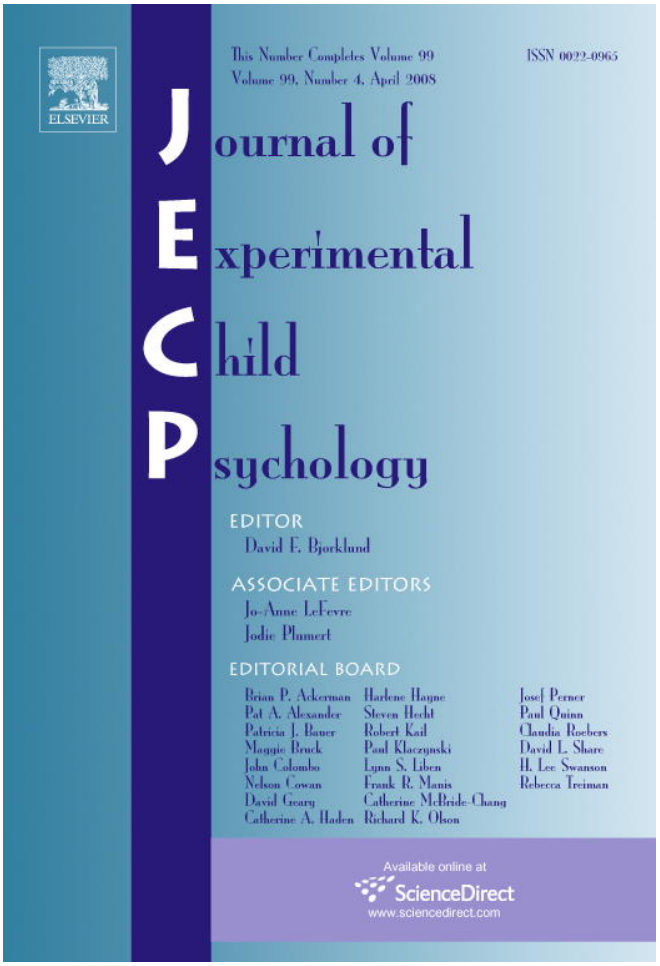

Available online at www.sciencedirect.com
ScienceDirect
Journal of Experimental Child Psychology 99 (2008) 252–270
Journal of Experimental Child Psychology
www.elsevier.com/locate/jecp

Can children resist making interpretations when uncertain?

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Received 11 June 2007
Available online 27 July 2007

Abstract

In two experiments, we examined young children's ability to delay a response to ambiguous input. In Experiment 1, 5- and 6-year-olds performed as poorly when they needed to choose between basing an interpretation on ambiguous input and delaying an interpretation as when making explicit evaluations of knowledge, whereas 7- and 8-year-olds found the former task easy. In Experiment 2, 5- and 6-year-olds performed well on a task that required delaying a response but removed the need to decide between strategies. We discuss children's difficulty with ambiguity in terms of the decision-making demands made by different procedures. These demands appear to cause particular problems for young children.

Keywords: Ambiguity; Knowledge; Implicit and explicit understanding

Introduction

Imagine the end of a film in which the hero has just seconds to defuse a bomb. As the countdown ticks by, he wavers over the red or green wire, unable to be certain which one must be cut. As the countdown reaches its final second, he cuts the red one. Fortunately, if unsurprisingly, he defuses the bomb and saves the day. In a tense situation, he who hesitates is lost. Of course, there are many other situations when being cautious is advisable.

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0022-0965/$ - see front matter
doi:10.1016/j.jecp.2007.06.002

If the hero in the thriller had several hours left on the countdown, it would have been ridiculous for him to gamble. Given the opportunity, he should wait for his specialist colleague to arrive and tell him, unambiguously, which wire to cut. In both scenarios, the hero finds himself confronted by uncertainty. The crucial wire is either the red one or the green one, and at the moment he does not know which one to cut. Two quite different courses of action are appropriate depending on the situation. In this article, we consider one of these responses, namely, delaying an interpretation.

There are two ways in which one might be described as resisting responding to problematic information. First, one might make a decision not to respond, recognizing delay as a good course of action on this occasion. In the (unlikely) film ending where our hero could wait for his colleague, this strategy would be the rational option. Second, sometimes people hesitate when they encounter problematic information. Although a response is delayed, this is incidental rather than deliberate. This kind of delay not only is unintentional but also might not be optimal. In the classic film ending, the hero must make a choice because hesitating means that it is more likely the bomb will explode.

In what follows, we examine when and how children can resist responding to a particular type of problematic input, namely, ambiguous information. We investigate the possibility that until around 7 years of age, children have difficulty in deciding how to respond to ambiguous input. To do this, we compare how children perform on two tasks: one where they need to decide to delay a response and another where the delay is more incidental. It is possible that this incidental delaying of a response might be described as implicit understanding. We return to this issue later.

Before we come to examine whether children can delay their responses to ambiguous information, we first briefly summarize the substantial literature on young children's difficulty with ambiguous input. In line with this literature, we define input as ambiguous when one piece of information, such as a word, a message, or a view, has multiple possible interpretations. When children older than around 7 years of age encounter an input that has more than one possible interpretation, they know that they cannot be sure of its meaning. They respond appropriately by stating their ignorance, seeking out disambiguating information, or perhaps making a tentative interpretation. On the other hand, this input causes serious problems for younger children. In a typical experiment, children see two pictures: a strawberry and a tomato. One of these pictures is then hidden behind a card so that all that can be seen is a small patch of red. Young children consistently claim that they can know which picture is hidden (e.g., Taylor, 1988; see also Bearison & Levey, 1977; Robinson & Robinson, 1982). They continue to do this in the face of feedback that they have been wrong in the past and when they are given incentives to be cautious.

One possibility is that children make a pragmatic interpretation of ambiguity tasks. They understand that they do not have enough information to be certain, but they judge that it is better to guess than to be cautious. One might think of children as treating every ambiguous situation as akin to the film climax where there are only a few seconds left. Making a snap decision seems to them to be the most sensible response. This is unlikely given children's performance on other measures. Children's problems are not limited to deciding whether or not to make an interpretation. They tend to describe ambiguous messages themselves as "good" or "clear" (e.g., Singer & Flavell, 1981), they claim that the speaker "said enough" for a confident interpretation to be made (Robinson & Whittaker, 1986), and they blame the listener rather than the speaker when communication fails (Robinson & Robinson, 1977).

Children's difficulty persists when the metacognitive and linguistic demands of these tasks are reduced. When offered alternative strategies to remove the ambiguity, children fail to employ them appropriately. Young children do not ask questions to disambiguate problematic messages (Ironsmith & Whitehurst, 1978), nor do they use a simple behavioral strategy to obtain more information such as looking in the potential hiding places before committing to a choice (Beck & Robinson, 2001).

Is there any evidence that children might be able to delay their responses when they encounter ambiguity? Several studies that have observed children's nonverbal reactions suggest that this is the case. In one study, 4- to 10-year-olds showed longer reaction times when a message had multiple interpretations. They also made more eye contact with the speaker and more hand movements, although the pattern of responses varied slightly among ages (Patterson, Cosgrove, & O'Brien, 1980). In a game where toys were hidden in a dolls' house and children were given clues to their location, 5-year-olds took longer to begin searching when a message could refer to more than one hiding place than when it had only one possible referent (Plumert, 1996). When children were asked to follow ambiguous instructions to build a model, 5- and 6-year-olds showed similar behavioral signs of problem detection, for example, pauses and puzzled expressions (Flavell, Speer, Green, & August, 1981). In all of these studies children's nonverbal behavior was out of line with their explicit responses (judging their own knowledge or deciding whether to ask a question). In keeping with the literature described above, 5- and 6-year-olds tended to be overconfident, saying that they knew the referent and avoiding asking questions. Data from an eye-tracking study with 4- to 7-year-olds offered further nonverbal evidence of understanding. When children heard an ambiguous pronoun, they looked more to an alternative pictorial representation of a sentence than they did on hearing an unambiguous pronoun (Sekerina, Stromswold, & Hestvik, 2004). Together, these articles indicate that children take a relatively long time to respond and appear to hesitate when they encounter ambiguous information.

Another group of studies does not offer such an optimistic view of children's ability to resist interpreting ambiguous input. These studies were motivated (at least in part) by a concern that children might find it especially difficult to say that they do not know or "can't tell" what the solution to a problem is. As an alternative, children were offered the choice between making an (inappropriate) interpretation or asking another character for information. In one task, 5- and 6-year-olds heard a story in which a doll gave a message to her friends about where she was going swimming, with her destination being one of two possible locations (Somerville, Hadkinson, & Greenberg, 1979). Half of the children were simply directed to say that they "couldn't tell" whether the message was inadequate. The other half were given the option to ask a shopkeeper who had seen which way the main character had gone. No advantage was conferred by elaborating the "can't tell" response with the option to "ask the man." A similar comparison was made by Robinson and Whittaker (1985, Experiment 2). Once again, the performance by a group of children who were directed to point to a "mystery man" (a doll covered in question marks) when they did not know the correct referent of a message was no better than the performance by a group of children who were told to tell the experimenter when they could not know. These studies suggest that 5- and 6-year-olds found it difficult to resist making an interpretation of ambiguous input, even when the alternative was to delay an interpretation briefly to gain disambiguating information.

Finally, a different task used by Klahr and colleagues (Fay & Klahr, 1996; Klahr & Chen, 2003) presented children with increasing evidence and examined whether they would

wait until they had sufficient evidence before judging that this was a determinate or indeterminate problem. For example, the children saw a target model made of red plastic pieces and four boxes were opened sequentially, revealing different colored plastic pieces in each. After each box was opened, children were asked whether they could identify for certain the box from which the model had been made or whether they would need to guess. Although 4- and 5-year-olds performed well when all of the boxes were opened (an age that is somewhat younger than when most studies find children will acknowledge their uncertainty in similar situations), when only some of the boxes were opened, children had substantial problems acknowledging that the contents of unopened boxes should influence their evaluation of certainty. Children judged whether they could tell or needed to guess which box the model came from based on the open boxes alone. If there was only one match among the open boxes, they judged that they could tell; if there were multiple possible matches, they said that they needed to guess. In this task, children did not take into account how information they were yet to acquire should influence their current judgment, and they did not appear to understand that sometimes one needs to wait so as to make an accurate evaluation. Children's performance improved on this task when they were given explicit feedback and training, and 5-year-olds maintained this improvement several months later. Perhaps this indicates that children will find delaying an easy strategy to adopt. Although we did not use a training paradigm in our study, we used a very simple delay task. Unlike in Klahr and colleagues' task, children will not need to decide to wait to see whether the new information will mean that they can or cannot make an interpretation. In our experiments, the goal always is to make an informed interpretation. The decision is about when to make it.

Thus, there is a discrepancy in the literature regarding whether or not children can delay making interpretations of ambiguous input. Some accounts of children's difficulty with ambiguity suggest that their problem lies in their inability to resist making an interpretation. One particularly specialized explanation is Acredolo and Horobin's (1987) premature closure theory. According to this theory, children search for a possible referent on receiving ambiguous input. As soon as they find a potential referent, it is accepted as the correct interpretation and children stop searching. The message is deemed to be a good one because it allowed them to find a referent. Other accounts suggest that children appreciate that there are multiple potential referents and the problematic nature of the message. Their pragmatic interpretation of the experimental setup is that one should make an interpretation whenever possible. Thus, they make guesses based on heuristics (Speer, 1984) and always will favor acting rather than withholding judgment (Ackerman, 1981). These accounts find it easy to explain why children have difficulty with many of the established tasks, including the "ask a man" tasks and Klahr and colleagues' indeterminacy tasks (Fay & Klahr, 1996; Klahr & Chen, 2003). According to these tasks, so long as children can make an interpretation, there is no need to consider alternative strategies. However, these accounts do have difficulty in accommodating the nonverbal data.

The accounts in the preceding paragraph focus on children's behavior in the particular circumstance where they encounter ambiguity. We group these as performance accounts. Other accounts focus on the representational demands of ambiguity tasks. According to Chandler and colleagues (Carpendale & Chandler, 1996; Chandler, 1988), children do not appreciate the interpretive nature of the mind until they are around 7 years of age. That is, they fail to understand that two people given the same input may make different judgments about it. In the example of the partial view of a tomato or strawberry, one per-

son could interpret the patch of red as being the tomato, whereas a second person could think that it is the strawberry. Development of this understanding allows children to recognize why ambiguous input is problematic and to deal with it appropriately. Related accounts based on the development of understanding and representing different psychological interpretations of the same physical input have been described by Pillow and Henrichon (1996) and Apperly and Robinson (1998). These accounts also have difficulty in explaining why children appear to hesitate when they encounter ambiguous input. They could argue that the nonverbal tasks rely on a more implicit representation of knowledge, although this has not been made explicit by any of these authors.

One reason for the discrepancy between performances on the nonverbal reaction and more explicit "ask the man" tasks might be that the latter makes various extra demands over the need to recognize that the input is ambiguous and could refer to multiple possible referents. Children need to know not only that they do not know the correct referent but also that further information will help. Perhaps they might even try to imagine what this information is. Furthermore, in some "ask the man" tasks, once children have made a choice between asking or interpreting, the trial appears to end; asking for more information does not help one to make an accurate interpretation. One possibility is that if children were offered a very simple choice between delaying and interpreting, they would reveal an understanding of how to deal with ambiguity as suggested by their apparently hesitant nonverbal reactions. We did this in Experiment 1.

On the other hand, it might be that another difference between the nonverbal reaction tasks and the "ask the man" tasks causes the discrepancy in performance. In the latter, children need to decide which course of action or strategy is best, that is, choose between interpreting and seeking new information. In the related field of theory of mind, Perner and colleagues have suggested that these decision-making or judgmental aspects of a task may be especially difficult for young children (Clements & Perner, 1994). One possibility is that if we remove the requirement to make a decision about how best to deal with the information, children might find it easy to succeed on a task that involves ambiguous input. In Experiment 2, we introduced a simple procedure that required no explicit judgment about how to handle the ambiguous input, namely, the stamp game. If children were to find this task to be easy, it would suggest that their problems lie with the decision-making demands of some ambiguity tasks.

Experiment 1

We designed a procedure in which children were given a choice between making an immediate response based on ambiguous input and delaying that response temporarily to make a better informed interpretation. We modeled our task on the cones game (Beck & Robinson, 2001) in which children were given a choice between two behavioral strategies to locate a hidden toy: making an interpretation and seeking new information. On different trials in the cones game, children received informative or ambiguous input about the location. It was appropriate to make an interpretation when the input was informative but to seek new information when the input was ambiguous. Overall, 5- and 6-year-olds found the cones game to be difficult and were unable to use the two strategies appropriately. In the new delay game presented here, a toy was hidden and, as before, children encountered a first clue containing either informative or ambiguous input. Children needed to decide

whether to make an interpretation immediately before a second clue was read or to wait for the second clue before making an interpretation. When the first clue was informative, the most efficient response was to make an immediate interpretation. When the first clue was ambiguous, it was appropriate to choose to delay interpretation. The new procedure shares qualities with the "ask the man" tasks in which children can make an interpretation or ask a character for disambiguating information. We made two modifications to our procedure. First, the presentation of the extra information was inevitable. Thus, the focus was not on the children deciding whether there was information missing that could help them to make a decision; they needed only to decide whether to make an interpretation yet. Second, the information was really given to the children to improve their choice.

We used a knowledge evaluation task as a comparison. The toy was hidden and an ambiguous or informative message was given. Then children were asked, "Do you really know where it is or don't you really know?" This type of question has been used extensively with young children and requires an explicit judgment about the quality of the information. Typically, 5- and 6-year-olds overestimate their knowledge in response to this question.

Methods

Participants

We tested 52 children from a primary school serving working- and middle-class populations in Birmingham, United Kingdom. There were 31 children in the younger group (11 girls and 20 boys, age range: 5 years 2 months–6 years 1 month), and there were 21 children in the older group (10 girls and 11 boys, age range: 7 years 2 months–8 years 1 month (individual ages were unavailable for this sample). The majority of children at this school were from Asian backgrounds. The other children were from Caucasian, African, and Caribbean backgrounds.

Materials

A video box containing a tape and an unmarked cardboard box ($\sim 30 \times 10 \times 3$ cm) were used for the ignorance check trials. In the experimental trials, we used pictures of two characters: "Peter" (in the *delay game*) and "Claire" (in the *know game*) ($\sim 15 \times 10$ cm), pictures of toys (10×10 cm), and two blank cards (10×10 cm). We used colored envelopes marked with spots, stripes, or (in the introductory trials) a triangle. A screen was used to prevent children from seeing the hiding process. Pieces of pink paper were used for the clues.

Procedure

We first checked whether children were prepared to acknowledge ignorance. They were shown the unmarked box and were asked, "Do you really know or don't you really know what's in here?" The correct answer was to acknowledge ignorance. If children offered a guess, we prompted them again by asking whether they really knew. We also included a trial using the video box. This was intended to make the game less intimidating for children given that we expected they would be able to say what was in the video box.

All children played both the delay game and the know game. The order of the two games was counterbalanced between children. Each game included two ambiguous trials and two informative trials. Within each game, trials were alternated. We counterbalanced the order of trials in the two games; that is, children who had an informative trial first in the delay game were equally likely to have an informative or ambiguous trial first in the know game and vice versa.

In the know game, children were shown the picture of Claire and the toy pictures. They were told that the experimenter would hide one of Claire's toys in one of three envelopes and that their job was to find the toy. They were shown the blank cards, and it was explained that they would not be able to work out which was the correct envelope just by looking. First, there were two introductory trials. The experimenter took three envelopes of different colors (e.g., one red, one blue, and one yellow). She hid the toy in one envelope (using the screen so that children could not see) and placed blank cards in the other two envelopes. The cards were laid out in front of children and the experimenter gave a clue: "I've hidden the ball in one of these envelopes. I'll tell you what color it is. It's blue." Clues were read from distinctive pieces of pink paper. The experimenter then asked the test question: "Can you just tell me, do you really know where it is or don't you really know?" Regardless of the response, on the introductory trials, the experimenter explained, "This time there's only one blue one, so you really know which one it is, don't you?" The toy was retrieved from the blue envelope. On the second introductory trial, three envelopes of the same color, but each of a different pattern, were used. The clue "It's yellow" did not allow children to make a confident interpretation. Children were asked the test question, and once again the experimenter explained that because all of the envelopes were the same, this time the children could not really know where the toy was. To complete the trial, the toy was removed from its envelope.

This was followed by four experimental trials: two ambiguous and two informative. On each trial, there were two envelopes of one color and one envelope of another color or two envelopes of one pattern and one envelope of another pattern. The key dimension (color or pattern) on each trial was counterbalanced. Informative messages referred to the uniquely colored or patterned envelope. Ambiguous messages referred to the two same colored or patterned envelopes. The experimenter read the clue and asked, "Can you just tell me, do you really know where it is or don't you really know?"

No feedback was given on experimental trials. To give the trial a satisfactory ending if children answered that they did know, they were asked to indicate which envelope they believed contained the toy. This envelope was put to one side, so it could "to be opened at the end of the game." If children said that they did not know, all three envelopes were stored for the end of the game.

In the delay game, there were also two introductory trials and four experimental trials. This game used the other character, Peter. As in the know game, a toy was hidden in one of three envelopes. The experimenter told children that on each turn there would be two clues. These were represented by two pieces of pink paper. On each trial, the envelopes were laid out in front of children, and the two clues were also placed clearly on the table away from the envelopes. Children made an interpretation by moving the doll to stand by an envelope. Alternatively, they could choose to delay by standing the doll by the next clue. The instructions were as follows: "If you can find the right one, then you can move Peter to sit by the envelope straight away [i.e., immediately]. But if you can't find the right

one straight away and want to wait for the next clue, then you can move him to wait by the next clue.''

On the first introductory trial, three different colored envelopes were used, and a clue that identified just one of them was given. The experimenter explained that this time children knew immediately which was the right envelope and so should move Peter to stand by the correct envelope. The experimenter assisted with this and then read the second uninformative clue: ''It's spotty'' (all of the envelopes were spotty on this trial). The toy was retrieved from the envelope. On the ambiguous introductory trial, after reading the first clue, the experimenter explained that because all of the envelopes were the same color, ''You can't tell yet, can you? You need to wait until I've read another clue, so we put Peter over here to wait by the next clue.'' Children (assisted by the experimenter) moved Peter to stand by the pink paper representing the second clue. The experimenter then read the second clue, which was informative. Children made an interpretation and the toy was retrieved from the envelope. At the end of the introductory phase, the experimenter reiterated the rules: ''Sometimes you can find the right envelope straight away and you can move Peter straight to the envelope, but sometimes you need to hear the next clue and so you move him here [to the clue].''

This was followed by four experimental trials: two informative and two ambiguous. The second clue always was read on each trial, but children were not allowed to change any interpretation. Because of the behavioral nature of this task, we retrieved the toy from an envelope on each trial. On ambiguous trials, if children made an interpretation, the second clue contradicted this. We used duplicate target toy cards so that if this did happen, we could open an envelope different from the one chosen. Thus, if children chose the inappropriate strategy on an ambiguous trial, we always gave them negative feedback; they did not find the toy. On informative trials, the second clue always was consistent with the first clue. Children who made an immediate interpretation had it confirmed. Those who chose to delay were now able to make an interpretation based on both clues.

Results and discussion

Performance on the ignorance check question was generally good. Of the 52 children, 45 said that they did not know what was in the unfamiliar box. Of these 45 children, 32 admitted that they did not know the contents of the box immediately in response to the question ''Do you really know or don't you really know what's in here?'' and 13 guessed possible contents of the box, but when the question was repeated to prompt children to evaluate only their knowledge, these latter children said that they did not know. Of the 52 children, 7 (six younger children and one older child) answered yes to the ignorance check question (two did so immediately and five did so following a guess). We excluded these seven children from further analysis because it seemed likely that they were exhibiting a yes bias. This was supported by the observation that these children answered yes to all experimental questions. Thus, in the sample used for analysis, there were 25 younger children and 20 older children. We repeated all of our statistical tests, including the children who failed the ignorance check. The findings were the same as when we excluded these children. We also noted that some children were prepared to say that they did not know what was in the video box, with 12 younger children and three older children saying that they did not know.

Table 1
Mean numbers of correct answers on delay and know games: Experiment 1

		Mean correct answers and 95% CI (maximum = 2)	
		Younger children ($n = 25$)	Older children ($n = 20$)
Delay game	Ambiguous	1.20 (0.82–1.58)	1.80 (1.56–2.04)
	Informative	1.52 (1.16–1.88)	1.90 (1.76–2.04)
Know game	Ambiguous	0.76 (0.40–1.12)	1.20 (0.78–1.62)
	Informative	2.00 (ceiling)	1.85 (1.62–2.08)

Note. The 95% confidence intervals (CI) are in parentheses.

The mean numbers of correct responses are shown in Table 1. Performance on informative trials was near ceiling for both age groups on the know game and for the older children on the delay game. To investigate whether younger children discriminated between trials on the delay game, we coded the number of times children chose to wait on each trial type (the correct response on ambiguous trials and the incorrect response on informative trials). Older children's results were not included in this analysis because of their ceiling performance. We ran a repeated measures analysis of variance (ANOVA) with trial (ambiguous or informative) as a within-subjects factor and game order (delay or know first) and trial order (ambiguous or informative first on delay game) as between-subjects factors. There was a main effect of trial, $F(1, 21) = 14.21$, $p = .001$, $\eta_p^2 = .40$. Younger children were more likely to choose to delay on ambiguous trials ($M = 1.20$) than on informative trials ($M = 0.49$). There were no main effects of, or interactions with, either order factor.

We considered the possible effects of the negative feedback in the delay game. Children might have learned from this feedback that choosing an envelope rather than waiting for the next clue was unsuccessful. In this case, we would have expected children to be more likely to select the alternative strategy on the second ambiguous trial. However, of the children who chose incorrectly to make an interpretation rather than to wait on the first trial of the delay game, all but one child made the same strategy choice on the second ambiguous trial. Is it possible that children's overall performance was depressed by this negative feedback, that is, that some of those children would have delayed on the second ambiguous trial had it not been for the feedback? Perhaps children who believed that they had made a plausible interpretation and were then told it was wrong would believe that it did not matter what they did in this game and adopted a strategy of always making a guess. Although this may account for some children's persistence with the interpretation strategy, we cannot separate them in our data from children who thought that it was appropriate to make an interpretation. We note, however, that in other studies children have been quick to revise their interpretations of ambiguous input when told they are incorrect and that they do not seem to be overly confused by finding that their plausible interpretation had been contradicted (Beck & Robinson, 2001).

To make comparisons between age groups, we identified those children who responded appropriately on three or four trials on each game (Table 2). This criterion meant that these children moved the doll to wait by the clue or said "don't know" more often on the ambiguous trials than on the informative trials. Using χ^2 tests (with corrections for continuity) to compare the distributions in the age groups, we found that a significantly higher proportion of children in the older group (95%) than in the younger group

Table 2
Numbers of correct answers on know and delay games: Experiment 1

			Delay game, number of trials correct (maximum = 4)	
			0–2	3–4
Younger children ($n = 25$)	Know game, number of trials correct (maximum = 4)	0–2	9	4
		3–4	5	7
Older children ($n = 20$)	Know game, number of trials correct (maximum = 4)	0–2	1	6
		3–4	0	13

(44%) achieved this on the delay game, $\chi^2(1, N = 45) = 10.81$, $p = .001$. There was no significant difference between the proportions succeeding in the older (60%) and younger (48%) groups on the know game.

Comparison between games

We made comparisons between games for each age group using two-tailed binomial tests. Younger children found the delay game to be as difficult as the know game (four passed the delay game but not the know game, and five showed the opposite pattern). However, older children's performance was significantly better on the delay game than on the know game (six passed the delay game but not the know game, and none showed the opposite pattern), $p = .031$.

Older children performed better on the delay game than on the know game. Perhaps children who understand about ambiguity find some strategies easier to use than others. Different strategies may make varying incidental demands, or some may be intrinsically more attractive. Yet younger children, who performed poorly on the knowledge evaluation task, found it no easier to choose to delay. A number of them passed only the know game or the delay game. Perhaps they too were susceptible to varying demands in the two somewhat different tasks. However, our main conclusion from Experiment 1 does not concern the relationship between the two tasks; rather, it concerns the finding that when children are given the chance to delay a response to gain further information, their performance remains poor. Choosing to delay a response is not an easy way for young children to reveal their understanding of ambiguity. We now turn to the second possibility: Might children pass a task where they do not need to explicitly choose between strategies and where any delay is incidental rather than deliberate?

Experiment 2

We devised a new procedure called the stamp game. A stream of information was presented, and children were instructed to wait until they knew for certain which referent was intended; that is, they were not required to make a decision about how to handle ambiguous input. To present the stream of information, we gradually slid a card across a picture, slowly uncovering the picture. Children had a picture sheet with four pictures on it and were directed to stamp on the matching picture as soon as they knew which one it was. The disambiguating feature was positioned so that it was revealed on either the first half

of the picture or the second half. Thus, we could code whether children stamped before or after the halfway point. We used three types of trials. In informative trials, the disambiguating piece of information was revealed on the first half of the picture, making it appropriate not to wait to but rather to stamp immediately. In uninformative trials, the first half of the picture did not offer any useful information. In narrowing trials, the first half of the picture narrowed one's choice of referents from four to two. In both uninformative and narrowing trials, the most appropriate response was to wait until the second half of the picture was revealed and then to stamp so as to indicate an interpretation. We used two types of ambiguous trials, uninformative and narrowing, to see whether children's performance when the initial information to which they were exposed increased their knowledge differed from when it told them nothing. Both types of ambiguous input have been used in previous studies that offered children a choice between obtaining disambiguating information and making an interpretation. For example, in Somerville and colleagues' (1979) study, there were two possible destinations, so on ambiguous trials the clue could not rule out either one destination. In Robinson & Whittaker's (1985) mystery man study, the clue narrowed the potential referents (dolls) to two from a set of three. We did not expect this to make a difference in children's know judgments (Beck & Robinson, 2001). However, we speculated that uninformative trials (where the first half of the picture revealed no useful information) might give children the best chance possible of resisting making an interpretation on the stamp game.

Methods

Participants

We tested 80 children from two schools serving working- and middle-class populations in Birmingham. There were 40 girls and 40 boys (mean age = 5 years 11 months, range = 5 years 6 months–6 years 5 months). Children were alternately allocated to either the *know group* or the *stamp group.* There were 41 children in the know group and 39 children in the stamp group.

Materials

We used sets of four pictures (e.g., four boys holding balloons) printed on sheets of paper approximately 20×15 cm. The key disambiguating feature was a different color for each picture (e.g., each boy wore different colored trousers). On narrowing trials, another feature differed between pictures, dividing them into two pairs (e.g., two boys held a green balloon and two boys held a red balloon). Picture sets always were presented in the same order: boats, boys, cups, butterflies, ladies, and flowers. There were three groups of sheets to counterbalance the order of trials. Trials could be uninformative, narrowing, or informative. Trials for Group A were in the following order: uninformative, narrowing, and informative. This order was repeated to give six experimental trials. The order for Group B was as follows: informative, uninformative, and narrowing. The order for Group C was as follows: narrowing, informative, and uninformative. For simplicity, we used only three trial orders; however, the orders chosen had the undesirable consequence of always presenting trials in the same relative order. We address this in the Results section for this experiment.

We used seven target pictures approximately 20×15 cm. Each target picture was identical to one of the four pictures on each picture sheet (referred to as the matching picture). We used a card approximately 21×16 cm that covered the target picture. Target pictures were drawn so that when they were half covered by the card, the first feature, but not the second feature, could be seen. For the warm-up trial, we used a target picture of a snowman and a picture sheet of four snowmen, all wearing pink hats and each having differently colored buttons. For the stamp group, we also used a rubber stamp and an inkpad.

Procedure

Children played either the know game or the stamp game. We used a between-participants design so that we could use the same materials for both games. At the beginning of each trial, children in both groups saw a set of four pictures and were asked to name the colors of the key features.

We used a warm-up trial to explain the procedure to children. The experimenter said, "I've got one of these pictures on this card, and your job is to work out which one it is." For the know group, children were shown the target picture of a snowman half covered by the card. Thus, the first feature, but not the second feature, could be seen. The experimenter explained, "You can see what color hat he's got on, can't you? But look, they've all got pink hats on, so you don't know which one he is, do you?" Then she said, "Let's look at all of the picture." After removing the card to reveal the picture, the experimenter explained, "Now, look, you can see he's got green buttons. So now you know which one is on the card, don't you?" Children were encouraged to identify the matching snowman on the sheet. For the stamp group warm-up, the experimenter explained that she had covered the target picture with the card but that she would gradually reveal it. She told children, "As soon as you know which picture is on the card, you stamp the picture on your sheet." The experimenter slowly moved the card across the target picture so that it was steadily uncovered over a period of approximately 6 s. As the first feature (the flag) was uncovered, the experimenter said, "Now we can see that he's got a pink hat, but they've all got pink hats, so don't stamp yet." As the card was slid to reveal the buttons, the experimenter said, "Now look, you can see he's got green buttons, so now you can stamp." As soon as children stamped a picture, the experimenter stopped revealing the card. The experimenter then lifted the card to reveal the whole picture, and both children and the experimenter identified the matching picture. The experimenter explicitly reminded children of the correct response in the stamp game: "Remember, as soon as you know which one it is, you stamp on your sheet."

This was followed by six experimental trials. Trials were uninformative where the first feature was the same for all pictures on the sheet and the second feature was different for all of the pictures. Trials were narrowing where the first feature was the same color for two pictures and a different color for another two pictures and the second feature was different for all of the pictures. Trials were informative where the first feature was different for all of the pictures but the second feature was the same color for all of the pictures. Both uninformative and narrowing were ambiguous trials, where the first feature seen did not pick out one referent. Children had two trials of each type in one of the three orders described above. On every trial, the experimenter told children, "I've got one of these [pictures] on this card."

For the know group, the experimenter showed children the target picture, half covered by the card so that the first feature, but not the second feature, could be seen. She asked, "Do you really know which one it is or don't you really know?" If children said that they did know, they indicated which one they had chosen and were shown whether this matched the target. If children admitted ignorance, the experimenter showed them the target so that they could find the matching picture. This was repeated for each experimental trial.

For the stamp group, the experimenter showed children the completely covered target picture. Children held the ink stamp in their hands and were ready to stamp at the start of each trial, and the experimenter reminded them to stamp as soon as they knew which picture was hidden. The experimenter then gradually revealed the target by sliding the card across the picture. A mark on the target card indicated the halfway point, and the experimenter used this to determine when children stamped. Once children had stamped, they were shown whether their choice matched the target. This procedure was repeated for each experimental trial.

As in Experiment 1, we used an ignorance check trial. This came at the end of the procedure for the know group. Children were shown an unfamiliar and unmarked box and were asked, "Do you really know what's in here or don't you really know?"

Results and discussion

In the know group, four children failed the ignorance check question. Of these four children, three answered yes to every question and one answered yes to all but one (uninformative) trial. We did not include an ignorance check for the stamp group because those children were not asked any metacognitive questions. Thus, to avoid excluding children asymmetrically from only one group, we included all children in our analysis. We repeated our statistical tests, excluding the children who failed the ignorance check. There was no difference in the pattern of results.

On the experimental trials, children gained 1 point if they made the appropriate response. On uninformative and narrowing trials, this was to answer no or to refrain from stamping until the second half of the picture had been revealed. On informative trials, the appropriate response was to answer yes or to stamp when the first half of the picture was revealed. Children had two trials of each type, and scores were summed across trial type (Table 3). These data show that, in line with our suggestion, children were slightly more successful in resisting stamping too early on uninformative trials than on narrowing trials. This makes sense if children experience some increase in confidence on the narrowing trials

Table 3
Numbers of correct answers for each trial on know and stamp games: Experiment 2

	Number of trials correct (maximum = 2)					
	Know game			Stamp game		
	0	1	2	0	1	2
Uninformative	11	12	14	0	0	39
Narrowing	16	9	12	0	9	30
Informative	0	1	36	3	6	30

when they are able to reject two of the potential referents. However, this difference is small.

Our main interest was to compare overall performance between the two groups. We identified the children who made the correct response on five or six trials. Overall, 34 children (87%) reached this criterion in the stamp group and 16 children (39%) did so in the know group. A chi-square test (with correction for continuity) comparing the distribution of children in the two groups showed that performance by the stamp group was significantly better than that by the know group, $\chi^2(1, N = 80) = 17.77$, $p < .001$.

Because we did not use a fully counterbalanced design, we looked at performance on each child's very first trial. These data are shown in Table 4. The same pattern is seen as in the overall results. We checked using χ^2tests whether children experiencing each order were equally likely to meet our criterion for success (one mistake or no mistakes). There was no difference between orders for either the know group or the stamp group. For the know group, three children were successful in the uninformative, narrowing, and informative order; six were successful in the informative, uninformative, and narrowing order; and seven were successful in the narrowing, informative, and uninformative order. For the stamp group, the corresponding numbers of children were 12, 10, and 12. Thus, we concluded that the order in which the trials were presented did not affect our overall results.

Note that a strategy of always waiting until the whole picture was revealed on the stamp game would not be successful as performance on informative trials, as well as on narrowing and uninformative trials, was taken into account. Children in the stamp group were not simply adopting an overly cautious strategy. On 85% of informative trials, they made a correct interpretation before the second half of the picture was revealed.

Also note that the warm-up procedures differed between the conditions so as to introduce children to the game they would be playing. It is possible that this difference led to the better performance by the stamp group. However, in both procedures, we modeled the appropriate response when one was well informed and when one was poorly informed, telling children in the know group that they did not know the correct referent and telling those in the stamp group that they should not yet stamp. This warm-up procedure for the know group goes beyond what typically is included in metacognitive tasks, and yet performance remained relatively poor. It would be interesting, in future studies, to see whether children's performance on knowledge tasks improves following exposure to the stamp game warm-up or experimental trials. Given the robustness of children's poor performance on these metacognitive tasks, we suspect that any improvement is unlikely.

One could parse the stamp game as offering multiple opportunities to choose between interpreting and delaying. Every moment when a tiny portion of the picture is revealed, children could be forced to make an explicit choice between making or delaying an interpretation. In Experiment 1, children found this kind of choice to be difficult to handle.

Table 4
Performances on first trials: Experiment 2

	Know game ($n = 41$)		Stamp game ($n = 39$)	
	Fail	Pass	Fail	Pass
Uninformative	6	8	0	14
Narrowing	4	9	2	12
Informative	0	14	3	8

When we look at tasks that require waiting (which children find to be difficult), we can see that they not only involve an explicit choice but also differ as to why children need to delay their response. In the delay game and the "ask the man" tasks, the appropriate thing for children to do is to wait until they are provided with information that allows them to decide between alternative possibilities. In Klahr's indeterminacy task (Fay & Klahr, 1996; Klahr & Chen, 2003), children must wait to see whether this will prove to be an occasion when they cannot tell. Perhaps understanding why children need to wait is critical here. We suggest that the stamp game is easy because it does not force children to make this explicit choice or to understand the purpose of waiting; instead, children simply wait until they can identify the picture. Children can delay making a response on encountering ambiguous input (the stamp game), but this is an incidental aspect of their waiting until they know the correct interpretation. There is no evidence that children can choose to delay in preference to making an interpretation (the delay game) or that they understand that delaying sometimes is a good strategy to adopt.

General discussion

Children's performance on these tasks offers new insight into their difficulty with ambiguous input. We considered two explanations for the apparent mismatch between the majority of studies that found poor performance on ambiguity tasks by young children and a subset that appeared to show appropriate hesitant behavior. One possibility was that we might reveal an early understanding of ambiguity if children were offered the strategy of delaying a response and waiting for new information. This strategy had not been offered to children in previous studies, although other alternatives to making an interpretation (e.g., "ask the man," searching potential hiding places) had been used. In Experiment 1, we found that, although 7- and 8-year-olds could use the delay strategy reasonably well, 5- and 6-year-olds found it no easier to use this strategy than to answer a "Do you know . . .?" question. Both tasks were relatively difficult for younger children.

The delay game and the know game shared the need to make an explicit choice between strategies. A second possibility was that this element of decision making was particularly difficult for children. The stamp game did not require a choice between strategies (delay or interpret). Children's performance on this new procedure was impressive. In Experiment 2, only five children (13%) made two or more mistakes on their six stamp game trials, whereas 25 children (61%) made this many mistakes on the knowledge evaluation game. Children were able to delay their response, but this was when they were focused on waiting until they knew the referent rather than making a choice to delay based on understanding that this was the most appropriate response to ambiguous input. These results suggest that at least one reason why children find it difficult to handle ambiguous information is that the tasks require a judgment about how to deal with it or how suitable it is for interpretation.

How can we characterize this judgmental or decision-making difficulty more precisely? In the theory of mind literature, Perner and colleagues (see, in particular, Clements & Perner, 1994) have made a representational argument. They argued that judgmental false belief tasks require children to represent reality and their perspective on this reality. In contrast, tasks that do not make these judgmental demands can be solved by doing no more than representing reality. A similar argument made about the ambiguity literature

could suggest that children find it easy to identify the multiple possible referents of ambiguous messages. What children find difficult is understanding or representing the relationship between these potential referents and the input itself. Children need to relate the input to the referents to understand why the ambiguity has arisen (the message was inadequate because there were multiple possible referents) and how the problem can be resolved. Interestingly, studies where children were asked to identify the multiple possibilities that could fit the input, but not explicitly evaluate their knowledge, have found precocious success. Sophian & Somerville (1988) used a game where a toy was hidden in one of several possible locations. Children needed to put out mats under each possible location to catch the toy. Under some circumstances, 4-year-olds were able to mark multiple possible locations. Beck, Robinson, Carroll, & Apperly (2006) used a similar task in a study of children's counterfactual thinking. A toy mouse was positioned at the top of a slide that had two possible exits. To pass the task, children needed to put out two mats to ensure that the mouse landed safely no matter which route he took. Whereas 3- and 4-year-olds found this task to be relatively difficult, 5- and 6- year-olds' performance was substantially better; younger children put out two mats on 31% of trials, and older children did so on 68% of trials. When children play the stamp game, they need to monitor the possible referents as the game progresses until there is only one possibility and then stamp the matching picture. Children might find our stamp game and the two games described above to be easy because these games require thinking about the possibilities but not making an evaluation of knowledge or an explicit decision about how to deal with the input.

This is not the only way in which to explain what may be difficult about tasks that require children to make a decision about how to deal with ambiguity. An alternative explanation focuses on the demands of comparing the alternative strategies available. In the decision-making tasks, children need to imagine the consequences of the available courses of action. For example, in the delay game, they may try to imagine what information will be gained by waiting for the clue. The information processing involved in imagining the consequences and contrasting them might overwhelm young children. In the tasks that children find to be easy, there is no need to speculate about the consequences of different strategies. Our current data do not allow us to distinguish between these two possibilities, although it would seem to be more difficult to explain how a problem with imagining consequences could lead to knowledge evaluation problems. However, further investigation of the nature of these demands will allow us to be even more specific about children's difficulty with ambiguity.

Putting this issue aside, we now examine how our findings fit with the theoretical accounts of ambiguity. In the Introduction, we identified two broad camps: representational accounts, which see children's problems as resulting from failure to understand that multiple interpretations of information are possible (e.g., Apperly & Robinson, 1998; Carpendale & Chandler, 1996), and performance accounts, which suggest that children understand the difficulty in interpretation that arise from ambiguous input but believe that it is preferable to make, or cannot resist making, a guess (e.g., Ackerman, 1981; Speer, 1984). If these theories view children as being unable to resist making an interpretation (as would an executive performance account), it is not obvious how the latter performance theories could explain children's good performance on the stamp game. On the stamp game, children are instructed to wait until they know. If children are inclined to make a guess as soon as possible, we would expect poor performance on the stamp game—at least equivalent to that on the know game. Alternatively, might the stamp game reverse children's

expectations that normally it is best to guess such that they now think it is polite to wait until the card has been revealed? This cannot explain children's good performance on the informative trials, where they showed a strong tendency to stamp before the picture was revealed.

Difficulty with the judgmental aspects of ambiguity tasks may fit better with the representational theories. Children's difficulty arises because they are unable to represent the relationship between the ambiguous input and its potential referents. Previous support for representational accounts has come from children's difficulty with ambiguous input. In the stamp game, we see success on a task that we argue reduces these representational demands. Perner and colleagues discussed an implicit understanding of theory of mind that is seen when the judgmental or decision-making demands of false belief tasks are reduced (Clements & Perner, 1994; Dienes & Perner, 1999). One possibility is to see children's success on the stamp game as evidence for implicit understanding of ambiguity. Indeed, a similar claim has been made based on children's differential eye movements on hearing ambiguous messages (Sekerina et al., 2004). It is true that when the first half of the picture was ambiguous, children's responses nearly always were delayed until the whole picture was revealed. However, we are not convinced that this is best conceived as implicit understanding. Implicit understanding implies a type of understanding similar to that which is explicit but at a lower, or more inaccessible, level. Rather, we favor the idea that children's good performance on the stamp game does not reveal understanding of ambiguity but rather is an incidental consequence of other abilities. Children are able to wait until they can accurately identify a picture before they commit to an interpretation, but their focus here is on waiting for a single match with the target and not on evaluating their knowledge when they are uncertain. Children are dealing with ambiguity in the sense that information presented in the task is ambiguous. However, if we think about the task from the child's perspective, the task is to ignore ambiguous input and wait for disambiguating information. On our account, what makes the stamp game easy is that children do not need to represent or make a decision about how to deal with ambiguous input.

Does this mean that good performance on the stamp game is in fact irrelevant to our thinking about children's understanding of ambiguity? Certainly, we claim that the discrepancy between performance on the know game and the stamp game suggests that children have great difficulty in deciding how to respond to ambiguous input. However, the stamp game clearly involves ambiguity, yet it is critical that at no point do children need to recognize the input as such or to make a decision or judgment about it. Children are handling a task that involves ambiguous input by not responding to the ambiguity itself directly. This distinction is helpful in interpreting the recent finding that infants (14–20 months) used their shared history with an experimenter playing with a particular toy to interpret the experimenter's later ambiguous request, "Where's the ball?" (Saylor & Ganea, 2007). Although there were two balls, infants responded by finding the ball that they had played with together with the experimenter making the request. One could describe this task as involving infants' recognizing the problematic nature of the request, identifying that there are two potential referents, and drawing on their past experience to disambiguate the message. It is more simple to think of infants' experience in this task as never really involving handling ambiguity. In other words, the message is ambiguous only from the perspective of someone who has not had the experience of playing with the experimenter. We suggest that from these infants' point of view, the message never is really ambiguous; at the very least, it is not identified as such.

Our results support the claim that until the around 7 years of age, children have difficulty with ambiguity when they need to make a decision or judgment about it but not when this decision making is removed. Interestingly, this might have consequences for their behavior in everyday life. If children show a slight tendency to wait or hesitate, this often will result in the ambiguity being resolved, perhaps through parents' or teachers' disambiguating a message. However, if children are put on the spot, making an interpretation is a good strategy that is unlikely to have terrible consequences even if the guess is wrong. Speer (1984) suggested that when children make interpretations, they do so knowing about the inadequacy of the input. Our view is that children do not explicitly understand these limitations, nor can they make a choice about the best course of action to deal with ambiguity. Children may well be able to engage in different strategies, but they have difficulty in choosing between them. Although we would not attribute an implicit understanding of ambiguity to young children, we suggest that making the choice between strategies explicit is a key contributor to children's difficulty with ambiguity.

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