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ABSTRACT

The Piagetian finding that young children believe objects to be closer together when part of the distance between the objects is covered was explored among subjects of 3, 4, 5, and 6 years of age. In a standard Piagetian task, children were presented with two blocks of wood and asked whether they were "near together" or "far apart." A screen was placed over part of the distance between the blocks, and children were asked whether the blocks were "nearer together," "farther apart," or "still the same distance." Three distances were used (12, 18, 24, and 36 inches); six trials were presented at each distance with screens varying in height, width, and orientation. A second task required the child to choose a stick that would exactly fit between two blocks placed at three of the distances used in the Piagetian task. Results indicate that some understanding of the relationship between distance and length exists approximately 2 years earlier than indicated by performance on the Piagetian task. It is suggested that Gibson's ecological view--that organisms are primarily attuned to determining what the environment affords them--could provide the basis for a theory of transition into successful performance on Piagetian concrete-operational tasks. (Author/RH)

Length versus distance:

Bridging gaps in preschoolers' knowledge.

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Abstract

The Piagetian finding that young children believe objects to be closer together when part of the distance between them is covered was explored. Subjects at each of ages three, four, five and six years were tested on the standard Piagetian task as well as on a parallel procedure requiring them to judge whether a stick would still exactly fit between two points following similar transformations. Results indicated a lag of approximately two years between mastery of these tasks, with many children simultaneously asserting that the same stick would span a gap and that the endpoints were closer together. These findings are related to Gibson's (1979) view that perception primarily involves ascertaining the affordances of the environment. It is suggested that Gibson's theory could provide the basis for a theory of transition into successful performance on Piagetian concrete-operational tasks.

Length versus distance: bridging gaps in preschoolers' knowledge.

When presented with two objects some distance apart, preschool children will generally assert that the objects become closer together when part of the distance between them is occluded by a screen. This phenomenon was first described by Piaget (Piaget, Inhelder, and Szeminska, 1960), who suggested that preschoolers do not understand that there is a correspondence between length or filled space and distance or empty space. Piaget asserted that this failure to understand the correspondence between length and distance was no chance phenomenon, but rather related to the use by preschoolers of nonmetric topological frames of reference as opposed to an Euclidean frame of reference that could incorporate metric relations. As Piaget (et al., 1960) concluded:

> "It may be that common usage makes no sharp distinction between the concept of distance and that of length. But psychologically they point to two quite different situations which become interdependent only as a result of a gradual development...The building up of notions of distance enables children to pass from elementary topological relations to those of Euclidean space."

The phenomenon reported by Piaget has been essentially replicated by Lovell, Healey and Rowland (1962) and by Shantz and Smock (1966). As with other Piagetian tasks, however, it has proved difficult to provide a plausible explanation for the transition between the misunderstanding of distance and length demonstrated by preschool children and their eventual mastery of metric relations.

A possible answer to this puzzle of transition may be provided by

Gibson's (1979) theory of affordances. Gibson proposed that organisms are primarily attuned to what the environment offers (or affords) them for harm or benefit. While affordances may be based on invariant quantitative information, this need not imply that they are developed from any more general understanding of that invariance. In this view, it should not be surprising to find that young children show an understanding of length and distance that is limited to specific situations involving meaningful affordances.

What might the relation between length and distance afford a child? One situation in which it is possible to observe children making use of this relationship is in the context of building play "bridges" out of blocks. Whether a block will fit across a gap formed between two others is obviously a function of the relation between the length of the block and the distance it needs to span. If affordance-related tasks are to reveal any early understandings of the relation between length and distance, reasoning about whether an object will span a gap seems a good candidate for such a task. The present study was undertaken to compare children's reasoning about the relations between length and distance as assessed by Piaget with their reasoning about the same questions in the context of determining whether long objects would reach between two points.

Method

Subjects. Subjects were 64 children, 16 (8 boys and 8 girls) at each of ages 3 years (mean age 3 years, 6 months), 4 years (mean age 4 years, 8 months), 5 years (mean age 5 years, 8 months) and 6 years (men age 6 years, 6 months) from an urban Philadelphia preschool and a private elementary school.

Procedure. Two tasks were administered to all subjects, with order of presentation counterbalanced within each age x sex group. The first (**Piagetian task**) was a replication of the procedure employed by Piaget (Piaget et al., 1960) to assess children's understanding of the relation between length and distance. Children were presented with two blocks of wood and asked whether they were "near together" or "far apart." A screen was placed over part of the distance between the blocks, and they were asked whether the blocks were "nearer together", "farther apart" or "still the same distance apart" (with the order of choices varying across trials). Three distances were used (from the set 12", 18", 24", and 36"), and six trials were presented at each distance with screens varying in height, width, and orientation.

The second task (**Bridge-building task**) involved choosing a stick to form a bridge between the two blocks. In a practice task, the child was presented with the blocks at one of the four distances used in the Piagetian task and given four sticks of different lengths and colors from which to choose one that would just fit between the two blocks. The child was allowed to place the stick between the two blocks and to correct the initial choice if necessary.

Following this pre-training, children were presented with the blocks placed at the remaining three distances. For each distance, the child was asked to pick a stick from a set of four that would just fit between the blocks. The child was not permitted to check whether the stick would fit, but was instead uniformly told that the choice was correct. Then the same screens used in the first task were placed between the two blocks, and the child asked which stick would now just fit between them.

Results

An age x sex x order x task ANOVA (with task a within-subjects factor) of the percentage of correct answers is presented in Table 1.

INSERT TABLE 1 ABOUT HERE.

Order of presentation had no effect, and no significant interactions between variables were found. Along with a general age-related improvement on both tasks, a significant task effect was obtained, with the second (bridge-building task) being easier than the Piagetian task. An unanticipated sex difference was found, with boys performing better than girls on both tasks.

In a second analysis, children were rated as passing a task if they were correct on 100% of trials. This data is presented in Table 2. Using this strict criterion, all children in the 5-year-old group

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INSERT TABLE 2 ABOUT HERE.

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passed the bridge-building task. A majority (69%) of the 4-year-olds

passed the bridge-building task, while it was not until the 6-year-old group that the same level of performance (69% passing) was achieved for the Piagetian task.

Discussion

Our results suggest that some understanding of the relation between distance and length exists approximately two years earlier than would be indicated by the standard Piagetian procedure for assessing children's comprehension of this relationship. This result creates difficulties for the view that young children are globally topological in their representation of space, as this study indicates the early presence of a robust understanding of metric relations in the context of a particular type of task.

The precocious understanding of metric relations found here was demonstrated in the context of asking children questions based on a specific affordance of the relation between length and distance, the ability of objects of a certain length to span a certain distance. While it may seem natural that children should not be able to reason about such implications of the length/distance relation until they show a general understanding of that relation, such seems not to be the case.

Such a finding may be counter-intuitive, but it is consistent with Gibson's assertion that organisms are primarily attuned to determining what the environment affords them. While such affordances are in general determined by invariant relations (such as the relation between length and distance), there need be no requirement of any conscious awareness of the invariance itself.

The view advanced here may provide the basis for a more general model of transitions into the quantitative understanding assessed by Piagetian concrete-operational tasks. Early tacit knowledge of quantitative invariants (such as that assessed here) may be gradually disembedded from particular contexts as children become aware of the quantitative dimensions (such as length) that provide the basis for specific affordances. In this view, the cognitive accomplishments described by Piaget in the transition between preoperational and operational reasoning may consist less in constructing a better logical model of the world than in becoming conscious of the constancies that already form the basis for adaptive behavior.

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Table 1: ANOVA of Percentage of Correct Answers.

Source	df	MS	F
Age	3	22397	22.48**
Sex	1	8894	8.93*
Order	1	402	.40
Age x Sex	3	2293	2.30
Sex x Order	1	4	.00
Age x Order	3	491	.49
Age x Sex x Order	3	1258	1.26
Error	48	996	
Task	1	39235	51.79**
Task x Age	3	656	.87
Task x Sex	1	652	.86
Task x Order	1	855	1.13
Task x Age x Sex	3	1342	1.77
Task x Age x Order	3	418	.55
Task x Sex x Order	1	0	.00
Task x Age x Sex x Order	3	1625	2.15
Error	48	758	

*p < .01
**p < .0001

Table 2: Classification of Subjects

A. Three year olds

Piaget's Task	Bridge-Building Task −*	Bridge-Building Task +**
−	12 (75%)	4 (25%)
+	0	0

B. Four year olds

Piaget's Task	Bridge-Building Task −	Bridge-Building Task +
−	5 (31%)	9 (56%)
+	0	2 (12%)

C. Five year olds

Piaget's Task	Bridge-Building Task −	Bridge-Building Task +
−	0	8 (50%)
+	0	8 (50%)

D. Six year olds

Piaget's Task	Bridge-Building Task −	Bridge-Building Task +
−	0	5 (31%)
+	0	11 (69%)

E. All Subjects

Piaget's Task	Bridge-Building Task −	Bridge-Building Task +
−	17 (27%)	26 (40%)
+	0	21 (33%)

* less than 100% correct on that task: failed
** 100% correct on that task: passed