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ABSTRACT

In an investigation of children's spatial knowledge of a large-scale environment, forty-eight 3- to 6-year-old children (an approximately equal number of boys and girls of each age) were taken through an environment by a specified route. Once the route and landmarks along the route were learned, children were tested on their ability to (1) travel the route in reverse (route reversal knowledge), (2) name the sequence of landmarks along the reverse route (landmark reversal knowledge), (3) infer the relationship between parts of the environment not directly traveled between (inference), and (4) construct a model of the environment. Results indicated that route-knowledge develops before landmark reversal knowledge, and inference ability develops last; also supported was the suggestion that young children's spatial representations are route-like and poorly integrated in comparison with those of older children. In their models, children often exaggerated the route they travelled. No sex differences were found on any of the measures. (Author/MS)

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Development of Mental Representations of Spatial Layouts

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Abstract

In an investigation of children's spatial knowledge of a large-scale environment, 3- to 6-year-old children were taken through an environment by a specified route. Once the route and landmarks along the route were learned, children were tested on their ability to (1) travel the route in reverse (route reversal knowledge), (2) name the sequence of landmarks along the reverse route (landmark reversal knowledge), (3) infer the relationship between parts of the environment not directly travelled between (inferences), and (4) construct a model of the environment. The results indicated that route-knowledge develops before landmark reversal knowledge and inference ability develops last. In their models, children often exaggerated the route they travelled.

Development of Mental Representations of Spatial Layouts

Tolman (1948) coined the phrase cognitive maps to refer to both animals' and people's knowledge of the layout of an environment. Although we know people are aware of their location in a familiar space, we know little about how these spatial r presentations are constructed and organized or what developmental changes occur in the organization of this knowledge. Siegel and White (1975) have proposed that the adult's first representation of a large-scale space consists of fragmented routes. Routes are characterized by sensorimotor knowledge and are primarily associations between landmarks. As people acquire more experience in an environment, their spatial representations become more gestalt-like, more configurational. The relations between various landmarks become integrated which enable the person to remain oriented even at unfamiliar locations and to create new routes between familiar landmarks. In other words, people become able to induce spatial relations with which they have not had direct experience. A similar sequence may underlie the development of a child's spatial representation.

Unfortunately, there is little research with which to evaluate this proposal. The few investigations of children's spatial representations have largely been confined to small model spaces. These findings have been extended to apply to large-scale spaces, but it is questionable whether spatial knowledge of small models is represented in the same way as is spatial knowledge of large spaces.

The study I'm going to talk about today was an attempt to investigate systematically the extent of the child's knowledge about a large-scale space by controlling the experience the child

has within that space. Children were taken through an environment by one of two routes that were assumed to differ in complexity. Once the route and landmarks along the route were learned, children were tested on (1) their ability to travel the original route in reverse, i.e., which way to turn their bodies, (2) their knowledge of the sequence of landmarks when they travelled the original route in reverse and (3) their ability to infer the relationship between parts of the environment which they had not directly travelled between. The first two measures, the route reversal measure and the landmark reversal measure were considered to be indicators of the extent of the child's route knowledge. The third measure, the inference measure, was considered to be an indicator of their ability to induce spatial relationships not directly experienced. Children were also asked to construct a model of the layout of the environment. We hoped children's models would reveal properties of their spatial representations.

Method

In order to produce a large-scale space where we could control the experience of the children in the space, we built a series of small rooms which we called the "animal house". The house consisted of a set of four rooms for 3-, 4-, and 5-year-olds and a six room set for 5- and 6-year-olds (see Figure 1). There were 24 subjects in each age level, and an approximately equal number of boys and girls of each age. Four doors were located in each room. There was a door in the center of each wall of each room. All the rooms were uniform except for a different toy animal in the center of each room which distinguished the rooms from each other. The animals served as landmarks.

The routes the children followed in the rooms are illustrated in

Figure 2. Half the children of each age always followed a U-route while the rest followed a zig-zag route, or Z-route. Training consisted of taking each child through the rooms by the specified route until the child could point to the appropriate door and anticipate the correct animal during two successive walks through the rooms. During training, children never retraced their routes in reverse in order to get to their original starting points.

During the test phase, children were asked to travel through the rooms by retracing the route in reverse. Three measures were taken during this time: (1) children had to point to the appropriate door along the reverse route (route-reversal test), (2) we asked children which animal they would see along the reverse route (landmark reversal test), and (3) children were asked which animals were located on the other side of doors they had never entered but led to another room (inference test). These doors are marked INF in Figure 2. Finally, children were asked to construct a model of the rooms with small boxes and small toy animals.

Results and Discussion

No sex differences were found on any of these measures. The overall pattern of results revealed that route-reversal knowledge developed before landmark reversal knowledge and that inference ability developed last.

In the four-room experiment, there were no differences between 3-, 4-, and 5-year-olds on the route reversal test (see Figure 3). The performance of the children on this measure was nearly perfect at all age levels. Also, in the four room experiment, we found that 4- and 5-year-olds made fewer landmark reversal errors than did the 3-year-olds. However, there was no difference between 3-,4-, and

5-year-olds on inference scores. Performance was relatively poor on this measure. These findings were confirmed by three separate 3 (age) X 2 (type of route) X 2 (sex) ANOVAs in which a significant main effect for age was found for landmark reversal scores ($F(2,60) = 6.09$, $p < .005$), but no significant effects were found in the analysis of route reversal or inference scores. A Tukey post hoc test ($p < .05$) revealed that performance on the landkmark reversal test significantly increased between the ages of three and four, but not between ages four and five. Thus, the 4- and 5-year-olds were significantly better than the 3-year-olds at anticipating the animals they would see along the reverse route, but all three age groups were good at anticipating which directions to turn as they reversed the route, and all three age groups were rather poor at making spatial inferences.

In the six room experiment, however, the pattern of results was different (see Figure 3). Again, performance on the route reversal test was nearly perfect for both age groups. However, while the 5- and 6-year-olds performed equally well on the landmark reversal test, the performance of the 6-year-olds was superior on the inference test. This was confirmed by three separate 2 (age) X 2 (type of route) X 2 (sex) ANOVAs in which a significant main effect for age was found for inference scores ($F(1,40) = 4.68$, $p < .05$) but not for landmark reversal scores or route reversal scores. Although there is a trend for the Z-route to be more difficult than the U-route on some of these measures, there were no significant differences between the two conditions.

These data, especially the relatively good performance on the route reversal and landmark reversal tests, support the notion

that route-like spatial representations developmentally precede integrated configurational spatial representations. It further suggests that route maps may have two components. One component occurring early in development consists of knowing which direction to turn when one sees a particular landmark. This knowledge could be conceived of as a motor map of a route. A second component consists of being able to reverse a sequence of landmarks and to anticipate the landmark which will appear next. This seems to involve a greater symbolic component associated with the route, which appears to be a later development. Finally, the ability to make spatial inferences, indicative of the beginning of a configurational spatial representation, develops last.

<u>Model Data.</u> We believe that the way in which children constructed models of this environment revealed important properties about their spatial representations. We scored the models on the basis of (1) the sequence of the animals in the model and (2) the overall shape of the model. We gave a "0" to models when both the shape and animal order were wrong and a "4" to models which were completely right. These categories and the categories between these two extremes are described in Table 1. A breakdown of scores by age and condition appears in this Table. The numbers below each category prepresent the number of children in an age group who produced models of this type. These categories are self-explanatory except possibly for category 3. Children who made this interesting type of error demonstrated knowledge of the sequence of animals and of the shape of the house. They were, however, unable to coordinate these two types of knowledge in their models to simultaneously include correct route and shape information.

One 5-year-old in the Z-condition, for example, first dropped the animals in the scattered boxes in the correct serial order. When we asked her to make the model just like the big house, she pushed the boxes together into the correct shape, thus destroying the order of the animals. She claimed her model was now correct, but when we asked her to indicate how she had walked through, her attention was drawn to the incorrect order of the animals. She then placed the boxes in a stepwise arrangement with the animals in the correct order. Thus, she was unable to integrate her knowledge of what the route looked like with her knowledge of the shell within which the route was located.

With the possible exception of some of the 3-year-olds, we believe the children basically understood what we wanted them to do with the small boxes and animals. Even children who were unable to construct the shape of the house correctly seemed to be making some attempt to reconstruct their spatial representation of the house.

The shapes of the incorrect models were not random. Figure 4 illustrates all of the incorrect shapes which appeared in both the four and six room studies, including shapes that children later changed. Incorrect models usually reflected the number of turns made or the general shape of the route taken. Most incorrect models in the U-condition reflect a U-shape, while incorrect models in the Z-condition are usually staggered, offset and asymmetrical. We beleive this indicates that the child's spatial representation of the route resembled, perhaps even exaggerated the actual shape of the route.

An inspection of Table 1 reveals that the errors of the younger children, especially the 3-year-olds, were of two main types. Either

the model was completely wrong or the children had the sequence of landmarks correct but the shape of the house wrong. This fact, along with the data showing a significant difference in ability to make inferences between ages five and six, but not between ages three, four and five, supports the suggestion that young children's spatial representations are route-like and poorly integrated in comparison with those of older children. The ability to form configurational spatial representations seems to depend not only on the ability to induce the shape of spatial layouts, but also on the ability to coordinate knowledge of the shape with knowledge of how route sequences fit into the shape.

References

Siegel, A. W., & White, S. H. The development of spatial representations of large-scale environments. In H. W. Resse (Ed.), Advances in child development and behavior. Vol. 10. New York: Academic Press, 1975.

Tolman, E. C. Cognitive maps in rats and men. Psychological Review, 1948, 55, 189-208.

Model Scoring Categories

4-Model completely right
3- Both house shape and animal order right, but shape and order are not coordinated.
2-House shape right, but animal order wrong.
1-Animal order right, but house shape wrong.
0- Both house shape and animal order wrong.

Four Rooms

Condition	Age	Scores:	0	1	2	3	4
U	3.0-3.11		5	4	0	2	1
	4.0-4.11		0	3	1	2	6
	5.0-5.11		1	3	0	1	7
Z	3.0-3.11		6	6	0	0	0
	4.0-4.11		2	4	0	0	6
	5.0-5.11		0	3	0	0	9

Six Rooms

Condition	Age	Scores:	0	1	2	3	4
U	5.0-5.11		0	0	0	0	12
	6.0-7.5		0	1	2	0	9
Z	5.0-5.11		3	1	2	4	2
	6.0-6.11		0	2	0	3	7

Table 1. Description and age breakdown of model scores.

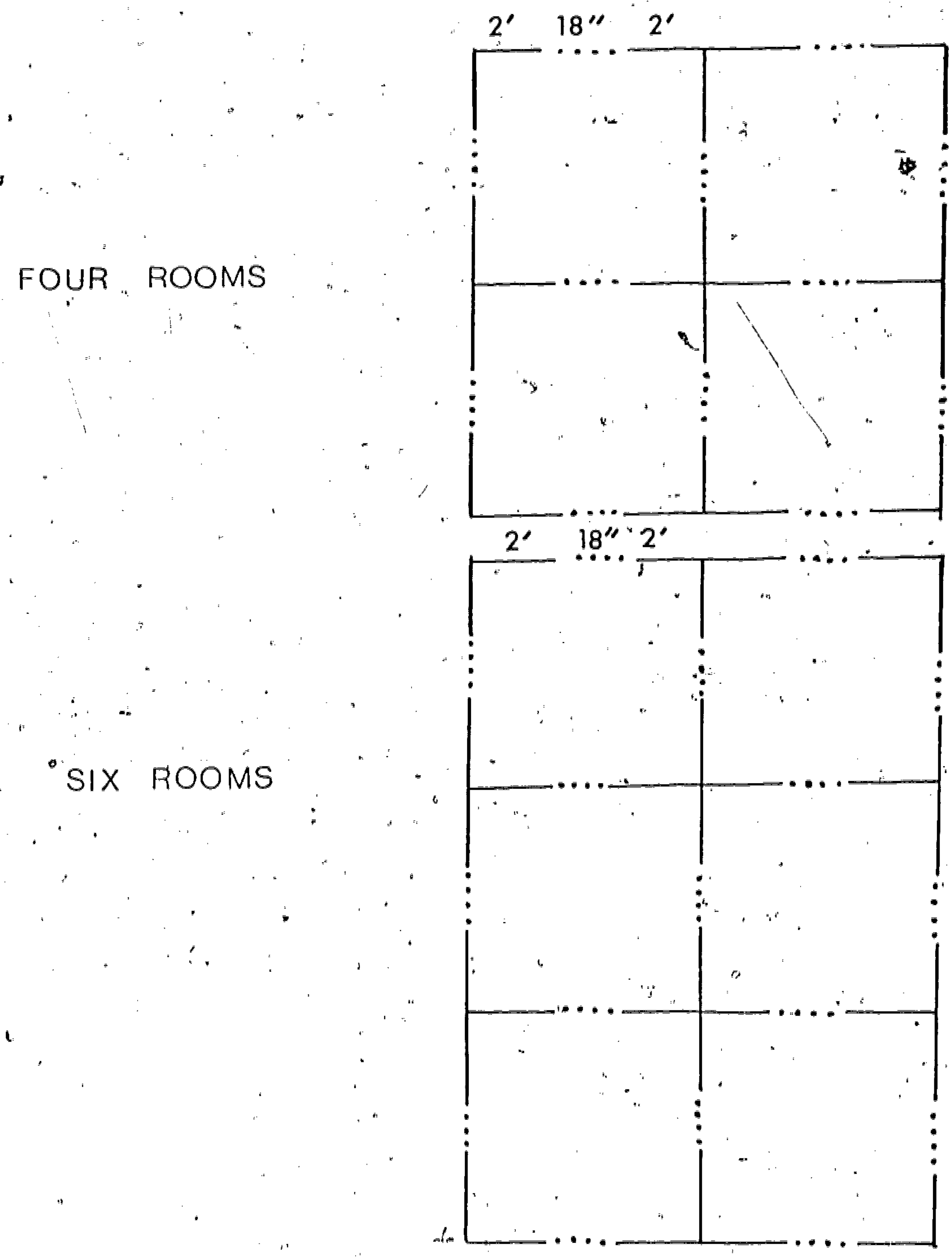

Figure 1: Maps illustrating layout of the four rooms and the six rooms, showing the location and dimensions of walls (solid lines) and doors (dotted lines). Walls were 6' high. Doors consisted of cloth curtains, and the entire layout was covered by a cloth ceiling.

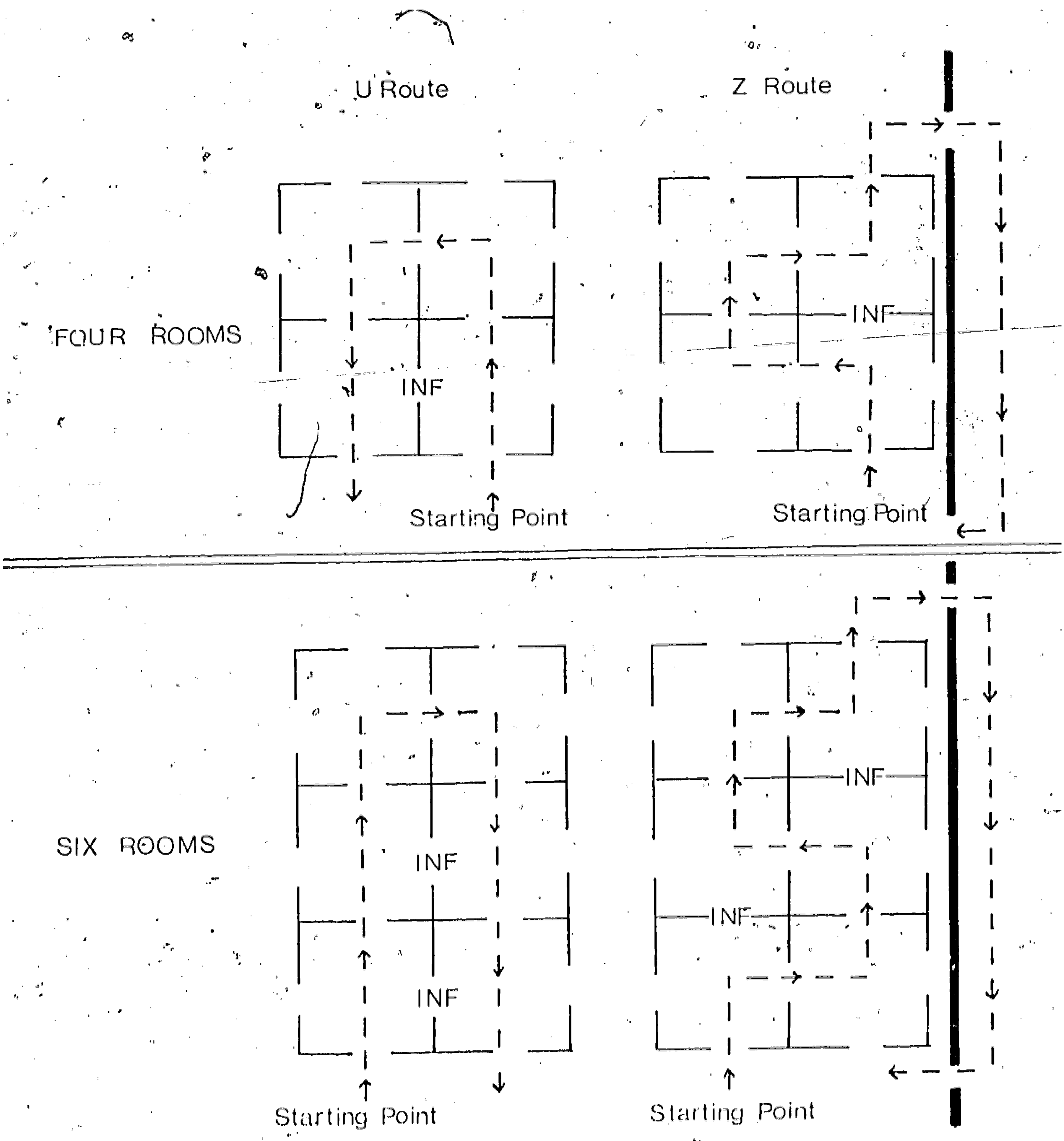

Figure 2: Maps showing the U route and the zigzag (Z) route in the four rooms and in the six rooms. In the Z condition, children walked through an adjacent room in order to return to the starting point. The doors at which the children were required to make inference judgements are labeled "INF".

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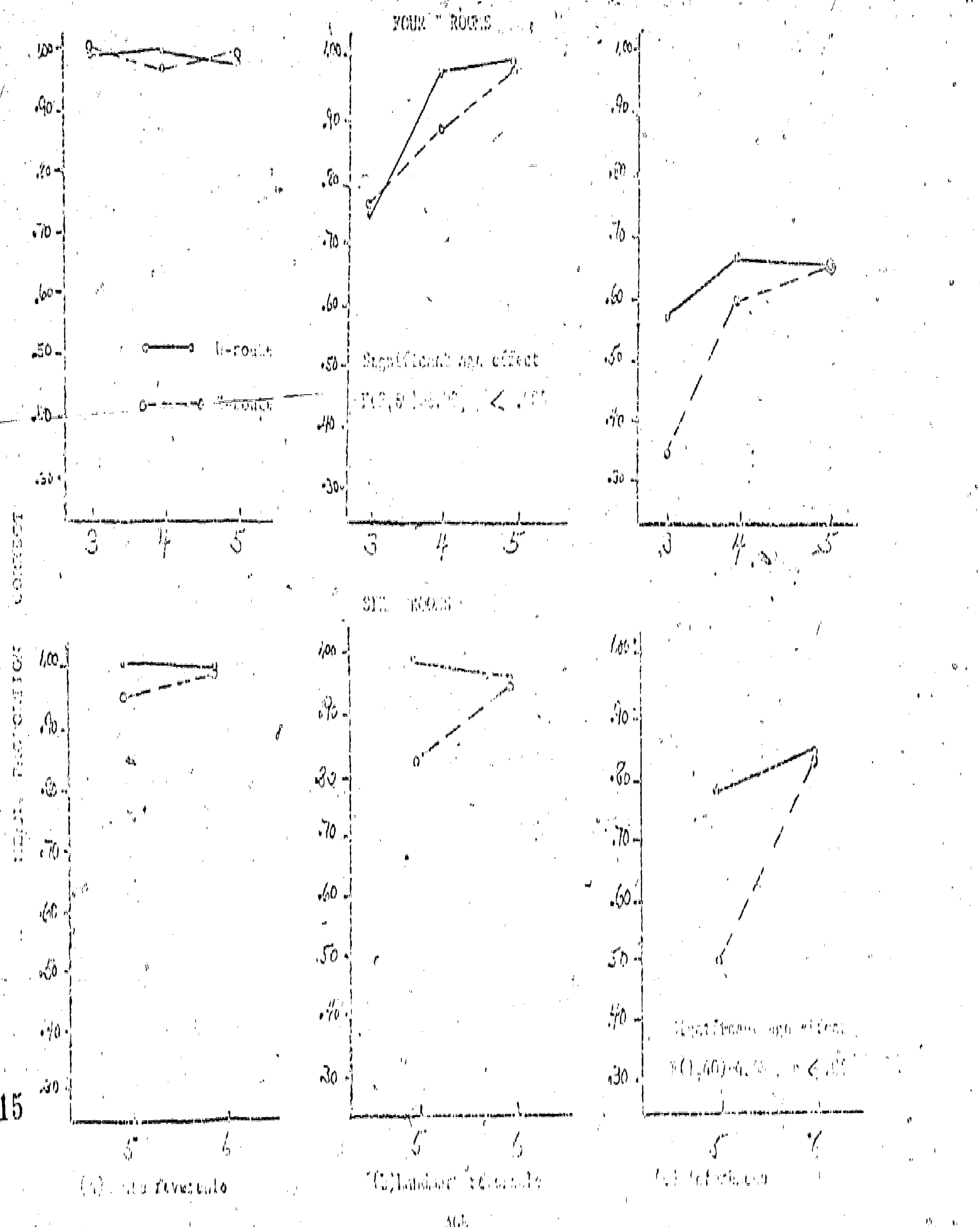

Figure 2. The mean proportion correct as a function of age on the (a) route reversal, (b) landmark reversal, and (c) inference measures.

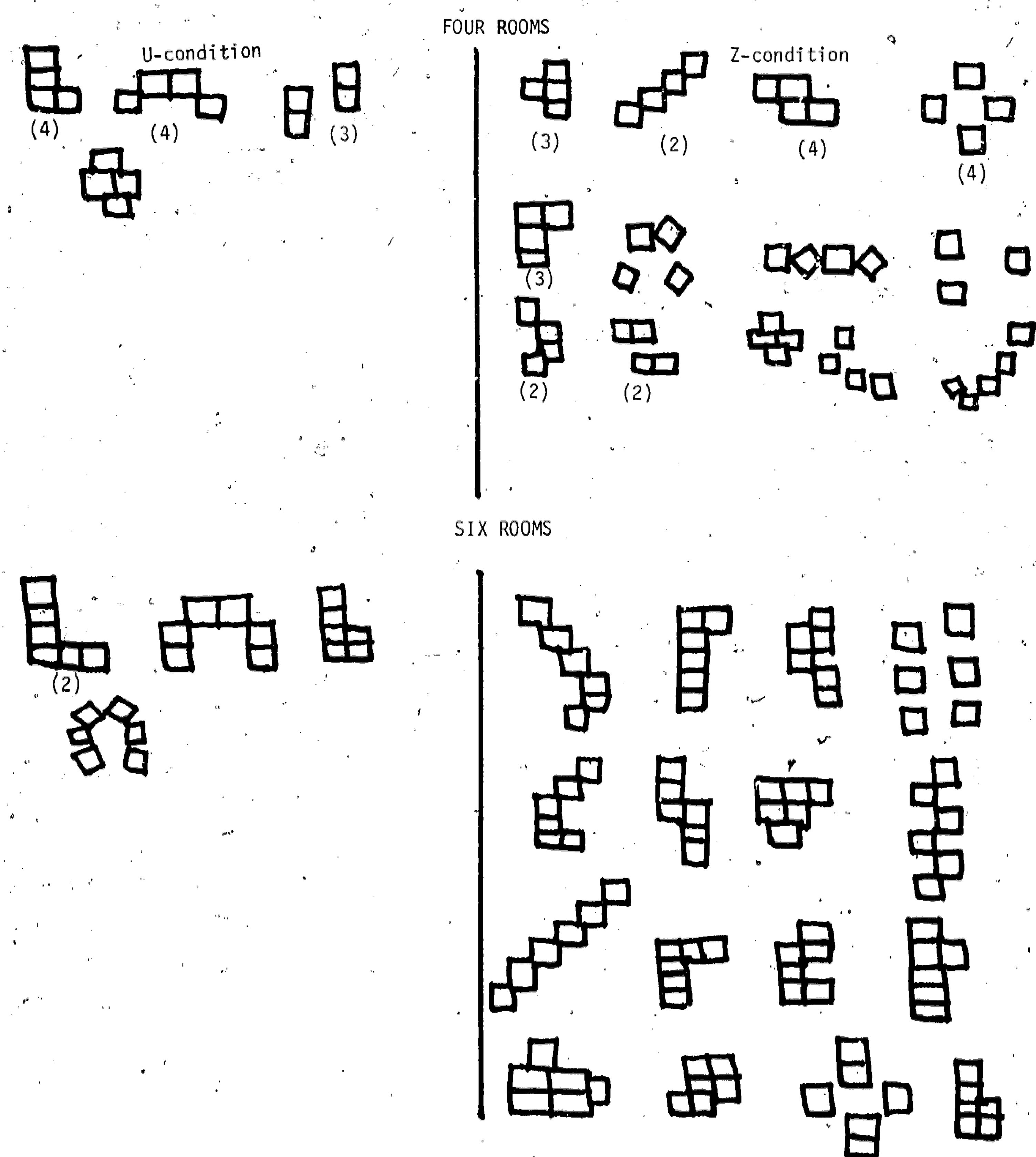

Figure 4. Illustrations of incorrect model shapes. These include shapes which were subsequently altered, but they do not include shapes in which boxes were places in a straight line. A number in parentheses below a particular model indicates the number of children who constructed a model of that shape. If no number appears below a model, that model was constructed by only one child.