Young Children's Understanding of the Role That Sensory Experiences Play in Knowledge Acquisition

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O'Neill, Daniela K.; Astington, Janet Wilde; and Flavell, John H. *Young Children's Understanding of the Role That Sensory Experiences Play in Knowledge Acquisition.* Child Development, 1992, **63**, 474–490. 3 studies investigated whether young children understand that the acquisition of certain types of knowledge depends on the modality of the sensory experience involved. 3-, 4-, and 5-year-old children were exposed to pairs of objects that either looked the same but felt different, or that felt the same but looked different. In Study 1, 36 children were asked to state, when one of these objects was hidden inside a toy tunnel, whether they would need to see the object or feel it in order to determine its identity. In Study 2, 48 children were asked to state which of 2 puppets knew that an object hidden inside a tunnel possessed a given visual or tactile property, when one puppet was looking at the object and the other was feeling it. In Study 3, 72 children were asked, in a scenario similar to Study 2, to state for each puppet whether he could tell, just by looking or by feeling, that the hidden object possessed a certain visual or tactile property. Children were also asked what was the best way to find out whether a given object possessed a certain visual or tactile property. Results of all 3 studies suggest that an appreciation of the different types of knowledge our senses can provide (i.e., modality-specific knowledge) develops between the ages of 3 and 5. The results are discussed in relation to young children's developing understanding of the role that informational access plays in knowledge acquisition.

"Monika knows the ball is red." When we utter this sentence, what mental state of Monika's are we describing by using the verb "to know"? According to Dretske (1981), we qualified Monika's belief as knowledge because there was evidence to support it and because the belief was based on that evidence. For example, Monika saw the ball and seeing the ball caused her to believe that it was red. As adults, this is the understanding that we have of knowledge states. But is this understanding of knowledge shared by children? Presumably, such a characterization of knowledge requires an understanding of how knowledge is acquired. If children do not understand this, then their understanding of what it means to *know* something may differ from our adult understanding. One fundamental aspect of knowledge acquisition that children must learn is that what we can know about an object or event depends on the sensory modality through which it is perceived. For example, we know that Monika could know

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the color of the ball from seeing it, but not from feeling it. The development of this understanding is the focus of the present three studies.

The impetus for the first study came from a study by O'Neill and Gopnik (1991) in which children had to identify different objects hidden under a toy tunnel just by seeing or feeling them. At times, young children did not appear to understand that *all* the properties of an object cannot always be derived from an isolated sensory experience. A number of 3-year-olds told the experimenter, after feeling a ball hidden underneath a toy tunnel—a ball that they had never seen before—that they could tell it was a *blue* ball. These children apparently did not understand that while they could know the ball's color by seeing it, or by being told it, it was impossible to find out its color just by feeling it. Because this finding was an incidental one, it was not explored further in the O'Neill and Gopnik (1991) study.

A few other findings suggest that young children have difficulty isolating the types of knowledge resulting from individual sensory experiences. Four-year-olds have a tendency to attribute their own personal knowledge of a picture (e.g., the name of a depicted animal) to a naive observer who just sees the picture (Sodian, 1986, cited in Perner, 1991; Taylor, 1988). Mossler, Marvin, and Greenberg (1976) used a privileged information situation to investigate young children's ability to engage in conceptual perspective taking. Children were exposed to both the audio and visual portions of a videotaped story and were asked about their mother's knowledge of both portions after she had received only the visual portion. Of the 3-, 4-, and 5-year-olds, 95%, 40%, and 15%, respectively, overattributed knowledge (i.e., attributed knowledge of the audio portion) to their mothers. Such results could be interpreted as a failure on the part of these children to differentiate the types of information that can and cannot be acquired from only one sensory modality.

In our first study, therefore, we explicitly tested whether preschool children understand that the acquisition of certain types of knowledge depends specifically on the modality of the sensory experience involved. *Sight* and *touch* were chosen as the two sensory modalities to be investigated. Children's understanding was assessed by their ability to state correctly whether they would need to see or to feel an object in order to determine whether it had a given visual or tactile property.

Study 1

Method

Subjects

Subjects were 36 children, largely from middle-class families, attending urban daycare centers: 12 3-year-olds (mean 3-6, range 3-0 to 3-11), 12 4-year-olds (mean 4-6, range 4-0 to 4-11), and 12 5-year-olds (mean 5-5, range 5-1 to 5-11). There were approximately equal numbers of boys and girls in each age group. Information on race was not systematically collected.

Materials

A red "tunnel" (approximately 30 × 25 × 15 cm) was constructed out of Styrofoam. The openings at either end were covered by felt flaps. Four pairs of objects were used. Two pairs looked the same but felt different: (*a*) two identical toy felt cats, one stuffed with beans that felt hard and lumpy and one stuffed with cotton wool that felt soft and smooth, and (*b*) two identical piggybanks, one full of pennies and one empty. They constituted the *feel* condition. The other two pairs of objects felt the same but looked different: (*a*) two small toy footballs of the same size, shape, and make, one green and the other red, and (*b*) two birthday cards of the same size, shape, and make, one depicting a striped dragon on the front and the other a polka-dotted dragon. They constituted the *see* condition. A small, hard, red ball and a small, soft, spongy, yellow ball were used in the introductory task. Two small picture cards of a hand and an eye were also used.

Procedure

Introduction.—Children were tested individually. They sat facing the tunnel, in front of which were placed the two small picture cards. They were told that in this game they would be asked about things we can know by seeing and things we can know by feeling. The experimenter then hid a red ball inside the tunnel and asked children to lift up the tunnel, look inside, and tell her what color the ball was. After children had responded *red,* the experimenter pointed out to them that they knew it was red because they could see with their eyes that it was red. At this point, children were shown the card with the eye on it and were told that this card meant "I have to see." They were reminded that this was one of the answers they might have to give in the game.

Following this, the experimenter hid a soft, spongy, yellow ball inside the tunnel without the children seeing it. They were asked to put their hands inside the tunnel and to feel whether the ball was soft or hard. It was made clear to children that they could only feel the object under the tunnel and not look at it. Care was taken here to ensure that they did not pull the object out of the tunnel while feeling it, or peek inside the tunnel. Once they had answered *soft,* the experimenter pointed out that they knew it was soft because they could feel with their hands that it was soft. Children were then shown the card with the hand on it and were told that it meant "I have to feel," and that this was also an answer they might have to give in the game. They were then reminded of the two answers they might have to give and were asked to state what each card meant. If they would not respond verbally, they were asked, "Which card means 'I have to feel/see?'" and were allowed to point to the answer. While this introduction was elaborate, pilot studies showed that it was necessary to ensure that children understood they could only feel or only see an object under the tunnel, but not do both.

Experimental task.—Following the introduction, children received four experimental trials. At the beginning of each trial, children examined one of the four pairs of objects. They were shown and told that the objects were the same size and shape, and told and shown, appropriately, whether the objects looked the same or felt the same. For example, given the footballs, children were told they felt the same and were encouraged to feel this for themselves. They were also told and shown, appropriately, how the objects felt or looked different, for example, that the two footballs were different colors, namely, red and green.

After children had finished examining the two toys, the experimenter told them she would now take both toys away, hide them behind her back, and put only one toy inside the tunnel. Once this was done, children were given the test question, which asked them what they would have to do to find out for sure the identity of the object inside the tunnel. For example, they were asked in the case of the footballs: "Now, to find out for sure what color the football inside the tunnel is, what would you have to do?" Children were first given a chance to respond spontaneously (either verbally or by pointing to the card) with one of the two alternatives, "I have to feel" or "I have to see." If children did not respond spontaneously, the two alternatives were presented in a forced-choice question (e.g., "Do you have to see the football or do you have to feel the football?"). The order of presentation of the forced-choice alternatives was counterbalanced across trials and subjects. This procedure was repeated for the remaining three pairs of objects. For the other see condition trial, the test question was: "Now, to find out for sure which dragon is on the card under the tunnel, what would you have to do?" For the two feel condition trials, the test questions were: "Now, to find out for sure which piggybank is under the tunnel, what would you have to do?" and "Now, to find out for sure what the toy cat under the tunnel is stuffed with, what would you have to do?"[1] The order of presentation of the four pairs of objects was counterbalanced across trials and subjects.

Results and Discussion

In the introductory task, all the children correctly answered the control question concerning the meaning of the two cards, and the majority did so without needing the forced-choice alternatives to be given. On each of the four test questions, children received a score of 1 if they answered a given see and feel condition trial correctly, 0 if they answered it incorrectly (see Table 1). Children's responses in each age group did not differ significantly as a function of the particular object pair used within a given modality condition (binomial test, all p's $>$ .38), and so the two scores in each of these conditions were combined. There was no main effect of gender, not did it interact with

[1] Where possible, the test question included mention of the superordinate distinguishing visual or tactile property (i.e., color, stuffing), without mention of the categorical instances of the properties themselves (e.g., red, soft). In two cases, however, this was not possible (e.g., weight, pattern) as the questions became too difficult for the children (e.g., What is the weight of the piggybank under the tunnel?). In these two cases, therefore, children were asked ". . . which piggybank/dragon . . . ." Since, however, the two objects on each trial differed only with respect to a visual or tactile property, asking the children what they had to do to find out "which X" or "what the property of X" was under the tunnel was equivalent in both cases to asking them what they had to do to find out X's identity.

TABLE 1

PERCENTAGE OF TRIALS ANSWERED CORRECTLY BY AGE AND MODALITY CONDITION IN STUDY 1

	Age		
Modality Condition	3	4	5
See	38	33	88
Feel	71	83	96

any of the variables of interest, so it will not be considered further.

A two-way, repeated-measures ANOVA, with age (3 vs. 4 vs. 5) as the between-subjects variable and modality condition (see vs. feel) as the within-subjects variable, revealed significant main effects of age, $F(2,33) = 8.63$, $p < .001$, and modality condition, $F(1,33) = 9.18$, $p < .005$. There was no significant age × modality condition interaction. Planned comparison tests revealed that although the 3- and 4-year-olds (M's = 2.17, 2.33, respectively) did not perform significantly differently from each other, $F(1,33) < 1$, they both performed significantly worse than the 5-year-olds (M = 3.67), $F(1,33) = 14.37$, 11.35, respectively, both p's < .002. The 3- and 4-year-olds' mean scores did not differ significantly from chance (95% confidence intervals around the mean included 2). These children may have been guessing. A closer look at the nature of their errors, however, suggests they may have had a response bias that resulted in a score of 2 (see Table 2).

The errors children made were not distributed randomly between the two modality conditions, and this uneven distribution accounts for the significant modality condition effect. Table 2 shows the error patterns of children who failed one, two, or three trials. The dominant error among 3- and 4-year-olds was to respond with the same chosen action (usually to feel) on all four trials: 33% of the 3-year-olds and 58% of the 4-year-olds consistently answered *to feel* on all four trials. Such a response pattern would have resulted in a score of 2. Overall, on 65% of the trials where children needed to see the object to find out the property being asked about (e.g., color), they said (incorrectly) that they needed to feel the object. These errors occurred despite the fact that in pretraining children showed they knew that they could either feel or see the object, but could not do both.

TABLE 2

NUMBER OF CHILDREN IN EACH AGE GROUP EXHIBITING A GIVEN PATTERN OF FAILED TRIALS IN STUDY 1

	Age		
Number of Errors and Trial(s) Failed	3	4	5
1:			
1 feel	0	0	1
1 see	1	0	1
2:			
2 feel	2	1	0
1 feel/1 see	0	0	0
2 see	4	7	1
3:			
2 feel/1 see	0	0	0
1 feel/2 see	3	0	0

Children's difficulty with this task was also captured in an unplanned response measure. On the last trial, 11 3- and 4-year-olds were allowed to carry out their chosen (incorrect) action. Among eight of these children, we noticed a hesitant silence as they carried out the action, followed often by a less than hesitant guess. These children seemed confused as to why their action did not let them find out the visual or tactile property in question. The fact that all but one of these 11 children performed only the one action chosen also provides some further evidence that children had understood that they could only see or feel the object, but not do both.

Therefore, 3- and 4-year-olds may have erred because they do not understand clearly what properties of an object are accessible through touch and what properties require seeing the object. That is, even though they understood that in this task they could only see or feel the object, they may not have realized the effects that being limited to one sensory modality would have on the possible types of knowledge they could acquire. In particular, they appeared to overestimate what could be learned from *tactile* experiences.

But such a conclusion may be premature, as children's errors may also have arisen because children found feeling the object hidden underneath the tunnel a more interesting thing to do than lifting up the tunnel to see the object. Study 2 was thus designed to provide more convincing evidence that young preschoolers have genuine difficulty differentiating the types of knowledge to be gained from individual sensory experiences.

Study 2

We designed Study 2 in such a way that children's responses would not be confounded by their own wishes to perform one action over another: Children made knowledge assessments of *puppets* who were seeing or feeling an object. We also tested the hypothesis that the ability to make modality-specific knowledge assessments is acquired in the later preschool years. Previous studies show that young preschool children perform well on tasks that require them to infer whether a puppet who has or has not looked inside a box knows what is in the box (Pillow, 1989; Pratt & Bryant, 1990). Presumably, they can master such tasks because they need to monitor only whether a puppet did or did not have perceptual access to the object (O'Neill & Gopnik, 1991). However, without an understanding of how different sensory experiences result in different types of knowledge, these same children should fail an equivalent question concerning a puppet's knowledge that requires them to differentiate among the features of objects perceivable by means of different sensory experiences. For instance, suppose that one puppet feels a toy and another puppet sees the same toy. When assessing which of the two puppets knows certain visual or tactile properties of the toy, these children may err because they will not take into account the *type* of sensory access that each puppet had. Since both puppets have sensory access to the toy in either case, these children may attribute knowledge to both puppets, regardless of the property or sensory experience involved, and give random answers about which puppet knows a certain property.

So, in Study 2, children were asked to assess the knowledge state of puppets who had either seen or felt an object hidden inside a tunnel. (We will call this *modality-specific knowledge assessment.*) Children were also asked (in a task modeled after that used by Pratt & Bryant [1990]) to assess the knowledge state of puppets when only one of the two puppets had visual or tactile access to an object hidden inside a tunnel *(primary knowledge assessment)*. If our hypothesis is correct, then young children should perform well on the primary knowledge assessment task, yet perform poorly on the modality-specific knowledge assessment task.

Method

Subjects

Subjects were 48 nursery school children, largely from upper-middle-class families: 16 3-year-olds (mean 3-5, range 3-0 to 3-11), 16 4-year-olds (mean 4-5, range 4-0 to 4-11), and 16 5- and 6-year-olds (mean 5-11, range 5-6 to 6-6; referred to hereafter as the 5½-year-olds). There were approximately equal numbers of boys and girls in each age group. Information on race was not systematically collected.

Materials

The same tunnel was used as in Study 1. In the primary knowledge assessment task, two pairs of objects were used. One pair looked the same but felt different: two identical yellow sponges, one wet and the other dry. The other pair felt the same but looked different: two plastic dinosaurs of the same size, shape, and make, one green and the other blue. In the modality-specific knowledge assessment task, four pairs of objects were used. Two of the four pairs of objects looked the same but felt different: (*a*) the two felt cats from Study 1, and (*b*) two identical "squeaky toy" pigs, one filled with plaster of paris that felt hard and one empty that felt squishy. These pigs were substituted for the piggybanks used in Study 1 because the dimension of hardness-squishiness was thought to be easier for children to understand than that of heavy-light, and to be more distinguishable as a tactile property. These two pairs of objects constituted the *feel* condition. The other two pairs of objects felt the same but looked different: (*a*) the two toy footballs from Study 1, and (*b*) two cardboard dragons of the same size and shape, one of which was spotted and the other striped. These two pairs of objects constituted the *see* condition. Two "Sesame Street" puppets, Ernie and Bert, were used. These puppets were familiar to all the children and were easily named by them. A toy spoon, a spongy ball, some blue and green marbles, and a toy car were used in the introduction, pretest, and control tasks.

Procedure

Introduction.—Children sat facing the tunnel, on either side of which stood Ernie and Bert (which side was counterbalanced). Children were given a small introduction to the puppets, the tunnel, and the task itself. First, we checked that children knew the names of the puppets. Then, using a toy spoon and a spongy ball, the experimenter familiarized children with how to look at or feel objects inside the tunnel. Following this, children were told that in this game they were going to help the experimenter hide some toys inside the tunnel and that Ernie and Bert were going to take turns seeing or feeling what was inside. They were also told that they would have to tell the experimenter which puppet, Ernie or Bert, knows what is inside the tunnel.

Pretest.—A pretest familiarized children with the procedure of choosing one of the puppets in response to the experimenter's questions. Children were shown some blue and green marbles and asked to name the colors of each. Then the experimenter said, "Now I'm going to give Ernie some blue marbles and Bert some green marbles." Following this, children were asked, "Now, who has the blue/green marbles?" and asked to point to this puppet. Half the children in each age group were asked one or the other of the test question forms.

Control task.—The control task was used to assess that children could easily distinguish the two actions of seeing or feeling what was inside the tunnel when the puppets performed them. A toy car was placed inside the tunnel. The experimenter then made one puppet look into the tunnel by bending its head over and lifting one flap up over its head. The puppet's hands stuck clearly out in back of it. The other puppet was made to feel inside the tunnel by lifting the other flap slightly on one side and sliding the puppet's hand into the tunnel. The contents of the tunnel were not made visible to this puppet at any time. To ensure that children understood that the puppet who was feeling could not see inside the tunnel, its eyes faced forward toward the children and 90 degrees away from the tunnel opening. Children were then asked: (*a*) "Which puppet is feeling the toy car inside the tunnel?" and (*b*) "Which puppet is seeing the toy car inside the tunnel?" Whether it was Ernie or Bert who saw or felt the car, the order in which they did so and the order of the test questions were counterbalanced.

Primary knowledge assessment task: See condition.—The two dinosaurs were placed on the table in front of the children. The children, the experimenter, and the puppets then looked at and felt these dinosaurs until all agreed that the two felt the same but looked different. Following this, children were told that Ernie and Bert were now going to turn around so that they wouldn't see which toy the children hid inside the tunnel. The experimenter then whispered, "Which one shall we hide?" Once children replied, the experimenter said, "Good, so we'll hide the [blue/green] one," and it was hidden inside the tunnel. As a memory check for the property by which the objects differed, children were then asked, "So which one is inside the tunnel?"

The puppets were now turned back around and the relevant actions of the puppets were carried out. For example, children were told, "Now, this time, Bert's going to look inside the tunnel. [Bert looked inside.] Bert's looking inside the tunnel. And Ernie's going to put his hand *on* the side of the tunnel. [Ernie's hand was placed resting on the front side of the tunnel, clearly in view and in front of the child.] Ernie's feeling on the side of the tunnel." While the puppets remained in these positions, children were asked the test question: "Now, one of them knows the dinosaur inside the tunnel is [blue/green] and one of them doesn't know. Who knows the dinosaur inside is [blue/green]?" Children responded by naming or pointing to the puppet. If they just named the puppet, they were asked to point as well. Note that, unlike in Study 1, the relevant categorical instances (e.g., blue, wet) were now mentioned in the test question itself. This presumably made it easier for children to remember the property by which the objects differed.

Primary knowledge assessment task: Feel condition.—The two sponges were placed on the table in front of the children. The children, the experimenter, and the puppets then looked at and felt these sponges until all agreed that the two looked the same but felt different. The procedure then continued in the same manner as in the see condition except that one puppet felt inside the tunnel while the other puppet placed his hand on the front side of the tunnel.

Which action each puppet performed and the order of the two actions were counterbalanced within and across conditions. The order of the see and feel conditions themselves was also counterbalanced. The two primary knowledge assessment trials were blocked to appear either before or after the four modality-specific knowledge assessment trials.

Modality-specific knowledge assessment task.—The procedure of this task was almost identical to that of the primary knowledge assessment task, except that both puppets now had access to the object inside the tunnel. The task consisted of four trials. On two trials the property in question was known only to the puppet who was feeling inside the tunnel (*feel* condition, cat and pig pairs). On two other trials it was known only to the puppet who was looking inside (*see* condition, dragon and football pairs).

On each trial, children, the experimenter, and the puppets all first examined the pairs of objects as already described for the primary knowledge assessment task. Then, Ernie and Bert were turned around and children hid one of the objects inside the tunnel. Next, the puppets were turned back around and one puppet looked inside the tunnel while the other felt inside the tunnel as described in the control task. While the puppets remained in these positions, children were asked the test question, which was identical to that used in the primary knowledge assessment task, for example: "Now, one of them knows the pig inside the tunnel is [hard/squishy] and one of them doesn't know. Who knows the pig inside is [hard/squishy]?"

The other three trials followed the same format. The order of the four trials was counterbalanced. The order of the see condition trials and feel condition trials alternated so that children never received two trials of the same modality type one after the other. (This included the *primary knowledge assessment* trials that came before or after.) Which action each puppet performed and the order of the two actions was counterbalanced within and across all four trials.

TABLE 3

PERCENTAGE OF TRIALS ANSWERED CORRECTLY BY AGE, TASK TYPE, AND MODALITY IN STUDY 2

	Task Type			
	Primary[a]		Modality-Specific[b]	
Age	See	Feel	See	Feel
3	81	69	62	40
4	100	94	88	47
5½ .	100	100	100	59

[a] Total number of trials is 16 per cell.
[b] Total number of trials is 32 per cell.

Results

All the children passed the pretest and control task without difficulty. In both knowledge assessment tasks, all the children also answered the memory control check correctly. In both knowledge assessment tasks, children received a score of 1 if they answered a given see or feel condition trial correctly, 0 if they answered incorrectly (see Table 3). Children's responses did not differ significantly (binomial test, all p's $> .16$) as a function of the particular object pairs used within a given modality condition of the modality-specific knowledge assessment task, and so these two scores were combined in each of these two conditions. Because the number of see and feel trials differed across the two tasks, all scores were calculated in terms of proportions, which were converted using an arcsin transformation prior to statistical analysis. There was no main effect of gender, nor did it interact with any of the variables of interest, and therefore this factor was not considered further.

A five-way, repeated-measures ANOVA was carried out with age (3 vs. 4 vs. 5½), trial order (see/feel vs. feel/see), and task order (primary knowledge assessment task first vs. modality-specific knowledge assessment task first) as the between-subject variables, and task type (primary vs. modality-specific knowledge assessment) and modality condition (see vs. feel) as the within-subject variables. The analysis revealed a significant main effect of age, $F(2,36) = 12.86$, $p < .0001$. Overall, performance on both tasks increased with age. Significant main effects of task type, $F(1,36) = 31.36$, $p < .0001$, and modality condition, $F(1,36) = 23.17$, $p < .0001$, were found, along with a significant task type × modality condition interaction, $F(1,36) = 7.39$, $p < .01$. This analysis also revealed significant interactions of modality × trial order, $F(1,36) = 4.43$, $p < .05$, modality × age × trial order, $F(2,36) = 4.49$, $p < .05$, and modality × age × task order, $F(2,36) = 6.10$, $p < .01$. From a close inspection of the data, however, it appeared that these interactions involving trial and task order resulted from unusually high scores in one cell and so are largely uninterpretable.

The significant main effects of task and modality condition must be interpreted with respect to the interaction that exists between these factors (see Table 3). The main effect of age is also more meaningfully described in terms of the task type × modality interaction. Although the relative difference between age groups in the four conditions of the interaction does not change (i.e., 5½-year-olds always perform better than 4-year-olds, who always perform better than 3-year-olds), the absolute performance of each age group does change across the four conditions. These changes are masked by an analysis that uses scores aggregated across age groups. So, the task type × modality condition interaction is examined for each age group separately (using repeated-measures t tests with Bonferroni adjustment). On see condition trials, the performance of all age groups did not differ significantly across the two tasks: 3-year-olds, $t(15) = 1.57, p = .14$, N.S.; 4-year-olds, $t(15) = 1.73, p = .1$, N.S. On feel condition trials, the performance of the 3-year-olds did not differ significantly across tasks, $t(15) = 1.86, p = .08$, N.S., but the performance of both the 4- and 5½-year-olds was significantly worse on the modality specific knowledge assessment task than on the primary knowledge assessment task, $t(15) = 3.53, 3.57$, respectively, both p's $= .003$. The results suggest, therefore, that the 4- and 5-year-olds did not perform uniformly worse on the modality specific knowledge assessment task than on the primary knowledge assessment task: only on feel condition trials was their performance significantly worse.

A somewhat different conclusion holds for the 3-year-olds, however. Three-year-olds' performance can best be summarized following a look at each age group's performance with respect to chance. On the primary knowledge assessment task, all age groups performed significantly above chance on the see condition trial: for the 3-year-olds, $\chi^2(1, N = 16) = 6.31, p < .05$. On the feel condition trial, the performance of the oldest age group was errorless and the 4-year-olds' performance was almost errorless, but the performance of 3-year-olds was not significantly above chance, $\chi^2(1, N = 16) < 1$. On the modality-specific knowledge assessment task, we used the Kolmogorov-Smirnov test for goodness of fit to compare each age group's observed score distributions to the distribution expected by chance. In the see condition, only the performance of the 3-year-olds did not differ significantly from chance ($N = 16, D_k = .125$, N.S.). In the feel condition, the performance of all the age groups did not differ significantly from chance ($N = 16, D_k = .125$, N.S., for the 3-year-olds; $N = 16, D_k = .188$, N.S., for the 4-year-olds; and $N = 16, D_k = .25$, N.S., for the 5½-year-olds). Simple effects analysis revealed that there was a significant effect of age on see condition trials, $F(2,36) = 11.20$, $p < .001$, but not on feel condition trials, $F(2,36) < 1$. In sum, 3-year-olds perform at chance in all conditions except the see condition of the primary knowledge assessment task. That is, unlike the 4- and 5½-year-olds, they do not perform well on feel condition trials of the primary knowledge assessment task, nor on see condition trials of the modality-specific knowledge assessment task.

The error patterns of children who made one, two, or three errors on the modality specific knowledge assessment task are shown in Table 4. There were two dominant error patterns among the 3-year-olds: failing both a feel and a see trial, or failing both feel trials. Failing both feel trials was also the dominant error pattern among both older age groups. Overall, 75% of all failed trials were

TABLE 4

NUMBER OF CHILDREN IN EACH AGE GROUP EXHIBITING A GIVEN PATTERN OF FAILED TRIALS ON THE MODALITY-SPECIFIC KNOWLEDGE ASSESSMENT TASK OF STUDY 2

	Age		
Number of Errors and Trial(s) Failed	3	4	5½
1:			
1 feel	1	2	3
1 see	1	0	0
2:			
2 feel	5	6	5
1 feel/1 see	6	1	0
2 see	2	1	0
3:			
2 feel/1 see	1	1	0
1 feel/2 see	0	0	0

feel condition trials. These children picked the puppet that was *looking* inside the tunnel as the one who knew whether the pig inside the tunnel was the hard or squishy one, or whether the cat inside was the bumpy or soft one. When it was possible, these children were asked why the puppet that was looking knew. The standard reply was "Because he's looking." As one child (age 4–7) replied, "Why? Because he's looking. That's why he knows it's hard." When asked why the puppet that was feeling didn't know, the common reply was "Because he's feeling," or, as one 6-year-old said, "Because feeling doesn't tell you anything!" It is interesting to note that this error pattern is opposite to that found in Study 1: children erred on feel trials as opposed to see trials.

In contrast to the performance of children who failed these trials, it is striking that several of the children who passed them seemed to display a thorough understanding of the task. These children would often state and justify both puppets' knowledge states. Especially for the 4–6-year-old children, understanding and performance on the modality-specific knowledge assessment task often seemed to be all or none.

Discussion

The results of Study 2 suggest four things. First, children 3 years of age and older perform well on primary knowledge assessment tasks that involve seeing as the mode of informational access. Second, only children older than 3 years of age also perform well on primary knowledge assessment tasks when feeling is the mode of informational access. Third, on see condition trials, 4- and 5½-year-olds perform well for both tasks, but 3-year-olds perform above chance only for the primary knowledge assessment task. Fourth, on feel condition trials, 4- and 5½-year-olds perform well for the primary knowledge assessment task, but at chance for the modality-specific knowledge assessment task, and 3-year-olds perform at chance for both tasks.

The interesting finding from the primary knowledge assessment task is not that children as young as 3 years of age do well when seeing is the mode of access—this finding has already been established in several previous studies (Pillow, 1989; Pratt & Bryant, 1990). In the present study, though, children's performance was a little better than that found previously, perhaps because the puppets' actions were in view when children were asked the test question and so they did not need to rely on their memory of the puppets' actions. The intriguing finding, however, is that these young children do not do well when feeling is the mode of informational access. This suggests that 3-year-olds' understanding of the role of informational access in primary knowledge assessment tasks may be limited to situations in which seeing is the mode of access. Furthermore, it suggests that studies employing only a visual task cannot be taken as representative of children's knowledge of sensory accesses without the risk of overgeneralization.

Three findings were surprising with respect to children's performance on the modality-specific knowledge assessment task. First, most of the children who erred did not appear to ascribe knowledge randomly to the two puppets as we thought they might. Four- and 5½-year-olds tended to overattribute knowledge to the puppet that was looking. Only the 3-year-olds' performance tended to suggest random responding as it was essentially at chance in both modality conditions, albeit better in the see condition. How to interpret the 3-year-olds' responses is not clear, however. Perhaps these children inconsistently overattributed knowledge to the puppet that was looking, or perhaps they thought that both puppets knew, or that neither puppet knew, or had no idea what either puppet knew or did not know.

Second, the response pattern of the older children was opposite in direction to that found in Study 1. This could suggest that children's patterns of responding in Study 1 did not reflect a consistent, stable belief that tactile experiences provide more information than visual experiences, but rather a response bias such as a preference for touching an object rather than just looking at it.

The third surprising finding was that this task proved to be substantially harder for children than the task in Study 1. Even the oldest 5½-year-old age group did not perform without error. This finding was surprising because three changes had been made to simplify the task: (*a*) the hard-squishy pigs replaced the heavy-light piggy-banks, (*b*) the actions of seeing and feeling were more clearly differentiated and represented, and (*c*) the test question explicitly mentioned the relevant visual or tactile property on which the objects differed. Although the test question had also been changed to ask children to assess another person's knowledge rather than their own, we do not believe this was the source of children's difficulties with the modality-specific knowledge assessment task. Rather, we think the difficulty may have arisen because the test question focused not on the actions of seeing and feeling in relation to each puppet's knowledge state, but on assessing the two puppets' knowledge states and, moreover, comparing them. That is, if the test question had emphasized each puppet's behavior and had asked children separately about each puppet's knowledge (thus not requiring children to compare puppets' knowledge states), children might have had less difficulty with it.

Study 3

Given the difficulty that even the oldest children had with the task in Study 2, and the possibility that this difficulty was due to the task's focus on assessing and comparing the knowledge states of others, we conducted a third study in which the focus of the test questions was shifted away from comparing the knowledge states of others and toward considering the action performed by another person (looking or feeling) and the consequence this action would have on the other person's ability to gain a certain type of sensory information (e.g., color). Several procedural changes were made in order to encourage children to make use of the information about another person's sensory experience when assessing that person's knowledge. First, in order to make the actions of seeing and feeling more explicit, the tunnel was not used. Instead, both puppets had back pockets into which their hands could be placed to prevent them from feeling an object, and both puppets could be outfitted with a blindfold to prevent them from seeing an object. Second, when children were first introduced to the toys, they felt the objects *without* seeing them. This was thought to make it easier for children to realize that they were feeling certain properties and not seeing them (H. L. Pick, personal communication, May 11, 1990). Third, children were encouraged to carry out the same actions along with the puppets. This was done in order to make the actions being performed by a puppet as salient as possible and to make it easier for children to take into account the sensory information a puppet was receiving when assessing its knowledge. Our hypothesis was that, given these changes, the results would be similar to those of Study 1: 5-year-olds would perform well, whereas 3- and 4-year-olds would continue to have difficulty with the task.

We also designed Study 3 to probe for an earlier level of understanding about the modality-specific nature of knowledge on the part of 3-year-olds. We included a question that we thought children possessing only a rudimentary level of understanding could answer correctly. That is, children could provide an answer based on their ability to obtain information using different senses. Children were asked to state what the "best way" is to find out, for example, if a sponge is wet or dry—to feel it or look at it. Two new sensory contrasts, hot-cold and clean-dirty, were also added as these were possibly more familiar to children than some of the contrasts used earlier.

Method

Subjects

Subjects were 72 nursery school children, largely from upper-middle-class families: 24 3-year-olds (mean 3-8, range 3-0 to 3-11), 24 4-year-olds (mean 4-5, range 4-0 to 4-11), and 24 5-year-olds (mean 5-4, range 5-0 to 5-11). There were approximately equal numbers of boys and girls among the 3- and 4-year-olds, and 15 boys and 9 girls among the 5-year-olds. Information on race was not systematically collected.

Materials

The two puppets, Ernie and Bert, were outfitted with blindfolds to prevent them from looking at an object and with back pockets into which their hands could be placed to prevent them from feeling an object. Six pairs of objects were used. Of the three pairs of objects that felt the same but looked different (*see* condition trials), two pairs—the footballs and the dragons—were identical to those used in Study 2. The new pair consisted of two white socks, one clean and one dirty (covered with dirty brown marks). Of the three pairs of objects that looked the same but felt different (*feel* condition trials), two pairs—the pigs and the sponges—were identical to those used in Study 2. The new pair consisted of two clear plastic drinking glasses, one filled with warm water and the other filled with cold water. A large cloth was used to cover the objects. The remaining materials included: in the introductory task, a yellow, spongy ball and a toy car; and, in the control task, a red and a green ball of the same make, a blue and a green dinosaur of the same make, and a box (15 × 10 × 10 cm) with a removable lid. A tape recorder was used to record each child's session.

Procedure

Introduction.—Children were seated in front of a little table on which stood Ernie and Bert (which side was counterbalanced). Children were first familiarized with restricting the puppets to feeling or looking at an object by using the pockets or blindfolds. They were shown instances of Ernie and Bert feeling a ball, Ernie and Bert looking at a ball, both puppets neither looking at nor feeling a ball, and one puppet looking at a toy car while the other puppet felt it. In each case, children's understanding of what each puppet was doing was checked with questions such as, "Right now, are Ernie and Bert feeling the ball?" and "Right now, is Ernie looking at the toy car?" Ten such questions were asked in all, six of which required a negative response. Once children had answered all 10 questions, Ernie and Bert were placed out of sight under the table. Children were told they would now find out about some toys by looking at them and feeling them, and that they would have to pick some for Ernie and Bert to find out about.

Modality-specific knowledge assessment task.—This task consisted of six trials: three see condition trials and three feel condition trials, given in random order. At the beginning of each trial, one pair of objects was placed under a cloth cover in front of the children. The cover was then lifted up and children were shown the two objects and told appropriately if they looked the same or different. Children were also asked if they thought the objects looked the same or different and, if different, how they differed. Throughout this time the experimenter ensured that children did not feel the objects. Once children had agreed that the two objects looked the same or different, the objects were covered up again. Children were now shown how to feel both objects under the cover simultaneously without looking at them or removing the cover. Children were told appropriately if they felt the same or different. They were also asked if they thought the objects felt the same or different and, if different, how they differed. Once children had agreed they felt the same or different, the experimenter summarized how the objects were the same and how they were different. Children were then asked to pick one of the objects of the pair for Ernie and Bert to find out about. This object was hidden under the cover and the other was placed out of sight.

On each of the six trials, after the children had received this introduction to the object pair and one object had been hidden, three test questions followed—two knowledge assessment questions and one "best way" question. Of the two knowledge assessment questions, one pertained to the knowledge possessed by the puppet feeling the object and the other to the knowledge possessed by the puppet looking at the object. Children were told that Ernie and Bert were now going to find out about the toy hidden under the cover, and would take turns seeing or feeling it. The experimenter then brought one puppet up onto the table. For example, Bert appeared with a blindfold on and his hands out of his pockets. Children were told, "This time, Bert's not looking [and the experimenter pointed to the blindfold], Bert's just feeling [and the experimenter pointed to Bert's hands]." Bert now felt the object under the cover, and the experimenter stressed again, "Bert's feeling the [object name]." Children were encouraged to do just as Bert was doing—to feel the object under the cover without looking. While the children and the puppet were feeling the object, children were asked the appropriate first knowledge assessment test question. For example, if the child had hidden the wet sponge under the cover, he or she was asked, "Can Bert tell, just by *feeling*, that the sponge is wet?" Once children had answered "yes" or "no," this puppet was placed to the side and the experimenter brought the other puppet up onto the table (in this example, Ernie with his hands in his pockets and his blindfold removed). Children were told, "This time Ernie's not feeling [and the experimenter pointed to Ernie's hands in his pockets], Ernie's just looking [and the experimenter pointed to Ernie's eyes]." The cover was now removed and the experimenter stressed again, "Ernie's looking at the [object name]." Children were encouraged to look at the object, without feeling it, just as Ernie was. While the children and the puppet were looking at the object, children were asked the appropriate second knowledge assessment test question. For example, "Can Ernie tell, just by *looking*, that the sponge is wet?" After children had responded, Ernie was placed to the side and children were asked the final *best way* test question, for example, "So, what's the best way to find out if this sponge is wet or dry—to feel it or look at it?" The order of presentation of the forced-choice alternatives was counterbalanced. On each trial, children always received both knowledge assessment questions first, followed by the best way question. The order of the two knowledge assessment questions was counterbalanced.

Twelve random orders of six trials were used in each age group. The 12 random orders were constructed subject to the following constraints: (*a*) each of the six pairs of objects appeared twice as the first trial, (*b*) the second trial was opposite in modality condition to the first, (*c*) not more than two trials of the same modality condition occurred in a row, and (*d*) the same puppet would not be correct more than four times in a row. For six of the 12 random orders, Ernie was always the first puppet to examine the object; for the other six, Bert was. Each puppet repeated the same action for three trials. For example, for the first three trials Ernie would look at the object and Bert would feel it, and vice-versa for the last three trials. Each set of six random orders was repeated within each age group to allow each puppet to start with either of the two actions.

Results and Discussion

All children answered the introductory control questions without difficulty. In the experimental task, children received two scores for each trial (see Table 5). First, if children answered both knowledge assessment questions correctly (i.e., one yes response and one no response), they received a score of 1 for that trial. If they answered one or neither question correctly, they received a score of 0 for that trial. Second, children received a score of 1 or 0 for their answer to the *best way* question. Children's responses on the knowledge assessment and best way questions did not differ significantly as a function of the particular object pair used within a given modality condition, $\chi^2(2, N = 72) < 2.84$ for all object pairs, all p's $> .05$, so these three scores were combined in each of these two conditions. There was no main effect of gender, nor did it interact with any of the variables of interest, and therefore this factor is not considered further.

TABLE 5

Percentage of Trials Answered Correctly by Age, Task Type, and Modality in Study 3

	Test Question			
	Knowledge Assessment		Best Way	
Age	See	Feel	See	Feel
3....	42	19	53	74
4....	71	72	86	86
5....	89	89	94	99

Knowledge Assessment Questions

A two-way, repeated-measures ANOVA, with age (3 vs. 4 vs. 5) as the between-subjects variable and modality condition (see vs. feel) as the within-subjects variable, revealed a significant main effect of age, $F(2,69) = 24.13$, $p < .001$, a nonsignificant main effect of modality condition, $F(1,69) = 2.83$, $p > .05$, and a significant modality condition × age interaction, $F(2,69) = 3.43$, $p < .05$.

As Table 5 shows, performance in each modality condition increased with age. The performance of the 4- and 5-year-olds did not differ across modality conditions and was significantly above chance in both modality conditions (all $D_k > .458$, $N = 24$, $p < .01$). Three-year-olds' performance was poor and was worse in the feel condition than the see condition. The 3-year-olds' performance in both conditions was significantly different from that expected by chance. In the see condition ($M = 42\%$), this significant effect, $D_k = .333$, $N = 24$, $p < .01$, was due to the higher than expected number of children passing or failing all three trials (a U-shaped distribution). In the feel condition ($M = 19\%$), the significant effect, $D_k = .5$, $N = 24$, $p < .01$, was due to the high number of children failing all three trials.

Sixty-seven percent of the 5-year-olds and 50% of the 4-year-olds passed all six trials—only 4% of the 3-year-olds did so. The performance of the 3-year-olds remains poor in contrast to that of the older age groups even if a score of 4 out of 6 trials correct ($p = .033$ by chance) is designated as the criterion of understanding in this task. This score was achieved by 92% of the 5-year-olds, 71% of the 4-year-olds, and 21% of the 3-year-olds. By this criterion, only the 4- and 5-year-olds were responding correctly more often than would be expected by chance (binomial test, $p < .001$).

As in both previous studies, we examined the patterns of children's incorrect responses. Did children respond systematically to questions about the puppet that looked, the puppet that felt, or both? For example, did they always attribute knowledge to the puppet who looked and deny knowledge to the puppet who felt? Correct responding required attributing knowledge to the puppet that looked on only the three see condition trials, and to the puppet that felt on only the three feel condition trials. Four- and 5-year-olds displayed this response pattern: The average number of times (out of three) that they attributed knowledge to the correct puppet ranged from 2.79 to 2.92 (in contrast to .25 to .83 for the incorrect puppet). Three-year-olds displayed a strong tendency to attribute knowledge to the puppet that looked, regardless of whether the property being asked about was a visual or tactile one. They attributed knowledge to the puppet that looked an average of 2.71 times on see condition trials and 2.04 times on feel condition trials. Their ability to correctly assess the knowledge of a puppet that was feeling was limited: 3-year-olds attributed knowledge to this puppet an average of 1.46 times on see condition trials and 2.00 times on feel condition trials. Denying knowledge to both puppets on a single trial was infrequent among all three age groups. More frequently, children attributed knowledge to both puppets: on see condition trials, 35 (83%), 16 (76%), and 5 (62%) failed trials were failed this way by 3-, 4-, and 5-year-olds, respectively; on feel condition trials 34 (57%), 16 (80%), and 6 (75%) failed trials, respectively. The fact that 3-year-olds said yes more often in the see condition than in the feel condition argues against a pure and simple yes bias on their part. Yet, the tendency to say yes is notable and may reflect in part their own knowledge of the object's properties.

It is also interesting that 3-year-olds did not simply report their own experience when assessing the knowledge of the puppets. Children always performed the same action as the puppet did and could have used this information to answer the test questions correctly (e.g., they could have translated the test question as "Can I tell just by feeling that the pig is squishy?" or simply "Can I tell that the pig is squishy?"). Children's denials of knowledge to the puppets in cases where the action was sufficient to provide knowledge suggest that they were not using this strategy. Indeed, several children who denied knowledge to the puppet in such cases also mentioned that they themselves knew the property in question. These children may have been able to ascribe knowledge to themselves based on the sensory evidence directly available to them, yet have been unable to ascribe knowledge to the puppet because this requires understanding *how* they know that they know in order to be able to ascribe knowledge to another person in the same situation.

Children's verbal comments also display, as in Study 2, the thorough understanding that even the youngest children had who could answer these questions correctly. For example, comments about the puppet feeling the object on see condition trials included: "No [he can't tell]. He has to take this [the blindfold] off. He has to see it" (age 3-5); and "No, 'cause it [the puppet] doesn't feel that [referring to the spots on the dragon]" (age 4-1). Comments about the puppet who was looking on feel condition trials included: "No, he thinks it might be the hard one [referring to the squishy pig]" (age 3-11); "No, he can't tell. He has to put his hand in [the water]" (age 3-8); and, "No, only if it [the sponge] were really wet, then it would shine" (age 5-3).

Best Way Question

A two-way, repeated measures ANOVA, with age (3 vs. 4 vs. 5) as the between-subjects variable and modality condition (see vs. feel) as the within-subjects variable, revealed only a significant main effect of age, $F(2,69) = 19.00$, $p < .0001$. Overall performance increased with age. The mean scores per age group across all six trials were 3.79, 5.17, and 5.79 for the 3-, 4-, and 5-year-olds, respectively. Planned comparison tests revealed that the 3-year-olds performed significantly worse than both the 4- and 5-year-olds, $F(1,69) = 17.16$, 36.3, respectively, both p's $< .0001$. The 3-year-olds' performance in the see condition did not differ significantly from chance (95% confidence intervals around the mean included 1.5). In the feel condition, 3-year-olds' performance was significantly above chance, $t(23) = 3.4$, $p < .003$. Interestingly, in responding to this question, nine of the 3-year-olds responded with *to feel* on five or more of the six trials, and three responded with *to see* on five or more of the six trials. This feel bias seems noteworthy in view of the fact that in this task these answers were probably not motivated by a desire to actually carry out either action. The way the game was set up, children knew they only had to respond verbally to this question and did not have to carry out the action stated.

These results suggest an explanation for children's response biases in the three studies. Children's responses may reflect the relative familiarity of certain sensory experiences in different situations (Flavell, Green, & Flavell, 1989). When assessing their own ability to know, as in Study 1, children may choose to feel rather than to see because in their everyday experience feeling usually provides a much more detailed and direct experience of the nature of an object than just seeing it does. Of course, this everyday "feeling" is really looking at and feeling an object up close, not just feeling alone. If children interpreted the *best way* question as a request to state the best *action* to perform with an object to find out about it in general (as we think they did), they might have chosen to feel rather than to look, as in Study 1. When assessing the knowledge of others, however, children in both the primary and modality-specific knowledge assessment tasks may choose the puppet that looks, because they more frequently observe others looking than feeling when obtaining information from the environment. These explanations are only conjectures, of course, in the absence of further research evidence.

It is difficult to compare children's performance on this task directly with their performance on the knowledge assessment questions because of the differences in task structure (e.g., number of answers required per trial and question format). Nevertheless, the two older age groups, in particular the 4-year-olds, appear to have found the best way question easier to answer than the two knowledge assessment questions on a given trial. Both age groups performed almost errorlessly on this task, and the overall number of trials that 4-year-olds answered correctly on the best way task was 14.5% higher than those answered correctly on the knowledge assessment task. With respect to the 3-year-olds, it is more difficult to determine whether they found the best way question easier. Their performance improved, yet it was still significantly worse than that of the 4- and 5-year-olds, and it appeared to be influenced by a response bias that would have guaranteed a score of 50%.

Thus, the results of this study support our hypothesis that focusing the task on the sensory experiences involved enhances the performance of the 5-year-olds. The performance of the 4-year-olds was also enhanced. However, despite these changes 3-year-olds have difficulty with this task, even when it requires only a rudimentary level of understanding.

General Discussion

The results of these studies suggest three conclusions. First, on primary knowledge assessment tasks, 3-, 4-, and 5-year-old children perform well when seeing is the mode of informational access, but 3-year-olds do not perform well when feeling is the mode of informational access (Study 2). Second, 3-year-olds also show only a very limited understanding of the modality-specific nature of knowledge (Study 1, 2, 3). In contrast, 4- and especially 5-year-olds show evidence of such understanding (Study 1, 2, 3). Moreover, this understanding is enhanced when the task and the test question highlight the sensory actions involved and do not require a direct comparison of two puppets' knowledge states (Study 1, 3). Finally, 3-year-olds (Study 2, 3), as well as 4- and 5-year-olds, when given more difficult tasks (Study 2), tend to overattribute knowledge to a puppet that is looking rather than feeling. When assessing their own ability to know (Study 1), however, or when asked how they would find out modality-specific information (Study 3), 3- and 4-year-olds tend to err by choosing feeling as the mode whereby to acquire perceptual knowledge.

What accounts for these differential difficulties? That is, what can they tell us about the understanding that children must possess to succeed on these tasks? And how do these results fit in with research findings in the theory of mind and other relevant literature? The evidence to date suggests that young children's understanding of knowledge acquisition may proceed through three phases, eventually leading to a firm understanding of how their own and others' knowledge is related to conditions of informational access.

In the first phase, around 3 years of age, children have some understanding that knowledge and sensory experiences are associated. This association is understood only with respect to visual experiences—not tactile (and perhaps other) experiences. By "associated" we mean only that young children believe they and others can, or do, "know X" when they or others have visual contact with X. That is, they know that visual perception and knowing tend to go together (O'Neill & Gopnik, 1991; Perner, 1991). In primary knowledge assessment tasks, children can monitor visual access and use their understanding of this association to answer the test questions correctly. Young children may possess this associative notion without an appreciation of what facts about object X (e.g., its identity or properties) are causally connected to their sensory experiences with X, for example, what particular properties of object X will be accessible to them through different sensory experiences.

This view of the nature of this associative understanding is both similar to, and different from, the views presented by other researchers. It is similar to Chandler and Boyes's (1982) and Taylor and her colleagues' (Taylor, 1988; Taylor, Cartwright, & Bowden, in press) suggestion that these children equate seeing with knowing. Taylor (1988) has questioned the generality of the seeing = knowing hypothesis and suggests that children may be more likely to attribute some kinds of information (e.g., identity of an object) to a naive observer than other kinds of information. Similarly, we would question under what conditions children might equate knowing with a nonvisual type of sensory access, and with what generality children use the seeing = knowing equation with respect to their own ability to know.

This associative stage is also similar to Wimmer, Hogrefe, and Sodian's (1988) earliest stage of children's understanding of informational accesses as origins of knowledge. They describe informational accesses in this stage as functioning as origins of knowledge, but as not being understood by children as such. For example, children will make use of vision to find out X, but will be unable to explain that it was seeing that allowed them to find out X. Wimmer, Hogrefe, and Sodian (1988) argue that at this stage children fail such tasks as our primary knowledge assessment task because they lack an understanding of the causal origins of knowledge. However, our results and those of Pillow (1989) and Pratt and Bryant (1990) suggest that 3-year-olds can pass such primary knowledge assessment tasks when seeing is the mode of access involved. How then can these two views be reconciled? Three-year-olds succeed only in simple visual access tasks, therefore we do not wish to endow them with a causal understanding of sensory access and knowledge as others have done (e.g., Pillow, 1989; Pratt & Bryant, 1990; Wellman, 1990). Rather, we argue that 3-year-olds can pass such tasks by relying on their associative understanding of seeing and knowing. That is, these children have some understanding of *when* it is possible to say that another person can or does know something: namely, cases in which that person has visual access. This sort of associative understanding encompasses no understanding of informational accesses as origins of knowledge, and is therefore similar to Wimmer, Hogrefe, and Sodian's (1988) earliest stage, yet it can explain why 3-year-olds pass primary knowledge assessment tasks.

In a second phase, around 4 or 5 years of age, children develop a first understanding of how sensory experiences and knowledge are related causally. This understanding corresponds to the first part of Dretske's (1981) characterization of knowledge cited at the beginning of this article: the understanding that evidence is a necessary accompaniment of knowledge. Children who understand this are able to provide a reason for *how* they know something and their reasons suggest they understand that sensory experiences function as causal origins or sources of knowledge (Wimmer, Hogrefe, & Sodian, 1988). Just this type of understanding has been shown in source identification tasks. By 4 years of age, children are proficient at identifying the sources of their own and others' beliefs when seeing, telling, and feeling are the source types involved (Gopnik & Graf, 1988; O'Neill & Gopnik, 1991; Wimmer, Hogrefe, & Perner, 1988; Wimmer, Hogrefe, & Sodian, 1988). Perner (1990) has also recently offered another, similar way of conceptualizing this understanding. He suggests that around the age of 4 children develop "experiential awareness" and are able to encode that a sensory experience leads to a memory of an event.

Additional knowledge is needed for children to perform well on modality-specific knowledge assessment tasks, however. To illustrate, consider the distinction made by Goodman (1976) between something being a representation *of* an object and something representing an object *as being a certain way*. The modality-specific knowledge assessment task, but not the source identification task, requires an understanding that knowledge can represent an object as being a certain way. Identifying sources requires only an appreciation of the many causal processes that lead to one and the *same* type of knowledge, namely, knowledge of the identity of an object. The only knowledge about the object that the child must be aware of is the identity of the object. In the modality-specific task, on the other hand, children must understand which sensory experiences lead to which *different* types of knowledge, namely, knowledge about certain aspects of an object such as its color or texture (O'Neill & Astington, 1990). Such knowledge has been referred to by others as knowledge of *aspectuality* (Dretske, 1969; Perner, 1991). Thus, children who succeed on this task understand that although seeing may result, for instance, in knowledge that a *ball* is present, seeing is also the source of their knowledge that it is a *blue ball.* Similarly, they understand that should this blue ball also be spongy, then feeling would result in knowledge that a ball is present and in knowledge that it is a *spongy ball.* In other words, these children understand how an object's identity is constructed out of component properties and characteristics that are derivable separately by all the different sensory experiences occurring between the object and the person. They understand the specific aspects of knowledge, such as texture and color, that are the products of specific sensory experiences (O'Neill & Astington, 1990). They may also understand more complex intermodal equivalences, such as the fact that bumpiness is often perceivable not only by touch, but by vision as well.

Thus, understanding the modality-specific aspect of knowledge requires a grasp of the second part of Dretske's (1981) characterization of knowledge and represents the third phase of understanding how knowledge is related to conditions of informational access. Not only do children understand that some sort of evidence led them to be able to say they know a certain fact, they also have some understanding of the kinds of knowledge that can be supported by a given piece of evidence. In contrast to children who pass the primary knowledge assessment tasks and the source identification tasks, children succeeding on the modality-specific knowledge assessment task are showing a greater understanding of the conditions under which adults will characterize themselves or someone else as knowing something. That is, as adults we attribute knowledge to ourselves and others in situations where we are certain that the evidence is unambiguous. For example, we would describe someone as knowing the color of a ball if we knew that person had seen the ball, or perhaps been told its color. We would not describe someone who only felt the ball as knowing its color because we know feeling cannot provide unambiguous evidence for this type of knowledge. By 5 or 6 years of age, our results suggest that children are beginning to ascribe knowledge reliably to themselves and others in a manner consistent with how adults would, at least in conditions involving visual and tactile experiences.

We have argued that 3-year-olds possess only a very limited understanding of the modality-specific nature of knowledge, even at a rudimentary level. We do not, however, wish to claim that they possess no such understanding in any form. We would not deny that very young children can acquire modality-specific knowledge through actions that they decide to take. For example, we would predict that if we presented a 3-year-old with two objects, a wet one and dry one, and asked the child to find the wet one, he or she would be able to do so. But, even if the child were to look first at the objects, feel them, and then choose the wet one correctly, we would argue that this behavior would not specify the level of understanding that the child has. The child could simply possess a rule such as "look, then feel," or "best to grab and look" without having any explicit understanding of the epistemic effects of such actions. Moreover, which rule the child applies may depend on his or her experience and familiarity with exploring objects and the surrounding environment. Thus, our claim does not imply that children do not use their senses appropriately to gain modality-specific information. Our claim is rather that young children do not understand whence and how they got this modality-specific information. Predicting the knowledge of others, or having to choose between seeing or feeling to gain information oneself, requires such an understanding.

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