Research Article

Thinking of Things Unseen

Infants' Use of Language to Update Mental Representations

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ABSTRACT—*One of the most distinctive characteristics of humans is the capacity to learn from what other people tell them. Often new information is provided about an entity that is not present, requiring incorporation of that information into one's mental representation of the absent object. Here we present evidence regarding the emergence of this vital ability. Nineteen- and 22-month-old infants first learned a name for a toy and later were told that the toy had undergone a change in state (it had become wet) while out of view. The 22-month-olds (but not the 19-month-olds) subsequently identified the toy solely on the basis of the property that they were told about but had never seen. Thus, before the end of their 2nd year, infants can use verbal information to update their representation of an absent object. This developmental advance inaugurates a uniquely human and immensely powerful form of learning about the world.*

Human knowledge is based on a combination of direct and indirect experience. A large proportion of people's knowledge comes indirectly—much of it from another person telling them something new, what Harris (2002) refers to as testimony. Sometimes, testimony informs people about objects or events that are present and directly perceivable (e.g., "Look at that dog. Its paws are all muddy!"). Often, however, the subject of the information is absent at the time one hears it (e.g., "Matt's mom gave him his first haircut, and it looks terrible."). The new information can enter one's knowledge base because the mental representation of the subject one hears about is activated and then updated by this communication.

The ability to learn through indirect experience rests on the capacity to understand references to absent entities and events (Hockett, 1960). Although nonhuman animals may share this ability to limited degrees (e.g., monkeys may be informed of the presence of unseen predators by other animals' communicative calls; Hauser, 1996), most cases of updating in humans are made possible by language. Language allows people to acquire new information about any entity to which they can refer, and to update their knowledge of that entity in the absence of any direct contact with it. In the research reported here, we investigated the emergence of this ability in very young children.

Infants begin to talk about absent objects in the second half of their 2nd year (Lewis, 1936; Sachs, 1983; Scollon, 1979; Shimpi & Huttenlocher, 2004; Veneziano & Sinclair, 1995), but they understand someone else's reference to an absent object substantially earlier. Naturalistic observations in the home have documented comprehension of references to absent familiar objects at ages as early as 13 months (Huttenlocher, 1974; Lewis, 1936). For example, an infant who hears a favorite toy referred to might go search for it; this behavior indicates that hearing the name of the toy activated the child's mental representation of it.

Recent laboratory studies have confirmed that references to absent objects are comprehended early in the 2nd year of life, and they have provided additional information about the emergence of this important ability (Ganea, 2005; Saylor, 2004; Saylor & Baldwin, 2004). For example, Ganea (2005) reported that 13- and 14-month-olds can understand references to a relatively novel absent object. A group of infants first learned a proper name for a stuffed animal, which was then removed from view. When the infants subsequently heard the name of the toy, they spontaneously attempted to reestablish contact with it, providing evidence that this verbal reference had brought the toy to mind.

This research also revealed that infants' response to hearing someone refer to an absent object is initially fragile. Manipulations of the accessibility of the toy and of the timing of the subsequent reference to it demonstrated that the infants were less likely to search for the toy when slightly more effort was required to regain contact with it, or when its name was pronounced after a delay. Thus, for children as young as 13 months, hearing the name of an absent object can bring it to mind. Although infants' response to the mention of an absent object is initially fragile and context dependent, their mental representation

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of the object evidently can be activated by what someone else says.

This ability sets the stage for the development of the crucial ability to acquire new information about absent entities. If infants are able to activate a representation of an unseen object on hearing its name, then they may be able to update that representation when they hear of a new event that has befallen the object or a new property that it has gained. The present research tested for this latter ability. It is the first we know of to examine the emergence of the ability to learn something new from everyday conversations about absent objects and unseen events.

To investigate this ability, we first taught 19- and 22-month-olds a proper name for a stuffed animal. Then, with the toy out of sight in another room, the infants heard that the toy had undergone a change in state. The question was whether they would incorporate this information into their mental representation of the toy. When asked for the animal by name, would the children select from an array of toys the one that was identical to the original but whose appearance was inconsistent with the new information, or would they select the one that looked different from the original in a way that was consistent with the new information?

STUDY 1

In the first study, infants were shown three stuffed animals, two of which were identical (e.g., two green frogs and one pink pig). So that we could later refer to one of the toys in its absence, the infants were taught a proper name—"Lucy"—for the target animal (one of the two identical toys).[1] Then, the children went into another room, leaving the toys behind. While they were in the other room (with the toys out of sight), a different adult informed them that something had happened to the target toy—that she had "spilled water on Lucy." Finally, the children returned to the first room and were asked to identify which of the three toys was Lucy.

Of the three toys displayed, two were wet: the target (the original Lucy) and the distractor toy. The toy identical to Lucy (the nontarget toy) was dry. Thus, if the children were simply attracted to wetness, they should choose randomly between the two wet toys. If they remembered the kind of toy that Lucy was, but had not updated their representation of Lucy, they would either choose the dry toy (because it was more similar to what they had originally seen) or choose randomly between the target and nontarget toys. Finally, if the children had updated their representation of Lucy on the basis of what they had heard, they would choose the wet target toy, ignoring both the identical but dry toy and the wet distractor.

[1]Preschool children represent a proper name as referring to a unique individual even when the name refers to one of two identical animals that are present (Sorrentino, 2001).

Method

Subjects

The subjects were 40 children, 20 in each of two groups: 19-month-olds (range: 17.6–20.6, $M = 18.9$; 12 girls, 8 boys) and 22-month-olds (range: 21.2–24.0, $M = 22.3$; 11 girls, 9 boys). Twenty additional infants were excluded, because of fussiness (16), experimenter error (2), or parental interference (2). Children participating in all studies reported here were recruited through a database of published birth records. The majority of subjects were White and middle-class.

Materials

Materials included two sets of three stuffed animals (two identical green frogs and one pink pig or two identical pink pigs and one green frog), a bucket with water, and three aluminum trays. Half the children at each age were randomly assigned to each animal set.

Procedure

The procedure included three phases: familiarization, attribution of new information, and test.

Familiarization. The purpose of this phase was to teach the child a proper name (Lucy) for one of the three stuffed animals, as well as to provide the child with equal experience with the target and the distractor toy. The named animal—the target—was always one of the two identical toys.

The experimenter first showed the child a basket containing the three animals and then took out the *target* animal (e.g., one of the frogs) and labeled it with a proper name—"Lucy." Then she showed the child the *nontarget* animal, the identical toy (e.g., the other frog), saying that it was "Lucy's friend," who would sit on a cabinet to watch them play. Then the experimenter talked about the *distractor* (e.g., pig) without naming it ("Look at the piggy! It's a nice piggy."). The experimenter engaged the infant in various play activities with the target and distractor (e.g., talking about their body parts, playing peekaboo), spending an equal amount of time with each. Thus, the child played equally with the target ("Lucy the frog") and the distractor (pig), while the nontarget (frog) was visible but inaccessible.

The procedure ensured that the child had learned the name for the target animal, as the child had to identify it twice during familiarization. After the first play activity (e.g., peekaboo) in which the child had interacted with the two animals, the experimenter placed the target and distractor together and asked the child to get "Lucy." If the child chose correctly, the experimenter continued with another game and then later asked the child to identify Lucy again. If the child answered these two questions correctly, the experimenter went on to the next phase. If the child responded incorrectly to either question, the experimenter told the child which toy was Lucy and repeated the identification question after another play activity. The children were corrected from 0 to 4 times; the average was 1.45 ($SD =$

1.54) for the 19-month-olds and 0.84 (SD = 1.26) for the 22-month-olds.

To begin the next phase of the study, the experimenter said that the animals were tired, and she put all three animals in the basket. Then she and the child went into the adjoining room to read a story. The average length of the familiarization phase was 8 min.

Attribution of New Information. The purpose of this phase was to provide the child with new information about the target toy that he or she had played with earlier. As the child and the experimenter were looking at the book, an assistant came into the room carrying a bucket of water. The assistant announced that she was going to wash the table in the room next door (where the toys were). To make sure the child was aware of the water, she invited the child to touch the water in the bucket. Then she repeated that she was going to wash the table and went into the other room, closing the connecting door.

After approximately 2 min, the assistant returned and announced with a distressed expression: "I'm so sorry! I was washing the table, and I spilled water all over Lucy. Lucy is wet now! She's covered with water." The experimenter then told the child: "Oh, no! Did you hear that? Lucy got wet! She's all covered in water." Then the experimenter invited the child to go see the animal: "Do you want to go see Lucy? Let's go see Lucy!"

Test Phase. The test phase was designed to see whether the children would identify the target animal as the one that had undergone the change they had heard about. Figure 1 depicts what they saw when entering the room: a small table with the three animals sitting on trays. Two of the animals—the target and the distractor—were wet, whereas the nontarget was dry. The distractor animal was wet to control for the possibility that a child might choose the wet target animal just because it was more interesting than a dry one. The wet distractor was always in the middle, with the wet target animal on the left for half the children and on the right for the others. The experimenter asked the children to show the target animal ("Which one is Lucy? Show me Lucy!").

Fig. 1. The three test items for Study 1: dry nontarget (frog), wet distractor (pig), and wet target (frog).

Coding

Films of the test sessions were coded to identify the children's intentional choices of one of the animals. We counted as correct only responses that were judged to be intentional acts of indicating a test item—deliberately pointing to a toy or picking up a toy and showing or giving it to the experimenter. If a child simply touched or explored an animal without intentionally indicating it to the experimenter, then the experimenter repeated the question. On the few occasions that a child chose two animals, the experimenter asked the child to indicate which one was "Lucy."

The coding was the same for all three studies. One person coded all the tapes, and another coded 50% of the tapes for each study. The level of agreement between the coders for the three studies ranged from 89% to 100% (Cohen's κs = .77 to 1, ps < .05). Disagreements were easily resolved by a third coder.

Results and Discussion

When presented with three choices—the wet target, the identical but dry nontarget, and the wet distractor—all but 2 children selected either the altered target or the unaltered nontarget. Thus, both age groups had learned the name *Lucy* for the target object—one of the two identical animals.

The important question was whether the children realized that Lucy was the wet one of the two identical animals. That is, had they updated their mental representation of the Lucy toy to include the fact that water had been spilled on it? To answer this question, we compared their performance against a chance level of 50%. Although there were three animals for the children to choose from, which would make chance 33%, the fact that only 2 children ever chose the distractor meant that the children knew which category of animal Lucy was. Hence, chance performance—failure to update their representation of Lucy—would involve choosing randomly between the two identical toys. The more conservative—and appropriate—chance level was therefore 50% (rather than 33%).

As shown in Figure 2, most (16 of 20) of the 22-month-olds selected the correct toy when asked to show Lucy. This level of performance was significantly above the chance level of 50%, $\chi^2(1, N = 20) = 7.2, p < .05, p_{rep} = .99$. The rest selected the unaltered nontarget (3) or the other wet item (1). In contrast, fewer than half (9 of 20) of the 19-month-olds chose the target object (a level of performance clearly not above chance). The rest selected the unaltered nontarget (10) or the other wet toy (1). The number of children selecting the target toy differed significantly between the two age groups, $\chi^2(1, N = 40) = 5.22, p < .05, p_{rep} = .98, \Phi = .36$.

These results indicate that 22-month-old children can generally use new information they hear about an absent object to subsequently distinguish that object from an identical one.

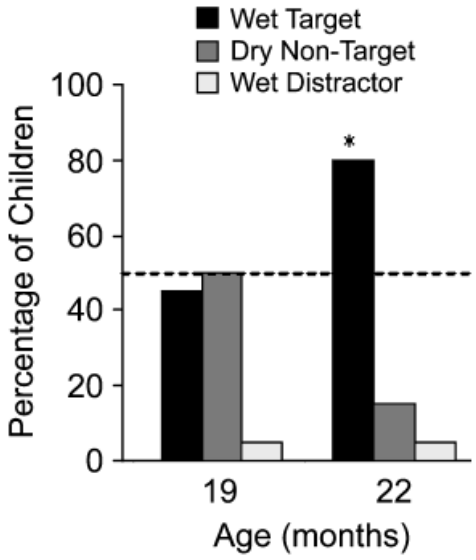

Fig. 2. Percentage of children who selected each of the three test items in Study 1. The asterisk indicates performance significantly different from chance (50%).

Thus, by 22 months of age, most children are capable of updating their representation of an object to incorporate new information about it.

The chance-level performance of the 19-month-olds indicates that the ability to update representations of objects on the basis of information communicated in the absence of those objects may emerge between 19 and 22 months of age. However, it is also possible that the three-choice test procedure used in Study 1 was cognitively or linguistically taxing for such young children and masked some fragile ability that might be evident with a simpler test. Accordingly, in Study 2, we tested a new group of 19-month-olds, using a simpler, two-alternative test in which they had to choose between two of the same type of toy—the wet target and the dry nontarget.

STUDY 2

Method

Participants were twenty 19-month-olds (range: 17.7–20.7, M = 18.8), 9 boys and 11 girls. Five additional infants were not included in the final data set because of inattentiveness (2), experimenter error (2), or parental interference (1).

With one exception, the procedure was the same as for Study 1. The infants learned a proper name ("Lucy") for one of two identical stuffed animals (the two frogs or two pigs from Study 1), and only those two toys (one wet and one dry) were used for the test.

Results and Discussion

Although there were fewer choices at test than in Study 1, only 40% (8 of 20) of the 19-month-olds selected the altered target, $\chi^2(1, N = 20) = 0.8, p = .37$. The rest selected the unaltered nontarget (50%) or both items (10%). These results are consistent with those of Study 1 for 19-month-olds, and they indicate that the reason for the poor performance of this age group in Study 1 was not that the three-choice test was too cognitively demanding.

An alternative explanation for the performance of the 19-month-olds in Studies 1 and 2 is that they had difficulty processing the linguistic information. Perhaps they simply did not understand what they were told about water having been spilled on a toy. We addressed this issue in Study 3 by testing another group of 19-month-olds who heard the new information about the target toy with the toy present. Thus, the need for updating their representation of an absent object was eliminated; all that was required was the ability to comprehend what they were told and attribute it to the wet toy that was in view.

STUDY 3

Method

Twenty 19-month-olds (range: 17.9–20.6, M = 19.0; 10 girls and 10 boys) participated. Seven additional infants were excluded, for inattention (6) and experimenter error (1).

The procedure was the same as for Study 2 with one important difference. In the attribution phase, the assistant provided the crucial information in the presence of the toys. When the assistant came out of the testing room (where she had gone to "wash the table"), she told the child that "something happened to Lucy." She then took the child into the testing room and drew the child's attention to the two toys (the wet target and dry nontarget), explaining, "Look, I was washing the table, and I spilled water all over Lucy. Lucy's all wet! Lucy's covered with water." Then the child was asked to indicate Lucy.

Results and Discussion

The majority (14 of 20) of 19-month-olds in this study selected the correct toy, $\chi^2(1, N = 20) = 3.2, p = .07, p_{rep} = .93$. Thus, the majority of the children were capable of using the new information when they heard it in the presence of the visible transformed object. This finding suggests that the failure of the 19-month-olds in the previous studies cannot be explained solely by a lack of understanding of what they were told during the attribution phase.[2] Instead, the children apparently had difficulty updating an existing representation of an object on the basis of information received when the object was not visible.

GENERAL DISCUSSION

This research shows that children under 2 years of age can update their knowledge about the world on the basis of what

[2]At the end of the test, the children (5 of 20) who failed to identify the target toy were also asked, "Which one is wet?" One child was not asked this question because of experimenter error. All but 1 of the children who received the question correctly indicated the wet animal.

other people tell them. The 22-month-old infants in this research identified an object on the basis of a property of the object that they had heard about but had not personally witnessed. For this updating to occur, they must have activated their mental representation of the object upon hearing new information about it, a process consistent with recent reports that even younger infants comprehend references to absent objects (Ganea, 2005; Saylor, 2004; Saylor & Baldwin, 2004). The children's representation of the new information was then incorporated into their existing representation of the object. This nascent ability for acquiring new, linguistically conveyed information about absent objects and events constitutes a significant cognitive advance—the onset of the uniquely human capacity for learning about the world from indirect experience (Baldwin & Moses, 1996; Tomasello, 1999).

Slightly younger children showed no evidence of revising their representation of the object on the basis of new information received in the object's absence. This failure cannot be attributed to faulty memory or language-comprehension skills, because the younger children knew both which kind of object the name *Lucy* referred to and what property was designated by the adjective *wet*. Given evidence that even younger infants comprehend references to absent objects (Ganea, 2005; Saylor, 2004), it is likely that hearing the object's name activated the 19-month-olds' mental representation of it. Nevertheless, the new information they heard in the absence of the toy was not incorporated into their existing representation of it.

These results suggest that 19-month-olds may have little or no ability to update the representation of an absent object on the basis of verbal information and that this ability emerges quite rapidly in the second half of the 2nd year (between 19 and 22 months). However, it is also possible that 19-month-olds are capable of updating, but that the manifestation of this ability depends on a complex interaction of representational and contextual factors, as is the case for understanding references to absent objects in general (Ganea, 2005).

Factors that might affect updating include the strength of the memory representation of the object itself (Munakata, 2001; Munakata, McClelland, Johnson, & Siegler, 1997), as well as the strength of the representation of the word-object relation. The more experience an infant has had with an object and with the pairing of the object and its name, the more likely it is that hearing the name will activate the child's representation of the object when it is out of sight. Thus, infants should be more likely to update their representation of a highly familiar object than to update their representation of an object they only recently encountered and learned a name for. Support for this prediction comes from evidence that young infants are more likely to search for a familiar hidden object than for a novel one (Shinskey & Munakata, 2005).

Contextual factors may also affect updating. Previous research has shown that infants are more likely to respond to references to absent objects if testing takes place in a familiar home environment (Huttenlocher, 1974; Lewis, 1936), if they are provided with reminders of the absent referent (Saylor, 2004), and if the object referred to is mentioned after only a short delay and is accessible (Ganea, 2005). These findings suggest that 19-month-olds might be capable of updating their representation of an absent object under less challenging conditions than those in the current research. They might, for example, be able to update their representation of a highly familiar toy when tested in a familiar environment.

The present finding that 22-month-olds can revise a mental representation on the basis of verbally communicated information stands in contrast to related findings regarding young children's use of other symbolic media, such as pictures and replica objects (Callaghan, 2000; Harris, Kavanaugh, & Dowson, 1997; Tomasello, Striano, & Rochat, 1999). For example, in research by Harris et al. (1997), 21- to 24-month-olds watched as an experimenter transformed a replica object (e.g., squirted ketchup on a toy pig). When asked to select which of three pictures (clean pig, pig with ketchup, or pig with a white spot) showed the outcome of the action, the 21-month-olds were not above chance at selecting the picture that showed the transformed object. In contrast, the majority of the 19-month-olds in the current research (Study 3) used verbal information about a toy's transformation when they heard this information in the presence of the altered toy.

Why might it be easier to use words symbolically—as a source of information about the world—than to use symbolic objects? An important factor may be the inherent nature of different kinds of symbols. Pictures and replicas can be interesting in and of themselves, so it can be difficult for very young children to achieve dual representation with them, that is, to mentally represent both the symbolic object itself and, at the same time, the relation between the object and what it stands for (DeLoache, 1995, 2002; Tomasello, Call, & Gluckman, 1997). The more salient a symbol is as an object, the more difficult it is to appreciate its role as standing for something other than itself. Words, in contrast, are of little interest in themselves (Tomasello et al., 1997), so the problem of achieving dual representation is minimal. Indeed, the immense power of words derives in part from their transparency—the fact that they provide "nothing but their meaning" (Langer, 1949, p. 75).

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