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ABSTRACT

The development of children's capacity to induce spatial relations between locations in a space was investigated in this study. The sample consisted of 60 children, 20 in each of three age groups: 3-4, 5-6, and 7-8 years of age. The children were trained to move one hand from a home base to each of three target positions. The positions were learned solely through motoric experience since the children could not see the targets. Once they had learned to find these three positions, the children were tested on their ability to move one hand directly from one target to another without going back to the home base. Each child's accuracy was recorded on a large sheet of paper (map) placed beneath the targets. Measures used in the analyses were the absolute accuracy for each position judgment in training and testing, relative accuracy for each test judgment, and angles formed by lines connecting test judgments. Results indicated a significant improvement in accuracy with age on all four measures, although some 3-year-olds were quite proficient in constructing maps on the experimental space. It is suggested that the induction of spatial relations may be a general characteristic of spatial behavior. (Author/ED)

Development of Cognitive Mapping Capacities

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Paper Presented at April 1975 Meetings of Society for Research in Child Development

The research I want to discuss today is a part of a larger project concerned with how people know where in the world they are. More specifically, our concern was with the development of the capacity to induce spatial relations between locations in a space. We assumed that: (1) every object within a space has a particular spatial relation with every other object in that space, and (2) with ordinary exposure to a space, we have direct experience with only a subset of all the existing spatial relations. Nevertheless, in familiar spaces, we stay oriented, in the sense that we know the direction of familiar objects even from unfamiliar locations. In short, given experience with a subset of spatial relations, we apparently induce the necessary remaining relations. In the study to be presented today, we modeled a situation in which it is necessary to induce spatial relations so that we could study the development of children's ability to do so. We were particularly interested in determining whether young children have this capacity at all.

In principle, this is similar to a study by Dr. Kosslyn and his associates. However, in order to make the situation experimentally manageable and to exercise specific control over the subject's experience with the experimental space, it was decided to utilize a small reaching space and to eliminate direct visual experience. In a previous pilot study with blindfolded subjects, using an extended locomotive space, there was some difficulty in the reaction of young children to the blindfold.

So, to meet our various experimental demands, the apparatus depicted in the first slide was used.

(slide #1 here)

There are two horizontal surfaces to this table. The lower shelf provided a working surface; the opaque table-top prevents vision of the lower shelf if the subject sits close to the table. All of the subject's relevant spatial behavior was carried out on the lower working surface.

Our sample consisted of 60 children, 20 at each of the age groups of 3-and 4-year-olds, 5-and 6-year-olds, and 7-and 8-year-olds. The children were selected from the University of Minnesota laboratory school.

The essential procedure consisted of training the children to move their hand from a "home base" to each of three target positions. The positions were learned solely through motoric experience. Once they had learned to find these three positions the children were tested on their ability to move their hand directly from one target position to another without going back to the home base. For example, consider the next slide.

(slide #2 here)

The X marks the home base and the 3 dots indicate the target positions.

In the training, the child was taught to go from X to A, X to B, and X to C. In the test situation, he was asked to draw a line from A to B, B to C, and back to A again. The child's accuracy, both in training and test, was recorded on a large sheet of paper taped to the lower shelf of the apparatus. An ideal set of judgments would have been a full scale map of the experimental space. In this case, the map would be a triangle formed by the three target locations.

Many of the maps of the 3-year-olds were hardly ideal, as you might well imagine. However, some children of that age were capable of very

reasonable map construction. The next slide is a tracing of a 3-year, 10-month-old child's map construction.

(Slide #3 here)

While many of our 8-year-olds produced maps as good or better than this one, there were some protocols among this older group that were decidedly less accurate. As I try to explicate our measurement procedures, please refer to your handout sheet. Here the actual locations of the target positions are marked with triangles; the circles refer to the position judgments made in the training; and the squares, to the position judgments made in the test. In the lower part of the handout the test judgments are joined by dots representing the lines actually drawn by the child while constructing the map. X again represents the home-base reference point.

For each position there are, in terms of error scores, 4 measures of interest: (1) a measure of the absolute accuracy for each position judgment in the training, here the distances between the triangles and the circles; (2) a measure of the absolute accuracy for each position judgment in the test, here the distances between the triangles and the squares; (3) a measure of the relative accuracy for each test judgment, here the distances between the squares as indicated by the dotted lines on the hand-out; and (4) a measure of the angles formed by the lines connecting the test judgments, which is also a relative measure.

In the training situation the child was limited to experiencing the positions with respect to a single reference point. From this information, the child had to induce a set of spatial relations in order to properly carry out the test. The two relative measures provide indices of the child's capacity to construct a spatial representation. This representation is logically independent of the absolute accuracy in

locating the positions on the test. The child could make any size error in locating the first test position and still construct a perfectly scaled map. That is, the triangle created by the test judgments on the lower half of the handout could have been located at any distance from the actual positions and there would be no effect on the scoring of the relative measures.

To repeat, our measures were designed to determine whether the children "knew" the positions in relation to each other or only in relation to the original "home-base" reference position.

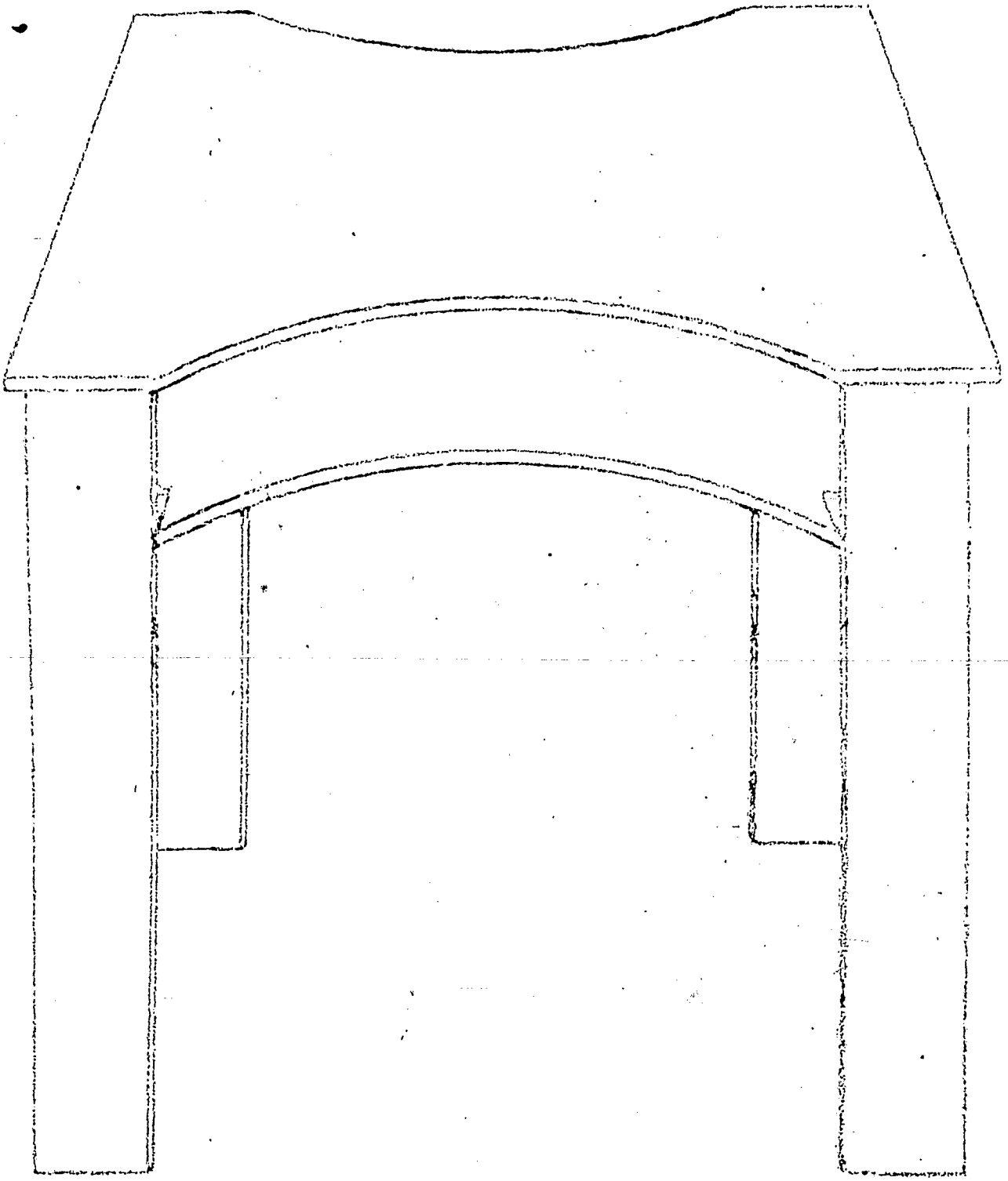
The results of analyses of variance on the measured data indicated that there was a significant improvement in accuracy with age on all four of our measures. Measures of absolute position accuracy were not significantly correlated with each other or with accuracy on the relative mapping measures, except in the youngest age groups. The fact that the measures were correlated in the young children is not surprising; a certain level of motor, "place" knowledge of the positions intuitively seems a necessary but insufficient condition for the induction of spatial relations between those positions. Moreover, some of our youngest subjects may have been attempting to match motor or proprioceptive sensations in the test with recalled motor or proprioceptive sensations from the training. However, we do not believe that such a "matching" of such sensations is an adequate explanation for the results of our mapping measures, especially with the older subjects. In addition to the correlative data, we divided each age group into equal groups of high and low accuracy for each of the measures. The subjects scoring high on the absolute training judgment measure appeared in the high group in the test measures no more often than chance. Moreover, when we examined the individual protocols there were instances

in which the logical independence of the mapping measures from absolute knowledge of the positions was achieved in fact. That is, there were subjects whose accuracy on the absolute test measure was low, but whose map construction was quite accurate.

The most obvious result of the test in our study was that children as young as three can perform, with some success, a task that seems to tap some inductive, cognitive-mapping capacities. That is, the children did seem to know the location of the points in relation to each other and not just in terms of the original reference point. While analyses of variance of our measures did reveal a significant age-related increase in successful performance, some 3 year-olds were quite proficient in constructing maps of the experimental space. That fact could be taken as an indication that the developmental improvement in cognitive mapping may reflect quantitative rather than qualitative changes in performance. Indeed, one might be tempted to speculate that the induction of spatial relations implies, in a Kantian fashion, some sort of quality of mind. But even the youngest of our subjects had had 3 years of experience with spatial relations.

The next subject for investigation is the relation between such inductive behavior and the reference system that is being utilized. Some recent work by Dr. Acredolo with infants may shed some light on that issue. It is a problem that is attracting our attention at this time.

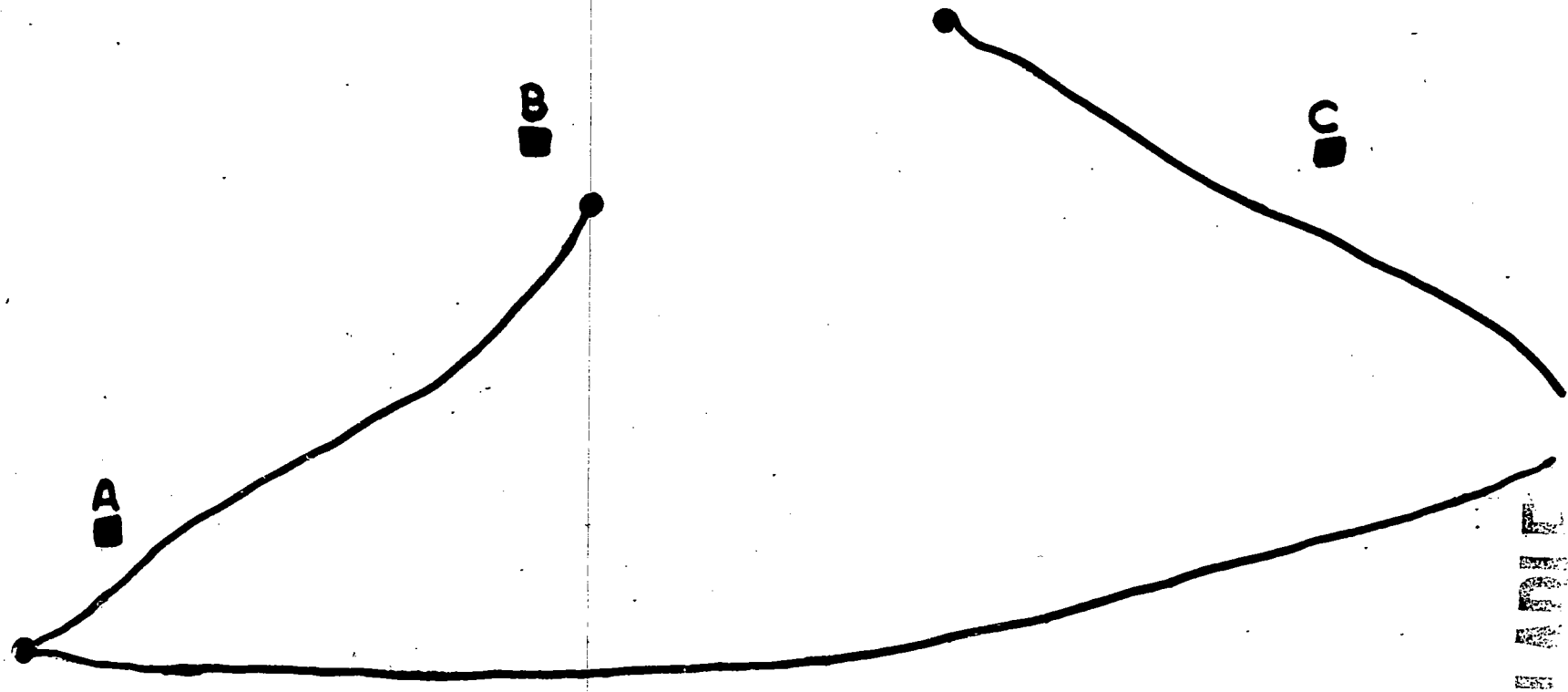
However, it seems to be the case that young children are no more confined to "route-mapping" in their representation of space than were Tolman's rats. The present study was restricted to a reaching space. But viewing these results in conjunction with those of the recent, similar study by Dr. Kosslyn in locomotive space, suggests that the induction of spatial relations may be a general characteristic of spatial behavior.



SLIDE #1

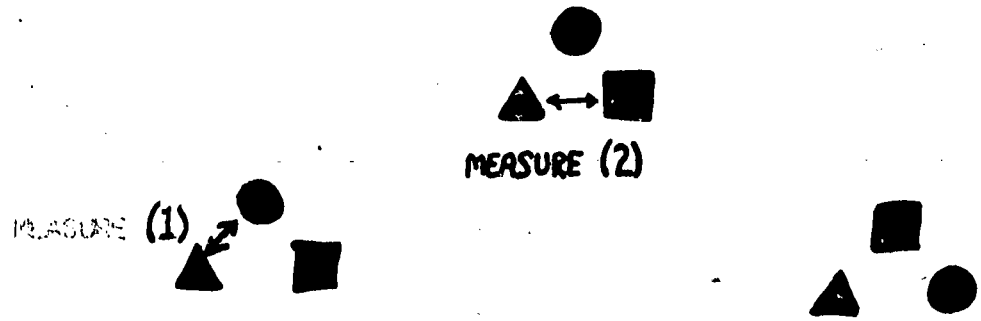
SLIDE #2

X



SLIDE #3

ABSOLUTE MEASURES

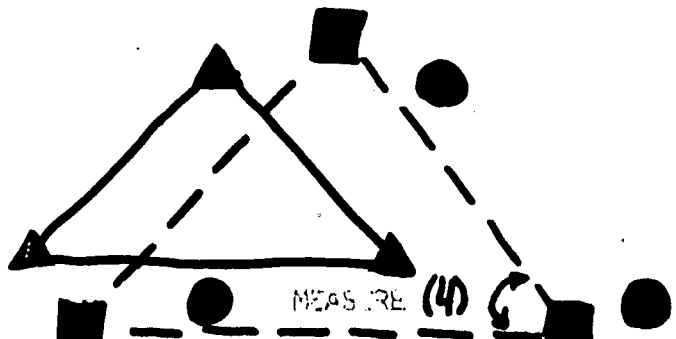


▲ ACTUAL LOCATIONS

● TRAINING JUDGMENTS

■ TEST JUDGMENTS

RELATIVE MEASURES



▲ ACTUAL LOCATIONS

● TRAINING JUDGMENTS

■ TEST JUDGMENTS