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Three- to Four-Year-Olds' Recognition That Symbols Have a Stable Meaning: Pictures Are Understood Before Written Words

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In 4 experiments 120 three- to four-year-old nonreaders were asked the identity of a symbolic representation as it appeared with different objects. Consistent with Bialystok (2000), many children judged the identity of written words to vary according to the object with which they appeared but few made such errors with recognizable pictures. Children also made few errors when the symbols were unrecognizable pictures. In Experiments 2 to 4 this pattern of responses was preserved in conditions that made it unlikely or impossible for children to answer correctly by taking the symbol to refer to one of the objects with which it appeared. Instead, correct answers required children to appreciate that the symbol had a generic, abstract meaning.

In the moving word task, 3- to 4-year-olds commonly judge that a written word such as *cat* says "cat" when it is placed in front of a toy cat, but that it says "bird" when placed in front of a toy bird (Bialystok, 1991). Bialystok (1991, 2000) claimed that children make such errors because they do not understand that written words have a stable meaning, independent of the context in which they appear. In the current article we examine whether this development is truly distinct from other aspects of symbolic understanding and whether the understanding is general across written words and pictures or specific to particular symbol types. Before addressing these empirical questions we begin by distinguishing the conceptual issue of symbolic stability from the questions addressed in the existing literature on children's understanding of the representational nature of written words and pictures.

DeLoache (1995) defined a symbol as an "entity that someone intends to stand for something other than itself" (p. 67). Even this relatively simple definition contains a great deal of embedded complexity. Clearly, children need to understand how the form of a symbolic entity relates to its function, how that function is determined by someone's intentions, and what is the "something other than itself" for which the symbol stands. Moreover, developments in these components of children's symbolic understanding may apply across all types of symbol or may occur at different times and in different ways across different symbol types. These complexities mean that the course of children's developing understanding of symbolic artefacts is likely to consist of many distinct achievements over a number of years (e.g., DeLoache & Burns, 1994; Liben, 1999).

Of most importance for the current study is understanding what it is that symbols represent and how this develops for pictures and written words. DeLoache and Burns (1994) pointed out that the same symbol may often be used to represent different things. For example, a photograph can be used to represent either a specific person or event, or to stand for a generic class of people or events. However, most research on children's understanding of symbolic representations deals exclusively with the first case, in which symbols represent specific situations. As a result, there is little evidence on whether the theoretical distinction noted by DeLoache and Burns actually identifies distinct problems for children. Establishing ways of addressing this question is important for advancing our theories of children's developing symbolic understanding. We begin by reviewing studies where symbols represent specific situations before describing research by Bialystok (e.g., 1991, 2000) that may test children's understanding of a symbol's generic, abstract meaning.

A substantial literature has examined the development of children's understanding of the representational relation between external representations and particular real-world objects or situations. The work of DeLoache and colleagues suggests age-related differences in children's ability to use veridical external representations as clues to the location of an object hidden in a room. Children aged $2\frac{1}{2}$ years, but not 2 years, are able to use information presented in photographs and videos to locate hidden objects

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(e.g., DeLoache, 1991; Troseth & DeLoache, 1998), and by age 3 years are able to use information from a scale model in this way (e.g., DeLoache 1987, 2000). However, the limited nature of these young children's abilities is highlighted in several other studies. For example Zelazo, Somerville, and Nichols (1999; see also Povinelli, Landry, Theall, Clark, & Castille, 1999; Suddendorf, 1999) also used tasks that required children to locate an object based on video (or verbal) evidence. However, unlike DeLoache and colleagues' (DeLoache, 1987, 1991, 2000; Troseth & DeLoache, 1998) tasks, children in Zelazo et al. had a prior belief (Experiment 3) or a reasonable expectation (Experiments 1 and 2) about the location of the object, which they had to change on the basis of the verbal or video evidence. In these tasks 3-year-olds performed relatively poorly and substantially worse than 4-year-olds. Despite this, Zelazo et al. did not draw strong conclusions about 3-year-olds' understanding of representations, arguing that 3- to 4-year-olds' problem could be with handling the conflict between their beliefs and the information from the video or message, rather than with understanding the media themselves (though see Suddendorf, 1999, for evidence that children's errors cannot be attributed to misunderstanding of the video media). Less equivocal evidence for continuing developments in children's understanding of representations comes from studies showing that 3- to 4-year-olds do not properly understand misrepresentation.

Misrepresentation tasks commonly begin with a representation being made of an object or scene—a photograph is taken (e.g., Slaughter, 1998; Zaitchik, 1990), a picture is drawn (e.g., Robinson, Nye, & Thomas, 1994), or a note is written (e.g., Thomas, Jolley, Robinson, & Champion, 1999). The referent object or scene then undergoes a change; for example, a star-shaped sticker placed on a doll is swapped for a circle-shaped sticker. With the doll referent and representation face down, children are then asked to judge the identity of the doll's sticker in the photograph, drawing, or note. In these studies, many 3- to 4-year-old children judged incorrectly that the representation accurately depicts the doll's new sticker. Similarly, in a variation of this procedure in which the picture rather than its referent is changed, Robinson, Nye, and Thomas (1994) found that 3- to 4-year-olds judged the face-down picture to have its original features in correspondence with the object it represented. These studies provide strong evidence that children ages 3 to 4 have difficulty handling the conflict between a misrepresentation and the object or situation it is supposed to represent.

The studies described so far are all concerned with children's ability to understand the relation between representations and particular objects or situations. However, there is also a clear sense in which certain media have a generic or abstract meaning that is not tied to any particular real-world referent (e.g., DeLoache & Burns, 1994). For example, although the word *cat* may be used to label a particular cat, it would apply equally well to any other cat, and indeed still means *cat* when there is no identifiable referent. Bialystok's (1991, 2000) moving word task seems to test children's understanding of this aspect of the representational nature of written words.

The general form of this task is as follows. Two toy objects (e.g., a cat and a bird) are introduced and placed on the table in front of the child. The experimenter next introduces a card on which the word *cat* is written. The 3- to 5-year-old participants are unable to read; therefore, the experimenter explains that there is the word *cat* on the card and, without further comment, places the card in front of the cat on the table. The child is then asked what word is on the card. Next, a puppet character causes a disruption, in the process ''accidentally'' moving the word card so that it is in front of the bird. The child is again asked what word is on the card. The experimenter moves the word back to its original position in front of the cat, and once more asks the child what word is on the card. The consistent finding is that when the word appears in front of the cat, 3- to 4-year-old children correctly judge it to say *cat*, but when it appears in front of the bird many children incorrectly judge it to say *bird*. From this finding, Bialystok (2000) argued that children who fail the task lack a crucial understanding of the stability of the meaning of a written word, and more specifically that they do not understand ''that the meaning of the printed word is determined entirely and exclusively by the printed letters'' (p. 178). From what has been described, it is clear that one should be cautious about the strength of this conclusion. The meaning of printed words may derive much from the objects to which they refer (e.g., Apperly & Robinson, 2002) and from the linguistic context in which they appear. What is more, it is not necessarily that children need to know the formal relation between letters, sounds, and meanings to pass this task. All that is necessary for the child to know is that a word is not the kind of thing that changes ''what it says'' according to the objects with which it appears. Nonetheless, in attempting to assess children's understanding of the stability of what a word means in isolation, independent of its relations to particular objects, the moving word task appears to test knowledge of

representations that is conceptually distinct from the understanding investigated in the experiments described earlier.

The two principal questions addressed in the current study were: (a) whether the moving symbol task really does assess children's understanding of abstract symbol meaning and (b) whether such an understanding develops at a similar age for written words and pictures. Bialystok (2000, Experiment 1) included a condition with a generic line drawing, rather than a word, on the card. In this condition, 3-, 4-, and 5-year-olds were consistently correct in saying that the card had a picture of a cat on it, whether it was in front of a toy cat or a toy dog. This finding is consistent with the possibility that children understand the symbolic stability of pictures before they understand the same for written words. However, such understanding was not necessary in Bialystok's experiment. For whereas children were unable to read the word stimuli, the identity of each picture stimulus was directly apparent, meaning that children could simply have been ''reading off'' what picture was on the card each time they were asked. The principal manipulation in the current experiments was to compare such representationally transparent pictures with picture stimuli that are representationally opaque, that is, unrecognizable pictures whose identity may not be read from their appearance. If children perform well on a moving symbol task with unrecognizable picture stimuli this would seem good evidence for knowledge of the symbolic stability of pictures.

Before turning to the current experiments, it is important to acknowledge several methodological concerns with the moving symbol task as a means of assessing children's symbolic knowledge. First, although a ''naughty'' puppet character is used to make the first movement of the symbol card (from toy cat to toy bird in the preceding example) seem unintentional, it is unclear whether this is effective in preventing children from erroneously believing that the experimenter intends them to change their response in conditions where they cannot read the symbol. Second, the repetition of the same test question three times for the same symbol may also be an important source of pragmatic errors: Children may change their judgment of what the symbol says merely because the repeated question leads them to infer that their previous response was incorrect (e.g., Siegal 1997, 1999). Third, Bialystok (1999) reported a correlation between children's performance on the moving word task and a test of attentional control—the dimensional change card sort task (e.g., Frye, Zelazo, & Palfai, 1995). This finding raises the possibility that the task itself makes performance demands that could obscure children's underlying understanding of the stability of symbol meaning. Fourth, although the symbol is not introduced as a symbol for either of the two objects, the initial placement of the symbol with a corresponding object may lead children to assume that it is a representation of that particular object. Such a construal by children would mean that the task did not test understanding of symbol meaning in the abstract, and thus would make the task much less interesting by undermining the factor that distinguishes it from other tests of children's symbolic understanding. These concerns might raise doubts about the suitability of Bialystok's (2000) procedure for assessing children's understanding of symbols. However, the impact of the first three concerns would be reduced, or at least modified, if children performed well on a version of the task that used unrecognizable pictures rather than words. All four concerns are addressed in the following four experiments.

Experiment 1

Method

Experiment 1 used a similar method to Bialystok's (e.g., 2000) and three types of symbolic stimuli: words, recognizable pictures, and unrecognizable pictures. Based on Bialystok's findings, we expected 3- to 4-year-old nonreaders to make few errors on trials using recognizable pictures and many more errors on trials using words. If children's strategy on recognizable picture trials is to read off their response from the picture, we would expect their performance on unrecognizable picture trials to be relatively poor. In contrast, if they understand something about the symbolic stability of pictures before a comparable understanding for words, performance on unrecognizable picture trials should be relatively good.

Participants. We tested 30 children (17 boys and 13 girls) aged 3 years 5 months to 4 years 7 months ($M = 4$ years 2 months). In this experiment, and in Experiments 2, 3, and 4, children were from nurseries serving a middle-class population in Birmingham, England. Approximately 15% of children were of Asian or African descent. The remainder were White. All spoke English as their first language and were judged to be nonreaders by their nursery teachers.

Design. The same basic design was used for all four experiments; they differed only in the specific conditions that children received. Following a

warm-up trial that used recognizable picture stimuli, each child undertook six experimental trials: two on which the moving symbol was a word, two on which it was a recognizable picture, and two on which it was an unrecognizable picture. Trials of the same condition were presented consecutively. The order in which conditions were presented was counterbalanced so that, across children, conditions were equally likely to be presented first, second, or third. The object pairs were presented in two different orders between children. The net result was that each object pair appeared equally often in each condition, thereby guarding against stimulus effects due to particular object pairs.

Materials. We selected 12 toy objects that we expected to be familiar to 3- to 4-year-olds and formed six pairs, one for each experimental trial: dog, boy; cup, girl; ball, boat; house, train; apple, pencil; bear, phone. For one object in each pair (the corresponding object) we created corresponding word and recognizable picture stimuli, presented on white 10 cm × 16 cm cards. Word stimuli were created using lowercase letters in Arial font size 48. Recognizable picture stimuli were hand drawn in black ink. Although each picture corresponded with an object, they were designed to be generic and included no specific details to indicate that the picture depicted that particular object (see Appendix A for an example of a recognizable picture stimulus). The six unrecognizable picture stimuli were also hand drawn. Although we needed these stimuli to be unrecognizable, we wanted them to be as similar as possible in other respects to the recognizable pictures. Thus, each unrecognizable picture was composed from the same number of separate lines as one of the recognizable pictures (see Appendix B for an example of an unrecognizable picture stimulus). To check that these novel stimuli were indeed unrecognizable, they were shown to 10 psychology undergraduate students at the University of Birmingham. None was able to identify any of the pictures.

The warm-up trial employed another pair of common toy objects—a cow and a car—and one other recognizable picture. A toy dog was used to effect the movement of the symbol card from the corresponding to the noncorresponding object. The dog was battery operated and produced a barking noise when a button was pressed. This dog was used for Experiments 1 and 2. Experiments 3 and 4 used a soft toy dinosaur for the same purpose.

Procedure. Children were tested individually at a table in a quiet room next to the main classroom of their nursery. The procedure was similar to that of Bialystok (2000). Children were first introduced to Scruffy the toy dog and were shown how he could bark and run around. Warm-up and experimental trials all took the same basic form. Two toys were introduced and placed on the table slightly to the left and slightly to the right of the child (the position of the corresponding object was varied across trials). The child was asked to name the objects. Incorrect names were corrected by the experimenter, and the child was asked to repeat the correct name.

Next, the experimenter introduced a symbol card. When the symbol was a word the experimenter said, ''This card has the word *X* on it.'' When the symbol was a recognizable picture the experimenter said, ''This card has a picture of an *X* on it.'' When the symbol was an unrecognizable picture the experimenter said, ''I asked my little sister to draw an *X* on this card.'' Children's knowledge of what was on the card was checked immediately by asking, ''Can you tell me what is drawn/written on this card?'' Wrong answers were corrected, and the card was then placed in front of the object with which it corresponded. This is a slight variation on the procedures used by Bialystok (2000), in which the child was asked what was on the card after it had been placed next to the corresponding object. The experimenter did not mention or otherwise draw attention to the fact that the symbol corresponded to the object. At this point, Scruffy the dog began barking and running around, in the process ''accidentally'' moving the symbol card to in front of the noncorresponding object. After removing the dog from the scene the experimenter asked the key inconsistent question: ''Can you tell me what is drawn/written on this card?'' This was the only question on which Bialystok found that children made a substantial number of errors. The experimenter then explained that Scruffy has ''made a mess'' and the symbol card was moved back to its original position in front of the corresponding object. At this point, children were once more asked, ''Can you tell me what is drawn/written on this card?''

Results and Discussion

No errors were recorded when children were initially asked what word or picture was on the card. Only four errors were recorded across 180 trials when children were asked what word or picture was on the card in its final position in front of a corresponding object. These findings are consistent with those reported by Bialystok (2000), suggesting that the fact that we asked this question before placing the symbol with the corresponding object (whereas

Table 1
Frequency and Mean Number of Correct Responses in the Three Conditions of Experiment 1

No. of correct responses	Recognizable picture	Unrecognizable picture	Word
0	5	5	10
1	0	8	14
2	25	17	6
M/2	1.7	1.4	0.9

Bialystok asked it afterward) had not affected children's ability to respond with high accuracy to this question.

For the inconsistent question (asked when the symbol was in front of the noncorresponding object), each child's number of correct responses on the two trials in each condition was tallied, yielding four totals of 0, 1, or 2 correct responses (the frequencies of these totals are presented in Table 1). Children's responses were tallied in the same way for Experiments 2 to 4.

Here and throughout, to investigate whether two conditions differed in difficulty, we examined the distribution of data for children who gave a different number of correct answers on the two conditions. Consistent with Bialystok's (2000) findings, 19 children gave more correct answers on recognizable picture trials than on word trials; and 2 children gave more correct answers on word trials than on recognizable picture trials. This distribution differs from what would be expected by chance alone ($p < .001$, binomial test). Fifteen children gave more correct answers on unrecognizable picture trials than on word trials; and 2 showed the opposite pattern ($p < .001$, binomial test). Eight children gave more correct answers on recognizable picture trials than on unrecognizable picture trials; and none showed the opposite pattern ($p = .008$, binomial test).

To test whether children were giving consistently correct or incorrect answers in the different conditions, or whether they were merely guessing, the distribution of 0, 1, or 2 correct responses for each condition was evaluated against the distribution expected by chance. For both picture conditions, children's performance was significantly above chance: both χ^2s$(2, 30) > 16$, both ps $< .001$. For the word condition, performance was not significantly different from chance, $\chi^2(2, 30) = 1.2$, $p > .5$.

In sum, 3- to 4-year-olds gave significantly more correct judgments when the moving symbol was a recognizable picture than when it was a word (consistent with Bialystok, 1991, 2000). Varying the representational transparency of the picture stimuli did make a difference, as children made fewer errors with recognizable pictures than with unrecognizable pictures. However, children nonetheless made many more correct judgments when the moving symbol was an unrecognizable picture than when it was a word. This finding suggests that children's good performance with recognizable pictures was not solely due to a strategy of reading off the correct answer from the picture stimulus. What could be responsible for this effect?

One interesting possibility is that children understand the symbolic stability of pictures before they understand the symbolic stability of words. However, there are at least two alternative interpretations. First, recall that the symbol card was initially placed in front of an object with which it corresponded. We already noted in the Introduction that this might unintentionally lead children to see the symbol as a representation of that object. Might this effect be more compelling when the symbol is a picture than when it is a word? Certainly, some children explicitly related the picture to the corresponding object, for example, "The teddy in the picture doesn't have a hat on though does it, you forgot the hat." If this were generally the case, children's knowledge of pictures might indeed be helping them solve the task, but this would reflect an understanding of pictures as representations of particular things rather than as symbols with a stable, abstract meaning. In Experiments 2, 3, and 4 we attempted to reduce the likelihood that children are adopting such a strategy. A second and less interesting reason children might have made fewer errors with unrecognizable pictures than with words is that the additional contextual information given for the unrecognizable picture stimuli ("I asked my sister to draw an *X* on this card") may have enhanced children's memory for the identity of the picture. In Experiment 2 we controlled for this possibility by adding a word condition with a similar justification.

Experiment 2

Method

Participants. We tested 30 children (11 boys and 19 girls) aged 3 year 8 months to 4 years 4 months ($M = 4$ years 1 month).

Design. A fourth condition (word+context) was added to the design for Experiment 1.

Materials. The word+context condition used new word symbol cards on which the word was handwritten in printed lowercase letters of a similar size

to the 48-point Arial font used for the standard word condition. Four new toy objects were selected: spoon, pig, hat, cat. These same materials were also used for Experiments 3 and 4.

Procedure. Word and recognizable and unrecognizable picture conditions had the same introductory wording as in Experiment 1. For the word+context condition, a brief explanation was given as the card was introduced, ''I asked my mum to write the word *X* on this card.'' To make it less likely that children were matching the unrecognizable picture stimulus (or any other stimuli) directly with the corresponding object, symbolic stimuli were introduced before the objects. Thus, children were first asked, ''What word/picture is on this card?'' without any potential referent objects on the table. After this initial question, the symbol card was placed on the table either slightly to the left or right of the child (varied across trials). Next, the experimenter introduced the objects, placing the corresponding object behind the symbol card and the noncorresponding object to the left or right. The rest of the procedure for all conditions followed that of Experiment 1.

Results and Discussion

No errors were recorded when children were initially asked what word or picture was on the card. Only five errors were recorded when children were asked what word or picture was on the card in its final position in front of a corresponding object.

Frequency of correct responses on the inconsistent question (asked when the symbol was in front of the noncorresponding object) are presented in Table 2. Consistent with Bialystok's (2000) findings, 15 children gave more correct answers on recognizable picture trials than on word trials; and 1 showed the opposite pattern ($p < .001$, binomial test). Thirteen children gave more correct answers on unrecognizable picture trials than on word trials, and 1 showed the opposite pattern ($p < .002$, binomial test).

Table 2
Frequency and Mean Number of Correct Responses in the Four Conditions of Experiment 2

No. of correct responses	Recognizable picture	Unrecognizable picture	Word	Word+context
0	3	5	13	10
1	3	4	5	7
2	24	21	12	13
M/2	1.7	1.5	1	1.1

The same pattern was apparent when picture and word+context trials were compared. Thirteen children gave more correct answers on recognizable picture trials than on word + context trials, and 1 showed the opposite pattern ($p < .002$, binomial test). Eleven children gave more correct answers on unrecognizable picture trials than on word + context trials, and 1 showed the opposite pattern ($p < .006$, binomial test). All of these results remained significant even if a strict Bonferoni correction for six multiple comparisons was applied.

Unlike Experiment 1 there was no significant difference in children's performance in the recognizable and unrecognizable picture conditions. Five children gave more correct answers on recognizable picture trials than on unrecognizable picture trials, and 2 showed the opposite pattern ($p = .45$, binomial test). In addition, there was no significant difference between children's performance on the word and word+context conditions ($p = .45$, binomial test).

For all conditions, children's performance was significantly different from chance: all χ^2s$(2, 30) > 9.1$, all ps $< .02$. In the picture conditions this was because a large number of children gave correct answers, whereas in the word conditions children tended to perform either consistently correctly or consistently incorrectly.

Experiment 2 replicated the principal finding from Experiment 1 that children's superior performance on the moving symbol task with pictures, compared with words, does not depend on the pictures being representationally transparent. Children's performance in the word and word + context conditions did not differ significantly, whereas children made more errors on the word + context condition than on the unrecognizable picture condition. Therefore, children's correct answers in the unrecognizable picture condition do not appear due to any contextual support that this condition provides. Unlike Experiment 1, there was no significant benefit in the recognizable picture condition compared with the unrecognizable picture condition, though there were more correct answers in the former case.

We also attempted to make it less likely that children would map the picture (or word) stimuli onto the corresponding object, by introducing the symbol card before the objects. This manipulation did not appear to diminish the difference between children's performance in the word and picture conditions, as might have been expected if children's strategy on picture trials had been disrupted. However, although this manipulation may have made the relation between symbol and corresponding object less salient, their placement together at the beginning of

the trial may nonetheless have highlighted the relation for children. In Experiment 3 we address this point by having conditions where the symbol card begins with the noncorresponding object.

Experiment 3

Method

Participants. We tested 30 children (17 girls and 13 boys) aged 3 years 3 months to 4 years 1 month ($M = 3$ years 9 months).

Procedure. The symbolic stimuli were introduced before the objects in the same way as in Experiment 2. The initially matched word condition was similar to Bialystok's (2000) standard procedure in that the corresponding object was placed behind the symbol card. Unlike Experiments 1 and 2 (but in common with Bialystok, 2000), children were asked what word or picture was on the card at this point (a consistent question). The word was then moved in front of the noncorresponding object in an incidental fashion (this time using a ''naughty'' toy dinosaur) and the question about the card's identity was repeated (this was the key, inconsistent question). Finally, the word was tidied back in front of the corresponding object and the question about the word's identity was asked for the last time.

In the initially mismatched conditions (using word and recognizable and unrecognizable picture stimuli), the noncorresponding object was placed behind the symbol card. Children were asked what word was on the card. For these conditions, this was the key inconsistent question. Next, the symbol was moved in an incidental fashion so that it was in front of the corresponding object and children were again asked what word or picture was on the card.

Results and Discussion

The consistent questions of the recognizable and unrecognizable picture conditions were answered accurately, with only 1 error in each case. In the initially matched word condition there were 4 errors on the initial consistent question and 4 errors on the final consistent question. In the initially mismatched word condition (where the consistent question was asked after the inconsistent question) there were 9 (of 60) errors on the consistent question. This error rate is higher than that observed in the standard procedure, when the consistent question is asked before the card is moved. This suggests that in all conditions movement of the card and repetition of the test question may be leading some children erroneously to switch their response, despite knowing the correct answer. It is important that in the current experiment such errors should not have occurred on the key inconsistent question because it was asked first, before the card was moved. Thus, all data from the inconsistent questions were retained.

Frequency of correct responses on the inconsistent question are presented in Table 3. It is clear from Table 3 that children performed close to ceiling in both the recognizable picture and unrecognizable picture conditions, and consistent with Experiment 2, with similar accuracy in the two conditions. Compared with these picture conditions, children made significantly more errors in both word conditions (all ps $< .001$, binomial test). Earlier we saw that when a word symbol began in front of a noncorresponding object (initially mismatched word condition), there were more errors on the consistent question that followed. However, there was no sign of a difference in children's error rates on the inconsistent questions in the two word conditions, and indeed their performance in the two conditions was highly correlated (partial correlation coefficient controlling for age $= 0.80$, $p < .001$). Thus, there was no evidence that the initial position of the word made any difference to the way children construed the task.

For all conditions, children's performance was significantly different from chance: all χ^2s$(2, 30) > 13.9$, all ps $< .001$.

Table 3
Frequency and Mean Number of Correct Responses in the Four Conditions of Experiment 3

No. of correct responses	Initial mismatch between symbol and object			Initial match between symbol and object
	Recognizable picture	Unrecognizable picture	Word+context	Word+context
0	0	0	13	11
1	1	1	4	5
2	29	29	13	14
$M/2$	1.97	1.97	1	1.10

The attempts in Experiment 3 to make it less likely that children would view the unrecognizable pictures as pictures of the corresponding object did not appear to diminish children's consistently correct responses. In Experiment 4 we made such a strategy impossible in a condition where neither object corresponds to the unrecognizable picture.

Experiment 4

Method

Participants. We tested 30 children (11 girls and 19 boys) aged 3 years 3 months to 4 years 2 months ($M = 3$ years 8 months).

Procedure. All four conditions used the same introductory procedure as for Experiment 2. However, in the no-match unrecognizable picture condition and the no-match recognizable picture condition, neither of the two objects corresponded with the picture on the card (e.g., the two objects might have been a boat and a dog, and the child would be told that the picture on the card was a cat). The initially matched word condition and the initially matched recognizable picture condition followed the more standard method in which the first object placed behind the symbol card was the corresponding object. In each condition the child was asked what word or picture was on the card when the first object was placed with it, after the card had been moved to the second object, and when the card was returned in front of the first object.

Results and Discussion

There were no errors on consistent questions in the initially matched recognizable picture condition. In the initially matched word condition there were four errors on the initial consistent question and four errors on the final consistent question.

Table 4 shows that for these conditions children's performance on the inconsistent question was similar to that observed in Experiments 1 to 3, with significantly more correct answers in the recognizable picture condition than in the word condition ($p < .001$, binomial test).

In the novel no-match conditions, all questions about what was on the card were inconsistent. Children answered all of these questions correctly in the no-match recognizable picture condition. In the no-match unrecognizable picture condition, there were two errors when children were first asked what picture was on the card, two errors when the question was repeated after the symbol card was moved to the second object, and three errors after the card was returned to its original location. For brevity, Table 4 displays only children's responses to the question when the symbol card was in front of the second object (as it was for the inconsistent question for the other two trial types). Clearly, children's performance in all three recognizable and unrecognizable picture conditions was significantly better than their performance in the word condition (all ps $< .001$, binomial test).

For all conditions, children's performance was significantly different from chance: all χ^2s$(2, 30) > 15.0$, all ps $< .001$.

General Discussion

The results from all four experiments show a strong effect of symbol type on children's judgments about the stability of a symbol's meaning (see Table 5). Consistent with Bialystok (2000), many 3- and 4-year-olds incorrectly changed their judgments about what a written word says according to context (i.e., the object with which it appears when the question is asked) whereas very few made such errors when the symbol was a picture. Crucially, the current study provides much stronger evidence than Bialystok that children perform better with pictures than with words because children also made few incorrect judgments about pictures when the picture stimuli were unrecognizable. In the following we discuss the implications of this finding for what we can learn

Table 4
Frequency and Mean Number of Correct Responses in the Four Conditions of Experiment 4

No of correct responses	No match between symbol and object		Initial match between symbol and object	
	Recognizable picture	Unrecognizable picture	Recognizable picture	Word+context
0	0	0	0	10
1	0	2	0	5
2	30	28	30	15
$M/2$	2	1.9	2	1.2

Table 5
Summary of Conditions and Key Findings in Experiments 1 to 4

Experiment	Symbolic stimuli	Key procedural variation	Key result on inconsistent question
1	Word Recognizable picture Unrecognizable picture	Symbol initially placed in front of corresponding object	Recognizable picture > unrecognizable picture > word
2	Word Word+context Recognizable picture Unrecognizable picture	Corresponding object initially placed behind symbol	Recognizable and unrecognizable pictures > word and word+context
3	Word+context Recognizable picture Unrecognizable picture	Initial mismatch between symbol and object	Recognizable and unrecognizable pictures > word and word+context
4	Word+context Recognizable picture Unrecognizable picture	No match between pictures and object	Recognizable and unrecognizable pictures > word and word+context

from the moving word task and for theories of children's developing understanding of representations.

In the Introduction we noted several methodological concerns that, if valid, could raise doubts about the moving word task as a useful test of children's symbolic knowledge. First, the effectiveness of using a naughty teddy character to make the movement of the symbol card seem unintentional was not clear. Similarly, multiple repetition of the test question for the same symbol should be viewed with caution as a potential source of pragmatically driven errors. However, if such factors are solely responsible for children's errors on the moving word task, children should also make errors when the moving symbol is an unrecognizable picture. Experiments 1 to 4 show that children who fail the task when the moving symbol is a written word often pass when it is an unrecognizable picture. This suggests that stimulus-independent features of the task are not responsible for children's errors and should give confidence that the task assesses children's understanding of symbols.

A further concern raised in the Introduction arose from the correlation found by Bialystok (1999) between children's performance on the moving word task and the dimensional change card sort task (Frye et al., 1995). The latter is widely regarded as a test of executive function and attentional control (though see Perner & Lang, 2002, for an alternative view); therefore, the correlation raises the concern that attentional control demands specific to Bialystok's task may be obscuring children's understanding of symbols. As one possible demand, Bialystok suggested that the child may need to resist interference from the salient noncorresponding object which the word is in front of when the key inconsistent question is asked. However, in the experiments reported here, 3- and 4-year-old children resisted interference when an unrecognizable picture was placed in front of a salient noncorresponding item. Clearly, stimulus-independent features of the moving symbol task cannot be posing an overwhelming burden on attentional control if children can succeed with some unrecognizable stimuli but not others. Rather, the current findings suggest that although the particular form of children's error may be due to their failing to inhibit responding with the name of the salient noncorresponding object, the attentional demands of the task, and thus the tendency for such errors, vary with the type of symbol employed. Whether this crucial difference lies in properties of the stimuli themselves or in children's understanding of written words versus pictures is discussed later.

Thus, three concerns about the suitability of the moving word task as a test of children's symbolic understanding can be rejected on the basis of the current evidence. Of course, this is not to say that the task places no demands on pragmatic competence and attentional control. Were the task to be used to explore the limits of still younger children's ability, for example, with unrecognizable pictures, these issues would be raised again. However, the current findings cannot be explained by general task factors, raising the question of why the same moving symbol task is relatively easy with unrecognizable pictures and relatively hard with (unreadable) words. This explanatory slack can only be taken up by an account that proposes that these stimulus types differ in the problems they pose for 3- to 4-year-olds.

First, we consider whether differences in the features of our word and picture stimuli are responsible

for our results. Certainly, our word and unrecognizable picture stimuli differed systematically in form. Although the unrecognizable picture stimuli were representationally opaque, they looked distinctively different from words (see Appendix B). For example, whereas words are composed of discrete elements organized in a horizontal line, the elements of unrecognizable pictures commonly joined, crossed, or were contained within other elements. The question is whether these purely visual differences could have contributed in some way to the ease with which children were able to associate the symbolic form with the meaning they were told by the experimenter. There was no sign of any such effect when children were initially told what was on the word or unrecognizable picture cards. However, a strong test of this hypothesis would require an experiment where differences in form were manipulated systematically.

There are also less direct ways in which stimulus form could have an effect on children's judgments. It is possible that categorization of the stimulus as a word or a picture is vital but that children would have been less ready to accept the experimenter's categorization had the stimuli lacked features distinctive to words and pictures. There is mixed evidence on the sensitivity of 3- to 4-year-olds to such features. For example, Tolchinsky-Landsmann and Karmiloff-Smith (1992) found that children rejected pictures but selected words when asked to select symbols that were ''good for writing.'' However, Thomas, Nye, Rowley, and Robinson (2001) found that many children of this age selected indiscriminately among words, iconic line drawings, abstract patterns, and numbers when asked to select stimuli that were ''good as pictures.'' The moving symbol task could provide a useful paradigm for future research into the relationship between the formal characteristics of symbols and children's judgments about their representational properties.

Besides differences in the stimuli themselves, differences in the nature of children's early experiences with written words and pictures may be important to their judgments about the stability of the meaning of these two symbol types. For example, the symbolic stability of pictures is readily observable in the wide range of representationally transparent pictures with which young children are familiar. The same is clearly not the case with written words for nonreaders.

Young children may also have an appreciation that pictures are intended to have a meaning. For example, Gelman and Ebeling (1998) showed 2- and 3-year-olds' line drawings roughly shaped like nameable objects, such as a man. If children were told that the image had been created accidentally (e.g., by spilling paint) they tended to name the image according to the substance that made it, ''It's paint.'' However, if they were told it was created intentionally (e.g., as a painting) they tended to name it according to what it appeared to represent (e.g., ''It's a man''). Moreover, 3- to 4-year-olds judge that the meaning of a picture is at least partly specified by the intention of the person who draws it, not purely by its physical features (Bloom & Markson, 1998). It is unclear whether young children lack a similar appreciation of the meaning of written words. Certainly, children do not seem sensitive to the provenance of the word in the moving symbol task. In our word + context conditions, the fact that words were handwritten ''by mum'' might have been expected to raise the salience of the intention behind the words' creation. In fact the word + context condition was no easier than the condition using a mechanically printed word. This finding is consistent with Bialystok and Martin (2003), who reported that children made errors on a moving word task even when they saw the word written by an adult or when they were asked to ''write'' the word themselves (the children could not write accurately but would create marks on a blank card when asked to write). Independent evidence is necessary to decide whether 3- to 4-year-olds do in fact fail to appreciate that written words are intended to have meaning. If this turns out to be the case, work by Adi-Japha, Levin, and Solomon (1998; Richert & Lillard, 2002) suggests one reason why. These authors argued that children's understanding about pictures depends on experience with producing and attaching meaning to pictures of their own. If young children have more experience producing pictures than writing words, they may acquire expectations about picture meaning before they acquire similar expectations for written words.

Finally, we consider what understanding of symbols is actually tested by the moving word task and what the current findings add to accounts of children's developing understanding of symbols. The moving word task is intended to assess children's ability to think about the stability of what a written word means independent of its relations to particular objects. However, in the Introduction we noted that the initial placement of the symbol with a corresponding object in the standard task (e.g., the word *cat* placed in front of a model cat) could easily lead children to construe the symbol as referring only to that particular object. If this were the case the ability tested by the moving symbol task would not be

conceptually distinct from that tested by experiments concerned with representations of particular objects or states of affairs. Through Experiments 2, 3, and 4 we accumulated progressively stronger evidence against this interpretation. In Experiment 2 we introduced the symbol cards before the objects, with the aim of reducing the likelihood that children would immediately view the symbol as specifically representing the corresponding object. In Experiment 3, when the objects were introduced, the non-corresponding (rather than the corresponding) object was initially placed behind the symbol. As in Experiment 1, children nonetheless performed better in recognizable and unrecognizable picture conditions than in word conditions. Finally, Experiment 4 showed that children made accurate judgments about recognizable and unrecognizable pictures, even when neither object corresponded with the picture (no-match conditions). Although we did not include a no-match word condition in this study, Bialystok and Martin (2003) found that children performed no better in a no-match word condition than in an initial-match word condition (Experiment 3). These findings suggest that children's correct answers with words and unrecognizable pictures reflect a relatively abstract judgment about the stability of the symbol's meaning rather than a judgment about the symbol as referring to or standing for only the particular corresponding object in the experiment. In light of this conclusion, how do our results compare with those from studies that have examined other aspects of children's understanding of the representational nature of pictures and written words?

A key feature of the current findings is the clear difference between the accuracy of 3- to 4-year-olds' judgments about the symbolic stability of written words and pictures. It would be valuable to know how this pattern compared with that observed for children's reasoning about misrepresentation, which is also known to develop in this period. If children showed a different pattern for misrepresenting words and pictures, this would be consistent with the view that understanding misrepresentation was a distinct problem from understanding symbolic stability. Support for the view that the type of representation can make a difference to the difficulty of a misrepresentation task comes from the finding that misrepresenting pictures (drawings and photographs) are understood before misrepresenting beliefs (e.g., Leslie & Thaiss, 1992; Peterson & Siegal, 1998; Slaughter, 1998). Perhaps surprisingly though, word and picture stimuli have never been directly compared in a misrepresentation task.

Effects of the representational medium have been found in studies of children's ability to use accurate representations (as opposed to misrepresentations). For example, in her studies of 2- to 3-year-olds' ability to use representations to guide their search behaviour, DeLoache (e.g., 1987, 1991, 2000; Troseth & DeLoache, 1998) found better performance with pictures, photographs, and videos than with scale models. In their more complex search task, Zelazo et al. (1999) reported that 3- to 4-year-olds were more likely to make appropriate use of photographs compared with drawings (Experiment 1) and verbal clues compared with video clues (Experiment 3). However, pictures have not been compared with written word stimuli in either of these paradigms.

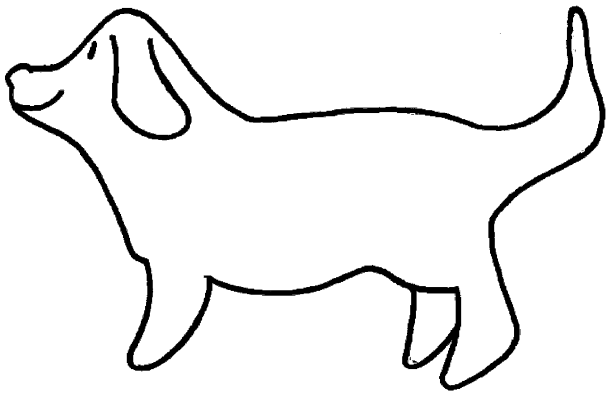
Thus, we are currently in a poor position to evaluate important questions about the form of 3-year-old children's developing understanding of representational artifacts or symbols, and about the development of this understanding for different symbol types. It could be, for instance, that progress in children's understanding of representations is essentially similar across symbol types, taking the same form but progressing at different rates for different types of symbol. Alternatively, progress with different types of symbol could be the result of separate developmental processes that have little influence on one another. Between these extremes there are of course intermediate positions, including the possibility that children's understanding is specific to particular symbol types at some points in development and interactive at others (e.g., see DeLoache, 1995; Liben, 1999, for broader discussions of these and other issues). Distinguishing between these possibilities requires further conceptual and empirical work. As already mentioned, differences in the age at which children pass the same task with different symbol types, and variation in these patterns across different tasks, can provide important evidence about the degree to which development is specific to particular symbol types or general across all symbols. Other important evidence can come from the patterns of statistical association between tasks. For example, Slaughter (1998) not only found that children perform better on false picture tasks than on false belief tasks, but also found little association in performance or transfer of training between the two types of task.

Future work will require systematic investigation of children's abilities on a range of tasks with a range of stimuli. With this approach it will it be possible to avoid the concern that children's responses are specific to a particular task or stimulus type. The use of unrecognizable picture stimuli in the current

experiment shows how symbol type and symbol characteristics can be manipulated experimentally to shed light on the basis of children's responses on a particular task. Developing this approach across a range of tasks would provide important new information about the nature of children's developing symbolic understanding. The approach of using multiple tasks also depends on having a sufficiently detailed theoretical framework for the formal demands of different tasks to be distinguished. A further contribution of the current study is to highlight the difference between reasoning about abstract symbolic meaning versus symbols as representations of particular objects, which may well constitute distinct problems for children to understand (see also DeLoache & Burns, 1994).

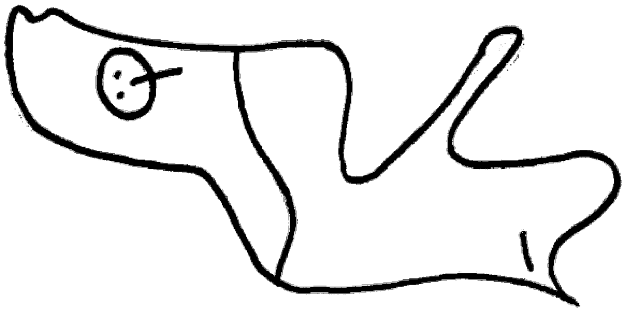
In summary, our findings support the moving word task as a useful test of children's judgments about the stability of symbol meaning. This conclusion, and the use of our moving unrecognizable picture condition as a control and comparison, should assist future use of the moving word task in research on typical and atypical development of children's understanding of written representations. Our findings establish that children were not viewing the moving symbol as a representation of a particular stimulus object. This suggests that research on children's developing understanding of representations should distinguish between reasoning about abstract symbolic meaning versus symbols as representations of particular objects. Finally, our findings are perhaps the best evidence of a dissociation between children's understanding of the representational nature of written words and of pictures.

Appendix A



Example of a recognizable picture stimulus.

Appendix B



Example of an unrecognizable picture stimulus.

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