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ABSTRACT

A total of 60 children, 20 preschoolers, 20 first-graders, and 20 third-graders, participated in a game involving communication of spatial information. Subjects gave verbal directions to help another person find a hidden object, in this case, a small toy hidden under one of a number of cups. Two experimental conditions were set up, the first offering a relatively rich assortment of distinctive markings that could potentially be related to the array of cups, and the other not offering such distinctive markings. Generally, findings illustrate some aspects of developmental change in children's use of spatial information and suggest that some unique task-related contextual effects exist in the communicative problem presented to subjects. Major findings revealed that (1) the use of self-reference increased with age; (2) the use of listener as a reference point increased with age, and exceeded self-reference for the two youngest groups; (3) the third-grade children used a reference system near the hiding location more than a more remote reference system, whereas first-graders showed an opposite preference; and (4) the cup array itself was used often as a reference system by all subjects, regardless of their age or the availability of other differentiated environmental cues. (RH)

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Spatial Cognition as Reflected in Referential Communication

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Much of our current knowledge about the development of perception, representation, and use of environmental information in spatial problems has come from studies that have focused on children's orientation during movement, or their search for hidden objects. (See reviews by Acredolo, 1981, Pick and Lockman, 1981, Huttenlocher and Newcombe, 1984, Landau and Spelke, 1985.) These lines of research were spawned, to some extent, by dissatisfaction with earlier research that used such "direct representation" tasks as model-building and map-drawing to assess spatial knowledge (eg. Piaget, Inhelder, and Szeminska, 1960) showing young children's inability to effectively use nonegocentric reference systems. The general strategy of the more recent spatial orientation studies has been to infer children's spatial reference systems from their locomotory or searching behavior in environments where potentially useful cues for orientation are carefully controlled.

One of the central problems in the developmental study of spatial cognition is how best to assess the subject's spatial concepts. There are several complicating factors. For example, almost any task designed to "tap" spatial concepts also has demands that are not spatial. These nonspatial demands may interfere with the subject's ability to fully utilize his or her spatial knowledge. (Siegel, 1981) Likewise, observable spatial behavior may or may not involve cognitive processes, such as encoding and representation of spatial relationships. It is possible that in some situations one's ability to move efficiently through space may be guided by "perceptual feedback" or unconscious "kinesthetic memories" rather than conscious spatial representations (Liben, 1982).

A general finding of research is that infants and very young children are able to make use of nonegocentric reference systems providing there are salient, differentiated landmarks available and the transformations involved are not too complex. (eg. Acredolo, 1979, Bremner, 1978, Deloache, 1984). In complex or unfamiliar environments or with complex tasks, the shift from egocentric to exocentric encoding or responding occurs at later ages. (eg. Pufall and Shaw, 1973) Another well-substantiated finding is that there seems to be a developmental trend for children to use landmarks or reference systems that are increasingly distant from their own location. (See Pick and Lockman, 1981, Huttenlocher and Newcombe, 1984.)

Because these apparent egocentric to exocentric or proximal to distal shifts seem to vary substantially from situation to situation, it will probably be productive to systematically study contextual and task variations influencing children's spatially-coordinated behavior, in order to learn more about the interaction of these factors. It is in this spirit that the current study was conceived.

Another area of developmental research that influenced the conception and design of the study is the work on acquisition of spatial language. Results from language studies suggest that spatial prepositions are acquired in an order corresponding to the semantic complexity or the perceptual salience of the spatial relations they represent. (eg. Washington and Naremore, 1978, E. Clark, 1980, Johnston, 1981)

The task selected for the present study was a game involving communication of spatial information. Our purpose was simply to observe the development of children's ability to give verbal directions to help another person find a hidden object, in this case a small toy hidden under one of a number of cups, within environments that offered contrast in the availability of potential reference cues. This task suggested to us some interesting possibilties. First, would the communicative goal itself influence children's selection and use of reference points, and if so, how? Second, how would the demand for explicit verbal representations of the experimental space affect the responses of children at different ages and levels of linguistic ability?

Four to 9-year old children participated in two experimental conditions, the first offering a relatively rich assortment of distinctive markings that could potentially be related to the array of cups, and the other not offering such distinctive markings. Consideration of the proposed task suggested a few tentative hypotheses. First and most obviously, the effectiveness and efficiency of direction-giving would increase with age. Second, we expected that the effectiveness of the younger children's directions would be enhanced more by the presence of salient, differentiating external landmarks than would older children's directions, because of the older children's greater flexibility in coordinating available reference systems. Third, we expected that when differentiated environmental cues were available, older children would use reference points more distal to the cup array than would younger children. Fourth, we predicted that use of the self as a reference point would decline with age. Finally, based on studies of the order of acquisition of spatial terms (eg. Washington and Naremore, 1978, Fisher and Braine, 1981) we expected that lateral ("left-right") distinctions in the cup arrays would be more difficult than "front-back" or "middle-end" distinctions for children of all ages to make, especially for the youngest children in the condition offering no differentiating landmarks.

Method

Subjects

Sixty children participated in the study, 20 preschoolers from a university laboratory preschool, and 20 first- and 20 third-graders from a metropolitan area elementary school serving a middle class neighborhood. Mean ages of the groups were: 4 : 7 years (range 3 : 11 to 5 : 3 years); 6 : 8 years (range 6 : 2 to 7 : 4 years); and 8 : 8 years (range 8 : 4 to 9 : 5 years.)

Materials

The experimental room (14' x7') contained a chair for the subject at one end, and another chair for the adult posing as the "Finder" at the other end. (See Figure 1.) Directly in front of the Finder was a small table (19.5 x 22.5 x18 inches.) The cups used to form the hiding arrays on the table were opaque blue and 5 inches in height. The objects to be hidden were a variety of small toys. The sides of the room were uniform white panels, with 6 equally spaced doorways covered by colored curtains. The ceiling, 7 feet in height, was made from translucent cloth material.

A differentiated and an undifferentiated experimental condition were distinguished by the distinctiveness of colors of the curtains in the doorways and the colors of the strips of tape on the edges of the table. In the differentiated condition, opposite sides of the table or the room were marked by tape or curtains of different colors. (Refer to Figure 1.) In the undifferentiated condition, opposite colors were always the same.

Procedure

Equal numbers of girls and boys at each age participated in an identical set of games, either in the differentiated or undifferentiated condition. Two adult experimenters, one a "Finder" and one an "Observer", participated along with the children.

The Observer told each subject that he or she would be playing a number of hiding and finding games, in which the Observer would help the child hide a small toy under one of a number of cups, while the Finder was out of the room. After the toy was hidden, the child took the seat across the room from the table, the Observer checked to make sure the child remembered the hiding location, and the Finder was called back into the room. The Observer then stood slightly behind and to the child's right side while the child gave directions to the Finder.

The child's task in the game was to, "Help (the Finder's name) find the toy as quickly as possible, using only words and not pointing." If the Finder judged the child's first verbal direction in each game to be effective, the toy was revealed and the child praised. If the child's direction was inadequate to specify the toy's location precisely, the Finder prompted the child to provide more information or try again. (eg. "I can't find it yet. Can you tell me something else about where it is?") If the direction was still ineffective after 2 such prompts, the Finder "guessed" at the toy's location, basing the guess as closely as possible on the information the child had given. The child was then given a chance to supplement the direction further. Eventually, the Finder revealed the toy, and the child was praised for his or her effort.

After successfully completing two easy practice games, each subject repeated this procedure for 16 games, including all possible hiding locations in 5 different cup arrays. (See Figure 2.) All subjects received the cup arrays in the same prearranged order, devised to both alternate the orientation of the cups and increase in difficulty from easiest to most most challenging. (The arrays were presented in the order they appear in Figure 2.) Pilot work had indicated that some of the arrays were quite difficult for the preschoolers. The reason for the standard order of presentation was so that the youngest subjects would not be overly discouraged early in the session if they failed to give effective directions for the difficult arrays.

Results

Each child's directions for all 16 games were transcribed from audio-cassette tapes. The present report is based on the coding of subject's first directions only. For each game, the subject's first directions (prior to prompting by the Finder) were coded for the following variables: number of words; effective/not effective; and error type (failure to make necessary left-right, middle-end, or front-back distinctions). In addition, first directions were coded for the presence or absence of the following types of reference points: 1) self; 2) other person (the Finder); 3) cup array (references to another cup or the entire array); 4) tape on the table; 5) curtains; and 6) nonspecific (when the child apparently used a reference point, but the coder was unable to identify what type it was.) Reliability for the two coders was determined by calculating per cent agreement in scoring all variables for 6 (10%) randomly selected subjects. Per cent agreement on the coded variables ranged from 86.5% to 100%, with a mean of 94.8%.

For each subject, frequencies for all variables were summed across all 16 games, giving scores that were reflective of overall performance with all of the cup arrays. The data were subjected to ANOVA (Age x Differentiation Condition x Sex) using a critical alpha value $p<.05$. Relevant pairwise group comparisons were completed using Tukey's HSD method, $p< .05$. Matched-sample t tests were used to determine the significance of some differences across variables, also using a critical value of $p< .05$.

Results for effectiveness of directions, displayed in Table 1, were consistent with our hypothesis of general improvement with age, and better performance in the differentiated cue condition. There were significant main effects for both age and experimental condition.

The expected age x condition interaction, however, with younger children benefitting more from the availability of differentiating environmental features than older children, was not borne out by the data. Although the pattern of results for the third- and first graders suggests a divergence of effectiveness scores between conditions, there may have been a "floor effect" for the preschoolers, with the task being sufficiently difficult for them that the differentiated features were of little use. (This possibility is developed further in the final discussion.)

The mean number of words used by children in their first directions was taken as a rough measure of efficiency. There were no significant effects for either age or condition on this measure, suggesting either that our prediction that older children would produce more efficient directions was incorrect, or that this was not a good measure of efficiency.

A major aim of this study was to investigate developmentally the use of reference systems in the two experimental conditions. Means for the occurrence of the various reference point types in first directions are summarized in Table 2. Two results were rather surprising. First, while we expected that reference points distant from the cup array would be used more by the oldest children, we found that it was the first grade children that used the curtains most often in the differentiated condition, while the preschoolers and third graders' use of them was virtually absent. The third graders in the differentiated condition, on the other hand, showed a distinct preference for the more proximal tape on the table in their directions. (See Figure 3.) In the undifferentiated condition, use of tape and curtains by all age groups was low, as one would expect.

Second, references to self in the directions increased with age, again in contrast to the findings expected in keeping with the egocentric to exocentric shift hypothesis. In addition, references to the other person showed a similar increase with age, and were used significantly more than references to self by both preschoolers and first graders. (See Figure 4.) This is an interesting result, in that a point in space relatively distal from the speaker (ie. the Finder) was used more often than egocentric reference by the younger subjects in their attempts to verbalize the location of the hidden object.

References to the cup array ("It's in the middle.") or to another cup ("It's next to the one on the end.") were used with high frequency, and showed no effect of either age or differentiation condition.

Finally, results of the error analysis supported our hypothesis concerning the relative difficulty of the lateral (left-right) distinction in directions by children of all ages. Frequency of left-right errors showed a main effect for age, and left-right errors were made more frequently by children of all ages than either front-back or middle-end type errors by children of all three ages, in both experimental conditions.

Discussion

The results of the present study illustrate some interesting aspects of developmental change in children's use of spatial information and suggest that there are some unique task-related or contextual effects in a communicative problem of the kind we presented to our subjects.

The most important set of findings is the pattern of use of spatial reference systems employed by children of different ages in their verbal directions to another person. To summarize those results briefly: 1) the use of self reference increased with age; 2) the use of the listener as a reference point increased with age, and exceeded self reference for the two youngest groups; 3) the third grade children used a reference system near the hiding location (tape) more than a more remote reference system (curtains), whereas the first graders showed an opposite preference; and 4) the cup array itself was used often as a reference system by all subjects, regardless of their age or the availability of other differentiated environmental cues.

This pattern of results suggests that the communicative goal of this task affected the process by which children perceived and processed spatial information in a way that is different from the ways that non-communicative tasks have been observed to influence these processes. The increasing use with age of both self- and listener- references may be attributable to the dual focus of the communicative task, in which the goal is to "tell you the whereabouts of something that I have hidden." The preferred use of the listener as a reference point in this task could be due to such a communicative focus, or alternatively, to the proximity of the listener to the cup array in our experimental setup. An additional experiment, in which the listener is positioned farther away from the hiding location, is being planned to address this question.

Why did the third grade children prefer to use the proximal tape reference system more than the remote curtain reference system, whereas the first grade children showed the opposite preference? The oldest children's attention may have been more focused on the cup array and it's immediate surroundings, or perhaps they appreciated the listener's visual perspective more accurately, including the cues that are most easily seen by the listener while looking at the cups. Additional studies in which the requirement for perspective-taking is varied may help answer this question.

Children related the hiding location to another cup or the entire cup array frequently at all ages and in both experimental conditions, suggesting that cup array references are a foundation upon which the use of other reference points is built. This idea may have some merit, if we consider the array of cups as the most proximal reference system in this task, being closest to the hiding location the child is trying to describe. Children seemed to use cup array references at all ages when making "middle-end" distinctions within the array, and even the youngest children referred to other cups or locations in the cup array in their directions, while not making much use of the tape or curtains.

This conception of the proximal-distal distinction, as viewed in relation to the target location rather than the location of the subject's body, is somewhat different than that originally proposed (eg. Pick, Yonas, and Rieser, 1979) although it has been used previously in interpreting developmental changes in orientation task performance. (eg. Acredolo and Evans, 1980) One potentially useful way to reconcile this difference would be to relate the proximity of reference systems to the point in space that is the subject's primary focus of attention. For some tasks, such as self-orientation, this point will be the subject's own body. For other tasks, such as the one described in this paper, the focus of attention may be objects at some distance from the subject.

A final set of questions raised by the results concerns the difficulty of the direction-giving task for the preschool children and the fact that they made little use of differentiated environmental cues when they were available, as did the older age groups. Did task complexity prevent the preschoolers from using cues they might have used in a simpler task (resulting in a "floor effect") or do features of the environment spatially removed from the cups have low perceptual salience for children of this age? Additional studies, including manipulations to decrease task demands (eg. marking the hiding location) and other manipulations to increase the salience of cues, are needed to address these questions.

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Table 1. Mean Number of Effective Directions (Out of 16)

	Experimental Condition	
	Differentiated	Undifferentiated
Preschool	3.9	2.1
First Grade	9.4	6.5
Third Grade	12.0	11.4

Table 2. Mean Number of Directions Including Reference Point Types

	Cup Array	Self	Other Person	Tape	Curtain	Nonspecific
Preschool						
Differentiated	6.8	1.5	3.1	1.6	.3	4.5
Undifferentiated	6.4	2.4	3.0	.7	1.3	6.8
First Grade						
Differentiated	7.2	4.3	4.7	3.3	5.1	3.2
Undifferentiated	7.6	3.1	5.8	1.1	.7	3.3
Third Grade						
Differentiated	7.0	3.8	5.4	6.6	.9	3.2
Undifferentiated	6.3	6.5	7.6	0	.2	.8

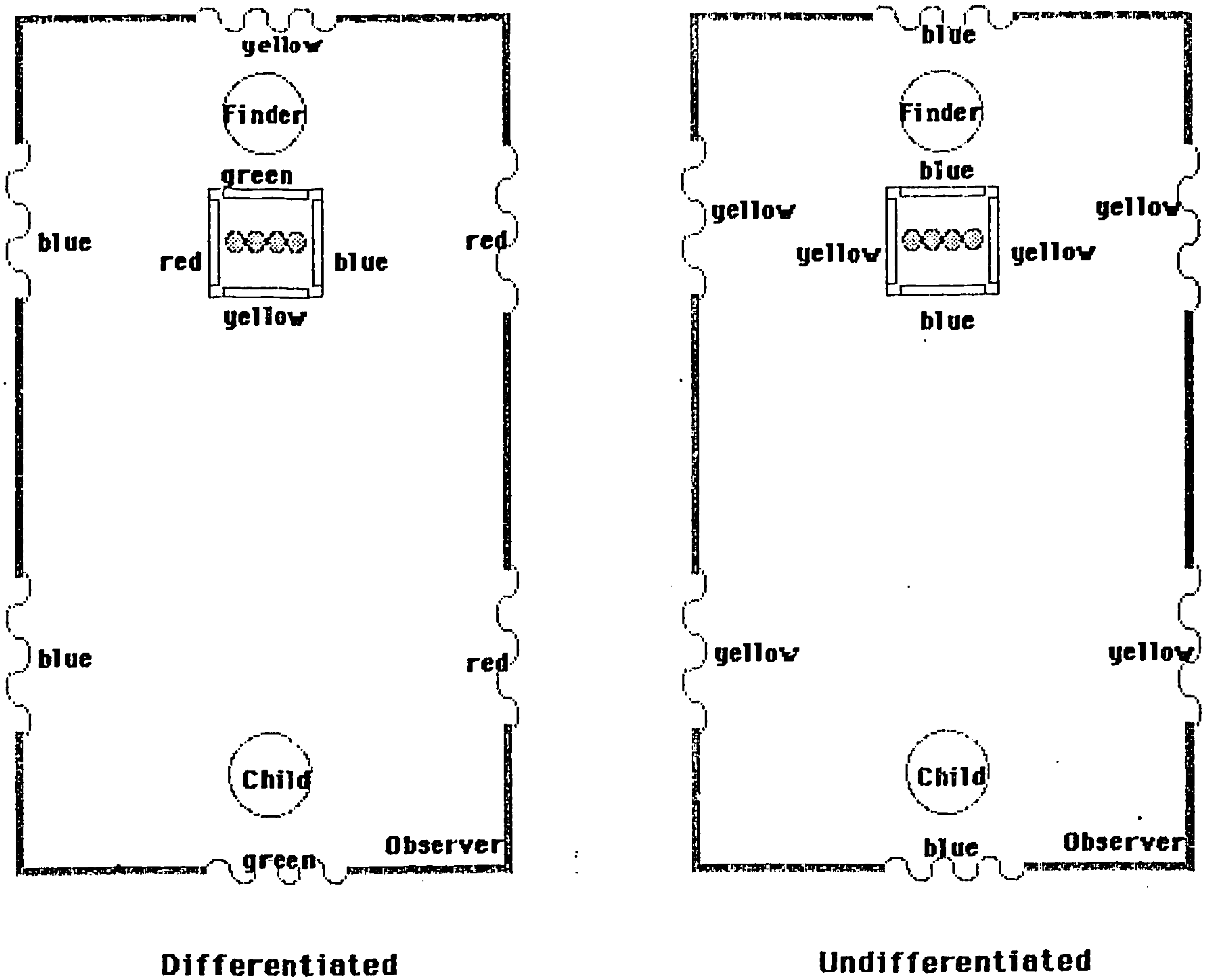

Figure 1. Room Layouts for Experimental Conditions

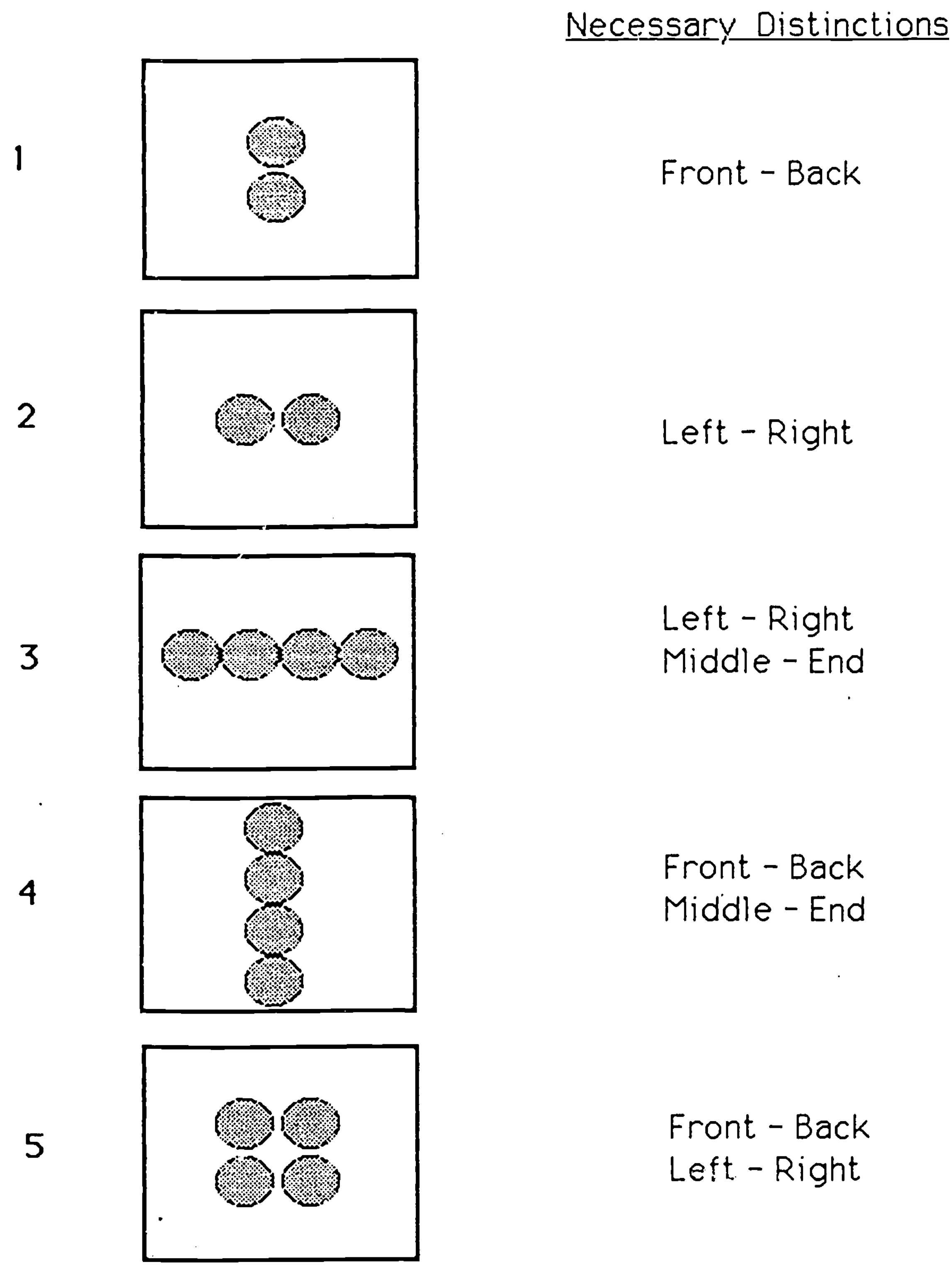

FIGURE 2. Cup Arrays. Shown in order of presentation.

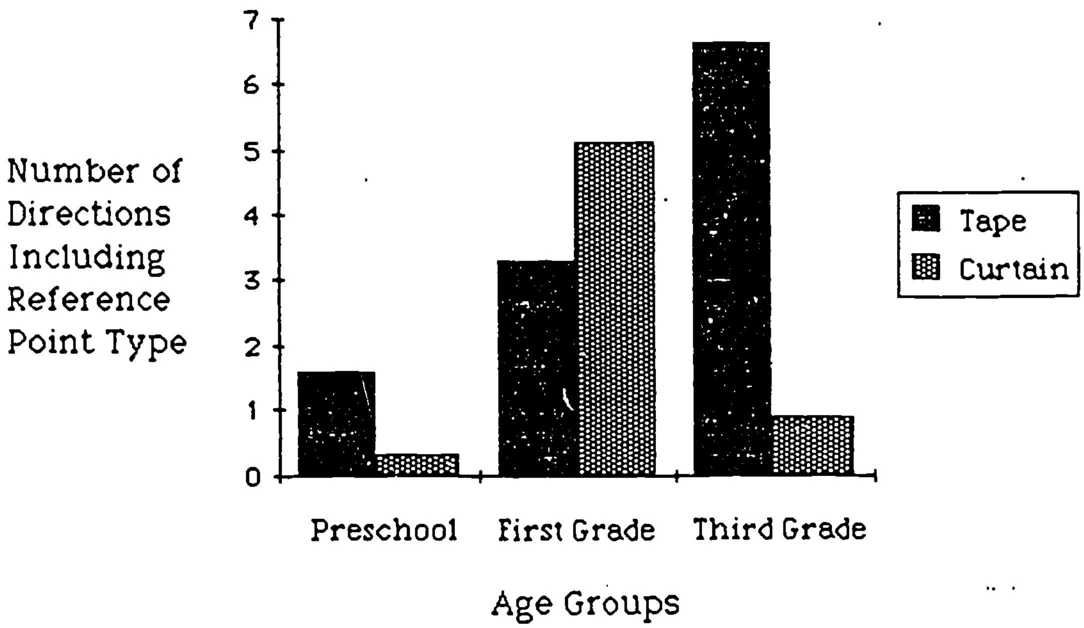

Figure 3. Use of Tape and Curtain References (Differentiated Condition)

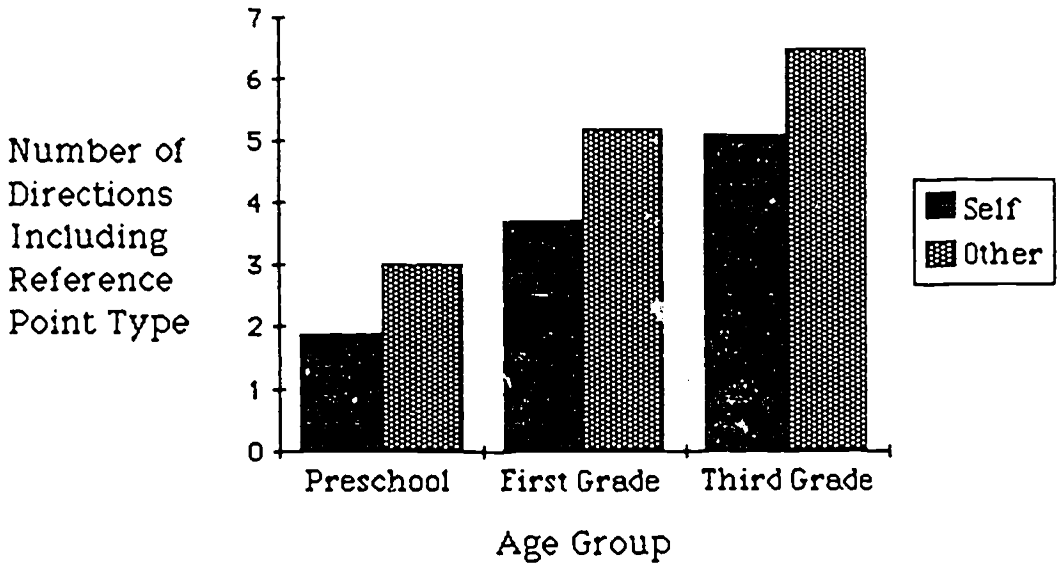

Figure 4. Use of Self and Other References
(Experimental Conditions Combined)