R E P O R T R E S U M E S

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DEVELOPMENT OF A GROUP MEASURE TO ASSESS THE EXTENT OF PRE-LOGICAL AND PRE-CAUSAL THINKING IN PRIMARY SCHOOL AGE CHILDREN.

BY- STRUTHERS, JOSEPH A. DE AVILA, EDWARD
BOULDER VALLEY SCHOOL DIST. NO. RE 2, COLO.

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A GROUP MEASUREMENT INSTRUMENT WAS CONSTRUCTED TO TEST THE DEVELOPMENT OF CRITICAL THINKING IN YOUNG CHILDREN. DESIGNED TO ELICIT CHOICES OF THE MOST SATISFACTORY OF 3 ALTERNATIVE CONCLUSIONS FOR EACH OF 26 INCOMPLETE STORIES PRESENTED IN CARTOON PANEL FORMAT, THE INSTRUMENT MEASURES THE DEVELOPMENT OF THE 4 PIAGETIAN CONCEPTS OF CONSERVATION, CAUSALITY, RELATIONS, AND LOGIC. THE TEST WAS INITIALLY ADMINISTERED TO 1,972 CHILDREN IN THE BOULDER (COLORADO) SCHOOL DISTRICT. HOMOGENEITY RATIOS, RELIABILITY COEFFICIENTS, AND INTERITEM CONSISTENCIES WERE COMPUTED FOR EACH OF THE CONCEPTUAL SCALES. THE LOGIC AND RELATIONS SCALES APPEARED TO CONTAIN ITEMS WHICH WERE TOO DISSIMILAR AND, AS A RESULT, FAILED TO CLUSTER SATISFACTORILY. THE CONSERVATION AND CAUSALITY SCALES, HOWEVER, EXHIBITED STATISTICALLY SIGNIFICANT INTERITEM CONSISTENCIES. MEAN SCORES ON THE CONSERVATION AND CAUSALITY SCALES WERE COMPUTED AS A FUNCTION OF CHRONOLOGICAL AGE, AND AGE-RELATED TRENDS WERE FOUND TO EXIST IN THESE AREAS. THE RESULTS THUS FAR SUGGEST THAT THIS GROUP MEASUREMENT INSTRUMENT IS A PROMISING MEANS FOR OBTAINING INFORMATION WHICH HAS HERETOFORE BEEN OBTAINED ONLY IN CLINICAL TESTING WHICH INVOLVES THE EXTENSIVE INTERVIEWING OF EACH SUBJECT. THIS PAPER WAS PRESENTED AT THE 1967 ANNUAL CONVENTION OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION. (JS)

Boulder Valley School District, Re-2

Boulder, Colorado

Development of A Group Measure to Assess the Extent of Pre-logical and Pre-causal Thinking in Primary School Age Children*

Joseph A. Struthers

Edward De Avila

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Introduction

In the Boulder School District we have under way a project to modify our elementary science program by making extensive use of the products of various curriculum development projects. Among several outcomes we are particularly interested in what effect, if any, these changes have on children's ability to think critically. Critical thinking in high school age or older persons has been measured successfully, most notably by the Watson-Glaser tests (1964), but when the question of critical thinking by younger children is raised there is no such ready guideline for defining and measuring critical thinking. In addition, the recently much discussed contributions of Jean Piaget seem to suggest that critical thinking of younger children differs not only quantitatively but also qualitatively from the Watson-Glaser formulations.

Such considerations have led us to attempt to design a group measure of the thought processes which might be seen as the developmental precursors to the reasoning required in critical thinking. This has necessitated the adoption of certain Piagetian conceptual reference frames, but at the same time practical considerations have forced the development of radically different methodology.

As is well known the experimental work of Piaget is founded on the "clinical method" (1963) which involves the extensive interviewing of each subject. One of the immediate concerns regarding Piaget's use of the clinical method is that both the test and inquiry procedure is quite variable for each subject and highly dependent on the skill and sensitivity of the interviewer. Though we would agree with Piaget on the richness of the information that this approach yields, the method was not seen to be feasible for the present purpose because of the large numbers of children involved.

The task of developing a group measure of children's ability to deal with Piaget type tasks was undertaken. A group of thirty or so situations, drawn from Piaget experiments, were identified and subsequently restructured into a cartoon panel format similar to the example on the following page. In this cartoon two boys are engaged in conversation and in actions relating to the task. The story is incomplete and the task for the child is to indicate which of the three choices best completes the story. The present form of the test contains twenty-six such items which represented four conceptual classes of tasks.

In the testing situation the reading difficulties were overcome by having the test administrator read the captions while pointing to a projected image of page while the children followed in their test booklets.

Conceptual Design

Four domains of thought seemed particularly germane to the development of critical thinking. These four concepts were conservation, causality, relations

and logic and were contained as sub-scales in the first form of the test. These scales are described in the following.

1. Conservation: The concept of conservation, as described by Piaget, is divided into five distinct types, (1) conservation of substance, (2) conservation of number, (3) conservation of volume, (4) conservation of distance, and (5) conservation of surface. The concept of conservation requires that the recognition of transformations of location, shape, position and so on are not related to changes in the amount of substance, distance, or volume in question. For example, changing the shape of a ball of clay from a ball to a pancake does not alter the amount of clay originally contained in the ball despite the obvious changes in dimensions.

2. Causality: Children are reported to interpret reality in ways different from the objective and mechanistic way of adults. These diverse ways are called precausal explanations and included are animism, dynamism artificialism among others. For example, a child who reasons precausally might well explain the fact that smoke tends to rise on animistic grounds. That is, smoke goes up because "it wants to."

3. Relations: The concept of relations has to do with the child's ability to perceive the relative nature of observations. That is, whether an object is on the right or left side of another object is contingent on the observer's point of view. Other relations such as family relations and order relations also are dependent on the reference frame. For example, whether a person is a father or a son is relative to the person being made reference to in a particular context.

4. Logic: The logic scale consisted of class logic items and items which depended upon the transitive property of the greater than relation. In addition to Piaget (1958) the work of Innis (1964) was used as a guide in the structure of the items.

RESULTS

Test Analysis - 1,972 tests were scored from the first administration. Data was subjected to a factor analysis utilizing the BC-TRY (Tryon, 1966) system. The BC-TRY cluster analysis is an empirical method for determining the interitem consistency within a set of items which go to make up a factor, cluster or scale. The system was thus used to empirically determine the interitem consistency within our conceptual scales. Two of the conceptual scales, namely, conservation and causality, appeared to hold together. The logic and relations scales, while showing some internal consistency, appeared to contain items which were too dissimilar and, as a result, failed to cluster satisfactorily. A fifth scale, called the residual scale, appeared in the empirical analysis, yet did not show any conceptual consistency. The following table summarizes some of the statistical properties of each scale and the total test.

Scales	Homogeneity Ratios	Reliability Coefficient	Mean Score	Standard Deviation	Number of Items
Conservation	0.276	0.694	.71	.28	6
Causality	0.239	0.550	.86	.23	4
Relations	0.001	0.001	.41	.33	2
Logic	0.047	0.227	.50	.22	6
Residual	0.120	0.350	.62	.26	4
Total Test	0.105	0.717	.64	.17	22

As can be seen the conservation scale had six items, a homogeneity ratio of .276, a reliability of .694, a mean score of .71 and a standard deviation of .28. The homogeneity ratio is based on Scott (1960) and provides a measure of the internal consistency of the conceptual scales as contrasted with the purely empirically determined scales derived by the BC-TRY. The reliability measure is Chronbach's alpha (1951) and provides a measure of reliability which is expressed as the mean of the split-half coefficients which are computed for all possible divisions of the test or scale into two parts.

Age Normative Findings. Mean scores on the conservation and causality scales were computed as a function of chronological age to see if developmental trends existed. Figure 1 shows the percentage of students who equalled or exceeded the criterion score for conservation of substance. The curve indicates that the conservation of substance concept develops in the primary grades, however, approximately twenty percent of the youngest children tested appeared to have the concept while approximately twenty percent of the oldest children tested did not.

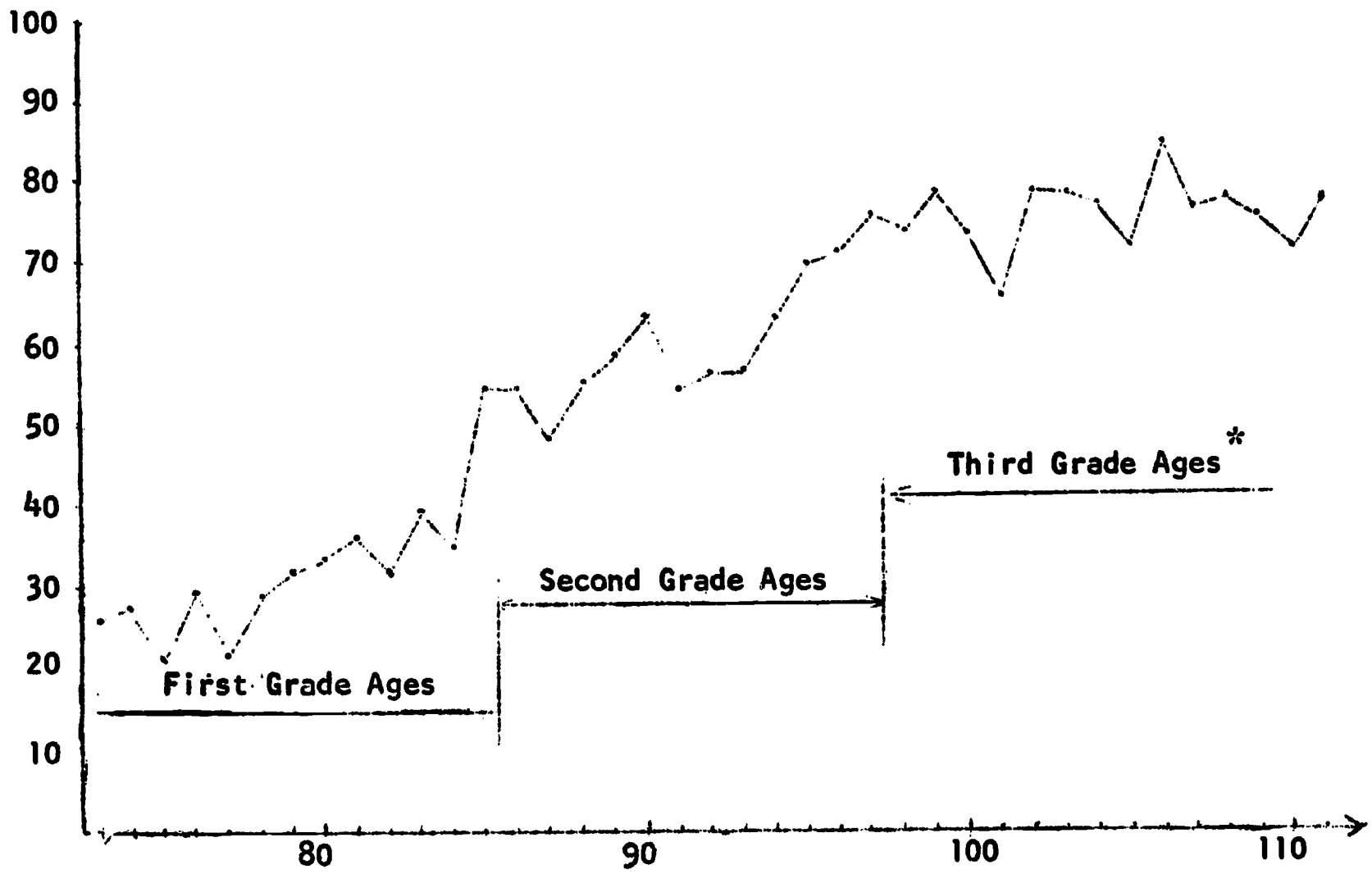

Figure 1 - Mean Scores on Conservation of Substance Scale as a Function of Age in Months.

*The grade level markings indicate normal age in grade at the time the test was administered.

Figure 2 shows the incidence of selection of precausal forms of explanation. Only 14% of the responses used precausal explanations but there were age differences in the incidence and type of selection. Finalistic precausal explanations were selected most frequently followed by dynamistic, animistic, artificialistic and realistic forms. All showed a decrease in use with age except for dynamism in which a slight increase with age can be detected.

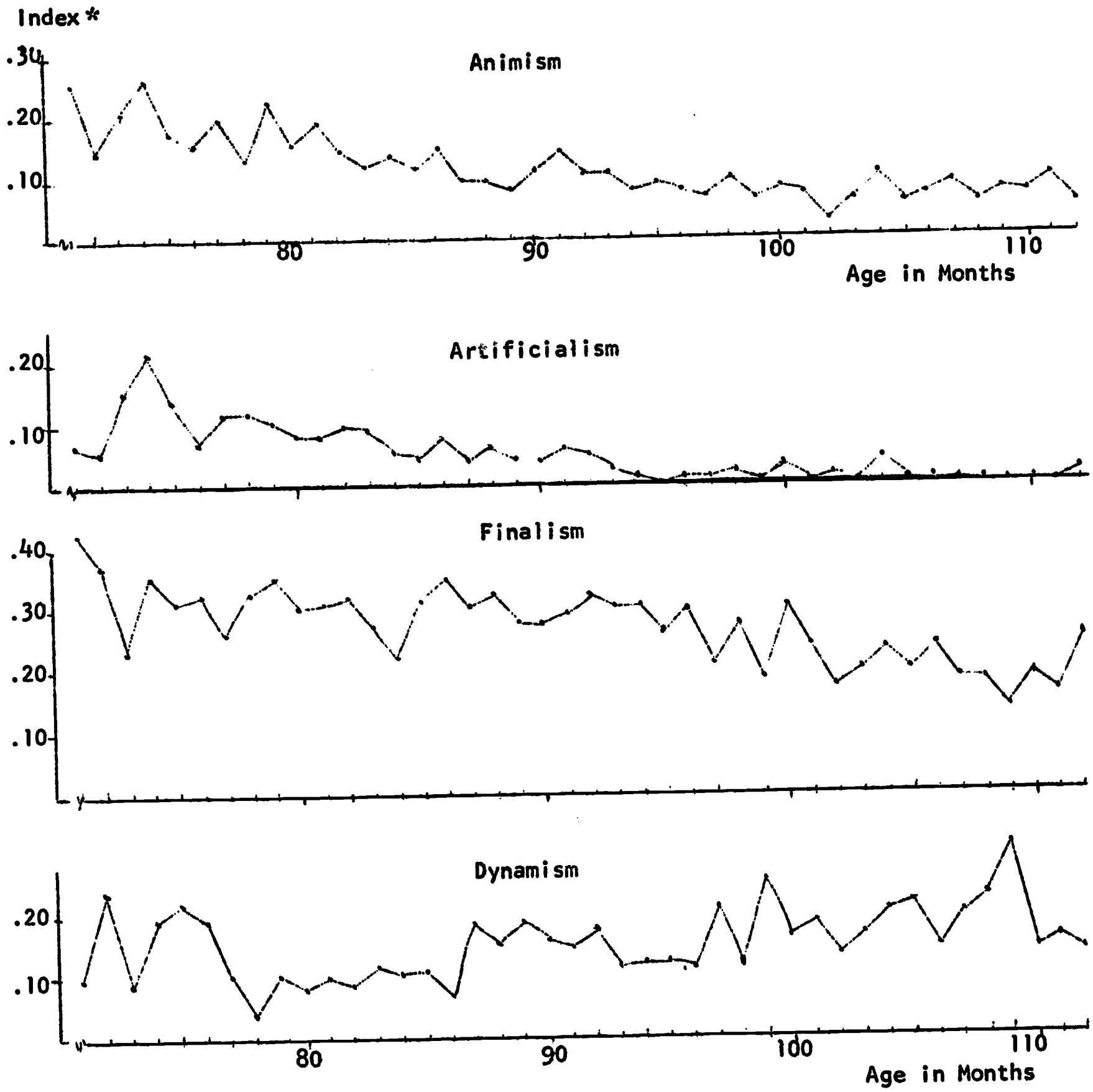

Figure 2 - Incidence of Selection of Precausal Explanation by Type as a Function of Age

*An index of 1.00 would mean every child of a given age in months picked precausal explanations of a particular type each time that type was available as a response.

DISCUSSION

The information derived thus far indicates that the test technique is a promising means for obtaining information about certain aspects of an individual child's thinking which has been obtained heretofor only clinically.

The age normative data obtained on the acquisition of conservation agrees substantially with that reported by Lovell (1962) and others. In the population tested, 87 months seemed to be the age at which half of the children had acquired the conservation concept. Of equal interest especially to primary teachers is the finding that in a first grade class (at least within our population) three out of ten children might be expected to have this concept; in the second grade, six out of ten might be expected to have the concept, while in the third grade only eight out of ten children can be expected to have the concept. This suggests that to the extent that conservation is an indicator of the child's capability to solve problems by inversion or by compensation, a given primary class will be divided in their instructional needs. Information provided by a means similar to this test should be of considerable diagnostic help to teachers in organizing such a heterogeneous class for instruction.

The order of extinction of precausal forms of explanation found is supportive of the recent description of this development by Piaget (1967) in which he suggests that sequential stages characterized by animism, dynamism and mechanistic explanations characterize children's thinking. The quantitatively smaller amounts of precausal forms of explanation found here are probably due to the picture test methodology. The child's actual precausal explanation may not be present in the limited number of available choices and as a result he would tend to select the one sounding most like the "adult" explanation. This tendency to choose an adult sounding explanation probably masks the extent of precausal explanations actually present.

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