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Children's Comprehension of Relational Terms:
Two Developmental Levels

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This study was designed to investigate the relationship between language and cognitive development; specifically, the relationship between children's comprehension of relational terms and their operational development, as measured by the ability to conserve. The ability to conserve is one of many abilities that Piaget took as evidence of concrete operational thought. For example, in the conservation of substance task, a child who believes that two balls of clay have the same amount of clay, despite changes in the height and diameter of the balls, is said to conserve substance and therefore demonstrates concrete operational thought.

Using conservation of substance as a further example, in the traditional conservation task, children are asked to ignore certain dimensions of the stimuli, such as height and diameter, and to decide whether the two balls of clay are equal solely on the basis of the relevant dimension, the amount of clay. Tasks that measure children's comprehension of relational terms often measure similar abilities. For example, when asked which of two balls of clay has more clay, a child must respond solely on the basis of the amount of clay, and not be misled by differences in the height and diameter of the balls. Thus, the two tasks, conservation and comprehension of relational terms, in part measure the same abilities.

Several researchers have offered this point as a criticism of the traditional conservation test: that the traditional test not only assesses the ability to conserve, but is also a test of children's understanding of relational terms. Griffiths, Shantz and Sigel (1967) suggested that children might fail the traditional conservation test only because they do not understand relational terms. While many studies (Donaldson & Wales, 1970; Holland & Palermo, 1975; Palermo, 1973; Townsend, 1974) have shown that young children do not perfectly comprehend relational terms, there has

yet been no study that has demonstrated that there are children who can conserve, but who fail the traditional test of conservation solely because they do not understand relational terms.

One of the principal purposes of this study was to determine whether there are children who can conserve but who do not understand relational terms. In order to test that hypothesis, two tasks were used: a conservation test and a test assessing comprehension of relational terms. In this study, the relationship between conservation and relational term comprehension was tested in six different content areas: continuous quantity, discontinuous quantity, number, length, area, and substance.

In testing for comprehension of relational terms, two types of stimuli were presented to the children for comparison. The first type involved sets of stimuli in which the relevant dimension covaried with another dimension of the stimuli (Covarying condition). For example, in testing for comprehension of the relational terms referring to area, rectangular shapes were shown to the children. For half the sets of rectangles, the width of the rectangles was equal, so the relevant dimension, area, covaried directly with the length of the rectangles. The longer rectangle was always greater in area. For the remaining sets, the length of the rectangles was equal, so that the area covaried directly with the width of the rectangles.

In testing for comprehension of the terms referring to continuous and discontinuous quantity, the relevant dimension, quantity, covaried with either the height or the diameter of the containers, in the Covarying condition. The covarying dimensions for the other content areas were as follows: number covaried with either the length or the density of rows of objects; length covaried with extension at either end of the stimuli; and substance covaried with either the height or the diameter of the stimuli.

In this Covarying condition, the relevant dimension in each content area had a functional relationship with another dimension of the stimuli. According to Piagetian theory (Piaget, Grize, Szeminska & Vinh-Bang, 1968), children who are pre-operational are able to establish functional relationships

between two dimensions, to understand that as one dimension increases, the second increases also. Thus, in the present study, it was expected that pre-operational children would be able to comprehend relational terms when shown sets of stimuli in which the relevant dimension covaried with another dimension of the stimuli.

The second type of stimuli used to test for comprehension of relational terms involved sets in which the relevant dimension did not covary with the other dimensions of the stimuli (Non-Covarying condition). In these sets of stimuli, one of the dimensions was not held equal between all stimuli in a set. For example, in testing for comprehension of the relational terms referring to area, the longest rectangle did not always have the greatest area, nor did the widest rectangle. In the sets of stimuli used in the Non-Covarying condition, there was no consistent relationship between the relevant dimension and the other dimensions of the stimuli. According to Piagetian theory (Piaget, Grize, Szeminska, & Vinh-Bang, 1968), children who are pre-operational are not able to coordinate variation in three dimensions simultaneously, and thus would not be expected to comprehend relational terms when comparing non-covarying stimuli. This ability to coordinate three dimensions simultaneously in part enables concrete operational children to conserve and should also enable them to comprehend relational terms when comparing non-covarying stimuli.

In the comprehension test, each child was shown 12 sets of covarying stimuli and 12 sets of non-covarying stimuli for each of the six content areas. Each set consisted of four stimuli, a standard and three alternatives. Each set was shown to the child and the child was asked to point to the alternative that was more than the standard, less than the standard, and the same as the standard along the relevant dimension. In the comprehension test, each child was scored as "passing" for each term if the child responded correctly on 9 or more of the 12 questions in each condition, Covarying and Non-Covarying, for each content area. The probability of a child guessing correctly on 9 or more of 12 questions is less than .05. Thus, each child was scored as "passing" or "failing" for each of the three relational terms in each condition for each of the six content areas.

Each child was also given a conservation test in the six content areas. In the conservation test given for each content area, relational terms were not used in questioning. This task was used to provide a measure of the children's ability to conserve, unconfounded by their understanding of relational terms. The conservation test used in this study followed the traditional methodology, except that, rather than asking the children whether the two stimuli were the same along the relevant dimension, the children were asked whether two dolls, each given one of the stimuli, were both happy. Before being given the conservation trials, the children were trained on this task to respond solely on the basis of the relevant dimension. Five conservation trials were used in scoring.

On the basis of performance on this conservation test, each child was assigned to one of three stages, for each content area. Children who gave no correct responses were assigned to Stage 1 as non-conservers or pre-operational; children who gave from one to four correct responses were assigned to Stage 2 as transitional; and children who gave five correct responses were assigned to Stage 3 as conservers or concrete operational.

For each content area, the stimuli for the conservation and comprehension tasks were constructed of identical materials. For continuous quantity, the stimuli were clear plastic tubes filled with colored sugar. The stimuli for discontinuous quantity were clear plastic tubes filled with small, beadlike candies. The stimuli for number were Smarties, a candy similar in shape to M&M's. The stimuli for length were pieces of licorice; for area, rectangular cookies; and for substance, marshmallows.

A total of 48 children served as subjects. The children were selected from six age groups, from 4 years old through 9 years old, with eight children in each age group. To summarize the design of the study, each child was tested for comprehension of three relational terms (e.g., "more," "same," and "less") in both the Covarying and Non-Covarying condition of the comprehension test and for conservation, in all six content areas. The order of presentation of the conservation and comprehension tasks was counter-balanced within each age group. Additionally, the order of presentation of the covarying and non-covarying conditions of the comprehension

test was counter-balanced. The order of presentation of the three relational terms within each condition and the order of tasks across the six content areas was randomized.

Table 1 shows the results of the conservation testing. None of the 4- and 5-year-old children were able to conserve in any of the content areas, while a majority of the 8- and 9-year-old children conserved in most content areas. These results correspond to predictions based on Piagetian theory and to results obtained on the traditional test of conservation.

Table 2 shows the results of the comprehension test. The majority of the non-conservers passed the covarying condition for each term. On the other hand, all of the transitional children and conservers passed the covarying condition, for every term. These results indicate that comprehension of relational terms when comparing covarying stimuli is attained at some point in the pre-operational period, before children are able to conserve.

Table 1

Percentage of Children in Each Age Group
in Stage 3 on Conservation Test

Content Area	Age in Years		
	4-5	6-7	8-9
Discontinuous Quantity	0.00%	6.25%	43.75%
Continuous Quantity	0.00	6.25	43.75
Substance	0.00	12.50	46.25
Length	0.00	31.25	62.50
Number	0.00	25.00	67.50
Area	0.00	18.75	81.25

Table 2

Percentage of Children in Each Stage
Passing the Comprehension Test, by Condition

	Covarying		Non-Covarying	
	Stage 1	Stage 2&3	Stage 1	Stage 2&3
Discontinuous Quantity				
"less"	73%	100%	3%	69%
"same"	70	100	0	25
"more"	73	100	0	56
Continuous Quantity				
"less"	74	100	6	59
"same"	68	100	0	25
"more"	74	100	3	47
Number				
"less"	70	100	10	71
"same"	65	100	10	61
"more"	75	100	40	89
Length				
"shorter"	85	100	60	100
"as long as"	75	100	60	100
"longer"	80	100	27	86
Area				
"less"	81	100	54	91
"same"	73	100	35	86
"more"	77	100	27	86
Substance				
"less"	78	100	26	76
"same"	70	100	19	52
"more"	74	100	15	62

In the Non-Covarying condition, a majority of the non-conservers failed to comprehend every term, except those terms referring to length. In contrast, a majority of the transitional children and conservers passed each term in the Non-Covarying condition, except the relational term, "same," referring to discontinuous and continuous quantity. These results suggest that comprehension of relational terms when comparing non-covarying stimuli is attained at some point during the concrete operational period.

One of the principal purposes of this study was to determine whether there are children who fail traditional conservation tests because they do not understand relational terms. Table 2 presents results relevant to this question. Every transitional child and every conserver was able to comprehend all of the terms of the comprehension test in the Covarying condition. In fact, the only children who did not succeed for all terms in the Covarying condition were the very youngest children tested. Thus any child who answered correctly on one or more trials of the conservation test (as well as a majority of the children who answered no questions correctly) was also able to comprehend all of the relational terms used in the traditional conservation test. These results suggest that children acquire the ability to comprehend relational terms when comparing covarying stimuli before they are able to conserve, for all content areas. Therefore, an inability to comprehend relational terms does not prevent children from succeeding on the traditional tests of conservation.

According to Piagetian theory (Piaget, Grize, Szeminska, & Vinh-Bang, 1968), the ability to coordinate two covarying dimensions is attained by children before they acquire the ability to coordinate three dimensions varying independently. Therefore, in this study, it was expected that children would be able to comprehend relational terms when comparing covarying stimuli before they were able to comprehend relational terms when comparing non-covarying stimuli.

The results of this study pertaining to this hypothesis are shown in Table 3. The first column shows that there were children who failed both conditions, for every term. These children demonstrated no comprehension of relational terms in either condition. The second column shows that, for every

Table 3

Percentage of Children Passing and Failing
Each Condition of the Comprehension Test

	Covarying: Fail	Pass	Fail	Pass
	Non-Covarying: Fail	Fail	Pass	Pass
Discontinuous Quantity				
"less"	17%	58%	0%	25%
"same"	19	75	0	6
"more"	17	69	0	14
Continuous Quantity				
"less"	17	60	0	23
"same"	17	75	0	8
"more"	17	63	0	20
Number				
"less"	12	40	0	48
"same"	12	46	0	42
"more"	10	29	0	61
Length				
"shorter"	6	17	0	77
"as long as"	10	17	0	73
"longer"	8	17	0	75
Area				
"less"	10	46	0	44
"same"	19	48	0	33
"more"	15	50	0	35
Substance				
"less"	12	46	0	42
"same"	17	50	0	33
"more"	15	52	0	33

term, there were children who passed the Covarying condition but failed the Non-Covarying condition. These children were able to comprehend relational terms when comparing covarying stimuli, but not when comparing non-covarying stimuli. The fourth column shows that, for every term, there were children who passed both conditions, children who comprehended relational terms both when comparing covarying stimuli and when comparing non-covarying stimuli. These results are in accord with the hypothesis that a functional understanding is acquired by children before an operational understanding of relational terms.

The third column of Table 3 shows that there were no children who passed the Non-Covarying condition, but failed the Covarying condition, for any of the relational terms tested. Thus, there were no children who comprehended relational terms when comparing non-covarying stimuli, but not when comparing covarying stimuli. These results support the hypothesis that there is a developmental progression in the attainment of the ability to comprehend relational terms. Children first achieve a level of comprehension in which they are able to comprehend the terms when comparing covarying stimuli, and only later achieve a second level in which they are able to comprehend the terms when comparing non-covarying stimuli.

Both the ability to conserve and comprehension of relational terms appear to be dependent upon operational development. Because pre-operational children coordinate dimensions functionally, they are able to understand relational terms when comparing covarying stimuli and they are also led to a belief that a given dimension must change when other dimensions are transformed. Similarly, because concrete operational children coordinate dimensions operationally, they comprehend relational terms when comparing non-covarying stimuli and they demonstrate a concept of conservation. Neither of these abilities, conservation or an operational comprehension of relational terms, necessarily precedes the other. There were children who could conserve but who did not operationally comprehend relational terms, just as there were children who operationally comprehended relational terms, but could not conserve. Rather than one ability being the necessary precursor to the other, both abilities are dependent upon and can be taken as evidence of the development of operational thought.

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