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FORMAL OPERATIONS AND ORGANIZATIONAL MEMORY STRATEGIES IN BRIGHT ADOLESCENTS

by

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The present research was designed to test the hypothesis that individual differences in organizational memory strategies are associated with formal and non-formal status as defined by Piaget. It was predicted that (a) both formal and non-formal adolescents would employ organizational strategies but that differences would occur in the efficiency with which the strategy was used and (b) if organization were induced, the non-formal adolescent would profit.

Six Piagetian tasks were used to identify seven boys and seven girls who are formal-operational and seven boys and seven girls who are not formal-operational. The subjects were selected from a pool of 15-year-old, ninth-grade adolescents with Lorge-Thorndike scores over 115. After the subjects received the Piagetian tasks, they were given a six-trial free recall of unrelated words task. In a second session, subjects were administered a six-trial free recall of categorized words task. The categorized words task was followed by a metamemory inventory in which the children described their approaches to real-world situations, involving memory of such items as locker combinations, material for tests, and items to buy in a grocery store. In a third session, subjects received a sort-to-criterion task, in which they sorted a set of words into as many piles as they wished. After they achieved the criterion of two identical sorts, they were asked to recall the words. The adolescents then answered metamemory questions concerning the strategies which they had used in the memory tasks.

Organizational differences were associated with operational status. In the free recall of categorized words task, the formal children clustered more than did the non-formal children. In the sorting task, the formal children needed only half the number of trials that were required by the non-formal children to reach criterion. In the free recall of unrelated words task, subjective organization increased across trials for the formal children but did not increase for the non-formal children. In the analysis of subjective organization, an interaction between sex and operations occurred. The formal boys surpassed the non-formal males, but the formal and non-formal females did not differ.

Metamemory results indicated that the formal children reported more systematic, orderly approaches to real-world situations than did the non-formal children. The non-formal adolescents profited when organization was induced; there were no differences between the two groups in recall organization when all subjects were required to reach a stable organization in the sorting task.

Recall differences paralleled organizational differences. In the free recall of categorized and unrelated words, the formal children were superior in recall on all trials except the first. A sex x operations interaction similar to the one described above occurred in the analysis of the free recall of unrelated words. Recall differences were minimal in the sorting task.

The results seem significant in bringing about a rapprochement between Piagetian and information-processing approaches to cognitive development. Strategies which information-processing theorists consider important have been related to the stages of cognitive development which Piagetian theorists postulate.

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CHAPTER I

INTRODUCTION

The fact that there are individual differences in memory strategies is certain. What is uncertain is the reason for these differences. Memory theorists have described information-processing models of memory and have concerned themselves primarily with strategies common to all people. Differences, for the most part, have been attributed to error variance. A few investigators, however, have probed individual differences. Earhard, for example (Earhard, 1967; Earhard & Endicott, 1969), analyzed the memory strategies of subjects who imposed a great deal of organization upon lists and subjects who imposed very little organization upon lists. Geis and Corriher (1977) compared the memory strategies of high-IQ children and average-IQ children. Hunt, Lunneborg, and Lewis (1975) compared the memory strategies of high-verbal college students with the memory strategies of low-verbal college students.

The present research is concerned with an additional explanation of individual differences in memory strategies: persons who are formal-operational in their thought may differ in their memory strategies from persons who are non-formal-operational in their thought. The purpose of the introduction of this paper is to describe Piagetian notions of formal-operational thought and its assessment and to describe information-processing concepts of a central processor and control processes. The development of formal-operational thought will be related to developmental changes in control processes; these changes will be related to current developmental approaches to memory. It will be argued that organization is a memory strategy whose utilization may be related to formal-operational thought. There may be evidence, not of a lack of organizational strategies in non-formal operational persons, but differences in the efficiency and systematic application of available strategies. An experiment testing the hypothesis that there is a relationship between formal-operational thought and systematic memory strategies will be outlined.

Formal-Operational Thought

Characteristics. According to Piaget (Inhelder & Piaget, 1958), formal-operational thought is the culmination of stage-dependent cognitive development. The formal-operational adolescent is concerned with the possible, not just the real and concrete in front of him. He can systematically consider all possibilities. Formal-operational thought is hypothetico-deductive; the adolescent can formulate an hypothesis and determine what should occur if the hypothesis is true. He can then test his hypothesis by seeing what, in fact, does occur.

Piaget's formal-operational thought system may be described by propositional logic. Copi, in his Introduction to Logic (1972, p. 6-7), explains that a proposition may be understood as a statement. There must be more than one proposition or statement in order to reach a conclusion. Boolean logic, upon which Piaget's system is based, employs binary or two opposing propositions. One such set of binary propositions is affirmation versus negation. The adolescent who affirms that the length of the string determines the arc of the pendulum also realizes he cannot say "length does not matter." The formal-operational adolescent can use the approach of implication. For example, he can reason, "If I add a third liquid to the vessel, then it will turn yellow," at the same time he uses nonimplication and can reason "but adding water will make no difference." He can combine propositions in order to reach a conclusion. He can pursue a course, find it wrong, and systematically select another course. Formal-operational thought, in short, is flexible, exhaustive, and methodical.

Piaget admits that his picture of the adolescent may be an optimal one in some instances and not always typical:

> Recent research has shown that subjects from other types of schools or different social environments sometimes give results differing more or less from the norms indicated. . . This does not mean that our observations have not been confirmed in many cases: they seem to be true for certain populations, but the main problem is to understand why there are exceptions and also whether these are real or apparent. (1972, p. 6)

Assessment of formal-operational thought. Although 9% of all manuscripts submitted to Developmental Psychology from 1968 through 1973 were Piagetian in approach (McCandless & Geis, 1975), only a small proportion of this research pertained to formal-operational thought. In most studies researchers have used the 15 original Inhelder and Piaget (1958) tasks in order to explore the nature of formal-operational thought. There have been no replications of all 15 tasks given to one subject, and certain of the tasks have been more frequently used than others.

Oscillation of the Pendulum, Combination of Colored and Colorless Chemicals, and Equilibrium in the Balance are among the most popular tasks.

In the pendulum task, the child is given a string which can be shortened and lengthened and a set of varying weights. He must discover, by exclusion, that the heaviness of the weight and push on the weight do not determine the pendulum arc. He must discover that only the length of the string affects the arc. Although Jackson (1965) found that no subjects in a sample of normal children aged 5 through 15 showed formal-operational thinking in the pendulum task, Pratt and Wyatt (1973) and Ross (1973) obtained a ceiling effect with this task.

In the combination of chemicals task, the child is given five flasks of chemicals: diluted sulphuric acid, water, oxygenated water (peroxide), thiosulphate, and potassium iodide (*g*). He must systematically determine that diluted sulphuric acid plus peroxide plus potassium iodide (*g*) will produce a yellow color, while the addition of thiosulphate will bleach the mixture. To be considered formal-operational, the child must conclude that the yellow color is produced by a combination of three chemicals. Lovell (1961) found a significant correlation (w = .59) between performance on this task and performance on other Piagetian tasks. Stephens, McLaughlin, and Mahaney (1971) found that the average mental age at which this task was accomplished was 15. On the basis of these results, it seems that the combination of chemicals task has formal-operational predictive validity.

In the balance task, the child is presented a balance and weights (dolls in baskets). The child must discover that a small weight combined with great distance is equivalent to a large weight with a small distance. Jackson (1965) reported that no subjects aged 5 through 15 reached formal-operations on the balance task, while Lovell (1961) reported that no subjects aged 8 through adult reached advanced formal-operations. Lovell and Shields (1967) reported that 10% of their 50 8- to 10-year-old subjects (with WISC verbal scores 140 or more) reached formal-operational thought on the balance task. Pratt and Wyatt (1973) found a correlation (ρ = .94) between age level and stage on this task. Webb (1974) found that 4 11-year-old boys of 25 bright (IQ over 160) children reached formal-operational thought in the balance task. Thus, this task seems to be a useful one in separating formal-operational children from non-formal-operational children.

Three other tasks which have not been as widely used but which have been found to differentiate formal thinking in previous research by the author are Hauling Weight on an Inclined Plane, The Equality of Angles of Incidence and Reflection, and Conservation of Motion in a Horizontal Plane (Pratt & Wyatt, 1973).

In Hauling Weight on an Inclined Plane, the child is given a toy dump truck suspended by a cable. The truck hauls weights on an inclined plane by counterweights at the end of the cable. The counterweights and the angle of the plane can be adjusted, and weights may be added to the truck. The child must coordinate the weight in the truck, the incline of the plane, and the weight on the counterweights. In addition, he must understand that there is a proportion between the weights and the incline of the plane (Inhelder & Piaget, 1958).

In the Equality of Angles of Incidence and Reflection task, the child is given an apparatus with a tubular spring plunger which can be aimed to shoot a ball at a projection wall so that the ball will rebound to hit drawings placed at various points. The child is then asked how to aim the marbles so as to hit a particular drawing. To be considered formal-operational, the child must recognize that the angle of incidence must equal the angle of reflection.

The Conservation of Motion in a Horizontal Plane task employs a spring device which launches balls of various sizes and materials. The child is asked to launch a ball and predict where the ball will stop and why it will not go farther. To be considered formal-operational, the child must incorporate the principles of inertia, friction, and resistance in his explanation.

Piaget's Stages of Cognitive Development

On the basis of detailed observations of children and adolescents, Piaget describes stage-dependent cognitive development. First, there is a sensorimotor stage bounded by the approximate ages of birth to two years. In this stage the child utilizes certain elementary schemata (generalized behavior patterns) for dealing with the external environment. Symbolic behavior appears in its elementary forms (Inhelder & Piaget, 1958). This symbolic behavior begins at approximately two years of age and marks the beginnings of the preoperational stage, which lasts about four years. The hallmark of the preoperational stage is the beginning of language.

Inhelder and Piaget consistently designate the preoperational period as Stage I in formal-operational development (Inhelder & Piaget, 1958). The Stage I child is concerned with his practical success or failure. He gives precausal explanations, failing to distinguish between his actions and the external process. For example, his explanation of why the chemicals lose color is that "The syrup has gone away" (Inhelder & Piaget, 1958, p. 110). In the balance task, he pushes on the balance and says, in answer to "Can you make it straight?", "You can't!" (Inhelder & Piaget, 1958, p. 166). In the inclined plane task, the Stage I child again does not distinguish between his own actions and objective processes; when he is asked "What can you do?", he replies, "Push it!" (Inhelder & Piaget, 1958, p. 183).

Concrete operations appear at approximately age seven. Inhelder and Piaget describe this stage:

> By concrete operations we mean actions which are not only internalized but are also integrated with other actions to form general reversible systems. Secondly, as a result of their internalized and integrated nature, concrete operations are actions accompanied by an awareness on the part of the subject of the techniques and coordinations of his own behavior. (1958, p. 6)

In early concrete operations (Stage II-A), the child does not question why he succeeds. In advanced concrete operations (Stage II-B), there is a more accurate formulation of why. For example, in the balance task, in early concrete operations the child says, "I should put one on each side" (Inhelder & Piaget, 1958, p. 169). In late concrete operations, he formulates, "because that one is there and it is less heavy than the other one" (Inhelder & Piaget, 1958, p. 171). In the combinations of chemicals task, the Stage II-A child systematically multiplies each factor by *g*; but when the experimenter asks what else can be done, he replies, "I don't know" (Inhelder & Piaget, 1958, p. 111). The II-B child, however, begins to multiply the chemicals and to use two by two and three by three combinations of the chemicals with *g* (Inhelder & Piaget, 1958).

Formal operations also consists of two substages. The early substage (III-A) is characterized by accurate experimentation; the later substage (III-B) is characterized by generalization and formulation of a law (Inhelder & Piaget, 1958). For example, in the inclined plane task, the III-A subject realizes that he must coordinate the weight on the truck, weight on the counterweight, and the incline of the plane; the III-B child also formulates the law, "The height is proportional to the weight" (Inhelder & Piaget, 1958, p. 195).

Lovell's transformation of Piaget's scale. Inhelder and Piaget subdivided Stages I through III into A and B substages. Lovell further subdivided these into nine stages thus providing transitional stages into which protocols that were doubtful might be placed. Pratt and Wyatt (1973) gave each of these nine stages an arabic number in order to simplify statistical analysis. In the diagram below, the arrows indicate where Lovell added transition stages; the numbers indicate the scores assigned to each stage by Pratt and Wyatt.

Piaget	I-A	I-B		II-A		II-B		III-A		III-B
Lovell	1	1	↓ 2	3	↓ 4	5	↓ 6	7	↓ 8	9

The Executive in Memory Theories

Memory theorists have increasingly emphasized the similarities between computers and humans and described memory processes in terms of information-processing. Input information to the sense organs is likened to input of card readers and tape drivers. Control processes which recode information by the action of neurons are comparable to control programs of electronic registers in computers. Output of information in humans by hand and mouth is analogous to teletype and line printers of computers (Loftus & Loftus, 1976).

A central processor. Earl Hunt in addressing the question "What Kind of Computer is Man?" gives an answer which includes the notion of an executive or central processor. Hunt writes:

> The system is characterized by a number of input channels containing buffer memories connected in series and a central computing device which contains a short term memory for information seen in the past few seconds, and an intermediate term memory which holds an abstract interpretation of events observed in the past few minutes. . . only the central device can write into long term memory. (1971, p. 57)

Neisser also offers a conception of a central processor:

> Common practice is to make all subroutines end by transferring control to the executive, which then decides what to do next in each case. One might well say that the executive "uses" the other routines, which are "subordinate" to it. Some programs may even have a hierarchial structure, in which routines at one level can call those which are "lower" and are themselves called by others which are "higher." However, the regress is not infinite--there is a "highest" or executive routine which is not used by anything else. (1967, p. 296)

Within an information-processing approach, a central processor, or executive, thus determines the way that stimulus input is processed. The concept of a central processor appears in the two widely cited models of memory, Atkinson and Shiffrin's multistore model (1969) and Craik and Lockhart's levels-of-processing model (1972).

Multistore model. In Atkinson and Shiffrin's (1969) model the distinction is made between structural components that represent the basic memory stores (the sensory register, the short-term store, and the long-term store), and the control processes that are selected, constructed, and used at the option of the subject. The computer analogy which Atkinson and Shiffrin describe is that the structural components are comparable to the computer hardware, while the control processes are analogous to the programs and instructions written by the computer programmer.

The control processes are not permanent features of memory; they depend upon the past history of the subject, the experimental task, and the instructional set. These subject-controlled processes may include mnemonics, coding techniques, or various schemes which the subject employs in an effort to remember (Atkinson & Shiffrin, 1969).

Levels-of-processing theory. Craik and Lockhart (1972) abandoned the box-storage approach of Atkinson and Shiffrin. According to their theory, the level of processing that an item receives determines its retention. Preliminary stages of processing involve analysis of physical and sensory features of stimuli. Later stages involve pattern recognition, extraction of meaning, and semantic elaboration.

Craik and Lockhart (1972, p. 681) distinguish between Type I processing which consists of recirculating a memory trace at a given depth of processing and Type II processing which entails further deeper analysis of the stimulus. Type II processing results in a more durable memory trace, while Type I processing does not enhance trace durability. Both types of processing are under the control of a limited-capacity central processor. Craik and Lockhart's framework, thus, focuses on the control processes described in Atkinson and Shiffrin's model.

Developmental changes in the central processor. In discussing the development of the processor, H. A. Simon concludes:

> A large part of all the changes that take place in a child's intellective processes during his development appears to be in the strategies or programs he carries around with him. (1972, p. 17)

Development of memory strategies may be dependent upon the development of a formal-operational processor. The concrete-operational child will be less likely to be systematic in selecting his memory strategies. He may not continue the same strategy throughout a list; he may use trial and error in selecting his strategy. If the strategy is not effective, he may nevertheless continue with it.

The formal-operational child will be more likely to look at memory as a problem-solving task and be more apt to look for a strategy in order to remember. He will consider all possibilities, and his executive processor will systematically apply strategies. He will evaluate the effectiveness of the strategy he is using and will shift or experiment with other strategies when necessary.

<u>A Formal-Operational Central Processor and Developmental Approaches to Memory</u>

The concept of a formal-operational processor is consistent with developmental approaches to memory.

<u>Piaget's theory of memory</u>. H. A. Simon comments on the development of the processor:

> ...during the long period when most of cognitive psychology lay frozen under glaciers of behaviorism--a glacierism that somehow never touched Swiss valleys--the area of child development, flourishing in these sheltered Alpine valleys, kept alive the concern for complex central processes. (1972, p. 5)

Piaget's theory of memory is summarized:

> The most likely hypothesis is that the memory code itself depends upon the subject's operations, and that therefore the code is modified during development and depends at any given moment upon the subject's operational level. (1968, p. 2)

Piaget considers memory, like other cognitive functions, dependent upon the stage at which the subject is functioning. Memory improves as the child grows older as a result of the development of his cognitive processes. While young children may be rigid rote memorizers, the older child is flexible and capable of abstracting. Inhelder (1969) describes memory as dependent upon operative functions and the child's level of operations. In this context, the concept of a formal-operational central processor is simply another description of Piaget's theory of memory.

<u>Reese's information-processing model of qualitative development</u>. The formal-operational central processor is quite consistent with Reese's conception of an information-processing model in which memory is an active system.

> ...what is remembered is not a set of stimulus-response associations, but rather a more or less highly organized set of materials, whose organization is imposed by the organism through various processing operations. What the organism does to the material determines what is remembered, and how it is remembered. (Reese, 1973, p. 407)

In describing developmental changes in the memory system, Reese argues that the most likely place to look for these developmental changes is in control processes and changes in the code (Reese, 1973, p. 412).

Brown's description of metamemorial knowledge and plans. Knowing about knowing is the phrase Ann Brown gives to the child's knowledge concerning the state and functioning of his own memory. According to Brown, young children are not proficient in this knowledge at all.

The young child appears oblivious to his memory limitations and is unaware that he can strategically intervene. He is not often faced with demands for exact reproduction of stud ɔd material, and some of his inefficiencies may be due to lack of practice. Brown believes that knowledge of one's own capacities plays a vital role in a person's ability to use effective and planful strategies (Brown, 1970). One could speculate that there would be differences in knowing about knowing between formal-operational adolescents and non-formal-operational adolescents. Formal-operational adolescents would be expected to be more systematic and reflective, and better able to evaluate their own processes.

Organization and Formal-Operational Thought

Definition. Webster defines organization as any unified systematic whole. Formal-operational thinking is characterized as a unified, systematic whole. Simply this congruence of definition might lead to an investigation of organization as a memory strategy related to formal-operational thought. There are, however, additional reasons for such an investigation. Loftus and Loftus (1976, p. 74) define organization as trying to make material fit into a framework or trying to create a new logical framework in order to bind material into a cohesive unit. Organization is so widely accepted as a memory strategy that the term appears even when one deliberately tries to avoid its use. Postman writes:

> The ultimate sign of success of a theoretical idea is that it comes to be taken for granted as a part of the current body of knowledge in a discipline. That is what has happened to the concept of organization in recall. (1975, p. 323)

Free recall of categorized words. One measure of organization in a free recall task is clustering. Subjects receive lists of words belonging to different taxonomic categories, e.g., name of animals, vegetables. Tulving defines clustering:

> The items are presented in random or quasi-random order, and organization is said to have occurred when items in a subset are recalled in immediately adjacent output positions more frequently than one would expect by chance. (1968, p. 26)

Geis and Hall (1976) summarized the results of developmental clustering studies. In the 20 free recall experiments which Geis and Hall reviewed, clustering increased with age in 18 of them.

There are several experimental manipulations that result in increased organization as measured by clustering and recall. These are blocked presentation, cued recall, and constrained recall (Cole, Frankel & Sharp, 1971; Moely & Shapiro, 1971; Yoshimura, Moely & Shapiro, 1971). In blocked presentation all instances of a category appear consecutively when the list is presented for study. Blocked presentation perhaps induces the child to store words more systematically. Cued recall consists of reminding subjects of categories as they appeared in the list at the time of recall, thus making the subject use a more systematic retrieval plan. Constrained recall occurs when subjects recall all members of a category after the experimenter gives the name of the category. Constrained recall may induce the subject to be systematic in his retrieval by requiring him to recall all of the words in a given category before attempting recall of words in other categories.

A formal-operational processor might spontaneously utilize organizational strategies which increase grouping and clustering at study and at test. In addition, differences between formal-operational and non-formal-operational subjects might diminish when the salience of list organization is enhanced by the experimenter, as in blocked presentation.

Free recall of unrelated words. In this task subjects are given unrelated words; the basis for organization is not built into the list as in categorized materials. Tulving defines subjective organization (SO):

> in terms of the subject's tendency to recall items in the same order on different trials in the absence of any experimentally manipulated sequential organization among items in the stimulus list. (1967, p. 270)

Prior to 8 years of age, SO has not been found (Geis & Hall, 1976). Because of the development of a formal-operational processor, SO should increase with formal-operations because the processor should be more likely to combine words in an orderly, systematic manner.

Sorting. Mandler (1967) objected to clustering studies because experimenter-imposed categories may hide the subject's organization; in addition, the procedure gives little information about how subjects go about organizing an input list (Mandler, 1967). Instead of penalizing the subject who utilizes his own organization, Mandler, in a sorting task, sought to analyze how subjects organize when they are left to their own devices. In a series of experiments, Mandler asked college students to sort 52 cards, each of which had a different word printed on it. They were asked to sort the cards in from two to seven categories, using any system they wished. The subjects were also instructed that, after their first sort, they would be given another deck of the same cards in a different order and would be asked to sort again. They were required to continue to sort until they achieved identical sorts on two successive trials (Mandler, 1967).

Subjects were divided into free and restrained groups. Free subjects made their own sorts, while constrained subjects were yoked to free subjects. Each constrained subject learned the sort of a free subject. Although constrained subjects required twice as many trials to reach criterion as did the free subjects, both groups recalled about the same number of words. Number of trials did not affect recall; if a stable categorization had been achieved, recall for the two groups was identical.

In a probe to explore whether organization is a sufficient condition for recall, Mandler used four groups of subjects who were instructed, or not instructed, to recall or to categorize. Recall instructions produced the same results as organizing instructions, an outcome supporting the hypothesis that organization is a sufficient condition for recall (Mandler, 1967).

If children are forced to organize, their recall improves. Liberty and Ornstein (1973) yoked fourth-grade children to other fourth-grade children and to college students. College students were yoked to college students and to fourth-grade children. Adults used sorts that were content-determined. Recall of the children yoked to adults improved. Although there were still differences between adults and fourth-grade children yoked to adults, the data supported the contention that organizational changes are sufficient to produce changes in recall.

Worden (1974) required second-grade children, fifth-grade children, and adults to sort until they reached criterion. In a second experiment, when sorting was terminated prior to reaching criterion, recall was reduced. Decreased organization at study, thus, resulted in diminished recall.

Because sorting insures some organization in a task, differences between formal-operational and non-formal-operational adolescents may be less than in some other memory tasks. The formal-operational processor may, however, go about the task in a more systematic manner and use optimal schemes for organizing the data, thus increasing recall.

Metamemory. Ann Brown's knowing about knowing or Flavell, Friedrichs, and Hoyt's (1970, p. 1) "potentially verbalizable knowledge and awareness about storage and retrieval" is another organizational measure of memory strategies. Such thinking about thinking is illustrated by answering questions such as "How many words will you be able to remember?" or "What are the things that are difficult for you to remember?"

There are indications that the memory system knows what it knows and whether it is retrievable (Lindsey & Norman, 1972). A formal-operational processor would be expected to be accurate in its feedback as it goes about knowing. Nevertheless, in a task where the individual has a great deal of experience in whether or not he will remember, differences between formal-operational and non-formal-operational individuals may not be as distinct. For example, all adolescents, formal and non-formal, probably have well practiced strategies for performing memory tasks which they encounter frequently, such as remembering where they left an item.

Plan of the Experiment

If we find that adolescents who are formal-operational also use efficient, effective organization in memory tasks and that adolescents who are non-formal-operational use less efficient strategies, can we infer a formal-operational central processor? Hypothetico-deductive thought would tell us that correlation is not causation, and other variables were not constant; however, an area worthy of more systematic, orderly analysis would have been identified.

Subjects were 15-year-old, ninth-grade children. Although Piaget considers 13- to 15-year-old children to be in the formal-operations stage, there is evidence that 15-year-olds are not necessarily characterized by formal-operational thought (Jackson, 1965; Neimark, 1975; Pratt & Wyatt, 1973; Tomlinson-Keasey, 1972).

The adolescents were drawn from a select population (Lorge-Thorndike scores of 115 or over), because there are discrepant findings concerning the relationships between performance in Piagetian tasks and psychometric test scores. Investigators have reported low correlations (Neimark, 1975), moderate correlations (Almy, 1966; Elkind, 1961), and high correlations (Jackson, 1965) between IQ scores and performance on Piagetian tasks. Correlations between mental age and speed and level of approach to a Piagetian task have been reported (Keating & Schaefer, 1975; Neimark, 1975; Webb, 1974). In order that mental age or IQ would not be a factor, the formal-operational and non-formal-operational adolescents were from the same population, and both groups had approximately the same median IQ score.

These subjects were administered six Piagetian tasks and classified as formal-operational or non-formal-operational in their thinking. Each group was then given tasks designed to assess organizational memory strategies: (a) free recall of unrelated words, (b) free recall of categorized words, (c) sorting task followed by free recall, and (d) a metamemory inventory. It was hypothesized that there would be differences between formal-operational and non-formal-operational adolescents in organizational memory strategies in these tasks. It was expected that differences between the groups would not be as great in those tasks in which organization was induced, such as sorting and blocked presentation of categorized words. Such results would imply the existence of a formal-operational central processor.

CHAPTER II

METHOD

General Procedure

Twenty-eight subjects were selected from 46 adolescents given the Piaget tasks. Seven boys and seven girls who are formal-operational and seven boys and seven girls who are non-formal-operational were identified. Table 1 gives a description of the subject sample.

Adolescents were tested individually in the playroom of the author's home. Each subject completed three taped sessions; each session consisted of two parts. In the first session, the subject was given six tasks from the Inhelder and Piaget (1958) scale. The purpose of the scale was to identify formal-operational children and non-formal-operational children. The subjects then received a free recall task involving unrelated words. After this session, subjects were divided into formal-operational and non-formal-operational groups. Only subjects who were classified as formal-operational or non-formal-operational completed the later sessions.

In the first session, the nature of the sessions, i.e., that the tasks were directed toward learning how adolescents think and did not have "right" and "wrong" answers, was explained. Children were encouraged to do the best they could on the tasks.

In the second session, the adolescents received a free recall task with categorized lists and a metamemory interview. In the third session, a sorting task, followed by free recall, was given. During this last

Table 1

Description of the Subject Sample

Formal	Birthdate	Lorge-Thorndike Score	Parental Occupation	Piaget Task[a]						Median
				P	C	B	IP	A	HP	
Boys										
1	7-8-62	115	Banker	8	9	9	9	9	9	9
2	9-29-62	119	Teacher	9	9	7	7	8	9	8.5
3	12-13-61	119	Furniture Store Owner	9	9	9	9	9	9	9
4	5-9-62	115	Forester	9	9	8	9	7	7	8.5
5	1-23-62	118	College Dean	3	9	7	8	9	9	8.5
6	2-25-62	121	Foreman	9	9	7	9	9	8	9
7	11-9-61	130	Lawyer	9	9	9	8	9	9	9
Girls										
8	12-23-62	119	Lawyer	9	9	9	7	9	8	9
9	7-12-62	125	Drug Store Owner	9	9	9	7	8	9	9
10	9-8-62	116	Post-Office Clerk	9	9	9	9	6	9	9
11	12-21-61	116	Milling Co. Owner	9	9	7	8	9	9	9
12	4-27-62	130	College Dean	8	9	7	8	9	9	8.5
13	10-18-62	130	Professor	9	9	9	7	6	9	9
14	8-31-62	117	Secretary	9	9	7	9	9	8	9

[a]P = Pendulum; C = Chemicals; B = Balance; IP = Inclined Plane; A = Angles; HP = Horizontal Plane.

Table 1 (Continued)

Non-Formal	Birthdate	Lorge-Thorndike Score	Parental Occupation	Piaget Task[a] P	C	B	IP	A	HP	Median
Boys										
15	7-24-62	118	Radio Technician	7	8	7	8	6	6	7
16	5-16-62	117	Teacher	7	9	7	7	9	6	7
17	8-16-62	121	Banker	9	9	7	7	7	7	7
18	7-2-62	121	Foreman	9	9	7	7	6	6	7
19	9-8-62	115	Post Office Clerk	9	9	7	7	6	6	7
20	12-23-61	115	Salesman	9	9	7	7	6	6	7
21	9-6-62	120	Salesman	7	9	7	7	6	9	7
Girls										
22	7-9-62	121	Overnite Transfer	7	7	7	7	6	5	7
23	1-25-62	115	Radiologist	9	9	7	7	6	6	7
24	1-25-62	115	Plumbing Co. Owner	9	9	7	6	6	6	6.5
25	3-2-62	130	Car Dealer	9	9	7	7	6	6	7
26	6-14-62	133	Chemist	9	9	7	7	6	6	7
27	5-17-62	117	Funeral Director	7	9	7	7	6	5	7
28	8-24-62	132	Salesman	7	9	7	7	6	6	7

[a]P = Pendulum; C = Chemicals; B = Balance; IP = Inclined Plane; A = Angles; HP = Horizontal Plane.

session, subjects also received a follow-up metamemory interview pertaining to their approach to the experimental tasks. Subjects were encouraged to ask questions about the study and were given bags of candy. All of the children completed a given session before any subjects began the succeeding session.

<u>Subjects</u>

Ninth-grade children with Lorge-Thorndike scores of 115 and over, aged 14 years, 1 month to 15 years, 2 months, served as subjects. These children were drawn from a pool of all ninth-grade children with Lorge-Thorndike scores over 115 in the Danville Public School system. Children in the pool were administered six formal-operations tasks until seven girls and seven boys who were formal-operational and seven girls and seven boys were not formal-operational were identified. The median IQ of each group was approximately the same. The median score for formal-operational children was 119 with a range in scores from 115 to 133. The median score for non-formal-operational children was 119 with a range in scores from 115 to 133.

<u>Assessment of Formal-Operational Thought</u>

<u>Materials</u>. Six formal-operational tasks, adapted from Inhelder and Piaget (1958), were administered to each subject. These six tasks were described in the Introduction. The order of presentation was randomized by having the first subject begin with Task A, the next with Task B, and so on.

Procedure. Specific instructions and scoring for each task are given in Appendix A. Subjects were encouraged to experiment, and there was no time limit.

The experimenter scored the protocols in the manner suggested by Lovell (1960); this numerical assignment was described earlier. Subjects who achieved a median score of 8.5 on the six tasks were classified as formal-operational. Subjects who achieved a median score of 7 or less on the six tasks were classified as non-formal-operational.

A second scorer checked the scoring of the protocols.

Free Recall of Unrelated Words

Materials. In this task, two lists of 24 unrelated words (List A and List B), compiled from lists described by Geis and Soderquist (1977), were used. Two lists were used to control partially for list-specific effects. The mean word frequency (Kucera & Francis, 1967) for List A was 38.2; the mean word frequency for List B was 39.4.

The experimenter decided as best she could which adolescents would be classified as formal-operational and which would be classified as non-formal-operational. Formal-operational girls drew pink slips which designated List A or List B. Non-formal-operational girls drew yellow slips which assigned them to List A or List B. Formal boys drew blue slips which designated List A or List B, while non-formal boys drew white slips which designated List A or List B. With this procedure, approximately equal numbers of formal and non-formal males and females were assigned to each list. Although this procedure was not ideal, it was necessary if a memory task were to be administered during the first session.

Six different orders of each list were prepared, with the restriction that each word occurred in a different serial order on the different orders. The orders of List A and List B appear in Appendix B. Order of presentation of the list orders was systematically counterbalanced across subjects.

The words for each order were typed in capital letters on 3" x 5" index cards, with one word per card.

Procedure. The subjects were told that their task was to learn 24 words and that, at the end of each study trial, they would be required to write as many words as they could remember from the list. They were allowed to recall the words in any order that they wished. The experimenter turned the cards at the rate of one card every 3 seconds and did not say the word. At the end of each of the six study trials, the subject was given an 8½" x 11" sheet of notebook paper and was told to write all the words that he could remember. A trial ended after 30 seconds during which the child did not remember a word. Subjects were not permitted to see previous recall lists.

Free Recall of Categorized Words

Materials. Two categorized lists (List A and List B) were prepared in order to partially control for list-specific effects. List A consisted of six categories: animals, male names, colors, vegetables, trees, and furniture.

These categories were matched for age of acquisition (a range of 4.25 years to 6.02 years). The age of acquisition values were taken from norms reported by Geis and Hall (1976) who required college students to estimate how old they were when they learned each category. Each category included six exemplars. The words in the categories were matched for frequency of occurrence. Battig and Montague (1969) asked subjects to list words which occurred to them in a given category. In the present experiment, the exemplars of each of the categories were matched on the frequency of how often it was mentioned by the Battig and Montague subjects as being an exemplar of its category. The means of these ratings for List A categories ranged from 8.80 to 9.17.

List B consisted of six categories: vehicles, clothing, flowers, fruits, female names, and parts of the body. These categories were matched for age of acquisition (a range of age 4.62 years to 6.02 years) (Geis & Hall, 1976). Each category included six exemplars. The words in the categories were matched for frequency of occurrence (mean ratings of 8.80 to 9.17) (Battig & Montague, 1969).

For Trials 1, 2, and 3, three different random orders of each list were prepared. No two words from the same category were permitted to appear consecutively; no two words occupied the same serial position across trials. The orders for the first three trials are given in Appendix C. Order of presentation of the list orders was systematically counterbalanced across subjects.

On Trials 4 through 6, blocked presentation was used. For each of these trials, words were randomized within a category, and the categories were presented in random orders; however, each category was presented entirely, as it is listed in the Appendix, before the next category was presented. Orders for Trials 4 through 6 are given in Appendix C. Order of presentation of the list orders were systematically counterbalanced across subjects.

The words for each order were typed in capital letters on 3" x 5" index cards, with one word per card.

Procedure. The subject was given a piece of 8½" x 11" notebook paper for each trial. He was told that he would be shown a list of words and that he would be asked to remember them. The experimenter turned the cards at the rate of 3 seconds per card. At the end of each of the six list presentations, the subject wrote the words that he could recall. A new trial began when the subject did not recall a word for 30 seconds. Lists were collected after each trial. The exact instructions are given in Appendix C.

Metamemory Inventory

A metamemory inventory was presented verbally by the experimenter. The subjects' oral answers were taped. The procedure was not timed. The inventory and instructions appear in Appendix D.

Sorting Task

Materials. Stimulus words were typed in capital letters on 3" x 5" index cards, one word per card. Two lists (A and B) were compiled. Each list was composed of 20 AA frequency (Thorndike-Lorge, 1944) English nouns equated for frequency of occurrence, concreteness, and imagery reported by Paivio, Yuille, and Madigan (1968) (for Set A, concreteness $\underline{m}$ = 6.55, imagery *m* = 6.72; meaningfulness *m* = 6.89; for Set B, concreteness *m* = 6.43, imagery *m* = 6.68, meaningfulness *m* = 6.76).

Six different random orders of Set A and six different random orders of Set B were prepared. The restriction was made that no two words could be adjacent in more than one order and that no word could occupy the same serial position in two orders. The orders are given in Appendix E. Order of presentation of the list orders was systematically counterbalanced across subjects.

Procedure. Subjects were instructed to sort cards at their own rate in as many categories as they wished. They were told to continue to make sorts until two consecutive, identical sorts were achieved. Subjects were told that they would be asked to recall the words after they achieved the identical sorts. Subjects were allowed to look at the top card, but not those underneath; they were prohibited from putting one card in a category and all others in a second category. Each sort was recorded by the experimenter. Following the last sort, subjects were given a sheet of notebook paper on which to write the words they recalled. Recall was terminated after 30 seconds in which no writing occurred. Subjects were then asked to explain why they grouped the words as they did.

Metamemory Follow-Up

After the preceding tasks were completed, the children were orally asked follow-up questions concerning how they went about the experimental tasks. The interviews were taped. The questions appear in Appendix F.

CHAPTER III

RESULTS

The probability level of all tests of significance was $p < .05$.

Preliminary analyses of variance with list as a factor indicated that neither the main effects of list nor its interactions with other variables were significant; therefore, for subsequent analyses the data were collapsed across the list variable.

Free Recall of Unrelated Words

Number of words recalled. A 2 x 2 x 6 analysis of variance, with the between-subjects factors of operations (i.e., formal and non-formal) and sex and the within-subjects factor of trials, was performed on the number of words recalled. The significant main effects of operations, $F\ (1, 24) = 32.85$, and trials, $F\ (1, 120) = 109.35$, must be interpreted with respect to the significant interactions that were obtained. An analysis of simple main effects was performed on the significant operations x sex interaction, $F\ (1, 24) = 5.19$. Although the difference between the recall of formal males (mean = 17.05) and that of non-formal males (mean = 11.52) was significant, the recall difference between formal females (mean = 16.50) and non-formal females (mean = 14.12) was not significant.

A similar analysis of simple main effects was conducted on the significant interaction between operations and trials, $F\ (5, 120) = 7.44$.

Means for the interaction are given in Table 2. The formal children recalled significantly more words than did the non-formal children on all trials except the first one. The simple main effect of trials was significant for both the formal children and the non-formal children. Subsequent Newman-Keuls analyses indicated that formal children showed significant recall increases on each trial. The non-formal children did not significantly increase their recall from Trial 3 to 4 or from Trial 5 to 6.

Subjective organization. For adjacent pairs of trials, subjective organization was evaluated for each child in terms of Bousfield and Bousfield's (1966) observed minus expected intertrial repetition measures. The measure assumes that on Trial *t* there are h-1 possible ordered bigrams (word pairs), and on Trial *t+1* there are k-1 possible bigrams, where *h* represents the number of words recalled on Trial *t*, and *k* represents the number of words recalled on Trial *t+1*. The observed intertrial repetition (IRT) score represents the number of bigrams common to the two recalls. An expected number of such bigrams is given by the formula,

$$E(IRT) = c\left[(c-1)\right]/hk,$$

where *c* is the number of words common to the two recalls. For each pair of adjacent trials, the value expected is subtracted from the observed value to give an IRT difference score.

A 2 x 2 x 5 analysis of variance, with the between-subjects factors of operations and sex and the within-subjects factor of trials, was performed on the IRT difference scores. The main effects of operations, F (1, 24) = 9.27, and trials, F (4, 96) = 2.91, were significant, as were the interactions between operations and sex, F (1, 24) = 9.27, and

Table 2

Mean Recall of Unrelated Words as a Function of

Operational Status and Trials

	Trials					
Operational Status	1	2	3	4	5	6
Formal	8.71	14.78	16.93	18.57	20.00	21.64
Non-formal	8.57	10.64	12.71	13.50	15.36	16.14

operations and trials, F (4, 96) = 2.49. An ana is of the simple main effects of the operations x sex interaction indicated that the difference between the means of formal males and non-formal males (2.35 and .16, respectively) was marginally significant, F (1, 24) = 3.10, p = .09, while the difference between the means for formal and non-formal females (1.12 and .92, respectively) was not significant. Means for the operations x trials interaction are given in Table 3. Analysis of the simple main effects of this interaction indicated a significant effect of trials for formal subjects but not for non-formal subjects; that is, only formal children showed increases in subjective organization across trials. Newman-Keuls analyses revealed that the formal children showed greater amounts of subjective organization on Trial 1 than on the second, third, fourth, and fifth trials, and greater amounts on Trial 3 than on Trials 4, 5, and 6. The simple main effect of operations was significant on Trials 4 and 5.

Free Recall of Categorized Words

Number of words recalled. A 2 x 2 x 6 analysis of variance, with the between-subjects factors of operations and sex and the within-subjects factor of trials, was performed ... the number of words recalled. The significant outcomes were the main effects of operations, F (1, 24) = 11.74, and trials, F (5, 120) = 290.19, and the interaction of operations and trials, F (5, 120) = 6.68. Means for the interaction are shown in Table 4. An analysis of simple main effects indicated that the formal adolescents recalled more words than did the non-formal adolescents on all trials, except Trial 1. The simple main effect of trials was significant

Table 3

Mean Subjective Organization Scores as a Function of

Operational Status and Trials

	Trials				
Operational Status	2	3	4	5	6
Formal	.76	1.02	1.59	2.81	2.51
Non-formal	.07	.81	.80	.41	.61

Table 4

Mean Recall of Categorized Words as a Function of

Operational Status and Trials

	Trials					
Operational Status	1	2	3	4	5	6
Formal	11.43	19.21	23.71	29.21	31.71	33.57
Non-formal	9.86	15.64	18.79	22.14	24.21	27.64

for both formal and non-formal children. Subsequent Newman-Keuls analyses indicated significant recall increases across all trials for both formal and non-formal children.

Clustering for categorized words. For each subject on each trial, Bousfield and Bousfield's (1966) observed minus expected stimulus category repetition (SCR) measure was used to evaluate clustering. The measure reflects the extent to which words from the same category are recalled in adjacent output positions. The expected value is given by the formula,

$$E(SCR) = \left[m_i^2 + \ldots m_k^2/n\right] - 1,$$

where m is equal to the number of items recalled in a category and n is equal to the total number of words recalled. The observed SCR value is the number of clusters (i.e., pairs of same-category words recalled in adjacent output positions) actually observed. The observed minus expected SCR scores were analyzed in a 2 x 2 x 6 analysis of variance, with the between-subjects factors of operations and sex and the within-subjects factor of trials. The formal group (mean = 9.07) had higher clustering scores than did the non-formal group (mean = 7.29), F (1, 24) = 5.28. The main effect of trials, F (5, 120) = 81.37, was the only other significant outcome. Newman-Keuls analyses indicated that all differences except that between Trial 2 and Trial 3 were significant.

Other analyses. A similar analysis of variance performed on the number of categories present in each recall trial for each subject indicated that the formal adolescents recalled more categories on each trial (mean = 5.77) than did the non-formal adolescents (mean = 5.50), *F* (1, 24) = 6.10. For each subject on each trial, a category was scored present if at least one exemplar from that category was included in the subject's recall protocol for that trial. The main effect of trials was also significant, *F* (5, 120) = 16.80. Further analyses with Newman-Keuls tests indicated significant increases in the number of categories present in the recall of all subjects from the first to each of the subsequent trials, and from the second trial to Trials 5 and 6. The means of Trials 5 and 6 approached a ceiling value of 6 ($\bar{X}_5$ = 5.93 and $\bar{X}_6$ = 5.96).

An additional analysis of variance was performed on the mean number of words per category recalled by each subject for each trial. The significant outcomes were the main effects of operations, *F* (1, 24) = 9.98, and trials, *F* (5, 120) = 203.24, and the operations x trials interaction, *F* (5, 120) = 6.85. Means for this interaction are shown in Table 5. An analysis of simple main effects indicated a significant effect of trials for formal and non-formal subjects, and a significant effect of operations on all trials except the first. Further analysis with Newman-Keuls tests indicated that for formal children mean recall per category increased across all trials, while for non-formal children mean recall per category did not increase significantly between Trials 4 and 5.

Sorting

Number of trials to criterion. A 2 x 2 analysis of variance, with the between-subjects factors of operations and sex, was performed on the number of trials required by each child to reach criterion on the sorting task. The main effect of operations was significant, *F* (1, 24) = 12.30.

Table 5

Mean Number of Words Recalled Per Category as a Function of Operational Status and Trials

	Trials					
Operational Status	1	2	3	4	5	6
Formal	2.25	3.33	4.05	4.87	5.30	5.58
Non-formal	2.14	2.94	3.26	3.93	4.10	4.67

The formal children reached criterion in 3.21 trials while the non-formal children required 6.43 trials.

Free recall. A similar analysis of variance was conducted on the free recall data. Formal children (mean = 17.57) recalled more words than did non-formal children (mean = 15.36), F (1, 24) = 4.80.

Clustering. For each subject, the sets of piles in his criterion sort were used as the categories for evaluating his clustering in free recall. The observed minus expected SCR measure, discussed earlier, was used. A 2 x 2 analysis of variance, with the between-subjects factors of operations and sex, was performed on the clustering scores for the sorting task. The fact that none of the outcomes were significant indicates that formal children did not differ from non-formal children in recall clustering following the sorting task.

Metamemory

The Fisher Exact Probability Test was used to evaluate metamemory answers. The probability of all tests of significance was $p < .05$.

Questions concerning the memory tasks. All subjects reported the use of the organizational strategy of categorizing or grouping in the task involving free recall of categorized words.

In the free recall of unrelated words, an answer such as "related items like *book* and *paper* to each other" or "associated items together" was scored as an instance of a relating strategy. "I just tried to remember them" or "just remember" were scored as instances of no strategy.

Table 6 summarizes the scoring of the formal and the non-formal children's responses to the question concerning free recall of unrelated words. According to the Fisher Test, when approaches to the task were classified as instances of "relating" versus instances of "no strategy," the proportion of the formal children judged to have used a relating strategy differed from the proportion of the non-formal children judged to have used a relating strategy. The proportion of non-formal girls who reported the use of a relating strategy differed from the proportion of non-formal boys who reported the use of a relating strategy, but this proportion of non-formal girls did not differ from the proportion of the formal children who reported the use of the strategy.

The children reported three approaches to the sorting task: (a) a relating strategy such as that described above, (b) alphabetizing, and (c) a story strategy, for example, "Alcohol caused a bloody crash into the village on the mountain."

Table 7 shows the number of formal and non-formal children who reported the use of the three strategies. If relating versus other strategies are combined in a contingency table, the proportion of the non-formal children who were classified as using a relating strategy differed significantly in a two-tailed test from the proportion of the formal children who were classified as using a relating strategy. The formal and non-formal children did not differ in the reported use of an alphabetizing strategy. If making up a story (Neimark, 1977), which has been considered an elaboration strategy by Flavell (1977), versus other strategies are combined in a contingency table, the formal and non-formal children differ in the

Table 6

Number of Formal and Non-Formal Adolescents Reporting Use of a Relating Strategy in Free Recall of Unrelated Words

		Approach to Task	
Operational Status	Sex	Relating	No Strategy
Formal	Male	7	0
	Female	7	0
Non-Formal	Male	3	4
	Female	7	0

Table 7

Number of Formal and Non-Formal Adolescents Reporting the Use of Various Sorting Strategies

	Sorting Strategy		
Operational Status	Relating	Storytelling	Alphabetizing
Formal	4	7	3
Non-Formal	12	0	2

proportion with which they fall into these two strategy classifications. The formal children apparently used story-telling elaboration more than did the non-formal children.

Questions on the inventory. Inspection of the protocols revealed no differences in the proportions of the formal and non-formal children who gave yes answers (n = 11 for both groups) and no answers (n = 3 for both groups) to Question 1, "Are you a good rememberer?" The proportions of the formal children and non-formal children who answered yes and no to Question 2, "Are you better than your friends?", did not differ (yes: n = 13 for the formal children, 10 for the non-formal children; no: n = 1 for the formal children, 4 for the non-formal children).

The formal and the non-formal children differed in the proportions with which they fell into the classification of responding with categories, such as "names" or "numbers," versus the classification of responding with instances, such as "when my baby brother was born," in answer to Question 3, "Do you remember some things better than others?" and Question 4, "Are there some things that are really hard to remember?" The subjects' responses to these questions are summarized in Table 8. The formal children appeared to respond with categories rather than instances more than did the non-formal children.

Answers to Question 5, "How would you go about trying to remember the names of the United States of America?", were classified as use of a sectionalizing strategy and use of an alphabetizing strategy in a 2 x 2 contingency table. The proportions of formal and non-formal children who were scored as using a sectionalizing strategy (ns = 10 and 8 for the

Table 8

Number of Formal and Non-Formal Adolescents Using Categories and Instances in Answer to Questions 3 and 4

	Easy to Remember		Hard to Remember	
Operational Status	Categories	Instances	Categories	Instances
Formal	14	0	14	0
Non-Formal	10	4	10	4

formal and the non-formal children, respectively) and using an alphabetizing strategy (ns = 4 and 8 for the formal and the non-formal children, respectively) did not differ.

The answers to Questions 6, 7, 8, and 11 were scored as to whether the subject used a system or did not use a system in order to remember. A system for the question, "How do you remember what you want to buy in the grocery store?" included using a list or an aisle of the store as a reminder, while the response "just remembered" was scored as an instance of no system. In answer to the question concerning packing for a trip "remembering my schedule" or "categories of things" was judged as an instance of a system, while "just throw it in" was not. In answering "How do you study for a test?", "stressing hard to remember items" was considered use of a system. "I don't study" was scored as failure to use a system. All subjects answered that they could supply a digit omitted from their locker combinations. In answer to "How do you remember your locker combination?", writing the combination down or noting a special digit sequence present in all combinations was scored as use of a system. "Just drum it in" was scored as an instance of no system. Table 9 summarizes the number of formal and non-formal adolescents who reported the use of a system in the various situations described in Questions 6, 7, 8, and 11. Approaches to the task were categorized either as instances of use of a system or as instances of no system. The proportions of the formal and non-formal children whose responses were classified as instances of a system versus instances of no system differed significantly in each situation. Thus, in each of these real-life situations, the formal children reported a more orderly approach to the task.

Table 9

Number of Formal and Non-Formal Adolescents Reporting Use of a System in Four Situations

	Shopping		Packing		Studying		Locker	
Operational Status	System	No System	System	No System	System	No System	System	No System
Formal	14	0	12	2	11	3	9	5
Non-Formal	10	4	6	8	5	9	3	11

With respect to Question 9, "How do you remember your assignments?", similar proportions of the formal children and of the non-formal children gave the response "Write it down" ($\underline{n}$ = 12 for the formal children, $\underline{n}$ = 8 for the non-formal children) versus the response "go through the day" ($\underline{n}$ = 2 for the formal children; $\underline{n}$ = 6 for the non-formal children).

Children were asked in Question 10 if telephone numbers were "hard to remember" or "easy to remember." The proportions of the formal children and the non-formal children who responded "easy to remember" did not differ ($\underline{n}$ = 13 for the formal children; $\underline{n}$ = 12 for the non-formal children). The proportions of the formal and the non-formal subjects who responded "hard to remember" were similar for both groups ($\underline{n}$ = 1 for the formal children; $\underline{n}$ = 2 for the non-formal children). The two groups did not differ in the proportions with which they responded that it would be difficult ($\underline{n}$ = 2 for both groups) or not difficult ($\underline{n}$ = 12 for both groups) if someone grouped the digits in telephone numbers differently from the manner to which the digits were ordinarily grouped.

All the subjects answered that they would use a retrace strategy in order to find a lost jacket. In answer to Question 13, "If you were a student council representative and asked to name the students in your homeroom, how would you go about it?", answers were classified as instances of a strategy (going up and down the rows to remember) and instances of no strategy (just remember). When the two categories were combined with operational status in a 2 x 2 contingency table, the formal and the non-formal subjects did not differ proportionately in the use of a strategy ($\underline{n}$ = 14 for the formal subjects; $\underline{n}$ = 13 for the non-formal subjects) versus no strategy (n = 0 from the formal subjects; n = 1 for the non-formal subjects). Answers to Question 14, "How do you remember where your car is parked in the school parking lot?", were classified into the two categories, instances of the use of a system and instances of no system. The proportions of the formal and the non-formal children falling into the category of instances of use of a system (n = 11 for the formal children; n = 12 for the non-formal children) versus the category of no system (n = 3 for the formal children; n = 2 for the non-formal children) did not differ.

CHAPTER IV

DISCUSSION AND CONCLUSIONS

Organizational Differences

In the present research, an information-processing model postulating structural and control processes was the theoretical basis for approaching the issue of whether individual differences in organizational memory strategies are associated with formal-operational and non-formal-operational status. The hypothesis that formal and non-formal adolescents differ in the efficiency of their control processes prompted two basic questions: (a) Are differences in formal-operational status associated with differences in organizational processes in memory and (b) If organization is induced, will the non-formal adolescent profit?

The first question can be answered by examining the children's organization scores in the tasks involving free recall of unrelated and categorized words. An affirmative answer to the first question (i.e., formal children are more efficient than non-formal children in their organizational memory strategies) is supported by the significantly higher clustering scores of the formal children, compared to the non-formal children. The clustering scores support the prediction that the formal and the non-formal children would differ, not in the use of a strategy, but in the systematic efficiency with which the strategy was used. It is possible that, given the formal child's propensity toward systematic approaches to a task, the formal child more effectively utilized the nature of the categorized materials and consequently increased his clustering by systematic, exhaustive mnemonic storage and retrieval activities. The mean number of categories present in recall was greater for the formal children than for the non-formal children. This finding supports the argument that formal children can more efficiently utilize the bases for organization present in categorized materials.

In the free recall of unrelated words task, the formal children showed increases in subjective organization across trials, while the non-formal children did not. On Trials 4 and 5, the formal children exhibited subjective organization to a greater extent than did the non-formal children.

The advantage of formal-operational status in subjective organization must be qualified because of the sex interaction that was found. Although formal boys showed greater amounts of subjective organization than did non-formal boys, formal and non-formal girls did not differ. One possible explanation for the similarity between the formal and non-formal females is related to the present sample of children. The subject sample consisted of children having relatively high intelligence scores. Other researchers have shown that females possess facility with verbal materials. Maccoby and Jacklin (1974, p. 57) document female superiority in verbal memory tasks and suggest that there are distinct phases in the development of verbal skills; they maintain that "it is about age 10 or 11 that girls begin to come into their own in verbal performance" (1974, p. 84). Thus, within the present select sample, the non-formal girls' verbal skills may have enabled them to match the performance of the formal girls. Naus, Ornstein, and Aivano (1977) suggested a similar explanation for sex effects which they too obtained in a task involving free recall of unrelated words. Use of a sample having average IQ scores might eliminate high-verbal females and, consequently, an interaction between sex and operational status.

It is possible to speculate as to why a sex x operations interaction occurred in the unrelated words task but not in the categorized words task. The present data parallel the findings of Naus, Ornstein, and Aivano (1977) who reported a sex interaction in a free recall of unrelated words task and the findings of Haynes and Kulhavy (1976) who did not find a sex interaction in a free recall of categorized words task given to concrete-operational children. It may be that the nature of categorized materials is such that high-verbal skills are not required for efficient relating of the words, and the subject's success depends upon his predisposition to be systematic in exploiting the salient category relationships built into the materials. In the unrelated words task, however, a subject's success may be more dependent upon verbal skills to establish relationships among the words and less dependent upon the tendency to be systematic. If this analysis of the two tasks is valid, one might expect sex effects in the task involving unrelated words. A difficulty with this explanation is that it seems to imply that formal females should show greater subjective organization than either formal males or non-formal females because the formal female has both verbal skills and the tendency to be systematic. Formal females did not show this superiority in the present research.

In answer to the second question, the non-formal adolescent profited when organization was induced. The purpose of the sorting task was to insure that all subjects reached a stable organization before recall. When all subjects were required to achieve organization at storage, differences between formal and non-formal children in recall organization (clustering) were eliminated. This finding implies that non-formal adolescents may be more deficient in storage strategies than in retrieval strategies.

In the free recall of categorized words task, there was no increase in clustering for all children from Trial 2 to Trial 3. When blocked presentation was introduced in Trial 4, both formal and non-formal children benefited as shown by increases in clustering. It should be noted that the improvement cannot be attributed conclusively to the blocking since the appropriate control group in which blocking was not introduced and subjects proceeded with random presentation was not included.

Recall Differences

The recall findings generally parallel the organizational findings. In the free recall of both unrelated words and categorized words, formal and non-formal children were similar on their first trial of recall. Thereafter, the formal children seemed to be able to adapt better to the tasks, for their recall was superior to that of the non-formal children on subsequent trials. Superior organizational skills may give the formal child an advantage which allows him to excel in recall.

In the free recall of unrelated words, the formal boys' recall was significantly greater than the non-formal boys' recall, but the formal and non-formal girls did not differ in number of words recalled. As suggested earlier, the subject sample may have included females possessing verbal skills that are especially beneficial in this particular memory task.

In the sorting task, the formal children required only half the number of trials that the non-formal children required to reach criterion. Once both groups achieved a stable organization at storage, the number of words recalled differed only marginally for the two groups.

Metamemory Differences

The memory tasks. In the unrelated words task, formal children reported relating items to one another more frequently than did non-formal children. The previously described sex interactions are reflected in the finding that non-formal girls more frequently than non-formal boys, but to the same extent as formal subjects, reported the use of a relating strategy. Subjects did not differ in their reported strategies in the free recall of categorized words task. Formal children used the strategies of alphabetizing and making up a story more frequently than a relating strategy in the sorting task. Because alphabetizing enables the child to achieve criterion on the second sorting trial and story telling links all words to each other, these strategies seem optimal for the sorting task; both strategies systematically organize the material into a unified whole.

Inventory questions. Formal children responded to questions concerning what was easy or difficult to remember with categories rather than instances. Kreutzer et al. (1975) reported that older children are more likely than younger children to show such a pattern. Thus, the formal children's responses may be considered more developmentally mature than those of the non-formal children. In answer to four metamemory questions, the formal children reported using a more systematic, orderly approach than did the non-formal children. In metamemory questions in which differences between the formal and non-formal children were not obtained, it is possible that all subjects had had a great deal of real-world experience in "knowing about knowing" on these particular tasks (e.g., finding a jacket) or that a given strategy was extremely obvious and modeled by much teacher behavior (e.g., going up and down rows to remember persons in a homeroom).

Implications

Future research. At least two additional experiments are suggested by the present results: (a) an investigation of the nature of the sex interaction in the free recall of unrelated words and (b) an additional analysis of the locus of the effect of operational differences on organization in memory. In the first experiment, the present study could be repeated with the inclusion of subjects of average IQ to determine if the sex interaction still obtained. With respect to whether differences between formal and non-formal children occur in their organizational memory strategies at storage and/or retrieval, the present research seems to indicate that the differences are at storage. The sorting task was a storage manipulation. When organization at storage was insured, differences between the formal and the non-formal subjects diminished. If a manipulation designed to minimize retrieval demands, such as cued recall of categorized words or recognition memory, still produced differences between the non-formal and the formal adolescents, there would be further evidence that the non-formal child's deficiency may be at storage.

Theoretical synthesis. The findings render validity to Piaget's premise that the memory code is dependent upon a subject's mental operations. Results from Neimark (1976), Haynes and Kulhavy (1976), and the present study seem significant in bringing about a rapprochement between Piagetian and information-processing approaches to cognitive development. Strategies which information-processing theorists consider important have been related to the stages of cognitive development which Piagetian theorists postulate.

Because these studies indicate that use of strategies is related to operational status, it seems reasonable to suggest that researchers can no longer ignore individual differences in operational status when matching subjects. Matching for operational status will be as necessary as matching for IQ, sex, and other organismic variables which may affect results.

Assessment. At present, operational assessment is an extremely difficult task, despite efforts to simplify its measurement (Neimark & Lewis, 1969; Tisher, 1971). In the present study, six tasks were used because no single Piagetian task clearly differentiated formal and non-formal children. More efficient ways of assessing formal operations may be devised by combining tasks, devising valid paper and pencil evaluation, or developing new tasks.

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Appendix A

Apparatus, Instructions, and Scoring for Formal-Operational Tasks

The Pendulum

Apparatus. The pendulum was modeled from the one pictured in Inhelder and Piaget (1958, p. 68). The problem utilized an apparatus consisting of a string which could be shortened or lengthened and a set of three weights -- one 50-gram weight, one 100-gram weight, and one 500-gram weight.

Procedure. The experimenter demonstrated how the subject could change the length of the string, the amount of weight, and the amount of push. She then asked a series of questions modeled from Inhelder and Piaget (1958, p. 67-79). The questions were:

"What factor, length, weight or amount of push, alone or in combination determines how fast the pendulum will swing?"

"To make it go fast?"

"Have you changed the rate?"

"Did you find out anything?"

"Why?"

"What do you have to do to make it go faster?"

Scoring. Answers were classified according to Inhelder and Piaget (1958, p. 67-79).

I-A (score 1): The child does not separate his own actions from the pendulum's motion.

I-B (score 3): The child does not separate the variables. He may respond, "The little weight goes faster, and you have to shorten the string."

III-A (score 7): The child separates the variables but not spontaneously. Maybe the weight has something to do with it. "That all?" questions the experimenter. "No, it goes faster high up."

III-B (score 9): The child uses the approach of holding all other things equal. He gives the length of the string as the correct variable.

Combinations of Colored and Colorless Chemicals

Apparatus. Chemicals were solutions of (1) diluted sulphuric acid, (2) oxygenated water, (3) thiosulphate, (4) water, and (5) potassium iodide. Two percent solutions of each chemical were used. The chemicals are pictured in Figure 6 of Inhelder and Piaget (1958, p. 108). A rack of medicine droppers was added to the flasks pictured.

Procedure. The method of presenting the problem was adapted from Inhelder and Piaget (1958, p. 107-122). The adolescent was given four similar flasks containing colorless, odorless liquids which were identical perceptually: (1) diluted sulphuric acid, (2) water, (3) oxygenated water (peroxide), and (4) thiosulphate. A fifth bottle called *g* contained potassium iodide. (1 + 3 + *g*) would yield a yellow color. The experimenter showed two flasks, one containing (1 + 3) and the other (2). As the subject watched, she put several drops of *g* in each of two flasks and noted the different reactions. The subjects were asked to produce the yellow color using (1), (2), (3), (4) and *g* as he chose.

The subject was asked questions adapted from Inhelder and Piaget (1958, p. 107-122). The questions were varied in order according to the subject's previous response.

The questions were:

"Can you change it to water?"

"Why?"

"Try to make the color again."

"Try something else."

"Take two bottles at a time."

"What else could you have done?"

"Add others."

"What makes it go away?"

"Can you make the color with fewer bottles?"

"Are you sure you have tried everything with two?"

"Try."

"What do you have to do for color?"

"Tell me what effect the bottles have."

"Can you show me?"

"So where does the color come from?"

"You think it's the water?"

"Do you think there is water in any bottles?"

Scoring. Protocols were scored according to Inhelder and Piaget (1958, p. 110-121).

I-A (score 1): The child gives a pre-causal explanation, such as "The syrup has gone away."

II-A (score 3): The child multiplies each factor by *g* and associates *g* with all other factors, but he uses no other combinations. When questioned about what else he could have done, he answers "I don't know."

II-B (score 5): The child multiplies operations with *n* by *n* combinations, but he does not use a system. His trials are random.

II-B/III-A (score 6); The child answers, "You have to mix all four," or "Two doesn't work; it takes three."

III-A (score 7): The child uses systematic n by n combinations. He tries four; then he tries each independently with g. An example would be the answer: "I'd better write down what I've done: 1 x 4; 4 x 3; 1 x 3 x g -- ah! 1 x 3 x g x 4 -- no, 4 keeps it from coloring."

III-B (score 9): The child's combinations appear in systematic fashion. An example would be "1 x g; 2 x g; 3 x g; 4 x g; no, you have to mix them." He then mixes the chemicals 2 x 2 and then 1 x 3 x g. Another example would be "1 x 3 x g x 2 stays the same, 1 x 3 x g x 4 turns white. 4 is the opposite of g." "Is there water?" "1 x g x water; 3 x g x water; no, 3 and 1 isn't water; no 4 makes it turn white."

Equilibrium in the Balance

Apparatus. A balance scale equipped with baskets which can be moved along a crossbar to different points was constructed according to Figure 9 in Inhelder and Piaget (1958, p. 165). Toy dolls were used as weights.

Procedure. The balance was presented with two equal weights at distances 14" and 9". Questions that were asked were taken from Inhelder and Piaget (1958, p. 164-181). The first question was always, "Can you make it straight?"

The questions that followed were asked in varying orders according to the subject's previous response. The experimenter chose the most appropriate question.

"Why is one way down and the other up high?"

The experimenter suggested adding weight to one side or the other.

"And if you put it at one end?"

"Why?"

"And if I put two dolls in one basket, and one in the other?"

"What is compensated?"

"How do you explain that?"

"How do you know?"

"Can you give a single rule?"

Scoring. Answers were classified according to Inhelder and Piaget (1958, p. 164-181):

I-A: The child fails to distinguish between his own actions and that of the process that is going on; for example, in answer to "Can you make it straight?", he pushes the balance, and fails to understand the role of weight and distance.

I-B (score 1): The child uses intuition. For example, the subject says, "You can't."

II-A (score 3): The child performs concrete operations on weight and distance without systematically coordinating them. The child recognizes that equal distances are necessary to make the balance, but does not comprehend the law: heavier $\rightleftarrows$ nearer.

II-B (score 5): The child recognizes the inverse correspondence of weights and distances such as, "The heavier it is, the closer to the middle." No further explanation is given.

III-A (score 7): The child discovers the law "large weight with smaller distance is equal to smaller weight with greater distance."

III-B (score 9): The child gives the law "Compensation between force and height." The child gives an analysis of the proportions involved or expresses the notion of leverage.

Hauling Weight on an Inclined Plane

Apparatus. A toy dump truck was suspended by a cable on an inclined plane which could be manipulated. Counterweights could be placed at the end of the pulley, and weights could be placed on the truck. The apparatus was designed according to Figure 10 of Inhelder and Piaget (1958, p. 183).

Procedure. The child was asked to predict the movement of the truck as a function of weights, counterweights, and incline of the track.

Questions which were asked were modeled after those of Inhelder and Piaget (1958, p. 182-198).

The first question was always, "Can you make the truck go up?" Other questions which were varied in order according to the subject's response were:

"Can you do anything else?"

"Can you make it go up?"

"And with weights?"

"And to make it go all by itself?"

"What else could you do?"

"Will it go up?"

"How can you make it go?"

"If you put it higher, will it go up?"

"What do you have to do to make it go up?"

"Why?"

"What will the wagon do?"

"What will happen if I add here?"

"And if I put weights in the wagon?"

"So what do you do to make it go up?"

"And if I take off one weight without adding any?"

"And to make it go down, what can you do?"

"Can you do something with the rack?"

"And if you raise the rail?"

"If you lift the rack, and add weight?"

"Can you give me a simple rule?"

"Is there something else you might consider?"

Scoring. Responses were classified by the examples given in Inhelder and Piaget (1958, p. 182-198).

I-A (score 1): The child fails to distinguish between his own actions and the process. For example, when asked "What could you do?", he will respond "Pull it up," rather than understanding that weight and incline are factors.

II-A (score 5): The child determines the role of weights but does not coordinate the role with incline of the plane. For example, he says, "Take off some weights, and put on some weights." When asked, "And to make it go down what can you do?", he answers, "Raise the chain, and take off a weight."

II-B (score 7): The child discovers the role of the incline and the beginning of the concepts of work. For example, the child says, "It's harder to go up, because the wagon gets heavier."

III-A (score 8): The child seeks to coordinate weight, height, and incline, but not as a function of proportions. To the question, "What can you do to make it go up?", the child might answer "Lower the rail," or "The higher you put the rail, the more weight you have to put to make it stay where it is." "You can take a weight off to make it go down or put one on to make it go up."

III-B (score 9): The child discovers the law. For example, he might state that "The height is proportional to the weight."

Angle of Incidence Equals Angle of Reflection

Apparatus. The principle of a billiard game was used. A tubular spring plunger was attached so that marbles could be aimed at a projection wall and would rebound to hit drawings placed at various points.

Procedure. The experimenter demonstrated how to insert a marble and aim the plunger. Questions that were asked were taken from Inhelder and Piaget (1958, p. 4-9). The questions that follow were asked in varying orders according to the subject's previous response:

"Try to hit the butterfly."

"Try to hit the tree."

"Try to hit the book."

"Try to hit the house."

"Try to hit the bird."

"Try to hit the flower."

"Try to hit the chair."

"How do you explain it?"

"Is that always true?"

"Tell me more about how you aimed it."

Scoring. Answers were classified according to Inhelder and Piaget (1958, p. 4-9):

I-A: The child is concerned with practical success or failure.

II-A (score 3): The child has the notion of a corner.

II-B (score 5): The child has the general notion of angling.

II-B/III-A (score 6): The child marks the angle.

III-A (score 7): The child generally understands the law that "It goes to the left and comes back right."

III-A/III-B (score 8): The child understands that "It comes back straight."

III-B (score 9): The child understands that the course of the ball will make equal angles.

Conservation of Motion in the Horizontal Plane

Apparatus. A spring device which launched balls of various sizes and materials was modeled after the one pictured by Inhelder and Piaget (1958, p. 124).

Procedure. The experimenter demonstrated how the balls were launched and asked the subjects the following questions, adapted from Inhelder and Piaget (1958, p. 125-132).

"Will they all go the same distance?"

"Why?"

"Where will the ball stop?"

"For a ball to go far?"

"So, why didn't it go farther?"

"What?"

"And if you compare balls?"

Scoring. Responses were classified according to Inhelder and Piaget (1958, p. 123-132).

I-A (score 3): The child gives precausal explanations such as, "They are stronger."

I-B (score 5): The child gives a braking or weight effect as the reason for slowing of the ball.

II-A/II-B (score 6): The child gives such reasoning as "the force gives out" or light weight prolongs motion, or the size of the ball.

III-A (score 7): In this stage, the child considers what makes the ball stop.

III-B (score 9): The child gives resistance, the principle of inertia or friction as a reason for the ball's stopping.

Appendix B

Materials and Instructions for Free Recall of Unrelated Words

<u>List A Orders</u>

1	2	3	4	5	6
peach	book	nest	bridge	key	mask
spoon	pencil	star	candle	rope	gun
pillow	nest	spoon	puzzle	peach	candle
rope	pillow	bridge	key	math	nest
mask	star	candle	curtain	cave	spoon
nest	bridge	peach	crowd	mask	dime
dime	math	key	cave	bridge	pencil
candle	spoon	wagon	mile	bench	key
pencil	key	cave	math	wagon	book
star	flag	dress	pencil	dress	peach
bridge	curtain	dime	peach	flag	cave
puzzle	cave	curtain	bench	pillow	mile
math	peach	rope	star	candle	dress
key	crowd	bench	mask	curtain	puzzle
bench	dime	pencil	flag	nest	wagon
flag	dress	mile	wagon	book	math
mile	gun	math	dress	spoon	star
curtain	wagon	flag	pillow	gun	bridge
wagon	bench	gun	book	crowd	pillow
crowd	mile	mask	gun	star	curtain
dress	puzzle	pillow	nest	dime	bench
cave	rope	crowd	dime	pencil	flag
book	mask	puzzle	spoon	puzzle	rope
gun	candle	book	rope	mile	crowd

List B Orders

1	2	3	4	5	6
spider	tooth	joke	glue	fever	rose
ax	thread	gate	cat	rose	glue
glue	drum	purse	nut	joke	milk
purse	grass	spider	drum	ball	box
joke	rose	nut	nap	glue	spider
tooth	turtle	glue	milk	chalk	thread
nap	cat	clay	fever	spider	truck
thread	gate	milk	box	tooth	purse
fever	truck	drum	joke	clay	ball
cat	ball	thread	truck	turtle	grass
clay	glue	ax	spider	thread	table
drum	table	fever	ghost	cat	ax
chalk	purse	ghost	tooth	truck	turtle
rose	clay	nap	turtle	ghost	nut
gate	nut	tooth	rose	ax	ghost
nut	fever	turtle	purse	box	gate
milk	box	ball	grass	nap	clay
ghost	joke	truck	ax	gate	tooth
grass	ghost	table	ball	milk	cat
truck	milk	rose	thread	grass	chalk
box	spider	chalk	table	drum	nap
turtle	nap	grass	clay	nut	drum
table	chalk	cat	gate	purse	joke
ball	ax	box	chalk	table	fever

Instructions

"You are to learn a list of 24 words. After I have turned the cards for you, you will be asked to write down as many words as you remember. You may write them in any order. I will repeat the procedure six times. Do you have any questions? Let's begin."

Appendix C

Materials and Instructions for Free Recall of Categorized Words

<u>List A Orders</u>

1	2	3
Barry	crimson	Amos
chipmunk	panther	weasel
crimson	beige	egg plant
melon	lounge	panther
white oak	melon	pumpkin
giraffe	chipmunk	love seat
love seat	white oak	turnip
sycamore	Scott	cot
egg plant	fuschia	bamboo
lime	spinach	piano
Alex	love seat	locust
beaver	locust	hi-fi
Dale	beaver	giraffe
gold	Hank	lounge
bamboo	lavender	pear
hi-fi	Dale	Barry
spinach	pumpkin	white oak
Amos	piano	beaver
panther	weasel	string bean
Hank	pear	Alex
weasel	camel	chipmunk
Scott	Alex	lavender
beige	turnip	camel
pumpkin	hi-fi	Scott
cot	Barry	coffee table
pear	gold	melon
lavender	string bean	Hank
piano	chestnut	gold
turnip	egg plant	sycamore
chestnut	Amos	lime
lounge	bamboo	chestnut
camel	giraffe	fuschia
fuschia	sycamore	spinach
string bean	cot	beige
coffee table	lime	Dale
locust	coffee table	crimson

4 (Blocked)	5 (Blocked)	6 (Blocked)
giraffe	spinach	beige
camel	turnip	crimson
weasel	eggplant	lime
beaver	pumpkin	fuschia
chipmunk	melon	gold
panther	string bean	lavender
Amos	chipmunk	hi-fi
Barry	weasel	lounge
Hank	giraffe	cot
Dale	beaver	love seat
Alex	panther	coffee table
Scott	camel	piano
lime	locust	Hank
gold	chestnut	Scott
beige	bamboo	Amos
lavender	pear	Alex
fuschia	white oak	Barry
crimson	sycamore	Dale
eggplant	fuschia	weasel
string bean	beige	panther
turnip	lime	giraffe
pumpkin	lavender	chipmunk
spinach	crimson	camel
melon	gold	beaver
cot	Alex	chestnut
coffee table	Hank	white oak
hi-fi	Amos	bamboo
piano	Dale	locust
love seat	Scott	sycamore
lounge	Barry	pear
bamboo	love seat	turnip
sycamore	hi-fi	melon
chestnut	cot	eggplant
pear	piano	spinach
locust	lounge	string bean
white oak	coffee table	pumpkin

List B Orders

1	2	3
Alison	raincoat	Anna
eyebrow	tonsil	torso
raincoat	panties	honey dew
raspberry	skateboard	tonsil
magnolia	raspberry	prune
thumb	eyebrow	sled
sled	magnolia	melon
baby's breath	Phyllis	cab
honey dew	bathrobe	geranium
pajamas	coconut	rickshaw
Anna	sled	crocus
nerve	geranium	limousine
Charlotte	nerve	thumb
scarf	Cindy	skateboard
crocus	jumper	sweet pea
cab	Charlotte	Alison
coconut	prune	magnolia
Cindy	rickshaw	nerve
tonsil	abdomen	blackberry
Sandy	sweet pea	Cindy
abdomen	torso	eyebrow
Phyliss	Sandy	jumper
panties	melon	abdomen
prune	limousine	racer
limousine	Alison	Sandy
sweet pea	scarf	raspberry
jumper	blackberry	Phyllis
rickshaw	camellia	scarf
melon	honey dew	baby's breath
camellia	cab	pajamas
skateboard	thumb	camellia
torso	pajamas	bathrobe
bathrobe	baby's breath	coconut
blackberry	Amos	panties
racer	crocus	Charlotte
geranium	racer	raincoat

4 (Blocked)	5 (Blocked)	6 (Blocked)
thumb	coconut	panties
torso	melon	raincoat
abdomen	honey dew	pajamas
nerve	prune	bathrobe
eyebrow	raspberry	scarf
tonsil	blackberry	jumper
Anna	eyebrow	limousine
Alison	abdomen	skateboard
Sandy	thumb	cab
Charlotte	nerve	sled
Cindy	tonsil	racer
Phyllis	torso	rickshaw
pajamas	geranium	Sandy
scarf	camellia	Phyllis
panties	crocus	Anna
jumper	sweet pea	Cindy
bathrobe	magnolia	Alison
raincoat	baby's breath	Charlotte
honey dew	bathrobe	abdomen
blackberry	panties	tonsil
melon	pajamas	thumb
prune	jumper	eyebrow
coconut	raincoat	torso
raspberry	scarf	nerve
cab	Cindy	camellia
racer	Sandy	magnolia
limousine	Anna	crocus
rickshaw	Charlotte	geranium
sled	Phyllis	baby's breath
skateboard	Alison	sweet pea
crocus	sled	melon
baby's breath	limousine	raspberry
camellia	cab	honey dew
sweet pea	rickshaw	coconut
geranium	skateboard	blackberry
magnolia	racer	prune

Instructions

"You are to learn a list of 36 words. After I have turned the cards for you, you will be asked to write down as many words as you remember. You may write them in any order. I will repeat the procedure six times. Do you have any questions? Let's begin."

Appendix D

Metamemory Inventory

Instructions

"I want to talk with you about how you remember. Again, there are no right or wrong answers. Let's see."

Questions

1. Are you a good rememberer?

2. Can you remember better than your friends, or do they remember better than you?

3. Sometimes, although a person is a good rememberer, he (she) can still remember some things better than others. Do you remember some things better than others?

4. Are there some things that are really hard to remember?

5. If you were trying to remember the names of the 50 states, how would you go about it?

6. If you are going to the grocery store, how do you go about remembering what you want to buy?

7. How do you remember what to pack for a trip? How do you remember where you packed it?

8. How do you study for a test?

9. How do you remember your assignments?

10. Do you remember telephone numbers easily? Do you group them? If someone groups them together differently, does it throw you?

11. How do you remember your locker combination? If someone called the combination out to you and left out a number, would you be able to tell it? Could you supply the number?

12. If you left your jacket at school, how would you go about remembering where you left it?

13. If you were a student council representative for your homeroom and were asked the names of the students in your homeroom, how would you go about remembering them?

14. How do you remember where a car is parked in the school parking lot?

Appendix E

Materials and Instructions for Sorting Task

List A Orders

1	2	3	4	5	6
house	lip	hospital	army	poster	mother
lip	horse	bird	blood	army	officer
market	street	wife	shoes	water	mountain
paper	star	market	horse	alcohol	wife
poster	house	alcohol	paper	village	water
mother	poster	street	bird	paper	bird
star	shoes	mother	water	street	army
bird	hospital	house	lip	mountain	village
blood	wife	horse	star	shoes	market
alcohol	paper	poster	market	star	street
mountain	bird	blood	officer	market	hospital
street	village	lip	mother	horse	shoes
wife	mountain	officer	hospital	blood	lip
shoes	army	water	house	mother	alcohol
water	market	mountain	alcohol	wife	house
village	water	star	wife	lip	blood
officer	blood	village	mountain	hospital	poster
hospital	officer	shoes	street	bird	star
horse	alcohol	army	village	house	paper
army	mother	paper	poster	officer	horse

List B Orders

1	2	3	4	5	6
forest	letter	home	arm	potato	money
letter	animal	baby	book	arm	woman
machine	rock	skin	sky	world	sea
party	stone	machine	animal	body	skin
potato	forest	body	party	newspaper	world
money	potato	rock	baby	party	baby
stone	sky	money	world	rock	arm
baby	home	forest	letter	sea	newspaper
book	skin	animal	stone	sky	machine
body	party	potato	machine	stone	rock
sea	baby	book	woman	machine	home
rock	newspaper	letter	money	animal	sky
skin	sea	woman	home	book	letter
sky	arm	world	forest	money	body
world	machine	sea	body	skin	forest
newspaper	world	stone	skin	letter	book
woman	book	newspaper	sea	home	potato
home	woman	sky	rock	baby	stone
animal	body	arm	newspaper	forest	party
arm	money	party	potato	woman	animal

Instructions

"I will give you a deck of cards, and you may sort them in as many piles as you wish, except that you can't put one card in one pile and all other cards in another pile. What I want you to do is sort them so that you can sort the next deck in exactly the same way. You may look at only the top, last card. When you are through, I will ask you to recall as many words as you can."

As the experimenter handed the child each deck, she said, "Sort them in exactly the same way as the last time."

After two identical, consecutive sorts were achieved, the experimenter said, "Now, I want you to write on this paper all the words that you remember."

Following the recall, subjects were asked, "Why did you put certain words together?"

Appendix F

Metamemory Follow-up Inventory

Instructions

"Now that we are through with the tasks, let me ask you some questions about them."

Questions

1. Do you remember the categorized lists of related words on these cards? (Experimenter shows a set of the cards.) If you were telling someone how to go about learning and remembering the list of categorized words, how would you tell them to go about it? What helped you?

2. Do you remember the lists of unrelated words? (Experimenter shows a set of the cards.) If you were trying to help someone learn and remember the unrelated words, how would you tell them to go about it? What helped you?

3. If you were trying to help someone remember the words in the sorting task, we just completed, how would you tell them to go about it? What helped you?