ODDITY PROBLEM SOLVING RELATED TO INTELLIGENCE QUOTIENT WITH MENTAL AGE CONSTANT

by

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ABSTRACT

Twenty-two children with average and superior intelligence quotients were equated for mental age and were given a series of oddity problem tasks. Statistical analysis of the results indicated that the children of higher chronological ages solved the problem more rapidly and made fewer errors. Analysis of the variances within the younger chronological age group indicated that oddity problem solving is facilitated by higher intelligence quotients.

Results are discussed in terms of differential learning experience.

INTRODUCTION

Concept Formation

The existence of concepts is inferred from the equivalence of responses to diverse objects of situations. Concepts are symbolic in that they depend upon properties of absent stimuli and situations as well as upon the properties of present stimuli and situations. The present situation must be related and compared to those which have been previously experienced. Concepts are not necessarily conscious, nor must they be verbalized. The fact that infra-human organisms may learn to respond on a conceptual basis is proof of this. For example, Fields (1932) demonstrated that rats learn to respond to triangles which differ widely in shape, position, size, brightness and background. In addition, Heidbreder (1934), using adult subjects, and Smoke (1930), using children, obtained responses in which the subject, although he could respond in an equivalent manner to the common properties of the stimuli, could not verbalize the general principle by which he selected the correct response.

The experimental studies of concept development in children are relatively few in number. In general, the studies deal with two primary facets of the problem:

(1) how the concepts of children are developed and the process of this development, and (2) the ability of children to form various concepts and the age at which these concepts can be formed.

Piaget (1929, 1930, 1933) is the major worker in the first area. He investigated children's concepts by the question and answer method. His primary interest was in the process by which a child develops concepts to an adult level. For example, in the study of the development of the concept of life four stages were observed. First, the child attributes life to activity in general. Then the child sees life in anything that moves. Thirdly, life is attributed only to things which move of their own volition. The fourth stage is that in which the child confines the concept life to plants and animals (Piaget, 1929). Piaget studied diverse concepts in this way and found in general that the concepts acceptable on an educated adult level are more consistently and closely approximated as the child grows older.

Grigsby (1932), using Piaget's methods but attempting to overcome some of the deficiencies of his method, discovered that the maturity of concepts is correlated more highly with mental than with chronological age. In this study eighty-three children were used. They ranged in age from two years eight months to six years four months.

Much more work has been done in the second area, that of studying specific concepts and the ages at which they can be developed. Munn and Steining (1931) studied the development of the concept of triangularity in infants. This study used only one subject and indicated that the concept of triangularity could be formed as early as 15 months. The positive stimulus was responded to correctly against five different negative stimuli with a forty-five degree rotation and five changes of background. Gellerman (1933), studying the same concept, compared its development in children and chimpanzees. He found that the children could discriminate a triangle under more conditions than could the chimpanzees. The conditions included such variables as rotation, size, background, changes in negative stimuli, and use of equivalent figures such as broken triangles.

Hicks and Stewart (1930) studied concepts of size. In the study, children two to five years of age were tested for ability to learn to select the middle-size box from the three presented. Forty children were used, ten in each of the age groups, two, three, four, and five years of age. It was discovered that the older children took fewer practice periods to learn the four series and made fewer errors in selecting the middle-size box than did the younger children. The correlations between chronological age and the practice period required for the 30 children ages three to five inclusive was $-.68 \pm .07$. The correlation between chronological age and number of errors for the same children was $-.43 \pm .10$. These coefficients indicate a definite tendency for both the number of practice periods and the number of errors to decrease as the age of the child increases. However, individual differences within the age groups were described by the experimenters as very large.

Hicks and Stewart had mental ages available only for the two and three year-olds. Using the rank-difference method, correlations were computed for the 10 three year-olds to show the relation of mental age to the ability to learn to select the correct box. The correlation between mental-age and practice periods was -.74. The correlation between mental-age and errors was -.69. These results must be interpreted with restraint but they suggest that mental-age is a more important determinant than is chronological age.

Thrum (1935), also working with the concept of size, dealt with the concepts of "large," "small," and "middle-sized." Twenty-five children ranging in age from two to four years were asked to hand the examiner the size object for which he asked. Accuracy was 88% for the "big," 68% for the "little," and only 48% for "middle-size." Age was not shown to be significantly related to accuracy of response within the age range tested.

Since the formation of a concept requires the perception of relationships between stimuli, one further study is of interest in this general area. Roberts (1932) studied the ability of preschool children to solve problems in which a simple principle of relationship was kept constant throughout a number of series. She wished to find out to what extent such an ability is related to mental and chronological ages. Forty-three children, ranging in age from two to five years nine months, were used as subjects. Intelligence quotients and mental ages were obtained using the Stanford and the Kuhlmann revisions of the Binet. The constant principle of relationship was identity of color between a desirable object and the means of obtaining the object. For the three through five year age groups there was a decrease in the number of trials required to solve the problems from Series I through Series III. This indicates that the children from three years of age through five years learned to apply a common principle in the series of problems. However, the individual differences within groups was extremely large. Analysis of the data for two year-olds showed no carry-over from one problem to the next. For this age group, as a whole, each series was responded to as a new situation.

In order to find out whether there was any relationship between the number of trials taken to learn a series and chronological age, Pearson coefficients of correlation were computed. There were no significant correlations for Series I or II. A correlation of -.63 ± .098 between number of trials required on Series III and chronological age existed for the younger subjects. The four and five year-old groups failed to show this relationship. The correlation between their chronological ages and the number of trials needed to solve Series III was only -.03 ± .128. A significant correlation of -.49 ± .078 was found between chronological age and number of trials needed for solution when the two groups were combined. Correlations for Series IV indicated that the older children made more correct choices than the younger ones, the correlation in this case being .51 ± .070.

Coefficients of variation computed for chronological-age groups revealed no consistent tendencies. The number of subjects was too few for generalized conclusions, and the variability in number of trials in each series for each age group was very high.

Treatment similar to that used with chronological-age groups was applied to mental-age groups. It was discovered that the children with two-year-mental-age increased their average number of trials from Series I to Series III. For all other mental-age groups the average of trials decreased from series to series.

Standard errors of difference were computed to determine whether there were real differences between means of trials on the different series for mental-age groups. The differences between series for the two- and three-year groups were found not to be significant. Significant differences existed between Series I and II and Series II and III for the four-year-mental-age group. No statistically significant differences between series were found for the five-year group, but the actual averages showed a marked decrease in the number of trials required for Series III. For the seven-year-mental-age group a significant difference occurred between Series I and III. In general, subjects with a mental-age above three years required fewer trials for Series III than for Series I and II.

The mean numbers of trials per series for the mental-age groups were also compared. These comparisons revealed no significant differences between any mental-age group on Series I. For Series II, III, and IV significant differences were found between the two-year-mental-age children and all other mental age groups. Significant differences were also found between three- and four-, three- and five-, and three- and seven-year-mental-age groups on Series IV.

Coefficients of variation for mental-age groups were computed and showed no consistent trends. The Pearson coefficients of correlation were also determined. The duration of solution period for Series I was not correlated with mental age. For Series II a correlation of $-.39 \pm .087$

was found when the whole group of 43 children was used; a slight indication that children with higher mental ages tended to take fewer trials on Series II. Correlations for Series III between mental age and the number of trials required to solve are similar to those in Series II.

A knowledge of concepts and their formation is important in studying the problem-solving ability of children since quite often the solution to the problem involves the formation of some principle or concept by which to select the proper response.

Oddity Problem Solution

At the present time, very little is actually known about the relation between problem solving and chronological age, whether considered from the standpoint of kinds of performance or of ability to achieve correct solutions. It is difficult to assess with accuracy the relative roles of maturational and learning factors in the human organism's development. Harlow (1958), in a program using macaque monkeys which were separated from their mothers at birth, has done the most work in this area. His work resulted in the conclusion, among others, that form discrimination is almost entirely a function of maturation rather than of learned formation of cell assemblies or any other postulated learning mechanism.

One of the most interesting types of problems and one commonly used in studying the development of concept formation in children is the oddity problem. Oddity problems are problems in which the solution involves the selection of the item which differs in some way from the other items in the problem. The basis for selection of the correct solution is not stated in the directions. The oddity situation was introduced by Robinson (1933) as a method of measuring abstraction in monkeys. The problem has been subsequently modified and extended to be appropriate to human subjects. It is well suited as a method of observing learning because it demands a response to relationships between simultaneously presented stimuli. Harlow (1952) described the oddity problem as multiple sign learning, for it involves ambiguous reward of several cues on any given trial.

Harlow (1958) stated that he feels that it is "a task that is beyond the intellectual capacity of the young child, although data defining the minimal human chronological age level for oddity problem solving are lacking." There are relatively few studies in the literature concerning the child's ability to solve oddity problems.

Lipsitt and Serunian (1963) studied children in kindergarten (ages 5-0 to 6-0), first grade and third grade. The third graders were subsequently dropped from the study since the problem was apparently too easy for them. The ability to solve the problem increased with chronological age. This result led to the conclusion that the ability to solve the problem and the rapidity with which it is solved is a developmental attribute. The intelligence quotient data which was available suggested the possibility that intelligence quotient is a correlate but not an important one. Therefore, they felt that the ability to solve oddity problems is a function of chronological age and indirectly of mental age.

Ellis and Sloan (1958) studied mentally defective and normal children grouped according to mental age. Their results showed that the ability of the two groups combined increased with increases in mental age (correlation coefficient .55). The data showed that performance on the oddity problem is dependent, at least in part, upon intellectual development. The subjects with mental ages of four years or less showed negligible improvement with practice, and only 15% attained solution. Progress on the problems was more evident in the six-year-mental-age group where the performance curve assumed a negatively accelerated form. The curves for the 7-7 mental age and the 9-7 mental age groups are fairly similar and differ mainly in elevation. They are more bowed than are those of the 6-year group. The curves for the normal subjects appear to differ in form from those for the defectives. The normal's curve tends to be more curvilinear. However, the form of the curves for the defectives tended to become more similar to that of the normals with increases in mental age.

Harlow stated that

> . . . probably the most definitive measure of learning difficulty is the absolute or relative age at which various problems can be solved by a representative member of a species, particularly if past experience is equated or controlled. This technique has been used with human beings in the construction of mental maturity scales and intelligence tests and has given us such constructs as maturation and mental age (1959, p. 504).

STATEMENT OF PROBLEM

The hypothesis of the presently reported study was that the ability to solve oddity problems is a function of an interaction between intelligence and chronological age and that as a child increases in chronological age there will be a progressive shift upward in his ability to solve oddity problems.

Previous experiments on this problem have failed to adequately control for the factor of intelligence. In this study, the experimenter equated mental age for all subjects and thus studied the effects of the intelligence quotient and chronological age upon solution of oddity problems.

METHODS OF STUDY

Subjects

The subjects were twenty-two children with mental ages from 7-0 through 7-11 from various private schools in Tucson. Each possible subject was given the Stanford-Binet--Form L-M, and retained if he obtained the required mental age. The subjects were divided into two groups: (1) a superior group (Group A) with intelligence quotients ranging from 130 to 178, and (2) an average group (Group B) with intelligence quotients ranging from 88 to 113. The average intelligence quotient for the members of Group A was 146.3, for Group B, 102.8 (see Table 1).

Group A, the superior intelligence group, ranged in chronological age from 3-11 to 5-9, with a mean of 5-3. There were 4 females and 7 males.

Group B, the average intelligence group, ranged in chronological age from 6-6 to 8-8, with a mean of 7-3. There were 5 females and 6 males.

The average mental age of both groups was 7 years 5 months.

Apparatus

The problem solving apparatus consisted of 18 cards each 14 by 7-1/2 inches with one figure mounted upon it.

Table 1

CA, MA, Sex, IQ for All Subjects

	Superior Group A				Average Group B			
	CA	MA	IQ	Sex	CA	MA	IQ	Sex
1.	3-11	7-2	178*	F	8-8	7-10	88	M
2.	4-9	7-8	165	F	8-0	7-6	92	M
3.	5-9	7-6	134	M	6-10	7-8	113	F
4.	5-9	7-6	134	M	7-0	7-0	99	M
5.	5-6	7-2	134	M	7-1	7-10	110	M
6.	5-6	7-6	134	F	7-8	7-8	98	F
7.	5-5	7-4	139	M	6-6	7-0	108	F
8.	5-4	7-8	149	F	7-5	7-4	99	M
9.	5-7	7-9	144	M	6-9	7-0	104	F
10.	5-1	7-0	141	M	7-0	7-8	109	M
11.	5-3	7-6	147	M	6-6	7-2	111	F
M	5-3	7-5	146.3		7-3	7-5	102.8	

*An extrapolated value

All possible combinations of three forms (circle, triangle, and square) and three colors (red, blue, and green) were represented. These cards were presented grouped in threes in all 27 possible combinations excluding order. The order of the presentations of the sets was randomly determined but was consistent from subject to subject (see Table 2). The series was gone through a maximum of two times for each subject.

Procedure

The S entered the room with E and both were seated at a low table. The first trial stimuli were placed on the table in front of the S and the following instructions were given.

> This is the way we play the game. Each time I will put three cards in front of you like this. Each time I want you to guess which one is right, put your finger on it and I will tell you if it is the right one or the wrong one. The way you win the game is to pick the right one every time.

The reinforced stimulus on all trials was the odd card (by color, shape, or both) regardless of position. S was informed of the correctness of his response when he pointed to the card by either "Yes, that's the right one" or "No, that's the wrong one." Other statements such as "Very good," "You're doing fine," etc. were randomly interspersed in order to maintain motivation.

All Ss performed until they had either reached a criterion of five successively correct responses or had

Table 2

Presentation Order of Trial Stimuli

1.	TB, TR, TR	15.	SB, SB, TR
2.	SB, SB, SG	16.	SG, TR, CR
3.	TR, CB, CG	17.	CG, TR, CR
4.	CG, TG, TG	18.	TR, CG, CG
5.	TR, CR, TR	19.	SR, SG, SG
6.	CB, SR, CG	20.	CR, SG, SB
7.	SR, TB, TB	21.	TB, SR, CB
8.	CG, TR, SG	22.	TG, TR, CB
9.	TG, TG, SB	23.	TR, SG, TR
10.	TG, CB, SB	24.	CG, SG, TR
11.	CB, CB, TB	25.	SR, CR, TB
12.	SR, SR, CG	26.	CB, CG, TB
13.	SG, TB, SG	27.	SB, CG, CG
14.	CB, SG, SR		

KEY: S, Square B, Blue
T, Triangle R, Red
C, Circle G, Green

reached the maximum of 54 trials. The intertrial interval was approximately 10 seconds: the time necessary to collect the cards from the previous trial and lay out the cards for the next. No attempt was made to control this precisely.

RESULTS

Two measures were taken for each S; number of errors and trials to criterion. The performance of each child on the oddity-problem test is summarized in Tables 3 and 4. Table 3 shows the number of errors or wrong choices made in the series. Table 4 shows the number of trials necessary to reach the criterion of five successively correct choices. Both tables indicate that the children with higher chronological ages do better on the problem. They tend to require fewer trials to solve and to make fewer errors.

A Kruskal-Wallis test was run for both measures. The Kruskal-Wallis for errors is 5.02 and is significant beyond the .05 level (significance level is 3.84). The Kruskal-Wallis for trials to criterion is 4.4976 and is significant beyond the .05 level (significance level is 3.84).

The Cochran and Cox method for calculating t's with unequal variance was computed for both measures. The Cochran-Cox for errors is 1.8833 and is significant beyond the .1 level (significance level is 1.81) which indicates a tendency in the same direction as that indicated by the Kruskal-Wallis. The Cochran-Cox for trials to criterion is 2.157 and is significant beyond the .1 level (significance

Table 3

Number of Errors Per Subject

Group A		Group B	
1.	3	1.	19
2.	2	2.	0
3.	27	3.	1
4.	1	4.	3
5.	32	5.	0
6.	10	6.	0
7.	1	7.	2
8.	2	8.	5
9.	2	9.	5
10.	23	10.	0
11.	19	11.	0
M	11.09	M	3.18

Table 4

Number of Trials Required To Reach Criterion by Subject

Group A		Group B	
1.	10	1.	38
2.	8	2.	5
3.	54	3.	8
4.	6	4.	13
5.	54	5.	5
6.	22	6.	5
7.	8	7.	10
8.	11	8.	10
9.	8	9.	15
10.	42	10.	5
11.	37	11.	5
M	23.64	M	10.82

level is 1.812) and again indicates a tendency in the same direction as that indicated by the Kruskal-Wallis.

Due to the extremely wide variance within Group A (the superior group), a t test was run between the extremes in intelligence quotient within the group. The t test for errors is 2.7975 and is significant beyond the .05 level (significance level is 2.262) indicating that within this group the children with higher intelligence quotient did better. The t test for trials to criterion for this group is 1.736 and is not significant.

DISCUSSION

The results cited above indicate that there is a facilitative effect of increasing chronological age on the solving of oddity problems. It is possible that this tendency might be increased and substantiated by the use of additional subjects. However, in the light of the relative lack of statistical significance, the fact that some of the children seemed to solve the problem immediately, thus making no errors and the marked variance within the groups, it is this experimenter's hypothesis that the major variable operative in the development of this ability is that of differential learning experience rather than merely one of increasing chronological age.

The average group was composed of children in first and second grade. These children had the experiential advantage of one to two years of formal education over the children in Group A who had been exposed only to kindergarten at best. The formal educational experience to which Group B had been exposed would effect their performance in several ways. First, the learning experience itself was more familiar to these children. They had already developed the behavior so necessary to learning, of remaining seated for a considerable time and of focusing attention and concentration. They had a much clearer understanding of what was required of them in the situation than did the younger subjects. The younger children, Group A, had not developed these abilities to such an extent. They often had difficulty in remaining seated during the test. They were much more easily distracted and less able to focus their attention on the problem. There were, however, individual differences in this. The younger children, on the average, were much less certain of what was expected of them during the session. They asked many more questions and attempted to get the experimenter to provide additional structure.

The second way in which the formal education to which Group B had been exposed facilitated their performance lies in their previous exposure to problems of this type. For example, in the first grade children are given exercises in which they are required to circle the object that differs from the others. They have to a large extent already developed the concept of different or odd. These children were much more likely to verbalize the fact that the correct card was the one that was different. The younger children had not been so formally or consistently exposed to problems of this type and only one of these children verbalized the method of solution.

This hypothesis also offers an explanation for the variance within the groups and the fact that the younger group had a much wider variance. One can hardly deny the fact that learning experience and opportunities of children differ to a large extent. Thus it is not surprising to discover that children vary in performance of specific tasks even when they are in the same mental age range and have relatively equal chronological ages.

The fact that the younger group had a much wider variance than the older group can be explained in the following manner. The older children had been exposed to the relatively standard curriculum of the school system for at least one year. Thus their learning experiences had been standardized and equated to a much greater extent than had that of the younger children. On the other hand, the younger children had been more closely subject to the effects of experiences derived from and inherent in the family situation. Thus the differential effects of parental interests and pressure would be much stronger due to the lack of the ameliorative effects of a relatively standard learning curriculum such as that found in school. Also, even the more formal aspects of these children's learning experiences had varied widely. Some of the children were not in school at the time they were tested. Some were in kindergarten and some in nursery school. The kindergartens varied widely in function. Some were primarily day care centers, others were play schools with very little formal training, and still others were formal pre-school kindergartens. Some of the children in this group were in a special school for accelerated children and had thus received considerably more formal school training than the others. In view of the above it is not surprising that this group had a much wider variance than the older children even though their mental ages were in the same range both within and between groups. This is also supported by the examination of the variance within the younger group. The children with higher intelligence quotients made significantly fewer errors than the children with lower intelligence quotients within this group. Many of these more intelligent children were in the school for accelerated children and had thus had more educational training. It is also quite likely that these children were more stimulated by their parents in educational areas.

The results of this study indicate that children with higher chronological ages do significantly better on oddity problem tasks than do younger children even when they are in the same mental age range. The results also indicate that for younger children, oddity problem solving efficiency is facilitated by higher intelligence quotients. It is this experimenter's hypothesis that these two apparently contradictory results are, in fact, the result of the different learning experience and opportunities. The older group, although they had lower intelligence quotients, benefited from more extensive training and exposure. The younger children lacked this training with the exception of the more intelligent, many of whom did receive formal training and were probably more intellectually stimulated by their parents.

REFERENCES

Cochran, W. G. and G. M. Cox. Method for calculating t's with unequal variance. In Palmer O. Johnson and W. B. Robert. Modern statistical methods. New York: Rand McNally, 1959.

Ellis, Norman R. and William Sloan. Oddity learning as a function of mental age. Journal of Comparative Psysiological Psychology, 1958, 228-230.

Fields, P. E. Studies in concept formation. I. Development of the concept of triangularity by the rat. Comparative Psychology Monograph, 1934, 10, No. 1.

Grigsby, O. J. An experimental study of the development of concepts of relationships in pre-school children as evidenced by their expressive ability. Journal of Experimental Education, 1932, 1, 144-162.

Harlow, Harry F. Primate learning. In C. P. Stone (Ed.), Comparative psychology (3rd ed.). New York: Prentice-Hall, 1951, pp. 183-238.

Harlow, Harry F. The evolution of learning. In A. Ross and W. B. Simpson (Ed.), Behavior and evolution. Yale University Press, 1958, pp. 269-290.

Harlow, Harry F. Learning set and error factor theory. In Sigmund Koch (Ed.), Psychology: a study of a science (Vol. 2), New York: McGraw-Hill, 1959, pp. 492-537.

Heidbreder, E. F. A study of the evolution of concepts. Psychological Bulletin, 1934, 31, 736.

Hicks, J. A. and F. D. Stewart. The learning of abstract concepts of size. Child Development, 1930, 1, 195-203.

Kruskal, W. H. and W. A. Wallis. Use of rank in one-criteria variance analysis. Journal of the American Statistical Associates, 1952, 87, 584-621.

Lipsitt, Lewis P. and Sally Ann Serunian. Oddity-problem learning in young children. Child Development, 1963, 34, 201-206.

Munn, N. L. and B. R. Steining. The relative efficacy of form and background in a child's discrimination of visual patterns. _Journal of Genetic Psychology_, 1931, _39_, 73-90.

Piaget, J. _The language and thought of the child_. New York: Harcourt, Brace, 1926.

Piaget, J. _Judgement and reasoning in the child_. New York: Harcourt, Brace, 1930.

Piaget, J. _The child's conception of the world_. New York: Harcourt, Brace, 1930.

Roberts, K. E. The ability of pre-school children to solve problems in which a simple relationship is kept constant. _Journal of Genetic Psychology_, 1932, _40_, 118-135.

Smoke, K. L. An objective study of concept formation. _Psychology Monograph_, 1932, _42_, No. 4.

Thrum, M. E. The development of concepts of magnitude. _Child Development_, 1935, 6, 120-140.