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A COMPARATIVE STUDY IN PROBLEM SOLVING OF BRIGHT AND DULL CHILDREN

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CHAPTER I

INTRODUCTION

The problem solving processes of human beings have held positions of major importance for experimenters and writers in the past. One of the main areas of investigation concerns the thinking and reasoning processes of children. There has been considerable interest in characteristic differences in problem solving of dull and bright children. Systematic investigations have revealed differences relating to such factors as chronological age, mental age, and intelligence. Many methods of comparing problem solving performance, however, have yielded inconclusive results. This inconclusiveness arises because of the complexity of the problem solving process and the difficulty of obtaining objective data.

Comparative studies in problem solving cannot be made unless the process itself is fully understood. Definitions of problem solving differ depending on the particular problems used or the specific problem situations involved. Despite differences in definitions of problem solving, most problem situations have certain common elements.

Definitions of Problem Solving

Vinacke distinguishes three stages of behavior in a problem solving situation: "(1) Confrontation by a problem, (2) Working toward a solution, (3) Solution." Regarding the first period Vinacke says:

> In the first stage a situation is present, involving a goal together with an obstacle or difficulty between it and the individual. There follows some realization by the individual that such a situation exists. Motivation to overcome the difficulty ensues, accompanied by effort to attain the goal.

The second stage may involve "mental or symbolic processes, manipulation of the materials available, and verbalization such as interpreting the situation, expressing frustration, assigning names to the materials, etc. . . ." Of the second step Vinacke says "these activities are not mutually exclusive but can, and often do occur simultaneously."[1]

Dewey[2] analyzes problem solving into five steps: (1) a felt difficulty, (2) location and definition of the problem, (3) the suggestion of a possible solution, (4) development by reasoning of the bearing of suggestions, and (5) further observation and experimentation leading to

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[1]W. Edgar Vinacke, The Psychology of Thinking (New York: McGraw-Hill Book Co., 1952), p. 161.

[2]John Dewey, How We Think (Boston: D. C. Heath and Co., 1933), p. 72.

acceptance or rejection of the solution. The first step, a felt difficulty, implies the felt need or desire for solution of the problem. The second step, location and definition of the problem, refers to the necessity of determining the nature of the problem and analyzing it in relation to the available data. The third step provides a better understanding of the problem. The fourth step refers to the organizing of data in relation to hypotheses proposed for solution of the problem. The fifth and final step implies continued observation and the experimental use of hypotheses until a solution can be reached by deriving a generalization from the data.

Symonds[3] describes the problem solving process in four steps:

> (1) the isolation and definition of values which operate, (2) proposing a variety of solutions, (3) estimating the consequences of the various alternatives proposed, and (4) making decisions based on proposed solutions whose outcomes have most bearing on or relationship to the values at stake, and based on the probability that certain outcomes would result.

According to the descriptions cited above it would seem, then, that the first step in problem solving is the recognition of a problem and the desire to solve it. In any problem situation there must be alternatives available and a choice must be determined in relation to the problem. A desire or motive for solution must be present in any problem situation, regardless of the nature of the problem.

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[3]Percival M. Symonds, Education and the Psychology of Thinking (New York: McGraw-Hill Book Co., 1936), p. 126.

The second step in problem solving is an inductive process wherein the individual attempts to separate the various factors in the problem, recognizes the values of the elements, and organizes them into meaningful configurations. Through this process of organizing the data an attempt is being made to formulate generalizations.

The third step concerns the suggesting of possible solutions by proposing hypotheses. Symonds says "the matter of proposing hypotheses is in one sense the very heart of problem solving, particularly of the more creative or constructive sort."[4]

The fourth step is syllogistic in form. In this step the proposed hypotheses are checked deductively against the data to establish a generalization or solution to the problem.

The essentials of problem solving might, therefore, be the recognition of the problem and the desire for solution; inductive examination of the data through isolation, definition and organization of elements into meaningful configurations; and the testing of hypotheses against the data by a deductive process.

The need or desire for solution extends over a wide range of possibilities. It may range from a need for social approval to a motivating aspect characteristic of the particular problem situation. The inductive examination of the

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[4] Ibid., p. 126.

data provides the individual with a frame of reference from which he can further define and organize the data adequately. Of an inductive step, Dewey says "the meaning suggested supplies a mental platform, an intellectual point of view from which to note and define the data more carefully, to seek for additional observations, and institute experimentally changed conditions."[5] The deductive checking of hypotheses against the data tests the validity of the hypotheses, leads to a better estimate of the data, and makes possible more adequate hypotheses by returning to the inductive step.

The writer feels that an adequate test of problem solving should utilize those steps in the problem solving process described above. A good test should include, therefore, a situation conducive to the perception of the problem which will provide the motive for its solution; adequate data for isolation, definition, and organization; a possible solution which may be determined by further analysis and organization; and conditions whereby an individual may test hypotheses against the data.

It may be possible that problem solving occurs in some situations without utilizing all or any of the described steps. Under some circumstances an individual might solve a problem without conscious awareness of the problem or that it has been solved. Without awareness of the problem it would

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[5]Dewey, loc. cit.

be debatable whether problem solving could occur. Once a problem is perceived, a solution may be possible without fully understanding the related data. In some situations the solution of a problem may be accidental. Possibly a problem is solved in an existing situation where alternatives are available and a choice is made.

In the writer's opinion a good test of problem solving should provide for the possibility of using all the elements of problem solving as reviewed earlier. Inductive and deductive reasoning both play a part in the problem solving process. A good test of problem solving should, therefore, provide for both types of reasoning to operate. In certain types of problems where organization of the data would not be useful in determining a solution, inductive reasoning would not be utilized. The inductive element would not operate in a trial and error situation. In a situation where the available data would not lend themselves to the testing of hypotheses, the deductive element would be useless. A true test of problem solving would provide opportunity for inductive and deductive reasoning to occur.

Previous Investigations of Problem Solving

A review of the available literature reveals that the heaviest concentration of research concerning problem solving of children was reported prior to 1942. The comparative scarcity of more recent research does not imply a lack of current interest in problem solving but is more indicative of efforts on the part of experimenters to meet the needs of the times. During World War II there was an abundance of research concerning adult problem solving which can be attributed to the immediate demands of a war time economy. Within the past six years a large number of papers, theses, and books have been published concerning direction in problem solving; influence of set, critical thinking; and the formation of concepts.

Many methods have been used in comparing performance of dull and bright children in problem situations. At least five classifications are possible. They are as follows: (1) tests involving multiple choice, (2) mazes, (3) concept formation, (4) puzzles, and (5) syllogistic reasoning. Most investigations concerning problem solving of children employ one or more of these methods.

Yerkes[6] used a modification of an original multiple choice technique in an investigation of ideational behavior of normal, defective, and psychotic individuals. This original unit consisted of twelve keys which could be raised or lowered in a variety of combinations by the experimenter. It was the task of the subject to make a choice by pressing one of the keys which had not been elevated. The sound of a

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[6] R. M. Yerkes, "A New Method of Studying the Ideational Behavior of Mentally Defective and Deranged as Compared with Normal Individuals," Journal of Comparative Psychology, I (1921), pp. 368-396.

bell was used to indicate to the participant when the proper key had been pressed.

The modified device consisted of twelve keys which could be moved out of the keyboard in the direction of the subject. The subject made his choice by depressing the keys shoved out of the keyboard. A buzzer was substituted for the bell to indicate a correct choice.

Four problems were used: (1) the first key to the left of whatever combination of keys was presented to the subject, (2) the first key to the left and the first key to the right alternately, (3) the third key from the left, and (4) the middle key.

The Yerkes technique recognizes two types of solutions: (1) the selection of the correct key on ten successive trials with no formulation of the generalization involved, (2) the selection of the correct key in addition to a statement of the generalization involved. Yerkes notes that some individuals were able to solve the series of problems but could not verbalize the series of generalizations. Yerkes suggests that "it is possible for a subject to be capable of fulfilling the demands of the situation by selecting the proper mechanism each time" and be "quite incapable of formulating a description of the method or a definition of the right key."[7] He suggests that the subject's solution is in

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[7] Ibid.

"motor terms" and indicates that it is common to mentally defective and pathological subjects.

Yerkes used several groups of subjects: superior intelligence, average intelligence, defective, and pathological. Results of the experiment showed the superior groups requiring fewer trials to solve each of the series. The average group was next but the mentally defective and average groups overlapped in required number of trials.

In reporting results Yerkes states:

> It may be remarked that the responses of a subject to a series of multiple choice problems, no matter how the results be analyzed later or what significance be attached to them in the light of statistical data, are surprisingly illuminating to the observers, for they indicate in a remarkable manner the ideational characteristics and efficiency of the subjects.[8]

The method of approach used by the subjects was considered important in determining the "ideational characteristics." Some subjects were logical in their attack eliminating incorrect keys and indicating confidence in their abilities to solve the problems. Others pressed the keys randomly and gave no indication of confidence in their ability to solve the problems.

Heidbreder[9] used a multiple choice technique involving four generalizations: (1) right hand box, (2) flowered versus

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[8] Ibid., p. 386.

[9] E. Heidbreder, "Problem Solving in Children and Adults," Journal of Genetic Psychology, XXXV (1928), pp. 522-545.

plain box, (3) the nearer box with plain figures, and (4) the farther box with plain figures. The subjects tested ranged in chronological age from three years to adult level. It was found that the number of trials required for solution decreased with the chronological age of the subject. It was also reported that generalizations made by adults were more objective, and that verbal generalizations were possible by all subjects above the six year level.

Roberts[10] tested subjects from two to five years of age using a multiple choice technique. His apparatus consisted of a toy house with doors of different colors. It was the task of the subject to obtain a toy from within the house by opening a door of the same color as that of the toy. Verbalizations did not appear before the three year level although all children tested were able to solve problems. It was found that frequency of verbal generalization and correct solution of problems increased with chronological age and mental age.

Aarons[11] compared serial learning and generalizing abstraction using a Yerkes type multiple choice technique. He made comparisons between results on the multiple choice

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[10] K. E. Roberts, "The Ability of Pre-School Children to Solve Problems in Which a Single Principle of Relationship Is Kept Constant," Journal of Genetic Psychology, XL (1932), pp. 118-135.

[11] Leon Aarons, "Serial Learning and Generalizing Abstraction," American Journal of Psychology, XLV (1933), pp. 417-432.

device and those obtained in the learning of the order of cards in a deck. Low positive correlations were reported.

Long and Welch[12] used three tests in an attempt to investigate the ability to discriminate and match numbers: (1) selecting the box containing the greatest number of marbles in order to obtain a reward, (2) matching the number of marbles in a single group, and (3) matching the number of marbles in four groups. One hundred thirty-five children were used as subjects ranging in chronological age from 30 to 83 months. Positive correlations with intelligence were low but a steady improvement in the ability to discriminate and match numbers was found with chronological age.

Many investigators have utilized mazes in their investigations. A wide variety of mazes have been used to investigate problem solving.

Gellerman[13] used a large temporal alley maze in an investigation involving two generalizations: (1) twice to the right and twice to the left for children, (2) twice to the right and twice to the left repeated once for adults. It was found that the children required many more trials than

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[12]L. Long and L. Welch, "The Development of the Ability to Discriminate and Match Numbers," Journal of Genetic Psychology, LIX (1941), pp. 377-387.

[13]Louis W. Gellerman, "The Double-Alternation Problem: II. The Behavior of Children and Human Adults in a Double-Alternation Temporal Maze," Journal of Genetic Psychology, XXXIX (1931), pp. 197-227.

adults and made more errors. The number of trials and errors decreased as chronological age increased from the four year level. Low positive correlations between successful performance and intelligence were reported for adults. No correlations were reported for children.

Maier[14] used a maze in which the required task was to locate a toy windmill which would play a tune when a coin was inserted. Thirty-nine subjects were used. Improved performance with increasing mental age and chronological age was reported.

De Sanctis[15] studied visual apprehension by using a maze. The experiment involved nine normals from three to six years of age; nine feeble-minded children from seven to twelve years of age; ten imbeciles; one idiot; and one moron. Feeble-minded children were reported to be slower in visual apprehension although certain spatial data were learned even at the idiot level. Poor attentive capacity was suggested for the slowness.

Studies requiring maze performance and covering a wide range of intelligence, chronological age, and type were

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[14] N. R. F. Maier, "Reasoning in Children," Journal of Comparative Psychology, XXI (1936), pp. 357-366.

[15] Sante De Sanctis, "Visual Apprehension in the Maze Behavior of Normal and Feeble-minded Children," Journal of Genetic Psychology, XXXIX (1931), pp. 463-469.

conducted by Husband[16], Hicks and Carr[17], and Gould and Perrin[18]. No wide differences between children and adult performance were reported.

Experiments involving concept formation have yielded some interesting results.

A study by Ray[19] points to some differences in the problem solving of bright and dull children. The test consisted of a presentation of pairs of pictures. The subjects made a choice by pressing a key under one of the pictures. A green light would flash when a correct key was punched and a red light would indicate an incorrect choice. New pairs of pictures were presented after each choice was made. Twenty series of paired pictures were employed. Subjects for the experiments consisted of six bright, six dull, and six normal thirteen year old children. The bright subjects solved more problems and used fewer hypotheses. It was suggested that

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[16] R. W. Husband, "A Comparison of Human Adults and White Ants in Maze Learning," Journal of Comparative Psychology, IX (1929), pp. 361-377.

[17] V. C. Hicks and H. A. Carr, "Human Reactions in a Maze," Journal of Animal Behavior, II (1912), pp. 98-125.

[18] M. C. Gould and F. A. C. Perrin, "A Comparison of Factors Involved in the Maze Learning of Human Adults and Children," Journal of Experimental Psychology, I (1916), pp. 122-154.

[19] J. J. Ray, "The Generalizing Ability of Dull, Bright, and Superior Children," Peabody Contributions to Education, No. 175 (Nashville: George Peabody College for Teachers, 1936).

the perception of a great variety of clues was not necessarily an indication of superior intelligence. It was reported that the dull and average children used inappropriate clues and perseverated throughout the test. Bright children were able to verbalize their solutions to a far greater extent than were dull or average children.

Hull[20] studied the evolution of concepts with a test involving the selection of the common factor in Chinese characters. It was reported that the ability to select identical elements improves with age.

Hazlitt[21] studied concept formation by providing a group of children with large and small black cards and instructing them to differentiate through sorting them. As part of the same test the children were presented with a large egg containing smaller eggs and instructed to replace all the eggs but a green one. An attempt was being made to demonstrate that the reasoning process would be the same when the experience factor was held to a minimum and the problem situation could be understood by all subjects.

Smoke[22] investigated the formation of concepts in a

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[20] C. L. Hull, "Quantitative Aspects of the Evolution of Concepts," Psychological Monographs, XXVIII (1920), pp. 1-85.

[21] Victoria Hazlitt, "Children's Thinking," British Journal of Psychology, XX (1929), pp. 354-361.

[22] Kenneth L. Smoke, "An Objective Study of Concept Formation," Psychological Monographs, XLII (1932), pp. 1-40.

test situation involving the use of nonsense syllables. The task was to learn nonsense syllables associated with symbols. Smoke reported positive correlations between the ability to form concepts rapidly and superior intelligence.

Mechanical puzzles have been used with some success to investigate problem solving of dull and bright children. A study by Alpert[23] involved a technique similar to Kohler's. The subject was required to place a block under a wanted object and fit two parts of a rod together to obtain an object outside a pen. Random responses similar to those reported by Thorndyke[24] in his animal studies were reported. Alpert[25] reported three types of insight: (1) solution with immediate insight, (2) solution with partial insight, (3) solution with sudden insight. Matheson[26], using Kohler's technique reports few solutions by insight.

Among the researchers who have investigated the relation of syllogistic reasoning to intelligence are Broady[27],

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[23]Augusta Alpert, The Solving of Problem Situations by Pre-School Children (New York: Bureau of Publications, Teachers College, Columbia University, 1928).

[24]E. L. Thorndyke, Animal Intelligence (New York: The Macmillan Co., 1911).

[25]Alpert, op. cit.

[26]E. Matheson, "A Study of Problem Solving Behavior in Pre-School Children," Child Development, II (1931), pp. 242-262.

[27]L. Broady, "Comparable Tests of Verbal and Non-Verbal Reasoning: Their Construction and Application to Developmental Problems," Journal of Educational Psychology, XXXI (1940), pp. 180-194.

and Pyle[28]. Results of these and other tests reported a wide range of positive correlations. Experiments with tests of syllogistic reasoning involve only the deductive method.

Heidbreder[29] investigated the reasoning process of children ranging from the three year level to adulthood. Three problems requiring the mastery or the understanding of a general principle were used. It was found that the number of necessary trials decreased with chronological age level. Few of the three year olds were able to verbalize their solutions. Children from the six year level were able to verbalize their solutions in all cases.

Roberts[30] studied the ability of children to discover and apply to new situations the solving principle of a given problem.

Teska[31] investigated problem solving abilities of dull and bright children in a multiple choice problem situation. A total of 34 dull and bright subjects were used covering a

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[28]W. H. Pyle, "An Experimental Study of Development of Certain Aspects of Reasoning," Journal of Educational Psychology, XXVI (1935), pp. 539-546.

[29]Heidbreder, op. cit.

[30]Roberts, op. cit.

[31]Percy T. Teska, "Performance of Dull and Bright Children in a Non-language Multiple Choice Problem Situation" (unpublished Ph.D. dissertation, University of Wisconsin, 1942).

wide span of chronological age levels. It was found that the eight year olds, who were the youngest of the bright children, solved a higher percentage of problems than the fourteen year olds, who were the oldest of the dull children. The number of trials necessary for solution decreased as mental age increased. A comparison of dull and bright children of the same mental age revealed that bright children solved more problems in fewer trials.

Limitations of Previous Methods of Investigation

Each of the five techniques--multiple choice, maze learning, concept formation, puzzles, and syllogistic reasoning--has been proved useful in studying problem solving.

In many of the studies using multiple choice techniques, positive correlations were found between successful performance and chronological and mental age. The ability to generalize was found to be more common in subjects of superior intelligence and advanced chronological age. The criticism might be made that the large amount of material needed in many of these tests might prohibit their general use.

Maze type tests provided data for inductive and deductive reasoning. Most tests of this type, however, do not provide for the testing of hypotheses or the deductive step.

Tests of concept formation indicate that bright children are superior in their ability to form concepts. Many of the studies suggest that concept formation improves with increased mental age and chronological age. Many tests of concept formation are not appropriate for use over a wide range of age groups since it is difficult to arrive at concepts of equal difficulty for all chronological age levels.

The Multiple Choice Method

Of the five methods of investigating problem solving, the multiple choice technique appears to be the most adequate for testing over all levels of chronological age. The use of a multiple choice technique in problem solving can provide for inductive and deductive reasoning. Generalizations may be derived from the data and tested deductively against the data. There is sufficient data available for the solution of the problem by subjects at all chronological age levels.

The writer feels that a suitable test of problem solving for comparing problem solving ability of dull and bright children should meet certain criteria:

1. The problem situation should be understood by both bright and dull.

2. The problems should be such that desire for solution is assured.

3. Data must be equally obtainable for both bright and dull children.

4. The use of all elements of the problem solving process must be possible, including the formulating and

testing of hypotheses.

The writer feels that the device used in this study meets the above criteria. The instrument allows the problem to be understood by both dull and bright children at all levels of chronological age. There is no reading involved. The data available for solution is not dependent upon good reading ability or enriched vocabulary. Various hypotheses are possible and all hypotheses may be tested against the data. The desire for solution is assured by the unique design of the problem box.

In addition to meeting the stated criteria, the design of the problem box makes possible an accurate recording of trials and solutions. (See data sheet in Appendix.)

Statement of the Problem

The purpose of this study was to compare, by means of this instrument, the problem solving ability of dull and bright children. Specifically the problem was to investigate the performance of bright and dull children on this problem box in relation to chronological age, mental age, and brightness.

CHAPTER II

THE APPARATUS

The problem box used in this study was built by Dr. Percy T. Teska, Professor of Special Education and Psychology, University of Oklahoma. Illustrations of the problem box are presented in Figures 1 and 2.

The problem box is a portable unit approximately 15 inches high, 12 inches wide and 13 inches deep. On the face of the problem box is a window divided into four equal quadrants. Squares and triangles are projected on the face of the window in combinations of two and in different relationships. The subject being tested sits in front of the problem box facing the divided window. He is instructed that one of the four buttons located on the face of the problem box will cause a light to flash red. He is told to find the button which will cause the light to flash red every time. An example of a correct solution to a particular problem is pressing the button next to the triangle no matter in which quadrant the triangle appears. Pressing the button beside the quadrant containing the triangle produces a red light on each trial. The squares and triangles change position on the screen after a three second delay each time a button is

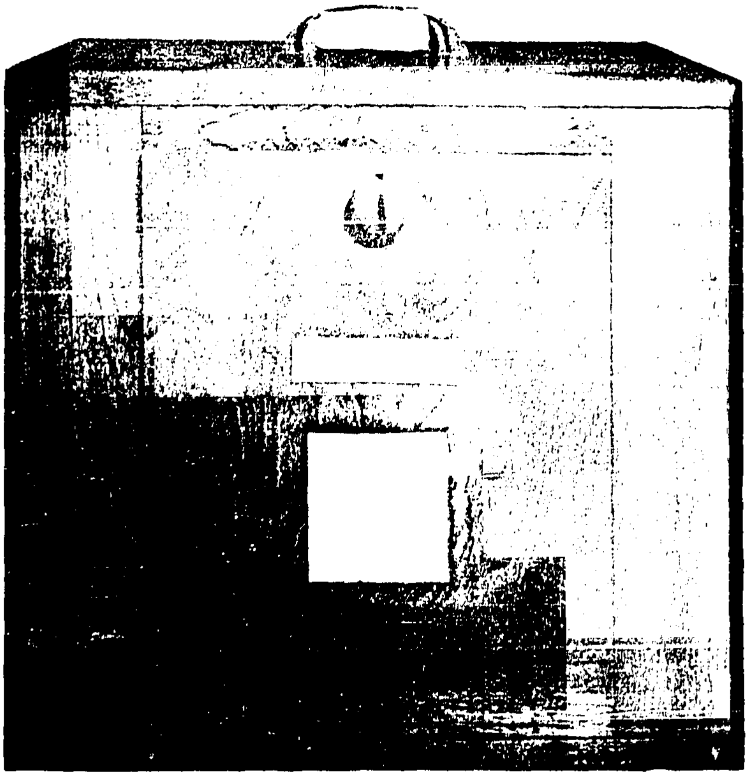

FIGURE I. FRONT VIEW, DOOR CLOSED

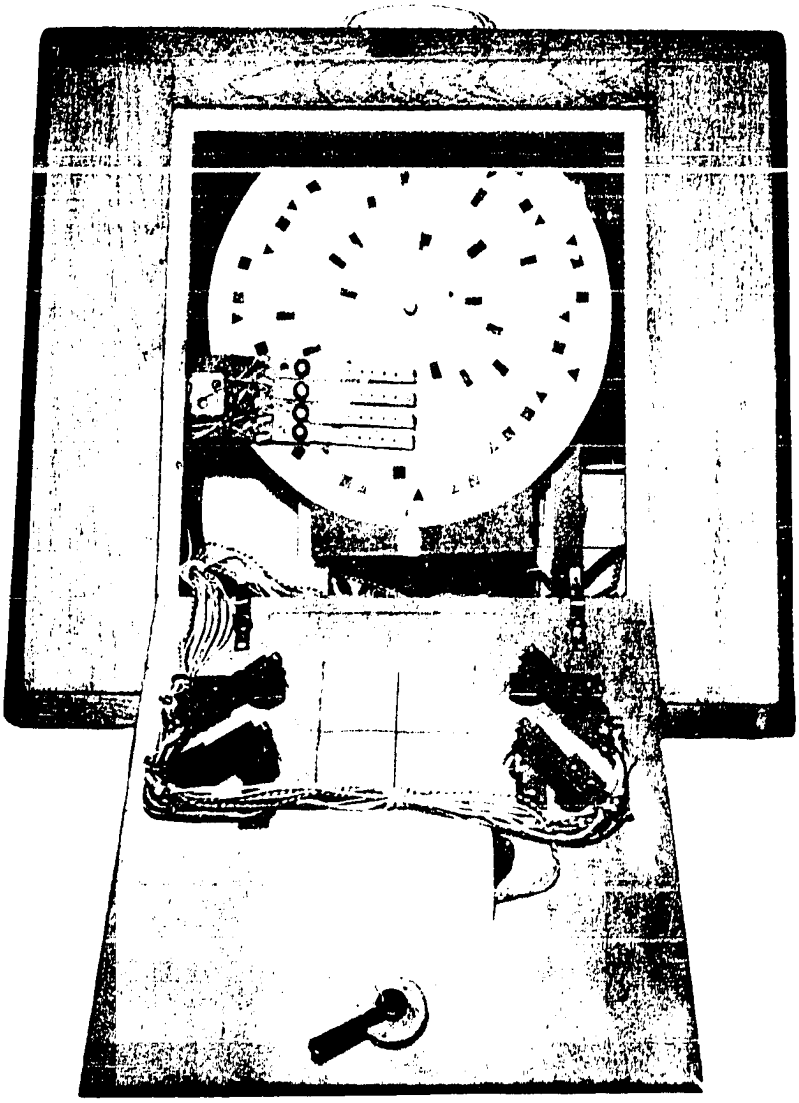

FIGURE 2. FRONT VIEW, DOOR OPEN

pressed. In the case of this particular problem (always the triangle), a red light will be produced on each trial when the button is pressed next to the triangle, no matter where the triangle appears on the screen. Another example of a correct solution to a problem is always pressing the button next to the figure when it appears on the left side of the screen. In this case, pressing the button next to a figure on the left side of the screen will produce a red light on each trial, no matter what figure appears on that side.

The following generalizations for correct solutions of problems in order of presentation were used in this study:

1. Always the triangle.
2. Always the green figure.
3. Always the figure on the right side of the window.
4. Always the red figure.
5. Always the figure appearing on the left side of the window.
6. Alternation--triangle to square.
7. Alternation--red to green figure square.
8. Always the red square, then green triangle.
9. Always the green square, then red triangle.
10. Always the square figure when figures appear horizontally on the window; always the triangle when figures appear diagonally on the screen.
11. Always the red figure when figures appear in a horizontal position on the window; always the green figure when figures are diagonal on the window.

A demonstration problem (always the square) was used but was not included in the series.

CHAPTER III

PROCEDURE

Operational Rules

Experience gained through the preliminary investigation at the University School, Norman, Oklahoma, provided the experimenter with certain operational rules regarding the problem box. They were as follows:

1. A maximum number of 100 trials was allowed each subject on any problem.

2. Two types of solutions were accepted. The problem was considered solved after ten successive red lights were obtained or after verbalization of the correct hypothesis occurred.

3. No session was terminated until the subject had an opportunity to attempt to solve every problem in the series.

The order of presentation was not altered throughout the experiment. Individual examination on the problem box required from thirty minutes to one and one-half hours.

The Subjects

Selection

This experiment was designed to provide a means of comparing performances on the problem box of two groups of bright and two groups of dull children.[32] Several comparisons were possible in terms of three types of data: (1) the average number of problems solved, (2) the average number of trials, and (3) the frequency of verbal generalizations.

Criteria for selecting the subjects were: (1) chronological age, (2) mental age, (3) sex, (4) level of intelligence, and (5) no apparent emotional disturbance.

No subjects with reported emotional disturbances were used in this study. Test data and information from classroom teachers provided the experimenter with information concerning the relative social and school adjustments of the children.

Comparison

The following types of comparisons were made: (1) chronological age, (2) mental age, and (3) I. Q., or brightness.

Six comparisons were possible in terms of the obtained experimental results:

1. Comparisons of older dull and younger dull

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[32] Two groups of dull children and two groups of bright children hereafter referred to as younger dulls, older dulls, and younger brights and older brights.

subjects, holding brightness constant but varying chronological age and mental age.

2. Comparisons of older dull and older bright subjects, holding chronological age constant but varying mental age.

3. Comparisons of older dull and younger bright subjects with the same mental age but different chronological age and I.Q.

4. Comparisons of younger dull and younger bright subjects with the same chronological age but different mental age and I.Q.

5. Comparisons of older brights and younger brights with the same I.Q. but different chronological age and mental age.

6. Comparisons of younger dull and older bright subjects where all factors varied.

These comparisons provided a means of analyzing the success or failure of bright and dull children on the problem box in terms of increased chronological age and intelligence.

Description

The subjects used in this study were obtained from the Public Schools, Oklahoma City, Oklahoma; Public Schools, Putnam City, Oklahoma; and the University School, Norman, Oklahoma.

Thirty-seven subjects were used in this study. There were nine dull subjects approximately seven years of age, with a mental age of approximately six years; nine dull subjects approximately twelve and one-half years of age, with mental age of approximately nine and one-half years; ten bright subjects approximately seven years of age, with a mental age of approximately nine and one-half years; nine older brights approximately twelve and one-half years of age with a mental age of approximately sixteen years. A complete description of the subjects is given in Table 1. It may be seen that the older dull children and the younger bright children are approximately the same mental age. The purpose of this selection of subjects was to make possible a number of comparisons in terms of chronological age, mental age, and brightness.

All necessary test information used in selecting the subjects was obtained from the schools which provided the subjects. Intelligence test data were based on results from California Tests of Mental Maturity and Stanford-Binet scores. All subjects used in the study had been tested within three months prior to the time of the experiment.

TABLE 1

BRIGHT AND DULL SUBJECTS LISTING NUMBER, SEX, CHRONOLOGICAL AGE, AND MENTAL AGE

Dull				Bright			
Number	Sex	Chron. Age	Mental Age	Number	Sex	Chron. Age	Mental Age
1	M	7-2	6-1	1	M	7-3	9-3
2	M	7-3	6-2	2	F	7-3	9-1
3	M	7-1	6-2	3	F	7-2	9-4
4	F	7-4	6-4	4	F	7-3	9-3
5	M	7-1	6-0	5	F	7-3	9-3
6	M	7-2	6-1	6	M	7-4	9-2
7	F	7-3	6-2	7	M	7-3	9-3
8	F	7-0	6-2	8	M	7-3	9-10
9	M	7-2	6-1	9	M	7-3	9-2
10	F	12-10	9-9	10	M	7-4	9-4
11	F	12-4	8-10	11	M	12-8	15-10
12	F	12-5	9-10	12	M	12-5	16-0
13	F	12-8	9-7	13	F	12-7	16-2
14	M	12-6	8-9	14	F	12-6	15-8
15	M	12-8	9-0	15	M	12-10	16-2
16	M	12-8	8-10	16	M	12-7	16-1
17	M	12-4	9-7	17	M	12-6	15-8
18	M	12-5	9-1	18	M	12-6	16-3
				19	F	12-9	16-0

CHAPTER IV

RESULTS

Detailed results of this study are presented in tabular form in the Appendix.

The experimental results are given in Tables 2 through 6. Four types of experimental results are reported for each of the four groups of dull and bright children:

1. The number of problems solved by each subject.
2. The particular problems solved by each subject.
3. The number of trials used by each subject per problem solved.
4. The frequency of solution with verbal generalization.

An examination of the results show that the older brights solved an average of 8.5 or 77 per cent of the problems. The younger brights solved an average of 4.9 or 44 per cent of the problems. The older dulls solved an average of 5.2 or 47 per cent of the problems and the younger dulls solved an average of 1.7 or 15 per cent of the problems. The older bright group was superior to the other groups in the number of problems solved.

Figure 3 shows the average number of problems solved and the percentage of problems solved by each of the four groups.

The number of trials used for solution is shown in Figures 4, 5, and 6. Figure 4 shows the average number of trials used by each group for all problems. The average number of trials for each problem is shown in Figures 5 and 6. Since all subjects were tested on all problems and allowed a maximum of one hundred trials per problem, the number of trials used is based on both solved and unsolved problems. For all eleven problems the older brights used an average of 35.5 trials; the older dulls required an average of 67.5 trials; the younger brights required an average of 67.6 trials; and the younger dulls used an average of 94 trials.

The first five problems in the test were solved by more subjects and required fewer trials. A comparison of the number of trials required by each group on these problems only reveals that older brights required fewer trials than subjects of the other groups. The older brights required an average of 14 trials; the older dulls required an average of 40 trials; the younger brights required an average of 56 trials; and the younger dull subjects required an average of 82 trials. Tables 5 and 6 in the Appendix show the order of difficulty in terms of number of problems solved and number of trials necessary for solution.

The frequency of verbal generalizations for all four

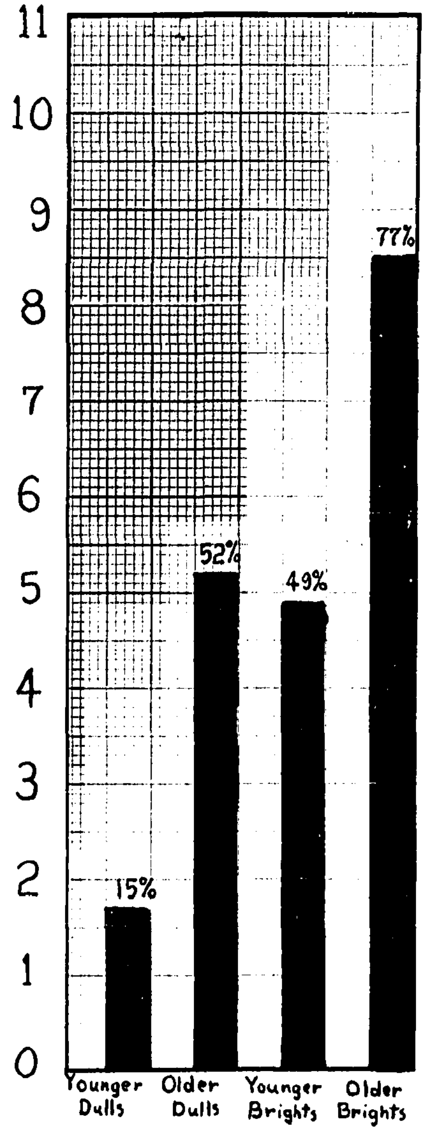

Fig. 3.--Average Number of Problems Solved and Percentage of Problems Solved by Each Group.

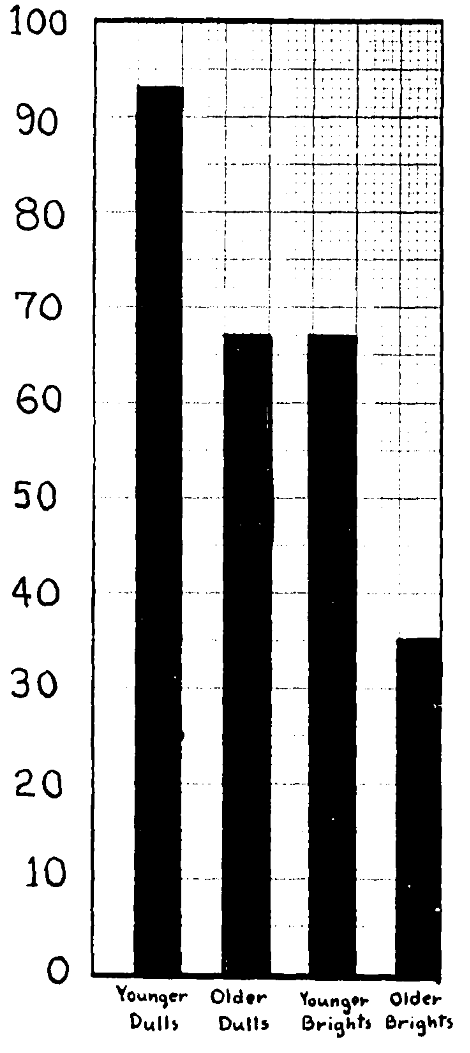

Fig. 4--Average Number of Trials Used by Each Group of Bright and Dull Subjects.

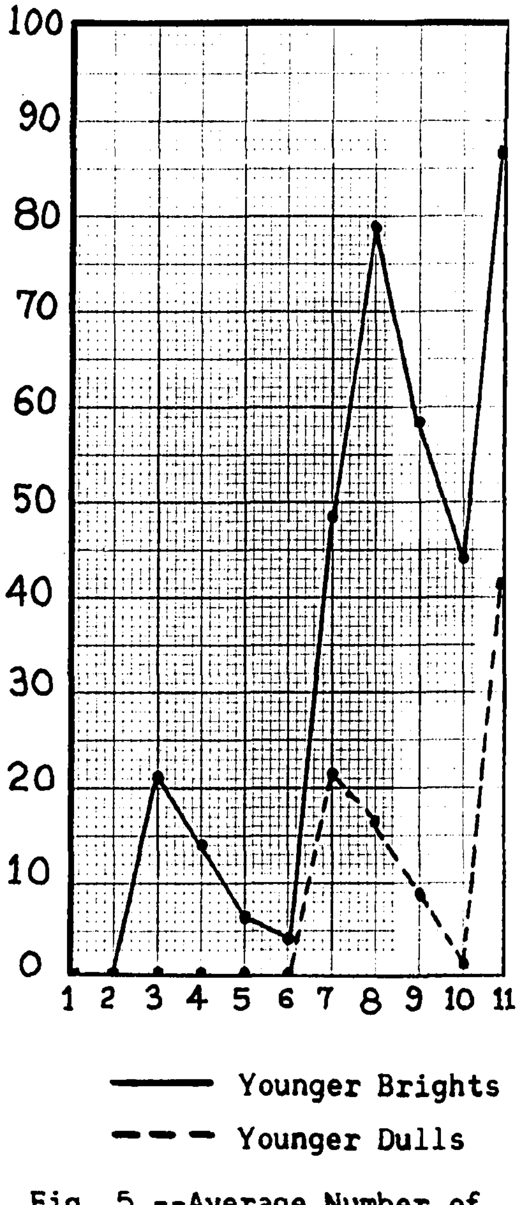

Fig. 5.--Average Number of Trials Per Problem by Younger Dull and Younger Bright Groups.

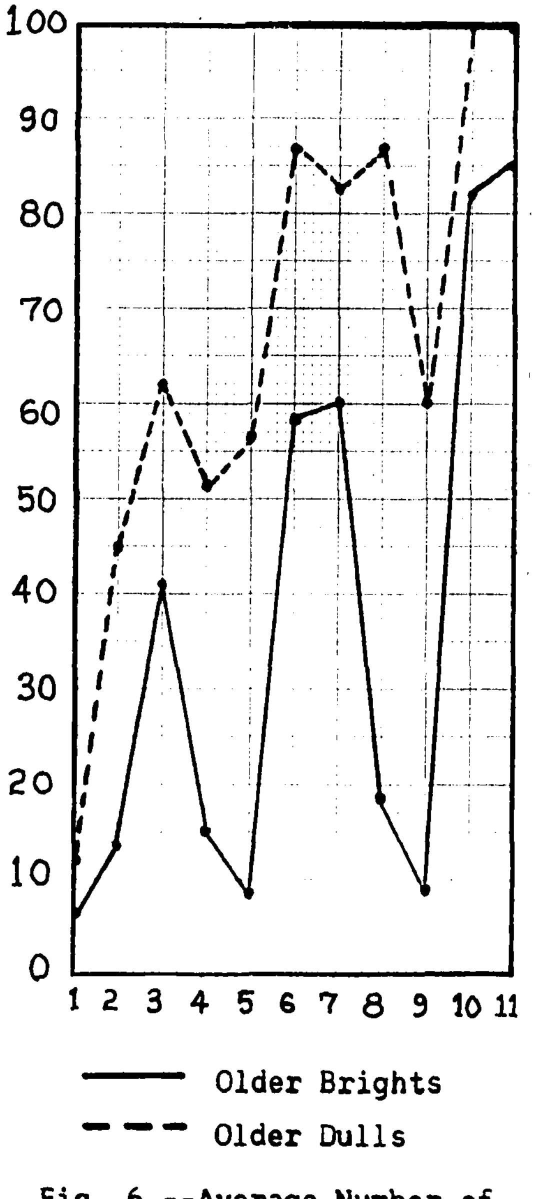

Fig. 6.--Average Number of Trials Per Problem by Older Dull and Older Bright Groups.

groups is shown in Figures 7 and 8. Figure 7 shows the average number of problems solved with verbal generalization by each of the four groups. Figure 8 shows the percentage of problems solved with verbal generalizations.

The older brights gave verbalizations on all problems they solved. The young brights were able to give verbalizations on 98 per cent of the problems they solved. The older dulls were able to give verbalizations on 66 per cent of the problems they solved. The young dulls were able to give verbal generalizations on 19 per cent of the problems they solved.

A comparison of groups of subjects of the same I.Q. but of varying mental age and chronological age reveals that older brights are superior to younger brights in the number or percentage of problems solved. There was no appreciable difference, however, in the percentage of solutions with verbal generalizations.

Another comparison of subjects of the same I.Q. but of varying chronological age and mental age reveals that older dulls are superior to younger dulls in the number or percentage of problems solved and the percentage of problems solved with verbal generalizations.

A comparison of subjects with the same chronological age but varying mental age reveals that older brights are superior to older dulls in the number or percentage of problems solved and in the percentage of solutions with verbal generalizations.

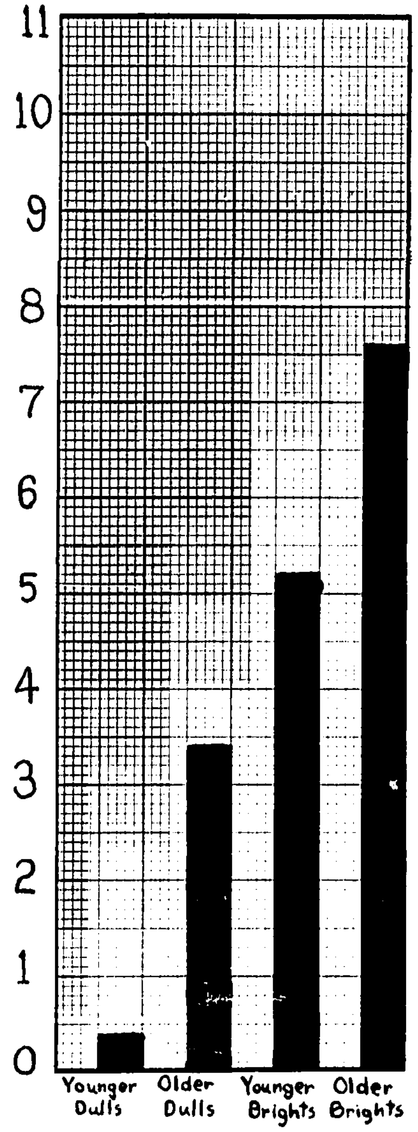

Fig. 7.--Average Number of Problems Solved with Verbal Generalizations by Groups.

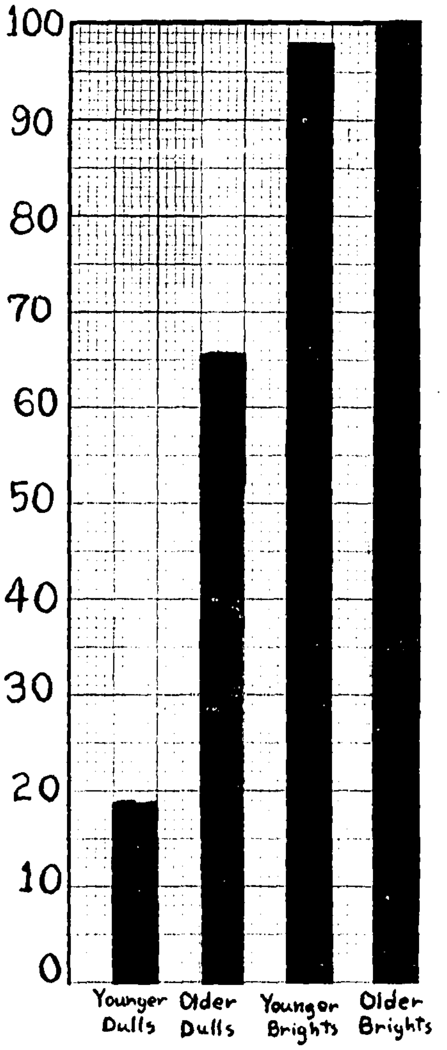

Fig. 8.--Percentage of Problems Solved with Verbal Generalizations by Groups.

A second comparison of subjects of the same chronological age but varying mental age reveals that younger brights are superior to younger dulls in the number or percentage of problems solved and in the percentage of solutions with verbalizations.

A comparison of subjects of the same mental age but varying chronological age reveals that there is no appreciable difference in the average number or percentage of problems solved by the older dulls and younger brights, but there is a difference in the number of solutions with verbal generalizations. The younger brights were able to give verbal generalizations on 98 per cent of the problems they solved as compared to 66 per cent for the older dulls.

It may be observed that in comparing performance on the problem box there is a difference in the number of problems solved wherever chronological age is held constant and mental age is varied. This difference is in the direction of increased mental age. Furthermore, there is a difference in the number of problems solved wherever I.Q. is held constant and mental age and chronological age is varied. This difference is in the direction of increased mental age and chronological age. Wherever mental age varies, there is an increase in the number of problems solved in the direction of the increase in mental age. Only when mental age is the same is there no difference in the number of problems solved.

In terms of these data it appears that mental age is probably a more discriminating factor than either chronological age or brightness in the number of problems solved.

When the same comparisons are made using frequency of verbal generalizations as the standard of comparison, it may be seen that there is a difference wherever chronological age is held constant and mental age is varied. This difference is in the direction of increased mental age and brightness. There is also a difference in the percentage of solutions with verbal generalization when mental age is held constant and chronological age and I.Q. are varied. This difference is in the direction of increased I.Q. or brightness. When I.Q. is held constant when older dulls and younger dulls are compared, there is a difference in the direction of increased chronological age; but when I.Q. is held constant when comparing younger brights with older brights, there is no appreciable difference in the percentage of solutions with verbal generalizations. In terms of these data brightness is probably a more discriminating factor than either chronological age or mental age in the frequency of solutions with verbal generalizations.

The same comparisons using the number of trials as the standard yields the same results as were found when comparing the number of problems solved. The smallest difference occurs when mental age is held constant as in the case of older dulls and younger brights. The number of trials used decreases as mental age, chronological age, and I.Q. increase;

but it appears that in terms of these data, mental age may be a more discriminating factor than chronological age or brightness in the number of trials required. The number of trials may be the least important aspect of problem solving in this study. There was considerable variation within each group of bright and dull subjects in the number of trials required to solve any given problem.

The older brights were able to solve problems throughout the entire series. Younger brights and older dulls achieved correct solutions through problem nine but none were able to solve problem ten or eleven. Problems eight, nine, ten, and eleven involved second order generalizations; that is, the correct generalization depended upon a condition or relationship between the two figures. Problems eight and nine were readily solved with verbal generalization by all the older brights. Three older dulls solved problem eight but only one achieved verbal generalization. Five older dulls solved problem nine but only two achieved verbal generalizations. Only two younger brights solved problem eight but both solutions were with verbal generalizations. Three younger brights solved problem nine, all with verbal generalizations. The correct solutions for problems eight and nine were red triangle, green square, and green triangle, red square, respectively. The older dulls solving the problem frequently gave the wrong generalization. When asked to repeat their performance on the problem box, they would continue to get the red light to flash by pressing the correct buttons. The fact that the older dulls were able to solve certain of the more difficult problems may indicate that although they were unable to verbalize their solutions, generalizations probably did occur but not at a level where they could be verbalized.

Although the younger dulls were able to solve certain of the easy problems, there were only three solutions with verbal generalizations. These occurred on problem one (always the triangle) and problem three (always the one on the right). The data sheets for the younger dulls revealed a lack of organization and an inability to formulate and test good hypotheses. The inability of the younger dulls to derive and test good hypotheses and their inability to solve more problems probably indicated that solutions to the problems which were solved were achieved purely by trial and error.

An inspection of the data sheets reveals that the older dulls, older brights, and younger brights showed good organizational ability and were able to derive good hypotheses from the data on problems one through five. That the brights were able to verbalize more generalizations on the problems they solved throughout the entire series is indicative of their superior ability to organize the data, formulate meaningful hypotheses, and test those hypotheses. In terms of these data the ability to formulate and test good hypotheses would appear to be an important factor in solving successfully more complex problems.

CHAPTER V

SUMMARY AND CONCLUSIONS

In a comparative study of problem solving, nine dull children seven years of age, nine dull children twelve and one-half years of age, ten bright children seven years of age, and nine bright children twelve and one-half years of age were tested on a multiple choice problem box. Comparisons were made between groups of subjects of the same I.Q., but of varying chronological age and mental age; of the same chronological age but of varying mental age; and of the same mental age but of varying chronological age and I.Q.

The following conclusions were reached:

1. The brights were superior to the dull in the number of problems solved at both chronological age levels. There was no appreciable difference in the number of problems solved by the younger brights and older dulls of the same mental age.

2. The brights were superior to the dull in the number of trials at each age level. The younger brights and older dulls of the same mental age required approximately the same number of trials.

3. A comparison on the basis of mental age, chronological age, and intelligence revealed that in terms of these data, the ability to solve problems was probably more a function of mental age than chronological age or intelligence.

4. The bright children were superior to the dull in frequency of verbal generalization at both age levels. The younger brights were superior to the older dulls in the percentage of problems solved with verbal generalization.

5. Comparisons of the dull and bright children of the same mental age revealed that the bright children were superior in their ability to give verbal generalizations. In terms of these data, brightness was probably a more discriminating factor than either chronological age or mental age in the ability to verbalize their generalizations.

6. No conclusions were possible regarding the inability of the younger dull children to solve more problems. Their failure to organize the data plus their inability to achieve verbal generalizations suggested that solutions were achieved in a random or trial and error manner.

7. The failure to achieve verbal generalization would appear to be the chief point of differentiation between the older dull children and the younger bright children.

Suggestions for Further Research

1. A further investigation should be made using average subjects at each of the chronological age levels tested.

2. A further investigation should be made using additional complex problems and testing bright and dull subjects of higher age levels.

3. A further investigation should be made extending the chronological age levels below and above the seven year level.

4. Further comparative studies of problem solving should be made using a larger number of older dull and younger bright subjects of the same mental age.

5. Further studies should be made concerning the role of order of presentation of problems.

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APPENDIX

TABLE 2

DULL AND BRIGHT GROUPS SHOWING THE NUMBER OF PROBLEMS SOLVED
AND THE NUMBERS OF PROBLEMS SOLVED

Dull			Bright		
Subject	Problems Solved	Problem Numbers	Subject	Problems Solved	Problem Numbers
1	1	1	1	5	1,2,3,4,5
2	1	4	2	4	1,4,6,7
3	4	2,3,4,5	3	4	1,3,4,5
4	1	1	4	5	1,2,3,4,5
5	1	1	5	4	1,2,3,4
6	3	1,3,5	6	4	1,2,3,4
7	3	1,4,5	7	4	1,2,3,4
8	2	4,5	8	7	1,2,3,4,5,8,9
			9	7	1,2,3,4,5,8,9
10	0	--	10	7	1,2,3,4,5,7,9
11	2	1,4	11	9	1,2,3,4,5,8,9,10,11
12	8	1,2,3,4,5,6,7,8	12	7	1,2,3,4,5,8,9
13	4	1,3,4,6	13	9	1,2,3,4,5,6,7,8,9
14	6	1,2,3,5,8,9	14	9	1,2,3,4,5,8,9,10,11
15	6	1,2,3,4,5,9	15	9	1,2,3,4,5,6,7,8,9
16	3	1,2,4	16	9	1,2,3,4,5,6,7,8,9
17	5	1,3,6,8,9	17	8	1,2,4,5,6,7,8,9
18	8	1,2,3,4,5,6,7,9	18	9	1,2,3,4,5,8,9,10,11
19	5	1,2,3,4,5	19	8	1,2,4,5,6,7,8,9

TABLE 3

TRIALS PER PROBLEM SOLVED BY THE BRIGHT GROUPS

Subject	Problem Numbers										
	1	2	3	4	5	6	7	8	9	10	11
1	20	80	72	11	20	-	-	-	-	-	-
2	11	-	-	10	-	63	64	-	-	-	-
3	8	-	34	62	20	-	-	-	-	-	-
4	14	66	19	10	12	-	-	-	-	-	-
5	27	100	46	68	-	-	-	-	-	-	-
6	6	29	32	14	-	-	-	-	-	-	-
7	31	57	33	8	-	-	-	-	-	-	-
8	6	13	57	11	47	-	-	44	30	-	-
9	15	13	15	9	10	-	-	18	6	-	-
10	6	11	13	9	13	-	76	-	59	-	-
11	8	33	74	6	6	-	-	8	6	31	58
12	6	11	18	18	9	-	-	6	29	-	-
13	6	20	19	6	6	57	100	42	6	-	-
14	6	15	18	6	9	-	-	12	9	40	8
15	6	12	11	76	9	16	8	6	6	-	-
16	6	6	28	6	6	30	10	11	6	-	-
17	6	20	-	6	14	9	8	26	6	-	-
18	6	8	9	9	8	-	-	15	6	80	100
19	7	6	-	6	9	15	15	47	8	-	-

TABLE 4

TRIALS PER PROBLEM SOLVED BY THE DULL GROUPS

Subject	Problem Numbers										
	1	2	3	4	5	6	7	8	9	10	11
1	40	-	-	-	-	-	-	-	-	-	-
2	-	-	-	15	-	-	-	-	-	-	-
3	-	91	100	85	15	-	-	-	-	-	-
4	8	-	-	-	-	-	-	-	-	-	-
5	12	-	-	-	-	-	-	-	-	-	-
6	22	-	39	-	91	-	-	-	-	-	-
7	57	-	-	64	87	-	-	-	-	-	-
8	-	-	83	-	19	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-
10	8	-	-	99	-	-	-	-	-	-	-
11	8	13	27	13	40	-	20	89	73	-	-
12	12	-	100	55	-	46	-	-	-	-	-
13	6	48	49	-	17	-	-	75	10	-	-
14	20	10	62	13	25	-	-	-	10	-	-
15	26	18	-	57	-	-	-	-	-	-	-
16	14	-	34	-	-	60	-	12	7	-	-
17	7	6	67	16	18	74	31	-	44	-	-
18	9	11	20	7	11	-	-	-	-	-	-

TABLE 5

ORDER OF DIFFICULTY ACCORDING TO FREQUENCY OF SOLUTION
BY THE FOUR GROUPS OF DULL AND BRIGHT CHILDREN

Bright Subjects		Dull Subjects	
Younger	Older	Younger	Older
Problem Number	Problem Number	Problem Number	Problem Number
11	11		11
10	10		10
6	7		6
7	6		8
8	3		7
9	8		3
2	4	2	9
5	2	4	5
3	9	5	4
4	5	3	2
1	1	1	1

TABLE 6

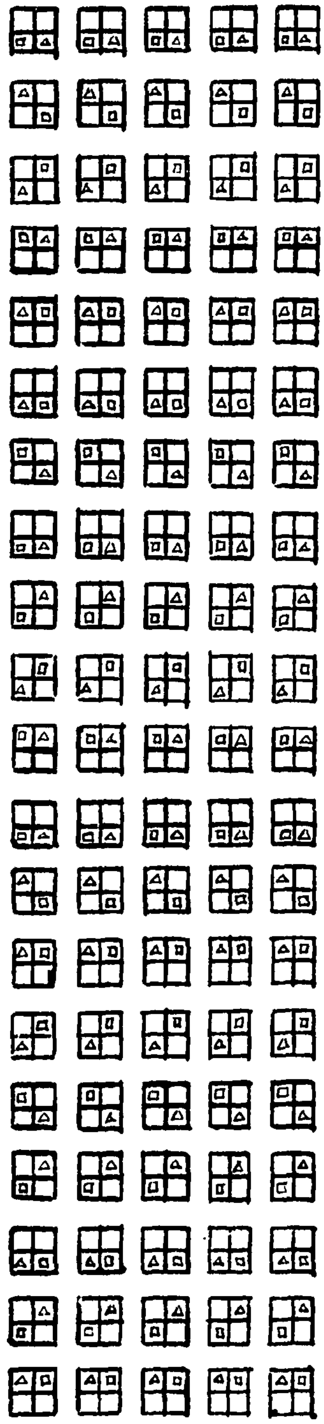
ORDER OF DIFFICULTY OF PROBLEMS ACCORDING TO THE AVERAGE NUMBER OF TRIALS BY THE FOUR GROUPS OF DULL AND BRIGHT CHILDREN

Bright Subjects		Dull Subjects	
Younger	Older	Younger	Older
Problem Number	Problem Number	Problem Number	Problem Number
11 10 6 7 8 9	11 10 7 6 3 8		11 10 6 8 7 3
2 5 3 4 1	4 2 9 5 1	2 4 5 3 1	9 5 4 2 1

TABLE 7

DULL AND BRIGHT GROUPS SHOWING THE FREQUENCY OF VERBAL GENERALIZATION

Problem	Bright Subjects				Dull Subjects			
	Younger		Older		Younger		Older	
	Total Number of Solutions	Solutions with Verbal Generalization	Total Number of Solutions	Solutions with Verbal Generalization	Total Number of Solutions	Solutions with Verbal Generalization	Total Number of Solutions	Solutions with Verbal Generalization
1.	10	10	9	9	5	2	9	7
2.	7	6	9	9	1	0	5	4
3.	8	8	7	7	3	1	8	4
4.	10	10	9	9	3	0	6	4
5.	8	8	7	9	4	0	6	6
6.	1	1	6	6	0	0	3	2
7.	2	2	5	5	0	0	2	1
8.	2	2	9	9	0	0	3	1
9.	3	3	9	9	0	0	5	2
10.	0	0	3	3	0	0	0	0
11.	0	0	[illegible]	3	0	0	0	0



DATA SHEET