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ABSTRACT

The purpose of this study was to attempt to train the horizontality concept in a group of first graders who were non-operational on the horizontality concept but transitional on what Piaget has termed the precursor concepts of distance and length conservation. There were two groups of subjects (training and control), all of whom had failed a horizontality pretest. In the pretest they were presented with outline pictures of tilted jars and asked to draw in a water line as it would look if the jars were half full of water. One week after the pretest, children in the training group were seen in individual sessions and again asked to anticipate the water line by drawing a line on outline pictures of straight-sided jars. Subjects were given explicit knowledge of results as well as experience copying the actual water line. Results indicated a significant improvement for the training group which held to the follow-up posttest a week later. There was also transfer of training to a round-sided jar not used in training. Results are discussed in terms of Piaget's theoretical notions of assimilation and accommodation as related to explicit feedback and visual-motor practice. (Author/MS)

Training the Horizontality Concept in a Group of Non-transitional Subjects

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Training the Horizontality Concept in a Group of Non-Transitional Subjects

In charting the development of the child's conception of spatial relations, Piaget (Piaget & Inhelder, 1956; Piaget, et al. 1960) placed special emphasis on the emergency of the concepts of horizontality and verticality. The concept of horizontality, especially as assessed by Piaget's water line task, has received a substantial amount of attention both in Piaget's writing and in recent research literature. Piaget and others (Barna & O'Connell, 1967; Beilin, Kagan & Rabinowitz, 1966; Dodwell 1963; Ford, 1970; Shantz & Smock, 1966; Smedslund, 1963) have shown that preoperational children lack an adequate conception of the horizontal; they are able neither to represent correctly nor to perceive accurately the horizontality of the water line in a tilted container. Piaget and Inhelder (1956) report that the ability does not become general across all angles of tilt until the middle of the concrete operational period at about eight or nine years of age. Others, however, have found that this is often not achieved until much later and is a absent in many adults (Dodwell, 1963; Rebelsky, 1964; Thomas, Jamison & Hummel, 1973; Willemsen & Reynolds, 1973).

In recent years several investigators have attempted to teach the concept with varying degrees of success. Smedslund (1963) had some success with a perceptual feedback procedure in 5-7 year olds, but only with subjects who showed some initial grasp of the concept. Beilin et al. (1966), using second graders, found a perceptual confirmation procedure to be most effective although it was not sufficient to produce a significant transfer of training effect; and here too, an unreported proportion of their subjects had shown partial understanding on pretest. Most recently a study by Sheppard (1974) has demonstrated success with a perceptual-feedback technique. However, these subjects were 8-years-old and did have some partial understanding prior to training. It may further be mentioned that in Sheppard's (1974) study as in the Beilin, et al. (1965) study there was no specific transfer of training to a jar shape other than that used in training.

The results of these training studies mirror the results of other training studies of Piagetian concepts of the concrete operational period (e.g. Brainerd & Allen, 1971). Successful training is common for transitional subjects, i.e. those with some previous partial understanding. It remains more controversial as to whether such cognitive concepts can be acquired by non-transitional subjects.

The purpose of the present investigation was to attempt to train the horizontality concept in a group of young children who were non-operational on the horizontality concept but transitional on what Piaget (et al., 1960) have termed the precursor concepts of distance and length conservation. By using a more intensive perceptual-feedback technique, it was felt that the concept could be mastered by non-transitional subjects, and that this understanding would transfer to a round-sided jar.

Method

Design

The experiment consisted of (a) a pretest, (b) a training session with immediate posttest, (c) a follow-up test after a 1-week interval. Thus, each child was seen individually on three separate occasions, spaced 1 week apart. Testing of distance and length conservation was made before the pretest and immediately after the follow-up posttest.

Subjects

Two groups of 20 subjects each (training vs. control groups) comprised the sample. All subjects were first graders (mean age 6 years, 9 months). These children were pupils at state college-affiliated teacher training schools in Buffalo, New York and Providence, Rhode Island. Each group of subjects had equal numbers of male and female children. Only subjects who failed four out of four presentations of the water line on the pretest were used in this study. Subjects in either the training or control groups who made one or more correct responses on the pretest were rejected at once.

Materials

A straight-sided jar, 4 inches high and half-filled with clear water was used for the training trials. An attempt was made to make the water line in this jar more salient for purposes of training. This was accomplished by floating small BB-sized black wax pellets on the water so that the surface was covered by approximately one thickness of the pellets. This device served to accentuate the water line sharply, relative to the other stimulus elements of the jar, when the subjects viewed the jar in the usual way with the water line at about eye level.

A second straight-sided jar, identical to the first, but empty, was used for the pretest, posttest, and follow-up test trials. An empty rounded-sided jar similar in size was used for the transfer test trials. An adjustable jar-holding apparatus was constructed which was used to present the stimulus jars in various degrees of tilt. Response sheets on which the subjects drew their water line representations were prepared which contained outline drawings of the jars in various angles of tilt corresponding to the angles at which the stimulus jar was presented. A heavy black line represented the table top in each drawing. This line could be used as a horizontal reference line, as could the borders of the response sheet itself. Pairs

of toy soldiers, dogs, and cars, a wooden block about 2 by 6 by 10 inches in size were used to assess distance conservation; a pair of 8-inch-long sticks was used to assess length conservation.

Procedure

Pretest. On the first day of testing, the child was presented with four distance conservation items, two involving filled versus empty space, and two involving direction of movement. A child was also given two length conservation items. In the filled-empty distance conservation test, the subject was first shown two toy cars about 15 inches apart and asked if they were "near each other or far apart." All subjects said the objects were far apart. A wooden block, slightly higher than the objects and about 2 inches thick, was then placed midway between them and the child was again asked if the objects were near each other or far apart. The procedure was then repeated using toy dogs in place of cars. In the direction of movement distance conservation test, the subject was first shown two toy soldiers, one on the table and one placed about 15 inches away on a box so that it was elevated about 12 inches above the table top. The subject was then asked, "Is it just as far from here to here (object A to object B) as it is from here to here (B to A)?" while the experimenter moved his finger from A to B and back again. The procedure was then repeated using the toy dogs in place of the soldiers.

In the length conservation test, the child was shown two 8-inch-long sticks. The sticks were placed side by side and the child was asked if the two sticks were the same length. All subjects described the sticks as being of equal length. One stick was then displaced 1 inch to the left and the child was asked whether the sticks were still the same length or whether one was longer than the other. The procedure was then repeated with the displacement being made to the right instead of to the left.

For the horizontality concept test, the child was first introduced to the procedure of drawing lines on response sheets by means of four warm-up items. In two of these items, the child completed a partially drawn geometric form (square or hemisphere) by drawing a straight line. In the remaining two items, the child was shown a drawing of a jar with a dot on each of its sides and was asked to draw a line from dot to dot. The purpose of these trials was to adapt the child to the line drawing task and to insure that all subjects had sufficient visual-motor coordination and control to draw a straight line.

After the warm-up items, the child was shown the straight-sided jar with the accentuated water line. The jar was held upright, and the fact that the top of the water forms a water line was pointed out to him. The experimenter said, "See the water in this jar? If you look closely, you can see that the top of the water makes a line right across the jar, just like this (E points). Do you see it? We call this the water line." This jar was then put out of sight and not shown again. The empty straight-sided jar was presented in the upright position, and the child was given a response sheet and asked to draw in the water line so that it would look just like the water line in the half-full jar he had just been shown. The remaining stimulus-jar positions were then presented in the following order: straight jar tilted right, round jar tilted left, round jar tilted right, straight jar tilted left. All tilts of the jars were 45° from the vertical.

Training. The training session followed 1 week after the pretest. The child was first given two warm-up items, as described above, after which he was shown the half-full jar with the accentuated water line and reminded that the top of the water formed a water line. This jar was then put out of sight and the child was presented with an empty straight-sided jar in the upright position and asked to anticipate the water line by drawing it on a response

sheet, showing an empty outline jar in the upright position. If the child's representation was correct, he was told that his drawing was correct. This was explicitly emphasized to him by the experimenter who replaced the empty jar with the half-full jar and placed a pencil first along the actual water line and then on the drawing and noted that they both lay "flat" or like the table edge or base of the jar holder.

Feedback. If the child's drawing was incorrect, he was so informed and was told how to correct it. Again using a pencil, the experimenter demonstrated how the actual water line was flat like the jar holder base and that the water line could not look as the child had drawn it but would lie flat. When the child's initial representation was incorrect, another outline drawing was presented and the child was asked to copy the actual water line from the accentuated jar. If this response was correct, the child was told so as described above. If the second drawing was still incorrect, the child was told that he was not correct and was encouraged to do better on the next trial.

The above procedures were repeated with the following additional orientations: 30° right, 30° left, 90° right, 90° left, 60° right, and 60° left. Only the straight-sided jar was used for the training trials. It should be noted that the angles of tilt used in the pretest, posttest, and follow-up trials were not the same as those used on the training trials.

Posttest. Immediately following the last training trials, the child was given a posttest identical to the pretest with the exception that the upright position was omitted. No knowledge of results was given during the posttest.

Follow-up. A follow-up test, identical to the immediate posttest, was administered in the third test session 1 week after the training and posttest session. No warm-up trials were used in the follow-up session. Immediately after this follow-up test, the distance and length conservation tests were

re-administered.

Scoring. The children's water line representations on the pretest, posttest, and follow-up test were scored as correct (horizontal) or incorrect (nonhorizontal); and the subject's score was the number correct summed across the four tilted jar positions. The upright position was used only on the pretest as a warm-up item and was not scored. Since the children drew their responses freehand, a tolerance of five degrees was allowed in scoring a response as correct.

Results

Training. An analysis of variance of the number of correct responses revealed a significant increase in performance across test periods ($F = 18.14$, $df = 2$ & 40, $p < .01$), as shown in figure 1. A Newman-Keuls analysis showed

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Insert Figure 1 about here

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a significant ($p. < .01$) increase in correct responses from pretest to posttest and a further but non-significant increase from posttest to follow-up test. For the control group there were no correct responses on either the pretest, posttest or follow-up test for any of the children.

Specific Transfer.

The foregoing analysis showed that there was a significant training effect disregarding jar shape. This effect involved a certain degree of transfer, in that the angles of jar-tilt used in test items were different from those used in the training procedure. The question of transfer to a different jar shape, however, is perhaps of more interest since Beilin et al. (1966) and Sheppard (1974) failed to obtain such an effect. Separate Newman-Keuls analyses showed that there were significant training effects for each of

the two jar shapes. For the straight jar, there was a non-significant increase

Insert Table 1 about here

in performance from pretest to posttest, but a significant ($p < .05$) increase from pretest to follow-up test. This indicated a significant effect of direct training on the straight jar. For the round jar, the increases in performance were significant from pretest to posttest ($p < .05$) and from pretest to follow-up test ($p < .05$). These results indicate that the training effect obtained with the straight jar transferred to the round jar, which was not used in the training series. Indeed, paradoxically, acquisition was more immediate for the round jar than for the straight jar.

Conservation Items

On the four distance conservation trials, the training group produced an average of 1.65 versus 2.40 for the control group ($p < .05$). On the two length conservation trials, subjects in both the training and control groups produced an average of 0.85 correct responses. Few subjects demonstrated complete success on these precursor concepts. For distance conservation only two subjects in the training group and five subjects in the control groups showed complete success. On length conservation, five subjects in the training group and eight subjects in the control group scored two correct responses. It thus appeared that these subjects were in transition in development of the precursor concepts of distance and length conservation.

Discussion

The results of the present investigation are important in several respects. First of all the results indicate a significant improvement in water line comprehension in a group of young, non-transitional subjects. Secondly, the improvement in performance was sustained for a week, at which time the follow-up posttest was administered. Perhaps most important were the findings that the effects of training transferred to degrees of tilt not used in training and to a round-sided jar, also not used in training.

By themselves the findings of a significant improvement on the horizontality concept following training as measured by the water line task, are not that unusual. Several previous studies eg. Smedslund (1963) Beilin, et al. (1966) and Sheppard (1974) have all demonstrated some success in training the concept. What is exceptional about these results is that successful training was accomplished with a group of children roughly a year younger than the previous studies. Subjects in the present investigation were considered to be non-transitional on horizontality, while in a transitional state on Piagets' hypothesized precursor concepts of distance and length conservation.

It is noteworthy, too, that previous studies of this sort have failed to find transfer of training to a jar shape other than that used in training. Failure to find transfer effects raises some question as to whether we can speak of successful training of the horizontality concept. For without transfer of training, it could be argued that the children merely learned specific behaviors for a specific task and not a generalized concept. The finding of specific transfer of training in the present study gives strength to the conclusion that with a more intensive training effort, the concept of horizontality can be acquired in a group of young, non-operational subject.

Having said all that, the question still remains as to what aspect or

aspects of the training effort resulted in the improved performance, or whether some combination of techniques was required for successful training. Unfortunately, the results of this study cannot provide a direct answer to these questions. However, by using Piagets' theory of cognitive development and the result of similar studies as guides, some tentative answers to these questions can be offered.

The first point of discussion involves Piaget's notion of cognitive growth in general. Piaget states many times (eg. Piaget, 1960) that cognitive growth entails accomodation of pre-existing schemata to "fit" the new reality. In terms of the waterline task the child must accomodate the pre-existing notion of "water always parallel to the base of container" to "water oblique across the container and parallel to the floor." Piaget further makes the point that accomodation requires some mental effort, and that when a child is presented with a new object or task the child will initially attempt to assimilate the new reality to the old schema.

These theoretical ideas have large implications for any attempts at accelerating cognitive mastery. Specifically the provision of feedback in a "passive" way, i.e. merely holding up for inspection, a real water line, is likely to provide no adaption of the child's mind. Indeed it was the author's experience that most children when asked to compare their incorrect representation of the water line directly, side by side with an actual water line, would insist that the water line in each jar was the same. By making explicit the discrepancy between the real water line and the child's representation of the real, it may be possible to overcome this "cognitive resistance."

However, pointing out the discrepancy alone may not be sufficient to instill a new concept of the water line. In this investigation children also were given the chance to correct their wrong representations. This practice

a significant role in the
his "learning through action"
of schema development. This
termed reafference, (Held, 1965),
lidation of new behavior patterns,
erning the issues of explicit
edback in the acceleration
o test these ideas using four groups,
ng variations in acquisition by
) perceptual-motor feedback only
ractice, and (d) no training,
training of these cognitive

TABLE 1

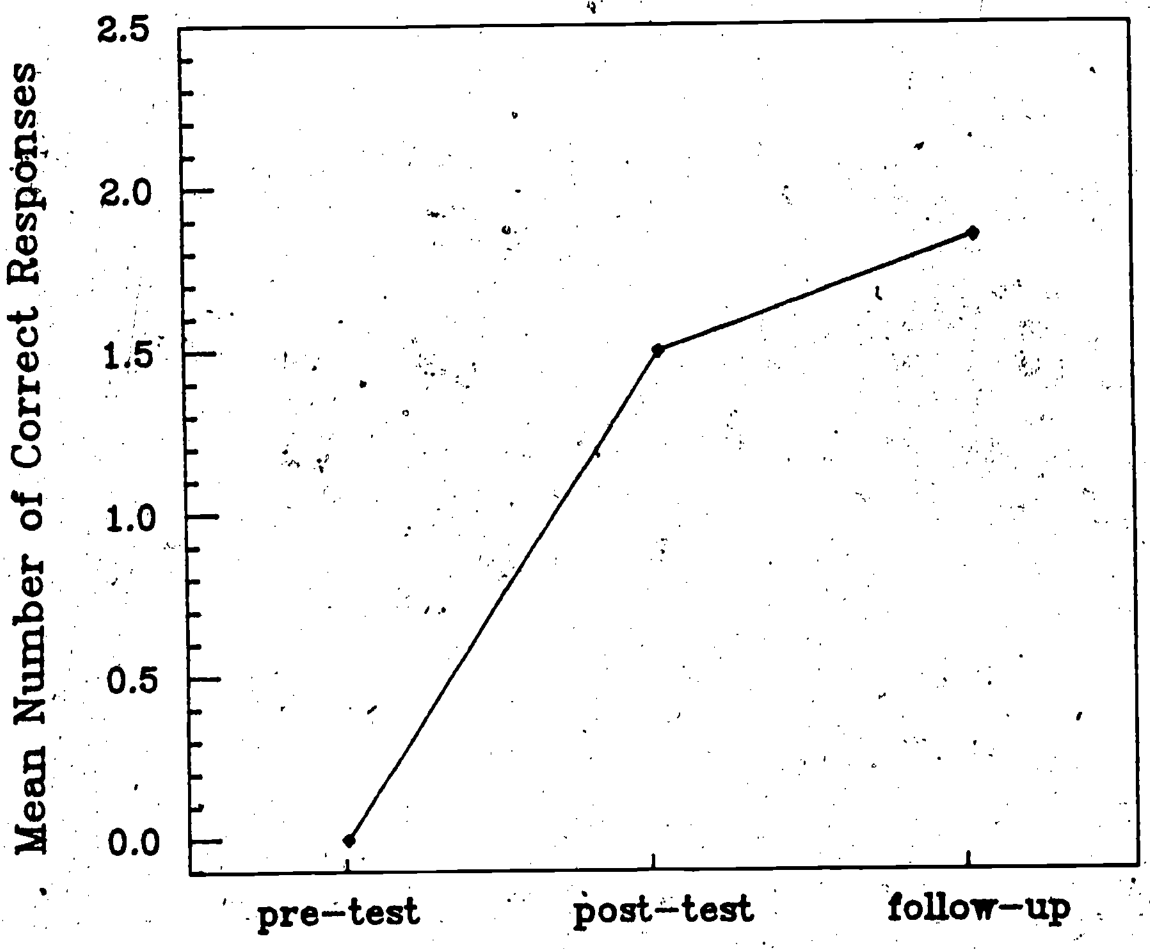
Results of Water-line Tests

JAR	HORIZONTALITY TEST		
SHAPE	PRETEST	POSTTEST	FOLLOW-UP
Straight	0.00	0.55	0.90
Round	0.00	0.95	0.95

Note - Maximum # correct would be 2.00

Figure 1

Results of training experience across the three testing sessions.



WATER-LINE TEST

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