Visual Perspective-taking Skills in Children

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GZESH, STEVEN M., and SURBER, COLLEEN F. *Visual Perspective-taking Skills in Children*. CHILD DEVELOPMENT, 1985, **56**, 1204–1213. The present study evaluated the effects of stimulus complexity and rule usage on a visual perspective-taking task. Preschoolers, first, third, and fifth graders, and adults were shown arrays of dolls and performed a series of perspective-taking tasks. Errors decreased with age, and more errors occurred with the more complex visual arrays. A significant number of errors were made in self-view trials, especially by the preschoolers, showing that the ability to relate an array to a pictorial representation of it is not perfect. A conditional probability analysis showed that most egocentric errors were *not* due to an inability to relate the array to pictorial representations, but rather to a lack of mastery of Flavell's different positions–different views rule. When the array was covered, however, even first graders showed almost perfect mastery of this rule. There were also task effects on the use of Flavell's same position–same view rule: children performed better for a task involving self and other than for 2 others. Response latencies and effects for the observer's relative position provided evidence for a new rule: opposite positions–opposite views. In addition, front and back views of the dolls were significantly easier than the side views, which suggests a role of labeling or stimulus-discrimination skills.

A child's ability to infer what another person is seeing has been assessed by means of various visual perspective-taking tasks. In Piaget's original studies, children under approximately 7 years of age tended to choose their own view as also representing that of another observer (Piaget & Inhelder, 1956). These findings have been widely replicated (Fishbein, Lewis, & Keiffer, 1972; Flavell, Everett, Croft, & Flavell, 1981; Flavell, Flavell, Green, & Wilcox, 1981; Liben, 1978). Generally, it has been observed that correct performance on a perspective-taking task declines as the number of stimuli in the array increases (Fishbein et al., 1972; Liben, 1978). Poorer performance is also associated with an increase of interposition of the elements within the visual array and a decrease in the overall visibility of the stimulus set (Coie, Costanzo, & Farnill, 1973; Flavell, Omanson, & Latham, 1978; Liben, 1978). The angle of orientation also has an effect on performance. Broadside views of an array are mastered before the corner or diagonal views (Schachter & Gollin, 1979; Walker & Gollin, 1977).

Flavell et al. (1978) proposed that identifying the view of another observer was accomplished through certain computations and rules. Computations refer to the actual cognitive processes that the child may use to calculate how a display appears to another observer at another position (e.g., mental rotation or imagining oneself at the other observer's position). Rules, however, refer to the general relationships among observer positions and visual experience. They are essentially invariant across displays and allow for rapid response times (Flavell et al., 1978). Salatas and Flavell (1976) proposed specific rules that are acquired in a developmental sequence: (1) one position–one view, an observer has only one view from any given vantage point; and (2) different positions–different views, a given view cannot be seen from more than one position, hence two observers in different positions will have different visual experiences.

The ability to correctly identify the view of another observer presupposes that the child is capable of correctly identifying his or her own view (Liben, 1978), yet there have been reports of the need to correct the self-views of young children (Fishbein et al., 1972; Flavell et al., 1978; Salatas & Flavell, 1976; Walker & Gollin, 1977). If a child is not able to infer his or her own view, then errors in perspective-taking tasks cannot necessarily be attributed to a lack of perspective-taking

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skills. Instead, errors may be due to a lack of understanding of the task or some related cognitive skill such as spatial or pictorial representation. Such a finding would demonstrate the need for researchers to examine children's ability to relate pictorial representations to a physical array before attempting to test for perspective taking.

The present study examined young children's perspective-taking abilities in five different tasks. In Phase 1, the mastery of choosing one's own view was tested. Phase 2 examined the use of Flavell's Rule 1 (same position–same view) by requiring the subject to infer another's view when both were looking at a display from the same place. Phase 3 examined Flavell's Rule 2 (different positions–different views) by having the subject select a representation that depicted what another observer was able to see at a different vantage point. In Phase 4, a cover was placed on the display, the view of another observer was given, and the subject was asked to decide what he or she would be able to see if he or she could see through the cover. This not only tested again for Rule 2, but also tested for other possible rules of perspective taking, for example, opposite positions–opposite views. In Phase 5, the array was also covered, but the view of a third observer was to be inferred based on the information of a second observer.

The present research extends the work of Flavell et al. (1978) in three respects. First, the children's ability to relate the pictures to the array is assessed systematically, which allows the ability to relate pictures to the array to be separated from the development of perspective-taking skills. Second, the study assesses the effects of stimulus complexity on the development of the two perspective-taking rules hypothesized by Flavell et al. Third, by using more than two response alternatives and factorially varying the viewpoints of the subject and observer, it may be possible to discover perspective-taking rules other than the global Rule 2 (different positions–different views). Flavell's Rule 2 is best applied to tasks where there are only two choices.

Method

Subjects

The subjects were 18 preschool children (nine boys and nine girls, mean age = 4.0 years) from day-care centers; 54 first, third, and fifth graders (18 in each age group with 10, 5, and 6 boys, and 8, 13, and 12 girls, respectively) from a predominantly white, middle-class public school (mean ages = 6.8, 8.7, and 10.9, respectively); and 18 introductory psychology students (8 males and 10 females, mean age = 19.9) who received extra credit toward their course grade for their participation. All children had parent permission. One additional grade school and seven preschool children were tested but discarded for lack of attentional capacity, strong picture position preference, or withdrawn consent to participate. An additional six adults and five fifth graders were also tested, but were randomly discarded to equalize N for statistical computations. Preliminary separate analyses of the full adult sample and full fifth-grade sample showed results that were similar to the reduced sample.

Apparatus and Materials

Three dolls (9 cm high) in different colored dresses were placed diagonally facing forward on a 35.5 × 35.5-cm board that rotated on a lazy Susan. To increase the differences between the right and left sides, each doll held a purse in its raised left hand and had its right hand lowered by its side. For the one-doll condition, the two corner dolls were removed, and the center doll remained in place. (Figure 1 presents a schematic representation of the array.) Two stuffed animals (30.5 cm high), Bugs Bunny and Sylvester the Cat, served as observers. Sixteen 5 × 7-inch color photographs (12.5 × 17.5 cm) depicted the eight 45° rotations for the one- and three-doll arrays. Four photographs were presented as response alternatives in all phases. In Phases 1 and 2, the four photographs consisted of the correct picture, 180° error, either ± 45° error, and either ± 90° error. The four combinations of photographs were counterbalanced across subjects. In the other three phases, the corner-view photographs were not used; hence the same four photographs were presented in random order. A 52 × 52 × 36-cm box covered the stimulus array in Phases 4 and 5. A 24 × 20.5-cm window was cut in the middle of each side; however, a panel was placed over the subject's window during the test trials. A small laminated picture of Bugs was used to mark the photograph of Bugs's view. An electronic stopwatch (Casio Melody 80) was used to record response latencies in Phases 3, 4, and 5 only, and was activated when the dolls stopped revolving (Phase 3) or when the picture of Bugs was placed on the appropriate photograph (Phases 4 and 5).

Design

There were five phases: (1) select the photograph that matches what the subject sees (self-view), (2) select the photograph that

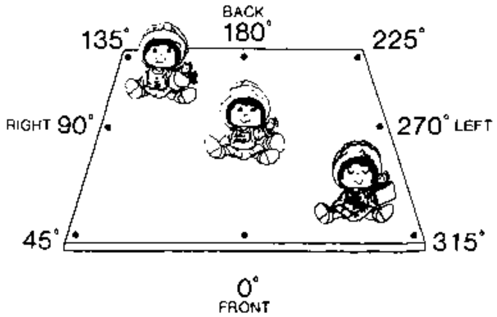

FIG. 1.—Schematic representation of the experimental stimulus. For the one-doll conditions, the center doll was displayed alone.

matches what Bugs sees when he is sitting on the subject's lap (same position–same view), (3) select the photograph that matches what Bugs sees when he is sitting at a different vantage point (different position–different view), (4) select the photograph that matches what the subject would be able to see under a covered array, given Bugs's view, and (5) given Bugs's view, select the photograph that matches what Sylvester is able to see when the array is covered.

All subjects completed the phases in the same order. The preschool children were tested in three to five sessions, depending on individual attention spans; the school children in three or four sessions; and the adults were all tested in a single session. The preschoolers were not tested for Phases 4 and 5 due to the difficulty of the tasks. Approximately one-half of the subjects in each age group were randomly assigned to do the one-doll trials before the three-dolls trials for each phase (N = 10, 8, 9, 8, 10, preschool through adult, respectively). The adults completed all five phases with a given number of dolls, and then repeated all phases with the remaining number of dolls. For the other age groups, the sessions were clustered: Phases 1 and 2, Phases 3 and 4, and last, Phase 5.

The design for Phases 1 and 2 consisted of 16 trials each in a 2 (number of dolls) × 2 (corner/side) × 4 (90° rotation of the array nested in corner/side) factorial design. Phases 3 and 4 consisted of 24 trials each in a 2 (number of dolls) × 3 (Bugs's position (± 90° or 180° from the subject) × 4 (90° rotation of the array) factorial design. For the grade-school subjects, Phase 5 consisted of 32 trials in a 2 (number of dolls) × 4 (relative position of Bugs and Sylvester [congruent: both 90° from the subject; ± adjacent: Bugs 180° from the subject, Sylvester ± 90°; opposite: Bugs + 90°, Sylvester − 90° from the subject]) × 4 (90° rotation of the array) factorial design. The adults received a slightly modified Phase 5 design, in that they completed 24 trials with only eight adjacent-position trials rather than the 16 completed by the grade-school subjects. Four sets of randomized stimulus orders were generated for each phase, from which two (one for each number of dolls) were randomly selected for each subject. For Phase 3, four additional sets of randomized stimulus orders were generated to serve as training trials.

Procedure

Subjects were seated to the left of the experimenter in front of the array. The initial instructions read as follows:

Today we are going to play with this doll[s]. I want you to pay close attention to how this doll looks. Let's take a look at how she can look different when we turn this platform. See, now we see the front, but if I turn it, we see a different view of her. Now we see her side and if we turn it some more, we see the back of her head, and now her other side.

I want you to notice how this side looks different from the other side. Here you can see her facing to the left, her arm is raised, and she's holding a little purse. But on the other side, she's facing to the right, her arm is down, and she's not holding anything. You can use these clues and many others to help see how one side looks different from the other.

A photograph of the doll was then shown. The children were to indicate if it exactly matched how they saw the doll. Two training trials were given with feedback following the procedures of Flavell et al. (1978). In all training trials, photographs were presented one at a time and the subject was asked if what he or she saw in the picture matched exactly with what he or she (or Bugs in Phase 3) saw. It was stressed that only one photograph would be the correct answer for any trial. After the training trials, the test trials were presented. Each trial was preceded by spinning the lazy Susan around several times and laying out all four photographs at once.

After the completion of Phase 1, the instructions introduced Bugs Bunny, who was placed on the child's lap. The child was asked, "Does Bugs see the doll the same way you see her?" All subjects agreed. The experimenter emphasized that because they were both at the same place, they'd see the same thing. Two training trials with feedback were given as in Phase 1. After these trials, it was again stressed that Bugs's view was to be chosen instead of the child's own for the following test trials.

Following Phase 2, the instructions for Phase 3 were given: "Why don't we let Bugs sit somewhere else now? Does he see the doll the same way you do now? That's right. Because he's at a different place than you, he's going to see her differently than you. Can you pick out the picture that shows how Bugs sees the doll from where he's seated?"

Training trials with feedback were presented until the criterion of two consecutive correct responses, or 12 trials (a complete factorial), had been reached. Eight preschoolers failed to reach criterion (two of those children failed with both one and three dolls); hence only their training trials were used in some of the analyses. One first grader also failed to reach criterion, but was subsequently tested nevertheless. Feedback stressed the importance of recognizing that Bugs would see a different view than that of the subject, and that a good strategy is to look at what part of the doll Bugs is looking at from where he is sitting. Following the training trials, the child was informed that a timer would be used, but that he or she should continue to take his or her time and think hard before answering.

After the completion of Phase 3, the experimenter covered the array with a "dollhouse," and allowed the subject to view the doll through one of the windows. The window was then covered while Bugs's window remained open. The instructions continued as follows: "Can Bugs still see the doll? That's right. Because I didn't cover his window, he can still see the doll. I'm going to spin the doll around inside the dollhouse. You can't see her, but Bugs can. See this photograph? This shows exactly how Bugs sees the doll right now. I'll put this little picture of Bugs right next to it so you'll remember that that's what he sees. Now think about where he's sitting. If this is what Bugs sees, what would you see if you could look through your window?" One training trial with feedback was given, followed by test trials.

After Phase 4, Sylvester was introduced with the instructions for Phase 5. The instructions stressed that now the subject was to figure out what Sylvester would see, given only Bugs's view. They were reminded that he would see the same thing as Bugs when they sat together, but that they would see different views when they sat apart. Neither training nor feedback was given for these problems.

Following Phase 5, subjects were asked to describe their task strategies for Phases 4 and 5. The college students wrote their answers; the children orally answered the questions when shown sample problems depicting the relative positions.

Results

The primary dependent variable was correctness of the picture choice on each trial (coded 0 if correct, 1 if incorrect). The response latencies provided another dependent variable in Phases 3–5. The results are presented below sequentially by phase for each dependent variable, and analyses relevant to rule usage and egocentrism follow the presentation of the basic results.

Phases 1 and 2

Phases 1 and 2 tested the subject's ability to relate the physical display to the photographs, and were analyzed together in a 5 (age) × 2 (number of dolls) × 2 (phase) × 2 (corner/side) × 4 (rotation nested in corner) analysis of variance (ANOVA). The mean number of errors decreased rapidly with age, $F(4,85) = 81.53$ (mean % errors: 49.7, 16.0, 9.7, 4.7, 1.0, preschool through adults, respectively).[1] Three dolls were found to be more difficult than one doll, $F(1,85) = 12.93$ (mean % errors: 18.6 and 13.8, respectively), and trials displaying corner views had a higher error rate than those with broadside views, $F(1,85) = 10.15$ (mean % errors: 18.2 and 14.2, respectively). The specific rotation also showed a significant main effect, $F(6,510) = 7.07$, in that the view of the front of the doll was found to be the easiest to discriminate (mean % errors: 6.6, 15.8, 16.1, 17.5, 18.1, 16.4, 16.1, and 23.1, 0°–315° [see Fig. 1], respectively). Significant interactions of age × corner, $F(4,85) = 4.54$, and age × rotation, $F(24,510) = 3.66$, however, indicated that the effects of corner and rotation decreased with age.

Phase 3

Response correctness.—Phase 3 represents the traditional perspective-taking task in which the subject infers another's view from a different vantage point. A 5 (age) × 2 (number of dolls) × 3 (Bugs's position) × 4 (rotation) ANOVA showed significant effects for age, $F(4,85) = 22.47$ (mean % errors: 59.0, 30.3, 25.7, 12.7, and 3.5, preschool through adult, respectively) and for rotation, $F(3,255) = 20.44$, such that views that showed the

[1] For all significant effects discussed, $p < .01$, unless otherwise noted.

front or back were easier to solve than views showing a side (mean % errors: front: 17.4; back: 21.9; sides: 30.4 and 35.4). There was also a significant effect for the number of dolls, showing the expected effect of stimulus complexity, $F(1,85) = 6.61$, $p = .012$ (mean % errors: one doll = 23.1; three dolls = 29.4). Bugs's position approached significance, $F(2,170) = 3.66$, $p = .028$. Fewer errors occurred when he was positioned 180° across from the subject (24.0%) than when he was 90° to the left or right of the subject (25.8% and 28.9%, respectively). This may be due to the presence of other perspective-taking rules, perhaps an "opposite positions–opposite views" rule.

Response latencies.—In this phase, only 10 preschoolers passed the criterion of two consecutive correct trials during training; hence only they had data for response latency analyses. This should bias the results in the direction of decreasing any age effects because the 10 preschoolers who passed the training trials should be more advanced than those who failed.

In many respects, the response latency results parallel the results for the error scores. There was a significant effect for age, $F(4,77) = 25.36$ (mean response latencies: 10.5, 9.6, 6.8, 6.0, and 3.1 sec, preschool through adult, respectively). Three dolls took significantly longer to answer than one doll, $F(1,77) = 19.59$ (mean latencies: 7.81 and 5.91 sec, respectively), and front and back views took significantly less time to answer than side views, $F(3,231) = 46.50$ (mean latencies: 5.57, 7.75, 6.38, and 8.16 sec, front, right, back, left, respectively). There was also an effect for Bugs's position. It took the least amount of time to infer his view when he was 180° across from the subject, $F(2,154) = 4.18$ (mean latencies: 7.24, 6.64, and 6.74 sec, Bugs to the right, opposite, left of the subject, respectively).

Phase 4

Response correctness.—In this phase, the array was covered, and subjects inferred their own view when given Bugs's view. A 4 (age) × 2 (number of dolls) × 3 (relative position of observer) × 4 (rotation) ANOVA again showed a significant effect for age, $F(3,68) = 24.87$, with all ages making more errors in this phase than in the previous three (mean % errors: 57.9, 47.7, 33.8, and 11.8, first grade through adult, respectively). The specific rotation and Bugs Bunny's position showed significant effects, $F(3,204) = 5.50$, $F(2,136) = 125.86$, respectively. As in Phase 3, front and back views were easier (mean % errors: 35.0, 38.2, 34.7, and 43.3, front, right, back, left, respectively), and a viewer position of 180° from the subject led to fewer errors (mean % errors: 52.1, 8.9, and 52.4, Bugs to the right, opposite, left of the subject, respectively); however, there was no effect for number of dolls, $p > .07$. There was a significant age × position interaction, $F(6,136) = 8.98$, as shown in Figure 2. All ages performed better when Bugs was directly opposite than when he was adjacent; however, this difference decreased with age.

Response latencies.—As in Phase 3, there was a significant main effect for age, $F(3,68) = 4.58$ (mean latencies: 8.0, 6.5, 6.2, and 3.9 sec, first grade through adult, respectively). There were also main effects for position and rotation, $F(2,136) = 17.27$, $F(3,204) = 9.27$, respectively. Positions 180° opposite the subject took less time to solve than ± 90° positions (mean latencies: 7.0, 4.8, and 6.6 sec, Bugs to the right, opposite, left of the subject, respectively), which supports the opposite positions–opposite views rule. Views portraying the front or back took less time than the sides (mean latencies: 5.4, 6.4, 5.7, and 7.1 sec, front, right, back, left, respectively). Consistent with the error score data, there was no effect for number of dolls, $F(1,68) = 2.24$, $p = .14$. There was one significant interaction, age × rotation, $F(9,204) = 2.46$. The difference in time needed to answer a trial involving the front/back versus the sides decreased as age increased. This could be the result of more effective naming or discrimination strategies used by the older subjects.

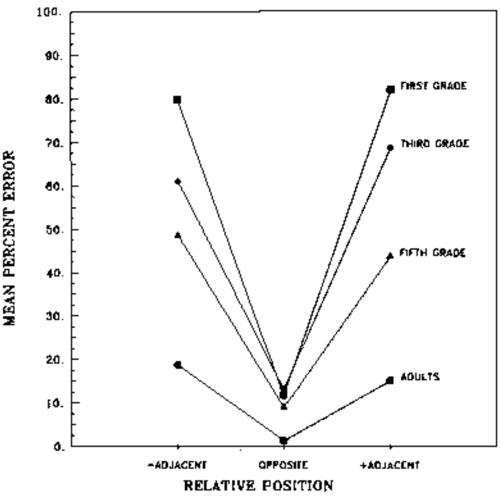

FIG. 2—Phase 4 error rates for position as a function of age.

Phase 5

In Phase 5, the task was to infer the view of Sylvester, given Bugs Bunny's view. Because the grade-school children had eight more adjacent trials than the college sample, both the error and latency data were first analyzed with only three grade-school age groups in order to determine whether there was any difference between the positively and negatively adjacent positions (i.e., Sylvester to right [+] or left [−] of Bugs). Because there were no significant effects due to ± adjacent position (error data: $p > .23$; latency data: $p > .07$), the data were collapsed across adjacent positions by taking the mean value for a given rotation across the two adjacent positions for the grade school subjects. Phase 5 was then analyzed as a 4 (age) × 2 (number of dolls) × 3 (position) × 4 (rotation) factorial design.

Response correctness.—There were significant effects for age, $F(3,68) = 14.61$ (mean % errors: 39.1, 27.5, 19.2, 8.3, first grade through adult, respectively), rotation, $F(3,204) = 7.87$ (sides more difficult than front/back; mean % errors: 44.0, 54.2, 39.1, 51.2, front, right, back, and left, respectively), and number of dolls, $F(1,68) = 10.52$ (mean % errors: 42.6 and 51.6, one and three dolls, respectively). Bugs and Sylvester's relative positions showed a strong effect, $F(2,136) = 108.13$, as shown in Table 1. Judgments of opposite positions were not significantly more difficult than congruent patterns, but judgments of adjacent positions did lead to many more errors (mean % errors: 9.0, 10.2, and 51.3 for congruent, opposite, and adjacent, respectively).

Overall, over half of the adjacent position trials were answered incorrectly. The majority of errors for these trials, as seen in the right-hand column of Table 1, were made by the younger subjects, as seen in a significant age × position interaction, $F(6,136) = 4.98$. The first graders had an average error rate of 75.7%, indicating that they were answering at chance level, and the third graders did not do much better. It is also interesting to note that the first graders actually performed more poorly on congruent-position trials than on opposite positions.

TABLE 1

Mean Percent Error Rates for Relative Positions in Phase 5 as a Function of Age

	Relative Position		
	Congruent	Opposite	Adjacent
First grade . . .	28.5	13.2	75.7
Third grade . .	5.6	15.3	61.8
Fifth grade . . .	2.1	10.4	45.1
Adults	.0	2.1	22.9

Response latencies.—The younger subjects had the longest latencies, $F(3,68) = 15.21$ (mean latencies: 6.6, 4.1, 4.1, and 2.3, sec, respectively), and front/back views were the easiest to answer, $F(3,204) = 3.22$ (mean latencies: 4.1, 4.3, 4.1, 4.6 sec, front, right, back, left, respectively). Overall, it took significantly longer to answer three-doll problems, $F(1,68) = 9.68$ (mean latencies: 4.7 and 3.9 sec, respectively); however, this was not observed in the congruent- and adjacent-position problems. As in the error scores, there was a strong effect for the relative positions of Bugs and Sylvester, $F(2,136) = 80.55$ (mean latencies: 1.9, 3.5, and 7.5 sec, congruent, opposite, and adjacent, respectively). There was a significant age × position interaction, $F(6,136) = 2.80$. As seen in Figure 3, differences between the congruent and adjacent response latencies decreased as age increased. There was also a position × rotation interaction, $F(6,408) = 3.15$, that showed hardly any effect of rotation for the congruent position compared to the other relative positions.

Rule Usage

Rule 1: Same position–same view.—Phase 2 and 5 assessed Flavell's Rule 1: when two observers are at the same position, they see the same thing. In Phase 2, the preschoolers made errors on 50.3% of all trials, compared to rates of 13.5%, 6.6%, 3.1%, and

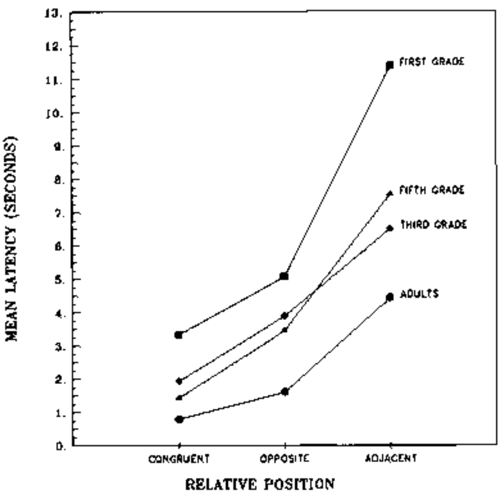

Fig. 3—Phase 5 latencies for position as a function of age.

0.7% for first grade through adult, respectively. The task, however, was confounded with the basic ability of knowing one's own view; therefore, the conditional probability of making an error given a correct response in Phase 1 was calculated. This indicated that preschoolers who were correctly able to identify their own view for a given rotation and number of dolls were not able to identify that same view for another observer at the same vantage point on 21.9% of all trials. This error rate quickly dropped to 8.3%, 4.5%, 2.4%, and 0.7%, first grade through adult, respectively. This is a conservative measure of lack of Rule 1 usage. Because Phase 2 always followed Phase 1, improvement due to practice should lower the conditional probabilities. Because the probabilities are conditional upon correct performance in Phase 1, then any observed errors provide a clear indicator of a lack of Rule 1 usage.

In Phase 5, the congruent-position trials also assesed Rule 1, but for two others, rather than self and other. As seen in Table 1, the first graders made errors on 28.5% of the trials in which Bugs and Sylvester were at the same location, but the error rate quickly declined with age. The first graders' higher error rates in Phase 5 trials than the Phase 2 trials show that it is overly simplistic to characterize a group as having or not having Rule 1. Instead it is more accurate to describe performance as varying jointly as a function of rule mastery and task demands.

Rule 2: Different positions–different views.—Rule 2 says that viewing an object from different positions causes different percepts. This rule results in a correct response when there are only two choices: self and other. The present experiment has more choices; therefore, evidence of use of this rule may come from any trial in which the subject chooses a view that is not egocentric.

In Phase 3, choosing the subject's own view would constitute an egocentric error, and, as expected, the preschoolers had the highest rate (mean % egocentric errors 31.5, 16.7, 20.8, 7.9, and 1.9, respectively, preschool through adult). It could be, however, that the preschool child did indeed know that Bugs saw something else, but he or she was simply unable to find that picture. By chance, the subject's own view may have been chosen. In order to unconfound egocentric responding due to a lack of Rule 2 knowledge from a misunderstanding of the basic task requirements, the error probability in Phase 3 was computed conditional upon the ability to answer a given rotation correctly in both Phases 1 and 2. As Table 2 shows, when a preschooler was able to correctly identify a given rotation in Phases 1 and 2, he or she had a 27% likelihood of choosing a self view when asked to describe Bugs Bunny's. Thus, the preschoolers' egocentric responses are not totally an artifact of their limited understanding of pictorial representations.

TABLE 2

PHASE 3 ERROR PROBABILITIES AS A FUNCTION OF PERFORMANCE IN PHASES 1 AND 2

	Response Type		
	Correct	Egocentric Error	Other Error
Preschool	.60	.27	.13
First grade	.76	.16	.08
Third grade	.77	.19	.04
Fifth grade	.90	.06	.04
Adults	.96	.02	.02

NOTE.—These values are the overall response type per grade. The probabilities are conditional upon having been able to consistently choose the correct photograph for a given view in both Phases 1 and 2.

In Phases 4 and 5, a lack of Rule 2 usage would be shown by choosing a photo that showed what *Bugs* was able to see. In both phases, almost no errors of this type were made. In Phase 4, mean errors were 0.7%, 0.2%, 0.9%, and 0.7%, first grade through adults, respectively. In Phase 5, for the opposite and adjacent positions (Rule 2 does not apply for congruent positions), the mean choices of Bugs's view were 0.5%, 0.7%, 0.2%, and 0.3%, respectively. These results show a fairly high mastery of Rule 2 by at least first grade when the array is covered. This contrasts with Rule 2 use in Phase 3 when the array is visible.

Opposite positions–opposite views.—The present findings support an opposite positions–opposite views rule. With stimuli as highly familiar as human forms (i.e., the dolls), it can be much easier to infer another's view when one knows the opposites: front/back and left/right. However, it is not enough to know that these are opposite aspects of a stimulus; one must also know that it is appropriate to use these aspects when observers are 180° across from each other. Phase 4 findings demonstrate knowledge of this rule as early as first grade. When Bugs was 180° across from the subject, all ages made significantly fewer errors than when he was 90° to either side (see Fig. 2). Results from Phase 5 support the same interpretation (see Table 1).

Response latencies.—One of the attributes of a rule user is not only that he or she can solve a problem correctly, but it should also take less time to solve than had a computation (e.g., mental rotation) been used. Flavell et al. (1978) proposed that rule users should be able to solve a two-choice task in "zero order" time (i.e., less than 1 sec). In the present experiment, any reduction in time when compared to other problems in the same phase may be taken as an indicator that some rule is being used.

Phase 3 latencies showed a consistent trend for position, with the subject taking less time to answer the opposite trials than the adjacent trials. Phase 4 latencies provided the clearest evidence for the opposite-opposite rule (mean latencies for 180°: 7.4, 5.2, 4.7, and 2.0 sec, first grade through adult, respectively; averaged 90° positions: 8.3, 7.1, 6.9, and 4.8 sec, respectively). The latencies observed in Phase 5 are also consistent with rule use (see Fig. 3). The opposite-position trials, although taking nearly twice as long as the congruent trials, themselves took nearly half the time required for the adjacent-position trials.

Discussion

The five phases of the present experiment made it possible to separate components of perspective taking related to knowledge of others' viewpoints, including rules of perspective taking, from other components, including task complexity, discrimination of stimulus characteristics, and the ability to understand instructions and interpret pictorial representations.

Knowledge of Pictorial Representations

The present experiment demonstrates that young children have difficulty matching what they see to a picture, and make errors on nearly half of all these trials. Although many studies have included a one- or two-trial assessment of this knowledge, most were not systematic about what views were assessed and did not attempt to separate this skill from perspective taking (e.g., Flavell et al., 1978; Schachter & Gollin, 1979; Walker & Gollin, 1977). The conditional probability analyses of Phases 2 and 3 make it clear that a thorough assessment of knowledge of pictorial representations should precede attempts to assess perspective taking.

Stimulus Characteristics

The task stimulus has the potential to affect performance as shown by the finding that an array with three dolls was found to be more difficult, even though it provides more information than a one-doll array. Why might this be expected? Some subjects reported using this extra information to reaffirm their intended response, while others reported that they ignored two of the dolls because the extra information was redundant. The problems associated with the more complex stimulus may be a function of the child's inability to perceive what is indeed redundant information, or an inability to effectively integrate multiple information sources. The longer response times may result from the extra time needed to perform these operations that are not required when only one doll is used.

Huttenlocher and Presson (1979) observed that task performance may be directly influenced by the nature of the stimulus. In the present experiment, highly familiar objects were used, yet the preschoolers performed poorly. It is apparent, however, that they were able to use some of the stimuli's unique properties because all age groups showed fewer errors and shorter response latencies with the front/back views. Individuals may be more familiar with the front and back of the body than the sides, partly due to social constraints of conversation. An alternate hypothesis may be one's familiarity with the *labels* of these parts of the body. The dolls can be spontaneously labeled with *front* and *back*, both simple and specific labels of views of the body. Verbally, however, it is not a simple matter to describe a given side. Multiword labels may be attached, such as *right side* or *left side*; however, making a clear distinction between left and right is known to cause difficulty in young children (Howard & Templeton, 1966; Wapner & Cirillo, 1968).

Age differences could also be a result of more sophisticated strategies used by older subjects. Knowing that it is relatively difficult to discriminate the two sides, or to express "right side," older subjects may instead look for more distinguishable features, such as purse/no purse, or arm position. These features were pointed out to all of the children; however, they may not have realized the importance of this information or how it might be applied. Another reason for age differences could be limited processing capacity (see Shatz, 1978). A younger child may need more capacity for basic requirements, such as discriminating important stimulus features or relating a picture to a physical stimulus, and may therefore not have enough processing capacity left to employ these naming strategies. Older subjects may be better able to monitor their own perceived abilities and efficiently modify procedural strategies to overcome possible shortcomings.

Rules and Computations

The present experiment strongly suggests that there is indeed a difference between rules and computations. This is particularly evident in Phases 4 and 5. In the absence of any hypothesized rule that can be used on the adjacent position problems, a computation is the only means available for the subject to solve the problem. If there were no rules in operation, response latencies would be expected to increase with the amount of mental rotation necessary for the solution, such that rotations involving a 90° turn would take less time than 180°. The data do not support this claim. Opposite position trials consistently took *less* time to answer, providing strong evidence for an opposite positions rule.

Egocentrism

In Phase 3, errors consistent with what has been classically attributed to egocentrism were present in all ages; however, the preschoolers made far more of these errors than any other group—nearly one-third of all trials. This finding is even more striking when one considers that the subjects were given explicit information and feedback when an egocentric error was made during the training trials. These results replicate findings of previous research (Flavell et al., 1981; Liben, 1978; Piaget & Inhelder, 1956). The present study, however, separates egocentric responses that are a result of an inability to relate a physical stimulus to a two-dimensional representation of it from true egocentrism. When the responses in Phase 3 were considered with the subject's ability to correctly match a photograph to a particular view, all ages were more likely to correctly solve the problem than make any kind of error. If, however, the subject did make an error, the likelihood that the error would be egocentric (or incompatible with Rule 2) decreased with age. Irrespective of the ability to take the perspective of another observer, children possessing Rule 2 should know that Bugs cannot see their same view. In this respect, it is essentially a rule for behaving nonegocentrically.

Conclusion

Perspective-taking abilities represent multifaceted knowledge of visual stimuli as well as the task situations. Knowledge of the relationships between interobserver positions may be facilitative because these have the potential for allowing available heuristics or rules to be used. Knowledge of aspects of an object may also have a facilitative effect on task performance, as shown by the varied difficulty of front/back versus side views and broadside versus corner views. The use of highly familiar stimuli such as dolls should give the subject an added advantage over other novel, abstract objects because the interrelationships of the parts of the stimuli (e.g., the opposites) are already established. Familiar objects are also more easily labeled, hence interrelationships that may not be known already may be more easily acquired.

It is also important to be able to develop a valid measure of the child's ability to perform a perspective-taking task separate from other related skills. This study has demonstrated that very young children cannot reliably match a photograph to a physical array. This finding has strong implications for future research, because without this prerequisite, it is not possible to make clear inferences as to why children cannot correctly solve a perspective-taking problem. They may indeed have an understanding of what it means to infer another's percept, but because they are unable to perform the basic task, this ability may be grossly underestimated.

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