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ABSTRACT

The way that children construct the representation they use to solve transitive inference problems was examined. Forty-eight children 4.5 to 5 years old and 48 children 6 to 7 years old were asked to learn either a three-item series or a four-item nonseries. They were asked to learn the relationships between different colors of faces that were all the same size; on each trial, they were asked which face was bigger or which face was smaller. During the testing phase, two visual feedback conditions were included to provide a test of whether children use absolute size information to answer the inference question. In the linguistic feedback condition, the child was told which face was bigger or smaller. It was found that the linguistic condition was harder than the visual absolute condition. Overall, the findings suggest that children do not remember absolute size information. Older children appeared more successful than younger children in learning the premise pairs in the series condition. Younger children were more successful in learning the premise pairs in the nonseries condition than in the series condition. The nonseries was easily learned by both groups since it did not have a common middle term and did not require seriation skills. The main conclusion is that there are developmental changes in children's abilities to order a series. It appears that children can use trial-and-error processes to learn a series and that they can use a linear order to make inferences. Implications of the findings to views proposed by Piaget and by Trabasso are also addressed. (SW)

The Development of the Ability to Make Transitive Inferences*

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According to Piaget (Piaget, Inhelder, & Szeminska, 1960), preoperational children cannot solve transitive inference problems because they lack the necessary logical abilities. Bryant and Trabasso (1971) have challenged this claim contending that the failure of many children on such problems is due to an inability to remember the premise items.

Trabasso has done several other studies on both children and adults (for a review see Trabasso, 1977), and from this work he has concluded that adults and children solve inference problems in the same way. First, they represent the premise information using a linear order, and then they read off this linear order to make an inference. Although Trabasso interprets this model as being anti-Piagetian, Piaget would probably have been more interested in how children construct a linear order than in whether they use a linear order to solve the inference problem (Breslow, 1981, has reached a similar conclusion).

The crucial issue, then, in examining the development of transitivity centers around how children construct the representation they use to solve transitive inference problems. Trabasso's contribution has been to show that children and adults can use linear orders to make transitive inferences. However, he has not convincingly demonstrated that children and adults construct the linear order in the same way.

*Presented at the meeting of the Jean Piaget Society in Philadelphia, May 1981

We have developed a three-stage model which synthesizes Trabasso's claims that children and adults can use a linear order to make transitive inferences and Piaget's claim that children's seriation skills change with age. This model is outlined in Table 1. Level 1 is called Use. At this level, if a linear order is present before a child, the child can make comparisons between the items. But the child cannot represent the order mentally if the items are not physically present and ordered. Level 2 is called Representation. At this level, the child is able to represent series information but is unable to construct a series except through a trial-and-error process. Such a child is able to use the representation to make comparisons between two items. Level 3 is called Construction; and at this level the child can represent a series and can construct a series using an algorithm.

The experiment that I'm going to report here will focus on the distinction between the last two stages, since this is where the predictions about series construction are made. A second aim of the study was to try to account for the differences between the linguistic and visual feedback conditions used in the Bryant and Trabasso paradigm. In this paradigm children are given either visual feedback--they see the objects which vary on the dimension to be remembered--or linguistic feedback--they are told if they are right or wrong. One problem with using visual feedback to test children's inference making abilities is that the children could be remembering the absolute sizes of the objects and using this information to make comparisons rather than making an inference. Although there is evidence that some young children can make inferences when given linguistic feedback, performance in the visual feedback conditions has been consistently higher.

Method

In order to examine how children construct the representation they use to solve transitive inference problems, children were asked to learn either a three-item series, A> B> C, or a four-item nonseries, A> B, C> D. There is the same number of relationships to be remembered in the series and nonseries so any difference in learning time is due to the nature of the information to be remembered.

The experimental task was divided into two phases, a training phase and a testing phase. During traning, the children learned the premises in either the series or nonseries condition to a criterion of 8 out of 10 blocks correct. Each block contained one trial for each premise. Training was stopped if the child had not reached criterion by 27 blocks. During training the children were asked to learn the relationships between different colors of faces which were all the same size. On each trial they were asked which face was bigger or which face was smaller. After the children responded they were given one of three forms of feedback. In the linguistic condition the child was told which face was bigger or smaller. In the visual absolute feedback condition the child was told which face was bigger or smaller and shown a picture of two dolls which had the same faces the child had seen earlier. The sizes of the dolls are shown in Figure 1. The dolls are represented as sticks because of the artistic limitations of the authors. In the visual relative feedback condition the child was told which face was bigger or smaller and shown a picture of the dolls. The sizes of these dolls are also in Figure 1.

The two visual feedback conditions were included to provide a test of whether children do use absolute size information to answer the inference question. If they use absolute size information, then they do not have to rely on what they know about the conceptual relationships between the items. Notice that in the nonseries, visual absolute condition the dolls actually form a series. If children remember absolute size information they will respond in accordance with this series when they are asked about the A,C and B,D comparisons. After the children reached criterion they entered the testing phase. In the testing phase children were not given feedback. In all cases, children were tested on the premise pairs and possible inferences in the absence of feedback. Because of time constraints only the testing data concerning the visual absolute nonseries condition will be reported. The inference data, however, support Bryant and Trabasso's claim that if children do remember the premises they are correct on the inference trials.

Forty-eight 4½- to 5½-year-olds and 48 6- to 7-year-olds were tested. Equal numbers of both sexes were included in each age group. Half the children in each age group were asked to learn a series, and half a nonseries. In both conditions the children received either visual relative, visual absolute, or linguistic feedback. During training and testing the children were asked which face was smaller on half the trials and which face was bigger on the other half. The position of the correct answer was counter-balanced across trials.

Results and Discussion

I will first review the results concerning the effects of the three feedback conditions upon learning the series and nonseries, then results concerning developmental differences, and finally results concerning how the children learned the series and nonseries problems. Unless otherwise specified the dependent variable is the number of trials it took a child to reach criterion.

An examination of the learning data revealed that the linguistic condition was harder than the visual absolute condition, just as in the Bryant and Trabasso study. But the difference between the visual absolute and visual relative conditions was not significant, suggesting that the availibility of absolute size information is not what leads to the ease of learning the premise pairs in the visual absolute feedback condition (see Table 3). There was no indication that children responded in accordance with the linear order formed by the absolute sizes of the figures, in the testing phase on the nonseries visual absolute feedback condition. Both of these pieces of data suggest that children do not remember absolute size information.

An examination of the learning data revealed that the older children were more successful that the younger children in learning the premise pairs in the series condition. Younger children were more successful in learning the premise pairs in the nonseries condition than in the series condition. These results are shown in Table 2.

This type of result is not easily explained by Trabasso's theory, because he predicts that everyone handles series information in the same way. But it can be explained by our model. The nature of the training is such that the reversible nature of the middle term is emphasized in the series. This means that the middle term, B, has two labels. When it is with A, it has the label "smaller"; and when it is with C, it has the label "bigger". The children in Level 2: Representation who lack seriation skills have a hard time dealing with this information because it seems to them to be conflicting information. Children at Level 3: Construction have seriation skills, and they do not have difficulty with the middle term. The nonseries is easily learned by both groups since it does not have a common middle term and does not require seriation skills.

We examined the errors the children made in learning the series and nonseries problems to determine whether, as predicted, children could learn the premises by trial-and-error. In this analysis we only examined children who made errors and were in training for more than 10 blocks. This included 34 of 48 children, the other 14 children were judged to have learned the series using algorithmic processes. Thirty-one of the children in training for more than 10 blocks appeared to be using trial-and-error processes and the other three seemed to have made errors due to such factors as inattention. The data for the different patterns characterizing learning are in Table 4. Three different trial-and-error patterns were identified. One pattern is that children seemed to go through a brief trial-and-error process before recognizing the series. Five children in the series condition fell into this category. Children in this category made five or fewer errors so it was not possible to characterize the nature of this trial-and-error process. Two trial-and-error patterns were identified for those children who made five or more errors while learning the series. The first is that one of the premise pairs was correct at least 67% of the time (pattern # 4 in Table 4). The second is that performance on each premise pair ranged between 40% to 60% correct (pattern #5 in Table 5). Children who showed the first pattern type (#4) were significantly more likely to reach criterion on the series problem than those showing the second pattern type (#5). Pattern #4 is more efficient than the other pattern. Children only have to test two combinations of relationships if they have one premise nailed down. For example, if a child knows $A>B$, he or she only has to figure out whether $B>C$ or $B<C$. This efficiency explanation could be the reason more children classified into this pattern reached criterion, or it could be that children who failed to reach criterion did not possess the ability to recognize a series.

The main conclusion which can be drawn from the part of this research that I've presented, is that there are developmental changes in children's abilities to order a series. This result is consistent with Trabasso's claim that children can use a linear order to make inferences, but inconsistent with his claim that there are no developmental changes in the way children handle series information. It is consistent with Piagetian claims that children can use trial-and-error processes to learn a series and consistent with the claims of the three-stage model that children can learn a series through a trial-and-error processes and use the representation of a series to make inferences.

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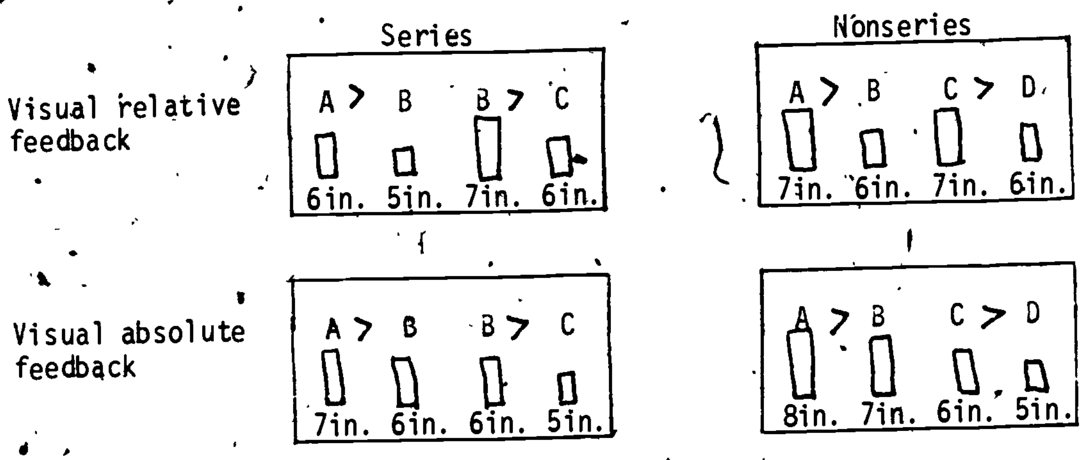

Figure 1. Schematic of the types of visual feedback used.

Table 1

Three-Stage Developmental Model for Transitivity

Level 1: Use	can make comparisons between different sized objects in a physically present series; cannot represent a series
Level 2: Representation	can represent a series; cannot construct a series, except through a trial-and-error process
Level 3: Construction	can represent a series can construct a series using an algorithm

Table 2

Trials to Criterion for the Age and Relationship Conditions

	Series	Nonseries
4½- to 5½-year-olds	21.667 [a]	12.625
6- to 7-year-olds	14.417	11.958

[a] range 8 to 27, this cell is significantly different from each of the other cells. ($p < .05$)

Table 3

Trials to Criterion for the Feedback Conditions

Linguistic	17.094[a]
Visual Relative	15.500
Visual Absolute	12.906

[a] range 8 to 27

Table 4

Patterns which Characterize How Children Learn a Series

Type of Pattern	Number of Children
1. Algorithmic pattern -- reach criterion in less than 10 blocks	14
2. Inattention pattern--- get 4 blocks in a row correct before the last 10 blocks	3
3. Brief trial-and-error pattern -- made fewer than 5 errors and took more than 10 blocks to reach criterion	5
4. Lenghty trial and error pattern (A) -- took more than 10 blocks to reach criterion, made more than 5 errors, at least 67% correct on one premise pair (67% errors on the other premise pair)	5 (2)[a]
5. Lengthy trial and error pattern (B) -- took more than 10 blocks to reach criterion, made more than 5 errors, between 40% to 60% correct on both premise pairs (errors equally likely on both premise pairs)	4 (15)

[a] Numbers in parentheses indicate those not reaching criterion.

Table 5

Inference and Premise Performance in the Series Condition

Premise performance	90.72% correct
Inference performance	93.55% correct