket based on noticing that the novel label mismatched the specific labels for the things in the bucket. It is also unlikely that the “I know” bucket received less activation than the “I don’t know” bucket because all of the objects were hidden, and the children could not recall the names of any of the objects in the “I know” bucket. On the other hand, if children represented the novel label as being a name they did not know, it is likely that they would decide it applied to one of the objects in the “I don’t know” bucket.

Slocum and Merriman (2018) found that most four-year-olds tended to select the “I don’t know” bucket. In contrast, most three-year-olds did not favor one bucket over the other. Thus, it may not be until age four that most children have a general metacognitive representation of the disambiguation effect that is accessible to conscious awareness. Only the four-year-olds showed that they believed novel labels tend to denote things “I don’t know” rather than things “I know.”

Performance on Slocum and Merriman’s (2018) task was positively correlated with the accuracy of word knowledge judgment (i.e., children’s tendency to report that they knew the meanings of various familiar words but not the meanings of various made-up words). This finding supports the view that development of a conscious belief that novel labels tend to denote objects “I don’t know” rather than objects “I know” is associated with development of an awareness that novel labels are words “I don’t know.” This awareness may even be a prerequisite for acquiring the belief. Children may only believe that novel labels tend to denote things “I don’t know” if they spontaneously represent novel labels as ones “I don’t know.”

Despite the evidence that four-year-olds can produce a purely metacognitive disambiguation effect, we do not know whether they ever consult metacognitive representations when solving an ordinary disambiguation problem. That is, they may select an unfamiliar object over a familiar object as the referent of a novel label solely based on the mismatch between the novel label and the known label for the familiar object (Halberda, 2006) and/or based on the greater activation of the unfamiliar than the familiar object (McMurray et al., 2012).

We investigated children's performance in a second purely metacognitive disambiguation task. In the initial phase of this task, children solved four disambiguation problems in which they had to decide whether an unfamiliar or a familiar object was the exemplar of a novel label. Each problem was presented as an example of how a game was played. After children had played the game, they were shown new pairs of familiar and unfamiliar objects and asked to predict which object in each pair would be "the right one." To solve these prediction problems, we hypothesized that children would need general metacognitive representations of their solutions to the first four standard disambiguation problems. They would need to represent these problems as instances in which they selected an object that evoked one kind of cognitive experience (such as a feeling of novelty) over an object that evoked a contrasting cognitive experience (e.g., a feeling of familiarity). Children were also administered tests of their awareness of lexical knowledge (word knowledge judgment in both experiments; object nameability judgment in Experiment 2) to assess whether such awareness was associated with successful disambiguation prediction.

In Slocum and Merriman's (2018) buckets task, the objects were hidden and the novel label was presented on each trial. In the current paradigm, the opposite was true. The objects were visible, but the novel label was not presented, at least not until after children had made their prediction about which object would be correct. Therefore, they could only make consistently correct predictions if they relied on a general metacognitive representation of their solution to the first four standard disambiguation problems.

Another contrast between the current task and the buckets task is that passing the current task did not necessarily require consciously representing objects as being ones "I know" or "I don't know." Unconscious metacognitive representations might be sufficient. For example, if children merely noticed that the correct answer in the game had always been the object that felt novel rather than the object that felt familiar, they might make correct predictions based on this observation.

Although four-year-olds were expected to perform better than three-year-olds, even the younger children might do well. Three-year-olds may have failed Slocum and Merriman's (2018) task only because they tend not to represent novel labels as ones "I don't know." This age group could well have a metacognitive representation of their tendency to map novel labels onto novel rather than familiar objects that enables them to make disambiguation predictions.

Experiment 1

Method

Participants

Forty-eight children were recruited from preschools in the middle- to upper-class regions of Northeast Ohio. There were 24 three-year-olds ($M_{\text{age}} = 3;7$, range = 3;2-3;11, 12 girls) and 24 four-year-olds ($M_{\text{age}} = 4;6$, range = 4;0-4;11, 12 girls). All of the children were monolingual speakers of English, and nearly all were Caucasian. Each child received a sticker for his or her participation.

Procedure

Children participated in a 15–30-minute one-on-one session in a quiet room at their preschool. Each child completed the disambiguation prediction task, the word knowledge judgment task, and the Peabody Picture Vocabulary Test–Fourth Edition (PPVT-4; Dunn & Dunn, 2007). The disambiguation prediction task was always completed first. The order of the other two tests was counterbalanced.

Materials

A different pair of objects was used on each of eight trials in the disambiguation prediction task. One member of each pair was familiar (sock, key, flower, toy car, toothbrush, spoon, ball, or cup), and one was unfamiliar (tea infuser, PVC plug, single serve coffee filter, cable hider, lamp cover, pourer spout, conduit cover, or t-clip). The objects were small in size and could be handled easily by the children. Eight pseudowords (e.g., *lerb*, *borp*, *jat*, *terch*, *dack*, *cheed*, *mig*, and *geet*) were used as novel labels. The word knowledge judgment task involved presenting five familiar words (*shoe*, *dog*, *truck*, *chair*, and *house*) and five made-up words (*hust*, *mave*, *gock*, *prad*, and *blim*). The Peabody Picture Vocabulary Test (PPVT-4, Dunn & Dunn, 2007) was also administered.

Disambiguation prediction

The child and experimenter sat across from each other at a small table. After the child was comfortable and assented to participate, he or she was told that they were going to play a game. The experimenter explained, “In this game, I am going to show you two things and ask you to pick the one I name.” The experimenter placed one of the pairs of objects on the table and asked the child to select the exemplar of a novel label (e.g., “Which one is the *lerb*?”). If the selection was correct (i.e., the unfamiliar object), the experimenter confirmed it (e.g., “Good job! That is right.”). If the selection was incorrect, the experimenter corrected it (e.g., “No, that is not the *lerb*. This one (pointing to the unfamiliar object) is the *lerb*. This one’s right.”). The objects were removed, and the experimenter announced, “Let’s play that game again.” The same procedure was repeated for three additional trials, each involving a different pair of objects and different novel word. Following the fourth trial, children were asked to make their first prediction. The experimenter placed another pair of objects on the table and announced, “Let’s play that game again. Which one do you think is going to be right?” After the child made a prediction, the experimenter said “Now let’s see” and then asked the child to select the exemplar of a novel label (e.g., “Which one is the *dack*?”) After the child made a selection, the experimenter either confirmed or corrected the selection, depending on whether it was correct. The remaining three trials followed the same procedure as the fifth trial, except that each involved a different pair of objects and a different novel label, and children were asked to justify the object they chose as the exemplar of the novel label (i.e., “Why do you think it’s that one?”). In summary, the children were asked to predict which of the two objects was “going to be right,” told “now let’s see,” asked which one was the exemplar of a novel label, and asked for a justification of their selection.

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 demonstrated with one familiar word and one pseudoword. "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 the five familiar words and five pseudowords. The child's accuracy score was the proportion of the 10 judgments made correctly. Order of presentation was random, except that words of the same type never occurred more than twice in a row. (See Hartin, Stevenson, & Merriman, 2016, for further details about the procedures in this task.)

Results

Disambiguation

Three aspects of children's performance in the main task were analyzed: selections on the initial four trials, predictions made on the final four trials, and selections made (after each prediction) on the final four trials. The novel object was considered the correct selection or prediction on every trial (see Table 1). On the initial trials, both age groups performed quite well (M correct = 3.61 out of 4), which is consistent with previous results in which corrective feedback has been delivered after every selection (see Marazita & Merriman, 2004). Three- and four-year-olds' performance on these trials did not differ, $t(46) = .64, p = .53, d = .19$. In both age groups, mean number correct exceeded chance (2.00)—four-year-olds: $t(23) = 14.46, p < .001, d = 2.96$; three-year-olds: $t(23) = 9.70, p < .001, d = 2.00$.

On the critical disambiguation prediction trials, mean number correct in the four-year-olds (3.04 out of 4) was significantly greater than in the three-year-olds (1.54), $t(46) = 4.13, p < .001, d = 1.19$. The older group's performance exceeded chance (2.00), $t(23) = 4.71, p < .001, d = .96$, whereas the young group's did not differ from it, $t(23) = -1.59, p = .13, d = .33$. A majority of four-year-olds (17 of 24) and minority of three-year-olds (7 of 24) made at least three correct predictions. On the very first prediction trial, which is the only one free from potential carryover effects, all but 1 four-year-old predicted correctly, whereas only 12 three-year-olds did so (two-tailed Fisher's exact test $p = .001$).

After a child had made a prediction, the experimenter said "Now let's see," then presented a novel label and asked the child to select its exemplar. Both age groups tended

Table 1. Mean Number Correct Responses (*SD*) in the Disambiguation Task

Age	Initial Selections	Predictions	Final Selections
EXPERIMENT 1			
3	3.54 (.78)	1.54 (1.41)	3.29 (.95)
4	3.67 (.56)	3.04 (1.08)	3.58 (.93)
EXPERIMENT 2			
3	3.79 (.59)	2.04 (1.27)	3.33 (.82)
4	3.92 (.28)	2.96 (1.08)	3.79 (.42)

Note. Maximum score = 4.

to select the novel object ($M = 3.44$ out of 4) and did not differ in how often they made this selection, $t(46) = 1.07, p = .29, d = .31$. Mean number correct exceeded chance in both four-year-olds, $t(23) = 8.35, p < .001, d = 2.14$, and three-year-olds, $t(23) = 6.63, p < .001, d = 1.35$. In both age groups, the number of correct selections on these trials did not differ from the number on the initial four trials.

Even though three-year-olds tended to make correct selections on the final four trials and were told after each selection whether they had responded correctly, they did not show an increasing tendency to make correct predictions over the final four trials. In fact, they tended to make more correct responses on the first two than on the final two predictions trials (M change = $-0.38, SD = .71, t(23) = 2.58, p = .02, d = .53$). Among four-year-olds, the trend was similar (M change = $-0.29, SD = .81$), though not significant, $t(23) = 1.77, p = .09, d = .36$.

Children were asked to justify their disambiguation selections on the final three trials. Most gave either uninformative answers (e.g., “Because it is”) or made reference to the object’s physical properties (e.g., “It has holes”). However, nine justified at least one selection of an unfamiliar object by citing the known identity of the familiar object (e.g., “Because that one is a spoon”). All except one of these children was a four-year-old. They made correct predictions more frequently ($M = 3.45, SD = 1.01$) than the other children ($M = 2.03, SD = 1.42$), $t(46) = 2.82, p = .007, d = 1.04$. If only four-year-olds are considered, the trend is similar (those justifying at least one selection appropriately, $M = 3.50, SD = 1.07$; other four-year-olds, $M = 2.81, SD = 1.04$) but not significant, $t(22) = 1.51, p = .15, d = .65$. Frequency of correct prediction among the four-year-olds who did not justify any of their predictions appropriately exceeded chance, $t(15) = 3.10, p = .007, d = .78$.

Other measures

Table 2 summarizes performance on the other tasks. Four-year-olds outperformed three-year-olds on both word knowledge judgment, $t(46) = 3.31, p = .002, d = .85$, and PPVT-4 (scores are not standardized by age), $t(46) = 4.57, p < .001, d = 1.35$.

Table 3 summarizes intercorrelations among disambiguation prediction (both overall and first trial performance), word knowledge judgment accuracy, vocabulary size, and age (in months). All measures were significantly intercorrelated except for the relation between disambiguation prediction and word knowledge judgment accuracy. This one exception is only suggestive, however. The latter correlation was not significantly different from the correlations between disambiguation prediction and either vocabulary size or age, $p > .10$.

Differences in vocabulary size did not fully account for the association between age and disambiguation prediction; the correlation between the latter two remained significant

Table 2. Mean Scores (*SD*) on Other Tests

Age	Word Know Judgment ^a	PPVT-4 ^b	Obj Nameability Judgment ^a
EXPERIMENT 1			
3	.74 (.19)	69 (16)	–
4	.91 (.16)	92 (18)	–
EXPERIMENT 2			
3	.78 (.21)	78 (19)	.89 (.16)
4	.88 (.16)	95 (15)	.91 (.18)

^aProportion of judgments correct; ^bRaw score.

Table 3. Intercorrelations in Experiments 1 and 2

MEASURE	2	3	4	5
1. Disambiguation Prediction:				
Overall	.49, .34	.43, .24	.11, .30	.36
1 st Trial	.48, .19	.44, .26	.11, .26	.33
2. Age (months)		.65, .54	.54, .33	.26
3. PPVT-4			.47, .40	.36
4. Word Knowledge Judgment				.25
5. Obj Nameability Judgment				

Note. In each pair, the first correlation is from Exp. 1 and the second is from Exp. 2.
 $df = 46$ for all correlations $r > .23, p < .10$ $r > .29, p < .05$ $r > .36, p < .01$.

even after associations with vocabulary size were partialled out, partial $r(45) = .30, p = .04$. Also, there was no evidence that differences in vocabulary size predicted performance on the disambiguation prediction test beyond what could be predicted by children's age, partial $r(45) = .18, p = .24$.

Discussion

As predicted, most four-year-olds passed the disambiguation prediction test, and most three-year-olds did not. Only the older group tended to select an unfamiliar object over a familiar object as the one that was "going to be right" after playing a game that involved four standard disambiguation trials. This finding is consistent with the age difference that Slocum and Merriman (2018) observed in children's tendency to select a bucket of objects with unknown labels over a bucket of objects with known labels as the one that contained exemplars of novel labels. It is also consistent with evidence that the strength of the disambiguation effect increases over early childhood in studies in which no conflicting cues and no corrective feedback have been presented (Lewis & Frank, 2015; Merriman et al., 1995)

Our hypothesis that word knowledge judgment accuracy would be associated with the disambiguation prediction effect was not supported. This finding was surprising given the evidence that children who show greater awareness of their word knowledge also show a stronger tendency to map novel labels onto novel rather than familiar objects in the absence of conflicting cues (Merriman & Bowman, 1989; Merriman & Schuster, 1991). Awareness of lexical knowledge has also been found to be associated with whether children show the metacognitive disambiguation effect (Slocum & Merriman, 2018) and with whether they justify the standard disambiguation effect by citing the name for the familiar object (e.g., "because that one's a cup") (Marazita & Merriman, 2004). This last finding was also not replicated in the current study; for the relation between accuracy of word familiarity judgment and frequency of offering this justification on the final three disambiguation trials, $r(46) = .20, p = .18$.

These null results regarding word knowledge judgment may just reflect sampling error. Alternatively, they may be due to the mismatch between the type of cue presented for word knowledge judgment and the type of cue presented for disambiguation prediction. The cue for word knowledge judgment is a single word presented in the absence of any potential referent (e.g., "Do you know what a chair/mave is?"). In contrast, the cue for disambiguation prediction is a pair of objects in the absence of any referring word. Note that the metacognitive disambiguation task that Slocum and Merriman (2018) found to be associated with word knowledge judgment involved judging a single word without being

able to see or recall any of the word's possible referents (e.g., "In which bucket is the zav?"). A measure of awareness of lexical knowledge that involves judging whether various objects have known names (Marazita & Merriman, 2004) may be more strongly associated with the type of object judgment that underlies the disambiguation prediction effect. This possibility was examined in Experiment 2.

Despite receiving corrective feedback after every trial, children's disambiguation prediction did not improve over trials. One reason may be that children were never told directly that they had made a wrong prediction. The experimenter only told them whether the object they selected as the novel label's exemplar was correct. On the other hand, the children may well have realized what this feedback implied about the accuracy of their predictions. They may just not have been able to learn from this information. They may have had little or no tendency to consider that some metacognitive dimension distinguished the correct prediction from the incorrect prediction (e.g., that the unfamiliar object evoked less feeling of familiarity and/or was the only object that they had not seen before). This possibility is consistent with Slocum and Merriman's (2018) finding that children performed no better in their metacognitive disambiguation task when they received direct corrective feedback than when they received uninformative feedback.

Experiment 2

One possible criticism of the procedures followed in Experiment 1 is that four standard disambiguation problems were not enough examples for the younger children to figure out what the solutions to these problems had in common. Also, the children never had the opportunity to observe someone other than themselves play the game. Perhaps seeing someone else play the game before they themselves played the game would help the younger children to figure out what the correct choices had in common. To address these possibilities, four additional standard disambiguation selection trials were added to the beginning of the procedure. On these trials, children watched a puppet make correct selections. The remainder of the procedure was identical to Experiment 1 in that children completed four disambiguation selection trials and then four disambiguation prediction-then-selection trials. If the two potential weaknesses that we identified in the procedures of Experiment 1 actually accounted for the poor performance of the three-year-olds, then this age group should make more accurate disambiguation predictions in the current experiment. Four-year-olds were also included to see whether their excellent performance on the first disambiguation prediction trial replicated and to see whether the new procedures might cause them to show a stronger tendency to continue making correct predictions after the first prediction trial.

In addition to the tests of receptive vocabulary and word knowledge judgment, children received a test of object nameability judgment (Marazita & Merriman, 2004). In this test, children are shown various familiar and unfamiliar objects and asked regarding each one whether they know its name. Typically, younger children are more prone than older ones to report knowing names for unfamiliar objects. We hypothesized that because this task involves not only reflecting on lexical knowledge/ignorance but also involves judging possible referents of words in the absence of the words themselves, it would be associated with the disambiguation prediction effect.

Method

Participants

Twenty-four 3-year-olds ($M_{\text{age}} = 3;8$, range = 3;0-3;11, eight girls) and 24 four-year-olds ($M_{\text{age}} = 4;6$, range = 4;0-4;11, 10 girls) participated. The sample's characteristics (i.e., geographic location, ethnicity, monolingual) were the same as in Experiment 1.

Procedure

The procedure remained the same as in Experiment 1 except for the addition of four modeled selection trials at the beginning of the disambiguation prediction task and the addition of the object nameability judgment task. The disambiguation prediction task was always performed first. Task order for the other three tasks was counterbalanced.

Materials

The materials for the disambiguation prediction task were the same as in Experiment 1 except for the addition of a puppet used to model the additional selection trials and four additional pairs of objects for these trials. In each pair, one object was familiar (pencil, scissors, balloon, or comb) and one was unfamiliar (door hook, staple remover, garlic press, or oil filter wrench). Four pseudowords (e.g., *garn*, *narp*, *kerm*, and *dort*) were used as novel labels. The materials for the object nameability judgment task included six familiar objects (e.g., flashlight, crayon, glove, toy car, fork, and toothbrush) and six unfamiliar objects (e.g., tube squeezer, egg slicer, plate hanger, spouncer, latch hook, and heel cushion).

Disambiguation prediction

The procedure for this task was the same as in Experiment 1 except that the experimenter introduced the game by having a puppet demonstrate how to play. The experimenter told the child, "This is my friend Dino the Dinosaur. We're going to play a game, but first my friend Dino and I are going to show you how to play it. So in this game, I am going to show Dino two things and ask him to pick the one that I name. So let's give it a try, Dino." The experimenter provided the puppet with four disambiguation selection trials following the same procedure as in Experiment 1. After the puppet had completed all four trials, the experimenter put the puppet away and stated, "Now it's your turn to play. Let's play that same game. Remember I am going to show you two things and ask you to pick the one that I name." The child then completed the same eight-trial disambiguation prediction task as in Experiment 1.

Object nameability judgment

The child was told, "Are you ready to play a game? I'm going to show you an object, and you're going to tell me if you know the name for it. If you know the name, say 'Yes.' If you don't know the name, say 'No.' I'll show you how it's done." The experimenter then demonstrated to the child a familiar object trial (e.g., flashlight) and said, "Let's see, do I know the name for this? Yes, I do. It's a flashlight. So I would say, 'Yes, I know its name. I know what it's called. Let's try another one.'" The experimenter then demonstrated to the child an unfamiliar object trial (e.g., plate hanger) and said, "Hmm, do I know the name for this? No, I don't. I don't know what this thing is called. So I would say, 'No, I don't know its name.' Now you try it." The experimenter then presented six familiar objects and

six unfamiliar objects one at a time in a random order to the child and asked the child, “Yes or no. Do you know the name for this?” The experimenter responded (e.g., “Very good”) regardless of the child’s response. The child’s accuracy score was the proportion of the 12 judgments made correctly. (See Hartin et al., 2016, for further details about the procedures in this task.)

Results

Disambiguation

Performance on the first four selection trials was excellent in both age groups ($M = 3.86$ out of 4) (see Table 1). In contrast to Experiment 1, where 15 of 48 children made at least one error on these selections, only 5 of 48 did so in Experiment 1, two-tailed Fisher’s exact $p = .02$.

On the critical prediction trials, four-year-olds responded correctly more often than three-year-olds, $t(46) = 2.69$, $p = .01$, $d = .78$. The four-year-olds’ mean (2.96) exceeded chance, $t(23) = 4.34$, $p < .001$, $d = .89$, whereas the three-year-olds’ mean (2.04) did not, $t(23) = 0.16$, $p = .87$, $d = .03$. As in Experiment 1, the majority of four-year-olds selected correctly on the very first prediction trial (19 of 24) and made at least three correct predictions overall (19 of 24). These proportions were greater than chance, $\chi^2(1) = 8.17$, $p = .004$. The number of three-year-olds who chose correctly on the very first prediction trial was near chance (13 of 24).

Figure 1 shows the distribution of scores on the critical prediction trials for Experiments 1 and 2 combined. The distribution for four-year-olds was significantly skewed, $z_{skew} = -2.84$, $p = .005$. Seventy-five percent chose correctly on at least three trials, and 39.6% chose correctly on every trial. In contrast, the distribution for three-year-olds had a nonsignificant skew in the opposite direction. It was also a bit flatter than a normal distribution, although a test of this deviation was not significant, $z_{kurtosis} = -1.62$, $p = .105$. The number of three-year-olds who chose correctly on at least three of four trials (15) was no different from what would be expected if all were responding randomly from trials to trial (15). However, there were more three-year-olds who chose correctly on every trial (7) than would be expected if all were

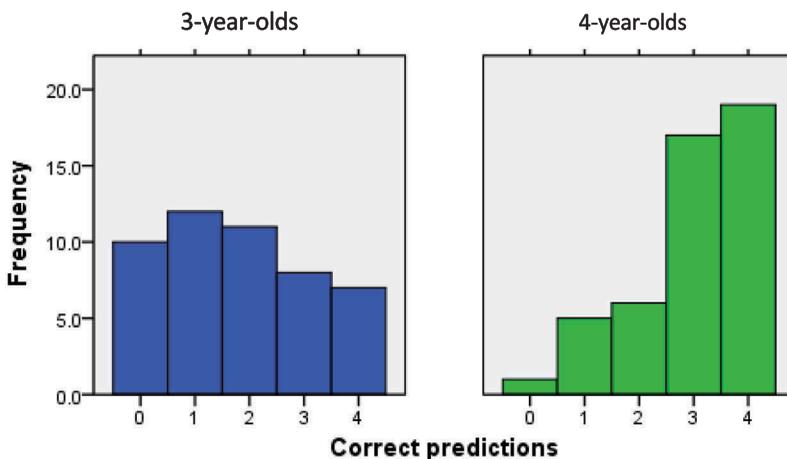


Figure 1. Distribution of disambiguation prediction scores in Experiments 1 and 2 combined.

responding randomly from trial to trial (3). The same was true of the number who chose incorrectly on every trial (10). It is possible that some of the three-year-olds who selected correctly on every trial did so because they had a general metacognitive representation of the disambiguation problem. However, even if all seven of them did, they constituted only 14.6% of the sample.

As in Experiment 1, children in Experiment 2 did not show an increasing tendency to make correct predictions over trials. The frequency of correct predictions on the first two trials did not differ from that on the final two trials in either three-year-olds (M change = + 0.04, SD = .95, $t(23)$ = 0.21, p = .83, d = .04) or four-year-olds (M change = -0.12, SD = .74, $t(23)$ = 0.83, p = .42, d = .17).

Unlike Experiment 1, an age difference was found in selections (following predictions) on the final four trials (four-year-olds: M = 3.79; three-year-olds: M = 3.33), $t(34, \text{equal variances not assumed})$ = 2.45, p = .02, d = .71. However, just as in Experiment 1, the frequency of correct selection exceeded chance in both four-year-olds, $t(23)$ = 21.16, p < .001, d = 4.31, and three-year-olds, $t(23)$ = 8.00, p < .001, d = 1.63. In contrast to Experiment 1, three-year-olds chose correctly less often on these trials than on the first four selection trials, $t(23)$ = 2.14, p = .046, d = .43. Four-year-olds' performance did not change over these two blocks, $t(23)$ = 1.14, p = .27, d = .23.

As in Experiment 1, only a small number of children (n = 5) justified their final three disambiguation selections by citing the name that they already knew for the familiar object (e.g., "because that one's a pencil."). All were four-year-olds. As in Experiment 1, they made correct predictions on nearly every trial (M = 3.40, SD = 0.89). However, they did not make correct predictions significantly more often than the other four-year-olds (M = 2.84, SD = 1.12), $t(22)$ = 1.03, p = .31, d = .53, and even in the latter group, frequency of correct prediction exceeded chance, $t(18)$ = 3.28, p = .004, d = .75. If the two experiments are combined to increase power, the difference in prediction performance between those four-year-olds who offered at least one such justification (n = 13) and those who did not (n = 35) is significant only by a one-tailed test, $t(46)$ = 1.87, p = .035, d = .62.

Other measures

Table 2 summarizes performance on the other tasks. As in Experiment 1, four-year-olds had larger receptive vocabularies than three-year-olds, $t(46)$ = 3.41, p = .001, d = 1.00. In contrast to Experiment 1, the two age groups did not differ in word knowledge judgment accuracy, $t(46)$ = 1.89, p = .06, d = .54, although the trend was in the same direction. Regarding the new measure of lexical knowledge judgment, object nameability judgment, both age groups performed quite well (M proportion correct = .89 and .91 in the three- and four-year-olds respectively) and did not differ, $t(46)$ = .32, p = .75, d = .12.

Regarding correlations among measures (see Table 3), PPVT-4 and age (in months) were not quite as strongly related to disambiguation prediction or word knowledge judgment as in Experiment 1. In contrast, the latter two measures were a bit more strongly correlated than in Experiment 1. None of these differences between experiments was significant, however, p > .10.

As predicted, children who responded more accurately when asked whether they knew names for various objects also made more correct disambiguation predictions. That is, object nameability judgment was positively correlated with both overall performance and performance on just the first trial of the disambiguation prediction task. Moderate

correlations were found between object nameability judgment and the other measures (r range = .25 to .36).

Restriction of range was a concern with object nameability judgment, however. Approximately two-thirds of the children made no errors in this judgment. We examined the correlations for a dichotomized version of this measure, where errorless performance was scored as 1 and less-than-perfect performance as 0. These correlations were stronger than the ones for the original measure, especially for the relation with disambiguation prediction—with overall prediction accuracy, r_{pb} (46) = .54, $p < .0001$; with first trial accuracy, $\Phi = .49$, $p < .0001$. Of the 31 children who made errorless object nameability judgments, 26 chose correctly on the first prediction trial, and 23 made at least three of four correct predictions overall. In contrast, only six of the other 17 children chose correctly on the first prediction trial, and only four made at least three of four correct predictions.

This last finding does not appear to be an artifact of using dichotomous scores. Changing the other measures to dichotomous scores had little effect on the strength of their association with disambiguation prediction. Two relations showed increases: word familiarity judgment and overall prediction accuracy (r_{pb} increased from .30 to .36) and vocabulary size and correct first trial prediction (correlation/phi coefficient increased from .26 to .40). Only object nameability judgment showed a substantial increase in its association with both measures of disambiguation prediction performance when a dichotomized score was used.

The tendency to make errorless object nameability judgments accounted for a significant proportion of variance in overall disambiguation prediction even after statistically controlling for word familiarity judgment, vocabulary size, and age, partial r (43) = .47, $p = .001$. In contrast, none of the other measures was associated with overall disambiguation prediction after statistically controlling for the tendency to make errorless object nameability judgments, partial r (45) ranged from .04 to .19, $p > .20$. That is, once the variance accounted for by errorless nameability judgment was removed, predictions were no more accurate in older children than younger children and no more accurate in children with larger vocabularies than children with smaller vocabularies.

The correlation between errorless object nameability judgment and overall disambiguation prediction was significantly stronger than the correlation between vocabulary size and overall disambiguation prediction, $t_{\text{difference}}$ (45) = 2.204, $p = .033$. However, it was not significantly stronger than the correlation between age and overall disambiguation prediction or word familiarity judgment and overall disambiguation prediction, both $p > .10$.

Discussion

The main finding of Experiment 1 was replicated. Most four-year-olds showed a disambiguation prediction effect, and most three-year-olds did not. There was no evidence that the addition of the puppet demonstration trials prior to the disambiguation prediction task improved children's prediction performance. However, the addition of these trials did bring nearly every child's performance on the initial disambiguation selection trials up to ceiling.

One reason why the additional demonstration trials only affected children's disambiguation selections may be that the trials only strengthened children's tendency to rely on a solution that depended on actually hearing the novel label. For example, it might have

strengthened their tendency to select whichever object was activated more strongly by the label (McMurray et al., 2012; Regier, 2005) or to reject whichever object had a name that mismatched the label (Halberda, 2003; Jarvis et al., 2004). It is unlikely that it caused them to realize that the correct choice was always the object that lacked a known name or that evoked a feeling of novelty or that was a kind that they had never seen before. Otherwise, their tendency to predict the correct object should have increased.

As predicted, awareness of lexical knowledge as assessed by the object nameability judgment task had a significant association with disambiguation prediction. Word knowledge judgment also showed a significant association with disambiguation prediction, but only object nameability judgment was significantly associated after the contribution of age was statistically controlled. Whether or not a child made every single object nameability judgment correctly was a particularly strong correlate of disambiguation prediction. A child may only note a way in which the two objects in a disambiguation problem contrast (apart from their relations to specific novel labels) if they readily encode the incorrect choices as ones that have known names and the correct choices as ones that do not have known names.

General discussion

In both experiments, the majority of four-year-olds showed the disambiguation prediction effect, and the majority of three-year-olds did not. As expected, both groups performed quite well in the initial phase of each experiment, showing a strong tendency to select unfamiliar over familiar kinds as the referents of novel labels. However, on subsequent trials when they were asked to predict the object that was “going to be right” (before a novel label was presented), only the four-year-olds tended to make correct predictions.

These results support concluding that only the older children had a general metacognitive representation of their solutions to the initial disambiguation problems. That is, they represented cognitions or mental experiences that are common to all instances of the effect. They might have noticed that the correct choice had always been the object that lacked a known name or that evoked a feeling of novelty or that was something they had never seen before. The specific way in which they characterized the metacognitive contrast between the object they selected and the object they rejected remains to be determined.

We propose that development of a general metacognitive representation of the disambiguation problem causes children’s tendency to map novel names onto novel objects to become more robust. We do acknowledge, however, that such a representation is not absolutely necessary for the effect. If a child consistently retrieves the name for the familiar object, notes its mismatch with the novel name, and rejects the familiar object because of this mismatch, they will show the disambiguation effect. They may even show it on every trial, as most of the three-year-olds did on the initial disambiguation selection trials in both experiments. Having a metacognitive representation may lead a child to make fewer mapping errors only when some factor is present that reduces their likelihood of carrying out all of the nonmetacognitive processes (familiar name retrieval, name mismatch detection, etc.) correctly.

Slocum and Merriman (2019) recently evaluated this hypothesis by varying the number of familiar choice objects presented in a disambiguation problem. As the number of choices increased, the likelihood of carrying out all of the nonmetacognitive processes

correctly was expected to decrease. Consistent with the hypothesis, the correlation between age and the tendency to select the novel object increased as the number of familiar choice objects increased. Moreover, the correlation between awareness of lexical knowledge and the tendency to select the novel object also increased as the number of familiar choice objects increased.

The finding of a similar age trend in two quite different metacognitive disambiguation tasks—one involving hidden objects and a presented novel label (Slocum & Merriman, 2018) and the other involving visible objects and an absent label (the current paradigm)—suggests that development of the same concepts or abilities may underlie developmental change in each task. On the other hand, there is evidence for the contribution of task-specific metacognitions. Slocum and Merriman (2018) found a significant correlation between performance on their buckets task and the accuracy of children’s word knowledge judgment, even after statistically controlling for the contributions of age and vocabulary size. Children who tended to say “yes” when asked whether they knew what various familiar words meant and say “no” when asked whether they knew what various pseudowords meant showed a strong tendency to select objects in the “I don’t know” bucket as the referents of novel labels. In contrast, there was no evidence of a relation between the accuracy of word knowledge judgment and performance in the current disambiguation prediction task.

In the current Experiment 2, a different measure of awareness of lexical knowledge—errorless object nameability judgment—was related to disambiguation prediction performance even after statistically controlling for the contributions of age and vocabulary size. Children who always said “yes” when asked whether they knew the name for a highly familiar object and always said “no” when asked whether they knew the name for an unfamiliar object showed a strong tendency to predict that the unfamiliar object rather than the familiar one “was going to be right” in the disambiguation game. Thus, whereas successful disambiguation prediction may depend on representing the metacognitive contrast between unfamiliar and familiar objects, successful performance in Slocum and Merriman’s (2018) buckets task may depend on representing the metacognitive contrast between unfamiliar and familiar labels.

Although both word knowledge judgment and object nameability judgment are measures of awareness of lexical knowledge, the two judgments were only moderately correlated in Experiment 2 (see Table 3; for the dichotomous measure of object nameability judgment, $r_{pb}[46] = .30, p < .05$). This result is not unusual, although most studies find a stronger correlation between the two (see Hartin et al., 2016, for a meta-analysis of seven studies). Other evidence supports the possibility that these two types of judgments involve some unique abilities. For example, the accuracy of preschoolers’ object recognition memory and the speed of their object naming were both found to be more strongly related to their object nameability judgment than to their word knowledge judgment (Lipowski & Merriman, 2011; see also Merriman et al., 2008).

We claim that children perform well in both the current task and Slocum and Merriman’s (2018) buckets task only if they tend to represent a cognition that is common to all instances of the disambiguation effect. In the buckets task, those who performed well were most likely aware that they were using such metacognitive representations. Those who consistently chose the “I don’t know” bucket over the “I know” presumably represented the test labels as names for objects “I don’t know.” In the current prediction task, conscious metacognitions may not have been required for success. For example, some children may have picked whichever object evoked a feeling of novelty, and thus performed well, but not have been

aware that they were basing their selections on this metacognition. However, the vast majority who chose correctly on the first prediction trial or who made at least three of four correct predictions also performed at ceiling in the object nameability judgment task. Because the latter is a test of conscious metacognitions (specifically, judging whether one “knows” the name for various objects), it is likely that most of the children who performed well in disambiguation prediction did so because they used similar conscious metacognitions. Most likely, they consciously represented the familiar object as something they knew and the novel object as something they did not know.

Although four-year-olds performed well in our task, we have not demonstrated that they tend to consult general metacognitive representations when solving an isolated instance of the disambiguation problem. They may only consult them when asked to consider what multiple instances have in common (i.e., how they are examples of the same “game”). We suspect that children can only perform well in our task if they already had some tendency to consider general metacognitive representations when confronting a disambiguation problem. At least we have demonstrated that four-year-olds are capable of abstracting a metacognitive pattern that multiple instances follow and then using this pattern in a generative manner (i.e., to predict which of two objects will be correct). We could not draw either of these conclusions from the success of four-year-olds in Slocum and Merriman’s (2018) buckets task. In that study, the experimenter provided the children with metacognitive representations of the objects (i.e., “I know” and “I don’t know.”) Four-year-olds could have succeeded in that task only because they applied one of these representations (specifically, “I don’t know”) to the novel labels, which then led them to pick the objects in the “I don’t know” bucket.

Regarding the three-year-olds’ failure to show the disambiguation prediction effect, we must be careful not to conclude the null hypothesis. It is possible that they detected what the solutions to the initial disambiguation problems had in common, or at least are capable of detecting it, but other factors interfered with their using this information to predict which object was “going to be right.” For example, they might not have believed that the correct choices in the “game” were based on a stable rule and so did not attempt to figure out what the rule might be. Or they may have noticed that the novel object was always correct but interpreted the request to predict the correct object on a next trial as a cue that the game was going to change. We know of no research that shows that three-year-olds would interpret a game this way or interpret the request to make a prediction this way, but more research is needed that directly examines their interpretations. In fact, in the dimensional card sort switch task (Zelazo, Frye, & Rapus, 1996), three-year-olds not only have little difficulty forming stable rules, they tend not to change them even when instructed to use a new rule.

One challenge for the view that three-year-olds actually noticed what the disambiguation problems had in common but erred because of how they interpreted the game or the request to make a prediction is the pattern of measure intercorrelations in the Experiment 2. Why would children’s tendency to make correct disambiguation predictions correlate so strongly and distinctively with whether they made errorless object nameability judgments if the key to their making correct predictions was simply whether they made appropriate interpretations of the game or the request to make a prediction?

According to the Mutual Exclusivity (Markman, 1989; Merriman & Marazita, 1995) and Pragmatic Contrast accounts (Clark, 1988; Diesendruck & Markson, 2001; Gathercole,

1989), the disambiguation effect results because children detect the mismatch between the novel label and the familiar object's known label, then reject the familiar object because of this mismatch (Halberda, 2003, 2006). According to competitive activation models (McMurray et al., 2012; Merriman, 1999; Regier, 2005), the effect results because children's representation of the unfamiliar object receives more activation than the representation of the object when the novel label is presented. The current findings as well as those of Slocum and Merriman (2018) support the view that as children develop an awareness of their own lexical knowledge/ignorance, general metacognitions about the novel label and the two types of objects also support their decision to map the label to the unfamiliar object.

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