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ABSTRACT

A total of 72 kindergarteners received eight conservation of number trials which varied in the degree of perceptual support for one-to-one correspondence (four levels) and type of stimuli (toy animals or corks). A between-subjects variable was the method of presentation (standard conservation presentation, a partially fixed array, or a fixed array). There was a strong order effect in the direction of increasing conservation over the eight trials. There was some evidence that the standard conservation presentation was easier than the other two presentations. The degree of perceptual support and type of stimuli had no effect. Results were discussed in terms of the competence-performance distinction and implications for assessment and training studies. (Author/CS)

PERCEPTUAL SUPPORTS FOR CORRESPONDENCE IN THE CONSERVATION OF NUMBER

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Abstract

Kindergarteners received eight conservation of number trials which varied in the degree of perceptual support for one-to-one correspondence (four levels) and type of stimuli (toy animals or corks). A between-subjects variable was the method of presentation (standard conservation presentation, a partially fixed array, or a fixed array). There was a strong order effect ($p < .001$) in the direction of increasing conservation over the eight trials. There was some evidence that the standard conservation presentation was easier than the other two presentations. The degree of perceptual support and type of stimuli had no effect. Results were discussed in terms of the competence-performance distinction and implications for assessment and training studies.

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The present study is one in a series of studies on perceptual-attentional factors in conservation (Miller, 1973; Miller, Grabowski & Heldmeyer, 1973; Miller & Heldmeyer, 1974; Miller, Heldmeyer & Miller, 1974). The previous research suggests that such factors play an important role in the transition from nonconservation to conservation. Variations in the stimuli, method of presentation, etc., often affect whether young children appear to be nonconservers or conservers.

The present study is an extension of a study by Miller, Heldmeyer & Miller (1974) in which perceptual supports for conservation of number increased the frequency of conservation in preschool and kindergarten children. The most effective supports were those which emphasized one-to-one correspondence and deemphasized length cues. The saliency of correspondence was increased by having pairs of beads of matching colors (2 reds, 2 blues, etc.) and pairs of matching toy animals (2 zebras, 2 turtles, etc.). In the standard conservation test, the only cue for correspondence is spatial position, i.e., the first chip in one row "goes with" the first chip in the other row, or the first egg goes with the first egg cup. The perceptual supports apparently helped the children keep track of the corresponding objects. That is, the supports aided attention and memory.

The present study more fully explored the role of perceptual supports for correspondence. All subjects received four levels of support ranging from weak to strong. The supports were chosen from studies by Miller, Heldmeyer, & Miller (1974), Piaget (1952), and Whiteman and Peisach (1970). Each level of support was examined in two different stimulus sets--toy animals and corks.

The between-subject variable was three conditions which differed in the degree to which the presentation of stimuli emphasized correspondence. Condition 1 was the standard procedure for assessing conservation in which two rows of objects of equal length were set up, the child was questioned about their equality, and then one row was spread out. In Condition 2, when the two rows of equal numbers were set up, one of the rows was already longer. It should be more difficult for the child to attend to correspondence in this condition because he never sees the corresponding pairs aligned with one object above the other. Thus, fewer children were expected to express a belief that the rows have equal numbers. Condition 3 was the same as Condition 2 except that the child did not see the pairs set down; he was shown rows of objects which were glued down. Even less conservation was expected here than in Condition 2 because there was neither an initial alignment of each pair (as in Condition 1), nor a setting out of objects pair by pair (as in Conditions 1 and 2). In order to use correspondence in Condition 3, the child himself must initiate a search for corresponding pairs, ignoring differences in the lengths of the rows. Beilin (1969) found that it was more difficult to conserve with a static presentation (like Condition 3) than with the standard tests of conservation of area and number.

Piaget emphasizes one-to-one correspondence in his analysis of the development of conservation of number (Piaget, 1952). He describes two types of correspondence--spontaneous and provoked. The difference is that in spontaneous correspondence there is no natural relationship between the two rows of objects, e.g., two rows of chips, while in provoked correspondence there is, e.g., a row of eggs and a row of egg cups. The development of these two kinds of correspondence is similar. Although Piaget argues that provoked correspondence is easier, he presents no data (Piaget, 1952, p. 49). The present study extends Piaget's work by examining not only trials with provoked and spontaneous correspondence, but also trials in which the members of each row are not interchangeable in forming pairs, e.g., there is only one red cork pair, one green cork pair, etc. This type of correspondence should be even easier than the two types described by Piaget because the division of the rows into corresponding pairs is encouraged by the distinctive appearance of the pairs of stimuli.

Method

Subjects

The subjects were 72 kindergarten children (mean age = 5 years, 10 months) from a predominantly white, middle class elementary school in Ann Arbor, Michigan. The 35 males and 37 females were randomly assigned to three experimental conditions. Four additional children were rejected because they did not pass all three parts of the verbal pretest.

Design

Each subject received eight trials -- four with small plastic animals and four with corks. Within each stimulus set there were four levels of emphasis on one-to-one correspondence. For half of the children the four animal trials came first and for half the four cork trials were first. Within each stimulus set there were four orders of the four types of trials (levels of emphasis) so that each trial was in each of the four positions an equal number of times. For a particular child, the order of the four trials was the same for the animal set and the cork set. This design was followed in the three experimental conditions which differed in how the experimenter presented the stimuli.

Materials

The materials were plastic animals (about 2.5 cm. wide and 4 cm. long), paper box "cages" (4 cm. wide and 5 cm. long), corks (2.5 cm. in diameter and 3 cm. tall), bottles (2.5 cm. in diameter and 6 cm. tall), and red yarn.

The four types (levels) of trials were as follows, listed in order of decreasing emphasis on correspondence. The correspondence cues are in parentheses.

A. Seven pairs of seven different animals or corks of seven different colors, with yarn connecting each pair. (Spatial, appearance, guidelines)

B. Seven pairs of seven different animals or corks of seven different colors. (Spatial, appearance).

C. Seven identical turtles paired with their identical cages or seven uncolored corks with their bottles. (Spatial, provoked)

D. Seven pairs of identical turtles or uncolored corks. (Spatial)

Procedure

One male graduate student tested each child individually in a small room at the school. The child was first given a pretest for the verbal terms which would be used in the conservation trials. The experimenter placed two groups of three chips in front of the child and asked, "Is there the same number of chips in this group as in this group (E points), or does one group have more?" (Version 1). The procedure was then repeated with groups of two and four chips, except the question was reversed -- "Does one group have more, or is there the same number of chips in this group as this group?" (Version 2).

The pretesting was followed by the eight conservation (or conservation-like) trials. There were three conditions which varied in how the stimuli were presented. Condition 1 followed the standard procedure for testing for conservation of number. Seven pairs of objects were set out, pair by pair, in two horizontal lines of 30 cm. After the child agreed that the lines had the same number of objects, one line was spread out to 48 cm., and the child was again questioned about their equality. The wording of the questions was the same as in the pretest. Versions 1 and 2 alternated from trial to trial. The longer line was nearer the child for one half the trials and equally often with each version of the conservation question. Children were asked for explanations for their answers. Test materials were removed from the child's view between trials.

Condition 2 was the same as Condition 1 except that when the pairs of objects were set out, one line was longer than the other. In other words, the child never saw the lines with identical length and never saw them being spread out. Each trial began with the end state of the trials in Condition 1 and the conservation question was asked. Condition 3 was the same as Condition 2 except that the child did not see the individual pairs set down; they were glued to cardboard.

Scoring

There were two types of criteria for conservation; a) a conservation judgment (C) and b) a conservation judgment accompanied by an adequate explanation (EC). A child was credited with a conservation judgment if he believed that the lines had the same number after the transformation. Explanations considered to be adequate were: same number (e.g., "They both have seven"), irrelevancy of the transformation, one-to-one correspondence, no addition or subtraction of objects, reversibility, compensation, and previous equality.

Results

Since there were no significant sex differences, analyses were done with sexes combined.

An analysis of variance was performed separately on conservation judgments (C) and conservation judgments accompanied by an adequate explanation (EC). The analyses indicated a highly significant effect of order (trials 1-4 vs. trials 5-8), F (1, 69) = 20.06, $p < .001$ for C scores and F (1, 69) = 18.25, $p < .001$ for EC scores. The conditions effect was significant for EC scores, F (2, 69) = 3.91, $p < .05$, but not C scores. The materials main effect and interactions were nonsignificant. Since the performance on each of the four types of trials was nearly the same (43%, 38%, 40%, and 40% of the Ss conserved (C) on trials A,B,C, and D) no analyses were made.

Table 1 shows the strong order effect in more detail. There is a gradual increase in conservation over the eight trials. The ordering holds up for individual

Insert Table 1 about here

as well as group scores. In a perfectly scaled performance there would be no nonconservation responses on any trials following a conservation response. Of the 25 children who were neither consistent nonconservers nor conservers, 17 had perfect scaling for C scores and 21 for EC scores. All of the children with imperfect scaling had only one or two trials out of order.

The significant conditions effect for EC scores reflects the fact that there was more conservat... in Condition 1 than Condition 2, Scheffe $F = 0.59$, $p < .05$, or Condition 3, Scheffe $F = 13.53$, $p < .01$. The mean number of EC responses in the three conditions was 3.7, 1.7, and 1.4. The superior performance in Condition 1 was expected, but it was also expected that Condition 2 would be easier than Condition 3. The significant differences for EC scores but not C scores is related to the fact that 95% of the conservation responses were supported by adequate explanations in Condition 1, while only 58% and ... were in Conditions 2 and 3.

The conditions also differed in the types of adequate explanations offered. In Condition 1, 57% of the adequate explanations referred to the fact that nothing was added or taken away and very few referred to counting (10%). In contrast, the largest category was counting in conditions 2(49%) and 3(61%).

Although correspondence explanations were not frequent, there was some evidence that the more perceptual supports for correspondence, the more frequently correspondence was offered as an adequate explanation. The percentage of correspondence explanations on trials A, B, C, and D was 29%, 22%, 7%, and 7%.

Discussion

The main finding was that as children are exposed to several conservation of number problems with correspondence cues they become increasingly likely to demonstrate conservation. This result was unexpected because the experiment was designed to assess conservation rather than teach it to nonconservers. There was no feedback from the experimenter as to the correctness of the answers and the entire session was quite brief (around 15 minutes). These factors suggest that the children who improved already had the concept of conservation of number (competence) but could not use it at the beginning of the testing (performance). The rapidity with which children switched from nonconservation to conservation, often accompanied by logic explanations, supports this conclusion. This distinction between competence and performance in cognitive development is discussed at length by Flavell and Wohlwill (1969).

One likely difficulty in the expression of the underlying competence is the child's lack of knowledge of which quantification strategy is relevant or most reliable in the standard conservation situation. Zimiles (1966) and Gelman (1969) among others have suggested that there is a period when children have a multidimensional definition of quantity, e.g., true number, length, density. All of these dimensions are reliable indicators of quantity at least part of the time. Which indicator they use depends on the experimenter's behavior, the nature of the stimuli, the child's past experience with similar situations, etc.

The conservation of number task is especially suitable for eliciting the appropriate strategy from among the various strategies the child has for dealing with quantity problems. A child can check his answers by simply couting the number of objects. It is more difficult to check answers in other conservation tasks (e.g., liquid quantity, area, length), especially if the child does not spontaneously reverse the transformation. In addition to the opportunity for counting, there may also be pressure to change because of the repeated questioning. (However, switches from conservation to nonconservation judgments rarely occurred). The fact that most of the trials emphasized one-to-one correspondence may also have directed attention away from length towards number. Further research could clarify what processes underlie the change to conservation and why the experience with several conservation trials elicits conservation in some children but not others.

It is noteworthy that once children began to conserve, most of them continued to conserve on all later trials. This suggests that the child is not randomly changing his answers as a result of repeated questioning. Once he selects the number dimension he seems to have more confidence in it than the perceptual dimension he used formerly. Further research with a delayed posttest would determine the durability of this change.

The present study has important implications for training studies. Most training studies provide particular experiences which are believed to underlie the development of conservation, e.g., training on compensation or reversibility, providing conflict. Yet, any gains in conservation may simply be due to the fact that the children have received a number of trials concerned with quantity. The particular training procedures used may have little importance. The gains, then, may reflect not increased competence but improved performance abilities. This may be especially true if the pretest-training-posttest design is used instead of one with a control group. The problem, however, is not avoided by using a control group which has a conservation pretest, a delay, and a posttest. In this design any superior gains made by the experimental group may be due to change in performance alone, competence alone, or both. The pretest and posttest typically consist of only one to three trials for each type of conservation of interest and rarely is the same type of transformation (e.g., lengthening one row) used in more than one trial. The present study indicates that there might be two ways to establish a proper control group. One way would be to give a number of conservation trials with no feedback for the pretest in order to end the pretest with a more accurate diagnosis of competence. A second way would be to give a number of conservation trials to the control group instead of a delay during the time the experimental group receives training. In this case any greater gains by the experimental group would likely be due to the particular nature of the training.

The implication for conservation assessment procedures is that extended testing is necessary for an accurate diagnosis of the child's true competence. Of course, it is necessary to discriminate two bases for changing answers: a false switch to conservation because the child thinks that the repeated questioning means that his earlier answers were wrong and true progress due to experience with the procedures and stimuli which eventually activate the correct strategy. Requiring logical explanations is one check for this problem.

The gap between competence and performance is also illustrated by the higher proportion of conservation in the standard conservation condition than the two conservation-like conditions. The latter conditions demand more initiative from the child. Only by counting or seeking out corresponding pairs can the child arrive at a conservation solution. Given these difficulties, most children may be content to use the more obvious perceptual dimension -- the lengths of the rows.

It is not readily apparent why the different levels of emphasis on correspondence did not produce different levels of conservation performance. It may be that correspondence does not play the important role in conservation that Piaget believes it does. On the other hand, the accompanying changes in the stimuli from trial to trial (corks, animals, bottles, cages, types of animals, color of corks) actually may have directed the child's attention away from the cues for correspondence.

The present study suggests that a detailed analysis of how the performance demands of the task affect conservation performance will be an important part of our understanding of conservation.

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TABLE 1

Proportion of Subjects with C and EC Responses

on Each Trial with Conditions Combined

Criteria for Conservation	Trial Number 1	2	3	4	5	6	7	8
C	.21	.31	.35	.44	.43	.47	.49	.51
EC	.18	.24	.25	.28	.29	.33	.35	.38