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ELABORATION PROPENSITY AND

FORMAL OPERATIONAL

ABILITY

by

Mary Kay Greenberg Reed

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APPROVAL PAGE

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Propensity for elaboration has been hypothesized by Rohwer (1976) to account for age and individual differences in performance on paired-associate tasks. Elaboration propensity refers to the spontaneous association of two members of a pair by creation of an event or situation which joins the words. The construction of a sentence connecting the two words is an example of an elaboration strategy. According to Rohwer (1976), the use of elaboration techniques increases effective storage of information and thereby enhances retrieval.

Rohwer, Raines, Eoff, and Wagner (1977) reported both age and individual differences in propensity for elaboration. Postadolescents (ages 16 to 17 years) who showed high proficiency on a paired-associate task demonstrated a propensity for elaboration. Preadolescents (ages 11 to 12 years) and postadolescents who performed with a medium or low proficiency on a paired-associate task demonstrated a minimal or weak elaboration propensity.

Although Rohwer et al. (1977) demonstrated individual differences in elaboration propensity in postadolescents, an explanation for such differences remained to be offered. Neimark (1976) argued that the use of well-developed, efficient mnemonic strategies reflects the development of formal operational ability. If this characterization is accurate, then propensity for elaboration should be predicted by the individual difference index of formal operational ability as described by Inhelder and Piaget (1958).

The present study investigated the relationship between propensity for elaboration in postadolescents and development of formal operational thought. An attempt was made to demonstrate that the operational structures underlying formal operational thought are sufficient for propensity for elaboration.

Two Inhelder tasks (Inhelder & Piaget, 1958), i.e., the Colorless Chemicals Task and the Pendulum Problem, were employed to assess formal operational ability. On the basis of their performance on the two tasks, postadolescents were assigned to the formal or concrete operational groups. The elaboration propensity of the postadolescents was examined with the procedure employed by Rohwer et al. (1977). Within each operational level, the postadolescents were assigned to one of three instructional conditions: conventional, repetition, and sentence.

The results supported the predictions. Formal postadolescents who received conventional instructions demonstrated better performance than concrete postadolescents who received conventional instructions. Formal postadolescents who received conventional instructions also demonstrated better performance than formal postadolescents who received repetition instructions. Repetition, it was argued, hindered the spontaneous elaboration strategy of the formal postadolescents. Concrete postadolescents, however, demonstrated equal performance levels in the conventional and repetition conditions. This result is interpreted as reflecting use of repetition strategies which was hypothesized to be the concrete postadolescents' spontaneous mode of strategy. Contrary to predictions, sentence instructions proved to be compensatory for both formal and concrete postadolescents, i.e.; performance levels were better in the sentence conditions than in the repetition and conventional conditions.

A direct examination of the spontaneous use of elaboration by formal and concrete postadolescents was also conducted. The postadolescents in the conventional condition were given 40 additional pairs of words and were instructed to learn the pairs as best they could. The students were told to perform their strategy aloud. The strategies employed by the students were recorded by the experimenter. The students were also questioned about the strategies they had used. Formal students spontaneously employed more elaboration strategies than did concrete students. No difference occurred in the type of strategies reported by the students.

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CHAPTER I

INTRODUCTION

The elaboration hypothesis was formulated by Rohwer (1973) to account for the occurrence of age differences in paired-associate tasks. The elaboration hypothesis postulates that propensity to engage in elaboration strategies develops with age, increasing significantly during adolescence. Elaboration refers to the relating of two members of a pair by creation of an event or situation which joins the words, e.g., construction of a sentence employing the two words. According to Rohwer (1976), the use of elaboration techniques increases effective storage of information and thereby enhances retrieval of the information.

Rohwer, Raines, Eoff, and Wagner (1977) conducted a series of studies examining age and individual differences in the use of elaboration by preadolescents (ages 11 to 12 years) and postadolescents (ages 16 to 17 years) in a paired-associate task. The method of paired-associates consists of presenting a list of nouns in groups of two to the subject for study. The assessment of learning involves the presentation of one member of each pair for recall of the second member. To measure individual differences, a criterion of recall success on a paired-associate list was employed. Rohwer et al. (1977) reported both individual and age differences in propensity for elaboration. Postadolescents who showed high proficiency on the paired-associate task demonstrated a propensity for elaboration. All of the preadolescents and the postadolescents who performed with a medium or low proficiency on the paired-associate task showed a minimal or weak propensity for elaboration.

The demonstration of individual and age differences in the use of an elaboration scheme, however, does not offer an explanation for the phenomenon. Rohwer et al. (1977) suggested that an increase in propensity for elaboration could be associated with cognitive changes occurring in adolescence. The development of formal operational ability as postulated by Inhelder and Piaget (1958) provides a theory with which to investigate this possibility.

According to Inhelder and Piaget (1958), the structural changes which characterize formal operational ability and which occur during adolescence allow for a wide range of cognitive operations, including mnemonic strategies. These operations can be adapted to any problem-solving situation. Neimark (1976) characterized individuals with formal operational thought structures as able to supersede memorization schemes and employ organization strategies which are adaptable to a particular memory situation. Inhelder and Piaget (1958) and Neimark (1976) represented the use of efficient problem-solving and memory strategies as reflecting formal operational development.

The present study investigated the relationship between the propensity for elaboration in postadolescents and the development of formal operational thought. An attempt was made to demonstrate that the operational structures underlying formal operational thought are sufficient for propensity for elaboration. Two Inhelder tasks (Inhelder & Piaget, 1958) adapted by Kuhn (Kuhn & Angelev, 1976; Kuhn & Brannock, 1977) were used to assess formal operational thought in postadolescents. A paired-associate task was employed to examine the elaboration hypothesis as formulated by Rohwer (1973) and the relationship of elaboration propensity to formal operational ability. The spontaneous use of elaboration strategies by formal operational and concrete operational postadolescents was examined directly through a procedure reported by Neimark (1976) in her investigation of subject-devised study strategies.

The Development of Elaboration Propensity

The determining processes in paired-associate learning, according to Rohwer (1976), involve storage rather than retrieval of information. Rohwer (1976) hypothesized that elaboration is essential to effective storage in a paired-associate task. Generation of a sentence involving a relationship between the two words is one example of elaboration. Connecting the two words of a pair to a subjective experience can also be considered elaboration. According to Rohwer (1976), retrieval of the second member of the pair at test is facilitated due to the establishment of the meaningful or subjective event at test.

Age differences in performance on a paired-associate task (Jensen & Rohwer, 1965) have been accounted for by Rohwer (1976) in the elaboration hypothesis. The elaboration hypothesis states that an increase in the use of elaboration occurs with age. According to Rohwer (1976), the spontaneous use of elaboration does not appear before adolescence. Jensen and Rohwer (1965) reported that children in second, fourth, and sixth grades had the ability to benefit from elaboration instructions when the elaboration sentences were presented. However, they reported that the children did not spontaneously employ elaboration strategies. Jensen and Rohwer (1965) and Rohwer (1966) demonstrated that elaboration instructions can be said to be compensatory for preadolescent children because the elaboration instructions improved the children's performance. In order to determine the compensatory effect of elaboration instructions, performance levels in elaboration conditions are compared to levels in conventional conditions. Conventional instructions, it is argued (Rohwer, 1973), assess the individual's own spontaneous mode of strategy.

According to Suzuki and Rohwer (1969) and Rohwer (1973), an increase in propensity for elaboration, i.e., the tendency to generate spontaneous elaborative prompts, is especially pronounced during adolescence. College students have demonstrated equal performance levels under compensatory and conventional conditions (Bobrow & Rohwer, 1969; Suzuki & Rohwer, 1969). Instructions to elaborate and the presentation of elaborative prompts did not increase the performance of adults in paired-associate tasks. This finding suggests that elaboration is used spontaneously by adults in paired-associate tasks. Both elaboration and conventional instructions appear to produce the use of elaboration schemes by adults in a paired-associate task and so result in equal performance levels.

In a series of experiments, Rohwer and his associates (Rohwer & Bean, 1973; Rohwer et al., 1977) investigated the elaboration hypothesis and developmental differences. Rohwer and Bean (1973) reported that contrary to prediction, postadolescents (17-year-olds) benefited from compensatory instructions. Performance under sentence instructions was better than performance under conventional instructions. This finding suggests that all postadolescents do not spontaneously demonstrate a propensity for elaboration as predicted. Rather than reject the developmental aspect of the elaboration hypothesis, Rohwer (1976) reexamined previous studies of postadolescents' and adults' propensity for elaboration. The subjects for the earlier studies, he reported, consisted of college students and potential college students, whereas Rohwer and Bean (1973) had used students from lower-middle-class neighborhoods where the students were not necessarily college bound. Differences reported within an age level for the effect of compensatory instructions suggest, according to Rohwer (1976), that propensity for elaboration is not solely an age phenomenon but also an individual one. In order to demonstrate differences in propensity for elaboration, Rohwer (1976) argued that a measure of individual learner differences within an age level was necessary.

Developmental and Individual Differences in Elaboration Propensity

Rohwer et al. (1977) conducted a series of experiments to examine age differences, individual learner differences, and propensity for elaboration. Their first experiment employed IQ scores as an index of individual differences. Rohwer et al. (1977), however, reported no support for the developmental increase in elaboration. Both the preadolescents and the postadolescents demonstrated higher performance levels with elaboration (compensatory) instructions than with conventional instructions. No variations due to IQ in the preadolescents' and postadolescents' performance occurred. IQ, therefore, was not an adequate index of individual differences for predicting propensity for elaboration in preadolescents and postadolescents.

A second individual difference measure employed by Rohwer et al. (1977) was learning proficiency on a paired-associate task. Three proficiency level groups (high, medium, and low) at two age levels (11 and 17 years) were examined. Assignment to a proficiency level was determined by the students' recall performance on a paired-associate task conducted before the initiation of the experiment. Students at each age and proficiency level were then assigned to one of three instructional conditions: conventional, repetition, and sentence. Students in the conventional condition were given standard instructions to study the word pairs. The repetition condition consisted of instructing the students to repeat aloud the members of each pair as often as possible until the next pair was presented. The sentence (elaboration) instructions consisted of telling the students to generate a sentence connecting the two members of the pair. The students were further told to repeat aloud the sentence until the next pair was presented.

In accordance with the revised elaboration hypothesis, Rohwer et al. (1977) predicted differences in elaboration due to age and individual learner differences. The tendency to use elaboration, Rohwer et al. (1977) stated, would vary due to age and learner proficiency on the paired-associate task. The results supported this prediction. High proficiency postadolescents demonstrated high levels of performance under both elaboration and conventional instructions. Repetition instructions, however, hindered the performance of high proficiency postadolescents. Elaboration instructions increased the level of performance of the medium and low proficiency postadolescents and all of the preadolescents. Performance under conventional and repetition instructions for the medium and low proficiency postadolescents and for all of the preadolescents was approximately equal.

These findings suggest both age and individual differences in propensity for elaboration. Elaboration propensity was evident only in the performance of the high proficiency postadolescents. None of the performance levels of the medium or low proficiency postadolescents indicated propensity for the use of elaboration, an outcome implying individual differences in propensity for elaboration in postadolescents. The hypothesis of age differences in the use of elaboration was supported by the difference between the performance levels of the preadolescents and the postadolescents. Elaboration instructions proved to be compensatory for all of the preadolescents, while equal performance levels were demonstrated by the preadolescents in the conventional and repetition conditions. Further, an age and individual learner differences interaction was indicated by the finding that compensatory instructions did not increase the performance of the high proficiency postadolescents. The medium and low proficiency postadolescents and all of the preadolescents, however, did benefit from the compensatory elaboration instructions. Therefore, the individual difference measure of learner proficiency on a paired-associate task was only successful in predicting elaboration propensity in postadolescents.

Rohwer et al.'s (1977) demonstration of individual and age differences in propensity for elaboration does not offer an explanation for the phenomenon. Although Rohwer et al. (1977) showed age differences, chronological age alone does not explain differences in elaboration propensity. Furthermore, Rohwer et al.'s (1977) successful use of learning proficiency on a paired-associate task to differentiate elaboration propensity in postadolescents does not offer a causal explanation. In order to explain individual and age differences in the use of elaboration, researchers must identify an individual difference index that not only can be used to predict elaboration propensity but also can be defended as a possible causal factor in elaboration propensity. The individual difference index should, therefore, be a measure of underlying and defining processing ability.

Indexing Individual Differences

The identification and characterization of individual differences have recently become a focus of interest in the study of development of cognitive abilities (Gagne, 1967). Indices of individual differences have typically included age, sex, socioeconomic status, ethnicity, educational level, and intelligence test scores (Rohwer, 1976). Underwood (1975), however, argues that the important variables for research in this area are not age, sex, IQ, or social status, but some measure of individual processing ability.

The indexing of individual differences should serve to differentiate a population with respect to the level of perfromance the subjects will demonstrate on a specific task (Rohwer, 1976). Age has typically been employed as a developmental indexing variable. Differences in performance between age levels have been explained as reflecting the distinctive characteristics of the individuals at a certain chronological age (Gagne, 1967). However, Keeney, Cannizzo, and Flavell (1967) and Rohwer et al. (1977) demonstrated performance differences, within age levels, that can be attributed to differences in processing activities. Indexing according to age, therefore, may not be a sufficiently sensitive measure by itself for assessing individual differences; other measures for indexing individual differences must be determined.

Jensen (1967) hypothesized two classes of indexing learner differences: extrinsic and intrinsic. Extrinsic indices include age, sex, grade, and IQ and may be considered as correlative to the level of performance shown on a task. Intrinsic indices are specific to a task. They consist of measures of processing ability assumed to be sufficient for the level of performance attained in the task. As described earlier, Rohwer and Bean (1973) and Rohwer et al. (1977) employed several extrinsic and intrinsic variables in a series of experiments investigating age and individual differences and the elaboration hypothesis. Their extrinsic variables, i.e., age and IQ, were inadequate for indexing their subjects according to an individual difference measure which would provide support for the elaboration hypothesis. Their intrinsic or processing measure, which consisted of learning proficiency on a paired-associate task, in conjunction with the extrinsic measure of age, sufficiently differentiated the subjects in the sample. Age and individual processing differences were then used to predict accurately the results in accordance with the elaboration hypothesis. Rohwer et al.'s (1977) successful use of a processing activity as an index of individual differences supports Underwood's (1975) argument concerning the appropriate measure for indexing individual differences.

The identification by Rohwer et al. (1977) of a predictive intrinsic processing activity, i.e., learning proficiency on a paired-associate task, does not offer an explanation for the individual differences in the elaboration propensity of postadolescents. A technique for differentiating postadolescents according to some underlying and defining processing ability that allows for both prediction and possible explanation of elaboration propensity is needed. The Inhelder and Piaget (1958) theory of formal operational thought may provide such an indexing scheme.

Characteristics of Formal Operational Thought

The fourth stage of Piaget's theory of intellectual development is the formal operational period (Inhelder & Piaget, 1958). This stage has been hypothesized by Inhelder and Piaget to begin with adolescence. According to Inhelder and Piaget, formal operational thought can be characterized by the presence of a wide range of cognitive operations which are ready for application in any problem-solving situation. These operations include those processes previously developed in the concrete operational stage which are adapted into formal thought during adolescence. These operations include negation and compensation, which during concrete operations were used separately but which during formal operations can be employed in conjunction with each other.

Hypothetico-deductive reasoning, i.e., logical thought, is characteristic of formal operational thought. Individuals whose structures can be categorized as formal operational have the ability to generate hypotheses, deduce their consequences, implement efficient experiments, and analyze data systematically. Unlike the concrete operational individual, those in formal operations can think beyond the present to future reality. Formal thought is reflective; the individual can now think about thinking and does contemplate his or her thought processes.

According to Inhelder and Piaget (1958), the development of formal operational thought depends upon the establishment of propositional logic and formal logic. Formal logic is reasoning according to all the possible combinations which are pertinent to a situation. In concrete operations, the individual can employ only a limited combinatorial system, i.e., a one-to-one correspondence or an unsystematic n-by-n combination. Only a structure characterized by formal intelligence can produce the total number of n-by-n possibilities in a systematic fashion.

Propositional logic permits the individual to reason according to the operations of exclusion. Due to propositional logic abilities, the isolation of a causal variable and the exclusion of other inoperative factors can be accomplished. Neither isolation nor exclusion of variables can be systematically performed during the concrete operational stage. Only in formal operations can they be systematically and jointly employed.

Piaget (1973) has stated that memory processes borrow their structures and the corresponding operations from intelligence. Because memory, for Piaget (1973), is but an aspect of intelligence, the development of memory can be said to reflect cognitive development.

Neimark (1976) examined the implications of the development of formal operational thought for memory. According to Neimark (1976), the main characteristic associated with the development of formal operations is obliteration of the need to rely on rote memorization. Formal operational thought is reflected in the ability to impose organization where none is inherent, to employ categorization schemes, and to accurately assess one's memory-related capabilities in relation to the demands of the task.

The development of formal operational cognitive abilities and memory schemes appears to parallel the development of elaboration propensity hypothesized by Rohwer (1976). The abilities of integration and organization and the deliberate ordering of experience in adolescents, as described by Neimark (1976), may be sufficient for the spontaneous use of elaboration. Elaboration involves integration and a systematic ordering of experience. Propensity for elaboration may, therefore, be affected by the attainment of formal operations.

Overview of the Present Study

Although Rohwer and his associates (Rohwer & Bean, 1973; Rohwer et al., 1977) demonstrated individual differences in elaboration propensity in postadolescents, an explanation for such differences remains to be offered. Neimark (1976) has argued that the use of well-developed, efficient mnemonic strategies reflects the development of formal operational ability. If this characterization is accurate, then propensity for elaboration should be demonstrated by formal operational adolescents and not by concrete operational adolescents.

Employing an intrinsic individual difference processing index of learning proficiency on a paired-associate task, Rohwer et al. (1977) reported that high proficiency postadolescents demonstrated equal performance in both sentence and conventional conditions. However, medium and low proficiency postadolescents demonstrated equal performance levels in the repetition and conventional conditions. These results may be interpreted as evidence that the preferred mode of strategy for high proficiency postadolescents is elaboration and for medium and low proficiency postadolescents, repetition.

In the present research, formal operational ability was employed as an intrinsic index of individual differences. By employing this index, the present study attempted to demonstrate that the operations which define formal operational ability are also sufficient for the spontaneous use of elaboration in paired-associate tasks. If this relationship can be demonstrated, then formal operational tasks can be employed to measure operational ability differences of both preadolescents and postadolescents. Elaboration propensity at both age levels, therefore, could be predicted from a single index of formal operational ability.

Two Inhelder tasks (Inhelder & Piaget, 1958), which have been adapted by Kuhn (Kuhn & Angelev, 1976; Kuhn & Brannock, 1977), were employed to assess formal operational ability. The two tasks were the Combination of Colorless Chemicals and the Pendulum Problem. These tasks are representative of the two defining operational characteristics of formal operational thought, i.e., formal logic and propositional logic (Martorano, 1977). The Chemicals Task, according to Inhelder and Piaget (1958) and Neimark (1975), is a technique for assessing the development of the use of systematic procedures and formal logic, i.e., the ability to produce a complete combinatorial system. The Pendulum Task, a problem involving the use of propositional logic, assesses the ability to use the operations of exclusion, i.e., to isolate an operative variable by excluding other inoperative ones (Inhelder & Piaget, 1958; Kuhn & Angelev, 1976). In a developmental examination of the ten Piagetian formal operational tasks, Martorano (1977) reported that operational performance on the Chemicals Task was positively correlated to operational performance on the Pendulum Task.

Postadolescents who scored at the formal operational level on both tasks were included in the formal operational category. Assignment to the concrete operational category depended upon failure to score at the formal operational level on both tasks. This method of sample determination was employed to increase the likelihood that the two groups operated on different levels. If a mean score had been used, a more heterogenous sample of formal operational and concrete operational postadolescents might have resulted. Subjects in the formal and concrete operational groups were matched for age, sex, and intellectual ability. This measure was taken due to the controversy concerning the correlation of sex and intellectual ability with formal operational ability (Keating & Schaefer, 1975; Wyatt & Geis, in press).

The elaboration propensity of the formal operational and concrete operational postadolescents was examined with the procedure employed by Rohwer et al. (1977). Within each operational level, the postadolescents were randomly assigned to one of three instructional conditions: conventional, repetition, and sentence. In the conventional group, the postadolescents were given standard paired-associate instructions to study each pair of words until the next pair was presented. The repetition group was instructed to repeat aloud each pair of words until presentation of the next pair. The instructions to the sentence group were to create a sentence in which an event occured that related the paired words and to repeat the sentence aloud until the succeeding pair was presented. Each student had two study-test trials with a 40-pair list.

The following results were predicted. Both conventional and sentence instructions should elicit elaboration schemes from formal operational postadolescents. Performance on conventional and sentence conditions, therefore, should be approximately equal for the formal operational postadolescents. Repetition instructions should hinder the performance of formal operational postadolescents whose preferred mode should be elaboration. Sentence instructions should prove to be compensatory for concrete operational postadolescents who should not employ elaboration unless prompted. Performance levels of the concrete operational postadolescents who are in the sentence condition should, therefore, be better than performance of the concrete operational postadolescents who receive conventional and repetition instructions. Repetition schemes should be employed by concrete operational postadolescents in the repetition and conventional conditions as repetition is hypothesized to be the concrete operational postadolescents' spontaneous strategy. Level of performance of the concrete operational postadolescents in the conventional and repetition conditions should, therefore, be approximately equal.

The concrete operational postadolescents' performance under sentence instructions should be approximately equal to the performance of the formal operational postadolescents who receive sentence and conventional instructions. Any difference between the formal operational postadolescents and concrete operational postadolescents under sentence instructions can be attributed to the formal operational postadolescents' hypothesized well-practiced use of elaboration. Performance levels of the formal operational postadolescents and concrete operational postadolescents in the repetition conditions should be approximately equal.

Formal operational postadolescents, it is hypothesized, employ elaboration as their unprompted strategy for learning, while concrete operational postadolescents use repetition. Use of different modes of strategies should be reflected in performance levels. Performance of the formal operational postadolescents who received conventional instructions and used elaboration should be higher than that of the concrete operational postadolescents who received conventional instructions and used repetition.

A more direct examination of the spontaneous use of elaboration by formal operational and concrete operational postadolescents was also conducted. A procedure described by Neimark (1976) was used to determine whether formal operational postadolescents spontaneously use elaboration schemes while concrete operational postadolescents rely on repetition. After presentation of the standard paired-associate task, the formal operational and concrete operational postadolescents in the conventional conditions received a second set of 40 paired-associate words with each pair of words printed on a card. In order to create a natural study situation, all of the cards were simultaneously given to the students. They were instructed that they could use any technique to learn the pairs. They were further instructed to perform aloud what they were doing to learn the word pairs so that the experimenter could record their methods. The students were told that they would be tested in the same manner as in the preceding paired-associate test. After the memory test, the students were questioned about the strategy they employed during the study period. Further, they were queried about the specific strategy they had employed for items they had not remembered and were asked why the strategy had not proved effective. These questions were asked in order to determine the individuals' verbalizable knowledge concerning their memory strategies and concerning the effectiveness of their memory strategies in the task (Flavell & Wellman, 1977). If the hypothesis for the spontaneous use of elaboration as presented here is accurate, then the formal operational postadolescents should spontaneously use elaboration schemes as their study strategy and the concrete operational postadolescents should employ rote memorization.

The present study, thus, asked two main questions. First, can propensity for elaboration in postadolescents be predicted by the individual difference index of formal operational ability? Second, does the type of strategy spontaneously engaged in by formal operational and concrete operational postadolescents in a natural study situation provide support for the hypothesis of elaboration propensity differences in postadolescents?

CHAPTER II

METHOD

Subjects

The subjects consisted of 96 postadolescents who attended three senior high schools. Their age ranged from 16.0 years to 17.11 years. The mean age of the females was 17.1 years and the mean age of the males was 17.2 years. An equal number of males and females was tested at each operational level and instructional condition. A total of 118 students was assessed in order to identify 48 formal operational postadolescents and 48 concrete operational postadolescents who could be matched on age, intellectual ability, and sex. Fifteen students were excluded because they scored at the formal operational level on one task and at the concrete operational level on the second task. Procedural problems forced the exclusion of two students, while five students were not included because they could not be adequately matched according to age, intellectual ability, and sex.

Design

The design for the instructional paired-associate task consisted of five between-subject factors: operational level (formal operational and concrete operational), instructions (conventional, sentence, and repetition), sex (male and female), list (*A* and *B*), and list order (*1* and *2*). The within-subject factor was trials (Trial *1* and Trial *2*). The postadolescents were assigned to an operational level depending on their performance on the two adapted Inhelder tasks. Assignment to an instructional condition within an operational level was random.

The design of the natural study task consisted of four between-subject factors: operational level (formal operational and concrete operational, sex (male and female), list (A and B), and list order (1 and 2). The subjects in the natural study task were those students who had been randomly assigned at both operational levels to the conventional instructional condition.

Materials

The materials for the Colored and Colorless Chemicals Task, as described by Inhelder (Inhelder & Piaget, 1958) and adapted by Kuhn and Angelev (1976), consisted of seven glasses and four liquids. Four of the liquids were labeled one through four. The fifth glass, which contained a dropper, was labeled g. Glass 1 contained diluted sulfuric acid, Glass 2 contained water, Glass 3 held oxygenated water, Glass 4 had thiosulfate, and Glass g contained potassium iodide. Glasses 6 and 7 were unlabeled and were employed for demonstration of the task. Glass 6 contained a mixture of diluted sulfuric acid and oxygenated water (Glasses 1 and 3). The seventh glass held water (Glass 2).

Each student was provided with several mimeographed sheets depicting the four numerically lebeled glasses and Class g. The sheets consisted of rows of pictures of the glasses, each row containing pictures of Glasses 1 through 4 and Glass g. A sample sheet is presented in Appendix I. The use of mimeographed sheets, Kuhn and Angelev (1976) argued, allowed for the generation of all possible combinations and controlled for a possible memory factor if mixtures had actually been done. Dale (1970) reported that students unnecessarily repeated mixtures as if they had forgotten which liquids they had already combined. Dale (1970) argued that the students' inability to recall which mixtures they had already tried interfered with the production of all possible combinations. A pencil and paper measure allowed for a visual record of each mixture and permitted the student to check which mixtures had been tried and which had not. Each student was provided with more sheets than was necessary to generate all of the possible combinations.

The Pendulum Problem materials, as described by Inhelder (Inhelder & Piaget, 1958), consisted of four different weights, a string which could be varied in length, and a stand board. Two hooks were used on the stand board. One hook was used to fasten the string at the top of the board. This allowed for the length of the string to be varied. The second hook was used to attach the weights to the bottom of the string. The weights were 5, 10, 15, and 20 grams.

Two lists each consisting of 40 pairs of nouns were constructed for the memory tasks. The lists were drawn from the word frequency data provided by Carroll, Davies, and Richman (1971). The words were taken from the frequencies presented for the ninth grade, which is the highest grade level tested by Carroll et al. (1971). The words were limited to four to six letters and to frequencies of 20 through 80. The pairs were constructed so that no obvious associations between the words were evident. Each student in the conventional condition received one list in the instructional paired-associate task and the other list in the study situation. The students in the repetition and sentence conditions received only one list. Presentation of the lists was counterbalanced, and each list was presented an equal number of times. Two random orders of presentation of the pairs were constructed for each list. The presentation of the random orders was also counterbalanced. Two additional random orders of the pairs were constructed for each list and were used at test. Each pair of words was printed on 76 mm x 127 mm white index cards. The test cards consisted of only the first member of each pair printed on the card. The pairs of words are presented in Appendix I.

Procedure

Each student was tested individually. The students were seated next to the experimenter at a table. Testing was conducted on three different days. On the first day, the students were given the Chemicals Task or the Pendulum Problem. The second task was given on the second day. The order of administration of the two tasks was counterbalanced. Testing on the third day consisted of the instructional paired-associate tasks for all the students and the study task for the students in the conventional conditions.

The sessions were generally conducted on three consecutive days.

A female graduate student, the author, conducted the testing sessions.

The Colorless Chemicals Task. The five labeled and two unlabeled glasses were presented to the student. Into the unlabeled glasses in full view of the students, drops of potassium iodide from Glass g were placed. The mixture containing diluted sulfuric acid turned yellow while the water remained unchanged. The mimeographed sheets containing the rows of the glasses were given to the students. The experimenter explained that an actual combination of liquids could be represented by circling, on the sheets, the glasses which the student would want to include in an actual combination. The students were instructed to circle all of the mixtures which they would need to try in order to determine which combinations of the liquids could produce yellow. The experimenter provided an example by circling the combination of Glass 1 and Glass 2. The students were asked if they understood what they were to do. The instructions were repeated, and a second example was provided if necessary. As in the Kuhn and Brannock (1976) procedure, a prompt was provided the students if they appeared to have finished and had not produced all the possible combinations. As a prompt, the experimenter asked the students whether there were other combinations they should try to get the color yellow. The experimenter further asked the students to indicate, by placing checks on the sheet, which combinations they must try to determine if the liquid in Glass 4 affected the production of yellow. The instructions are presented in Appendix II, and the scoring procedure for this task is presented in Appendix III.

The Pendulum Problem. The subjects were presented the stand board with the string already attached. The experimenter demonstrated how the string could be adjusted in length. The set of four weights was also shown. The experimenter explained that the force of one's push and the height of the release point for the push could be varied. The 5-gram weight was attached to the string, and a demonstration of the pendulum and all four variables (weight, length of the string, force of the push, and height of the release point) was given by the experimenter. The students were instructed to experiment with the pendulum and to determine what makes the pendulum go faster or slower. After the student had manipulated the pendulum, the experimenter probed the student as to his or her solution. The experimenter asked for an explanation for the problem, treating in turn the four possible variables. The students were also asked how they could prove their solutions. The instructions and scoring procedures are presented in Appendix II and III, respectively.

After the completion of the second operational task, the students were assigned on the basis of their performance to the formal operational and concrete operational groups. Attainment of the formal operational level on both tasks was the criterion for inclusion in the formal operational group. Students who did not score at the formal operational level on either of the tasks were assigned to the concrete operational group.

The instructional paired-associate task. Within each operational level, the students were assigned randomly to an instructional condition. At the beginning of the task, each student received an explanation of the task. The students were instructed that they would be presented 40 pairs of words and that their task was to learn the pairs. The test situation was also described to the students. The students were told that the first member of the pair would be presented at test and that they must provide the second member. The students were instructed to learn the words as best they could. This directive concluded the instructions to the conventional groups. The repetition condition students were further instructed to repeat aloud each pair as often as possible until the next pair was presented. The students in the sentence conditions were told to create a sentence joining the two members of the pair into a meaningful event. An example was provided for the pair dog-lamp, i.e., the dog knocked over the lamp. The students were also instructed to repeat aloud the sentence until presentation of the next pair of words.

The students were then given six pairs of words for practice. The practice situation included both study and test of the words. If the subjects in the repetition and sentence conditions did not repeat the pairs or the sentence during the practice trials, they were prompted to do so. Before the beginning of the study period, the students were asked if they understood the task. The instructions were repeated if necessary.

Each student received two study-test trials. Each pair was presented for 15 seconds. Presentation of the pairs was done manually by the experimenter. The sentences generated by each student were tape-recorded and transcribed. The test words were presented for 5 seconds in the same manner as in the study procedure. The students were instructed to respond aloud with the second member of the pair. The experimenter recorded the student's responses. The second study-test trial was identical to the first. The instructions are presented in Appendix II.

<u>The study situation</u>. At the conclusion of the instructional paired-associate task, the students in the conventional groups were instructed that they would receive 40 more pairs of words. They were told that the experimenter was interested in how they study. It was suggested that the students should employ a study strategy similar to one which they would use for studying their

school work. The students were instructed that they were permitted to use any technique that they wished to learn the pairs of words. The experimenter instructed the students that they must perform the study strategy aloud so that the experimenter could record their strategy. The test situation, the students were informed, would be conducted as in the previous paired-associate task.

All of the cards with the pairs printed on them were given to the students. The students were given 8 minutes for studying the pairs. The test trial was conducted in the same manner as in the instructional paired-associate task. The first member of each pair was presented at test for 5 seconds, and the students were instructed to respond aloud with the second member of the pair. The experimenter recorded the students' responses. Following the test situation, the students were questioned about the strategy they employed during the study period. They were also questioned about the specific strategy they employed for certain missed items. The experimenter recorded the students' responses. The instructions for the study situation and the study strategy questions are presented in Appendix II.

CHAPTER III

RESULTS

Scheffé post hoc analyses (Winer, 1971) were conducted on all significant results. The level of significance employed for all tests was .01 except where indicated. The reliability indices were calculated according to a formula presented by Koppitz (1968) and Repp, Deitz, Boles, Deitz, and Repp (1976). The formula is number of agreements divided by the total number of agreements and disagreements.

Subject Characteristics

Each subject was assigned on the basis of his or her performance on the two Inhelder tasks to the formal operational level or the concrete operational level. A female rater who had conducted previous work with formal operational tasks (Wyatt & Geis, in press) independently rated 32 randomly selected protocols according to the scoring procedures presented in Appendix III. These ratings were compared with those performed by the experimenter. The reliability index for the Chemicals Task was 82%, while the reliability rating for the Pendulum Problem was 75%. The overall reliability index was 78%. Only seven inconsistent ratings occurred in the 32 protocols.

The formal operational students within each instructional condition were matched according to age, sex, and intellectual ability with the concrete operational students. Due to the necessity to conduct the research at three separate schools, different measures of intellectual ability were obtained. Each measure was a converted score, i.e., it was determined by the student's age and performance on an achievement or aptitude test. Therefore, the measures were approximations of an IQ score. One set of scores was based on the results of the Educational Testing Service Achievement Test. The second two sets of scores were based on the results of the Scholastic Aptitude Test.

The overall mean IQ score was 119.4, with a range of 94-140. The mean IQ score for the formal operational students was 120.3, with a range of 100-140. The mean age of the formal operational students was 17.0 years. The mean IQ score for the concrete operational students was 117.6, with a range of 94-139. The mean age of the concrete operational students was 17.1 years.

A Pearson's Product Moment Correlation was conducted on the students' ages, IQ scores, and the number of correctly recalled words. The correlation between age and number of correctly recalled words was $\underline{r}$ (96) = $^{-}$.16, $\underline{p} > .05$. The correlation between IQ scores and the number of correctly recalled words was $\underline{r}$ (96) = .28, $\underline{p} > .05$. This finding replicates Rohwer et al. (1977).

Memory Performance

Instructional task. The following procedures were employed to determine differences in memory performance. The number of words correctly recalled by each student in the instructional paired-associate task was calculated for the two trials.

A 2 x 3 x 2 x 2 x 2 x 2 analysis of variance was performed on the number of words correctly recalled on Trials 1 and 2 of the instructional paired-associate task. The between-subject variables were: operational level (formal operational and concrete operational), instructions (repetition, sentence, and conventional), sex (male and female), list (A and B), and list order (1 and 2). The within-subject variable was trials (1 and 2). The analysis of variance summary table is presented in Appendix IV. This analysis indicated two main effects. First, the instructions variable was significant, F (2,48) = 22.80. The mean for the repetition condition was 17.6, the mean for the sentence condition was 28.8, and the mean for the conventional condition was 21.4. The post hoc analyses indicated that students in the sentence conditions remembered more words than the students in the repetition and conventional conditions. Students in the conventional condition also remembered more words than students in the repetition condition. These findings replicate Rohwer et al. (1977). Second, the trials factor was also significant, F (1,48) = 616.35. The mean for Trial 1 was 16.9 and the mean for Trial 2 was 28.2. These results, however, must be interpreted in light of the significant instructions and trials interaction.

As shown in Table 1, a significant interaction of instructions and trials resulted, $F\ (2,48) = 5.42$. The post hoc analyses indicated that students in all three instructional conditions remembered more words on Trial 2 than on Trial 1. This finding reflects the simple main effect of trials. However, on Trial 1, the students in the sentence groups remembered more words than the students in the repetition and conventional conditions. The students in the conventional group remembered more words than the students in the repetition condition. On Trial 2, the students in the sentence conditions recalled more words than the students in the repetition and conventional conditions; but, no difference occurred in the number of words recalled by the repetition and conventional groups on Trial 2.

Five triple interactions resulted. An operational ability level x instructions x list order interaction occurred, $F\ (2,48) = 4.90$, $p < .05$. The means for this interaction are presented in Table 2. The post hoc analyses indicated that this result was due to two main differences. First, within the formal operational level, students in the sentence and conventional conditions remembered more words on List Order 1 than did the repetition group. Second, concrete operational students in the conventional condition remembered more words on List Order 2 than did the concrete operational

Table 1

Mean Number of Words Recalled as a Function of

Instructions and Trials

	Trials	
Instructions	1	2
Repetition	11.22	23.94
Sentence	24.19	33.38
Conventional	15.53	27.25

Table 2

Mean Number of Words Recalled as a Function of

Operational Level, Instructions, and List Order

	Operational Level			
	Formal		Concrete	
Instructions	List Order 1	List Order 2	List Order 1	List Order 2
Repetition	16.44	20.81	16.19	16.88
Sentence	25.25	31.25	32.19	26.44
Conventional	22.88	21.75	16.44	24.50

students in the conventional conditions.

An operational level x sex x trials interaction also resulted, $F(1,48) = 4.31$, $p < .05$. The means for this interaction are presented in Table 3. Formal operational males remembered more words than concrete operational males on Trial 1, while formal operational females remembered more words than concrete operational females on Trial 2. Further, formal operational males remembered more words on the first trial than did the formal operational females.

The third triple interaction was an operational level x list x trials effect, $F(1,48) = 5.98$, $p < .05$. The means for this interaction are presented in Table 4. Formal operational students remembered more words on List 2 than on List 1 on the second trial, while the concrete operational students remembered more words on List 2 than on List 1 on both trials. Formal operational students remembered more words than did concrete operational students on List 1 on the first trial.

The fourth triple interaction was sex x list x trials, $F(1,48) = 4.50$, $p < .05$. The means for this interaction are presented in Table 5. Males remembered more on List 2 than on List 1 on both trials. Females remembered more on List 2 than on List 1 on Trial 2. Males remembered more words than females did on List 2 on Trial 1.

Table 3

Mean Number of Words Recalled as a Function of

Operational Level, Sex, and Trials

	Trials	
Operational Level	1	2
Formal		
Male	18.63	28.71
Female	15.96	28.96
Concrete		
Male	16.79	28.08
Female	16.54	27.00

Table 4

Mean Number of Words Recalled as a Function of

Operational Level, List, and Trials

	Trials			
	1		2	
Operational Level	List 1	List 2	List 1	List 2
Formal	17.83	16.75	27.67	30.00
Concrete	15.00	18.33	26.38	28.71

Table 5

Mean Number of Words Recalled as a Function of

Sex, List, and Trials

	Trials	
List	1	2
List 1		
Male	16.46	27.50
Female	16.38	29.30
List 2		
Male	18.96	29.30
Female	16.13	26.42

The fifth triple interaction was list x list order x trials, F (1,48) = 5.96. The means for this interaction are presented in Table 6. For List 1, more words were remembered on List Order 2 than List Order 1 on the first trial. For List 2, more words were remembered on List Order 2 than List Order 1 on the second trial. Also, more words were remembered on List 1 than on List 2 on List Order 2 on the first trial and on List 2 than on List 1 on List Order 1 on the second trial. An instruction x sex x list x list order x trials interaction also occurred, F (2,48) = 6.93.

A 2 x 3 x 2 analysis of variance with the between-subject factors of operational level, instructions, and sex was conducted on the total number of words correctly recalled on Trials 1 and 2. The analysis of variance summary table is presented in Appendix IV. A similar analysis was conducted by Rohwer et al. (1977). The analysis indicated one main effect of instructions, F (2,84) = 27.53. The mean for the students in the repetition conditions was 34.21, the mean for the students in the sentence conditions was 57.6, and the mean for the students in the conventional conditions was 38.9. The students in the sentence conditions remembered more words than did the students in the repetition and conventional conditions. No differences occurred in the memory performance of the students in the repetition and conventional groups. The analysis also indicated an operational level x instructions

Table 6

Mean Number of Words Recalled as a Function of

List, List Order, and Trials

	Trials			
	1		2	
List Order	List 1	List 2	List 1	List 2
Order 1	15.96	16.04	25.38	28.87
Order 2	16.88	19.04	28.67	29.83

interaction, F (2, 28) = 2.12, $p < .20$. The mean number of words recalled for the operational level and instructions interaction is presented in Table 7. Although this interaction was only significant at the .20 level, a trend in accordance with the proposed hypotheses was indicated. Therefore, several t tests were performed to analyze further these data.

In accordance with the assumption provided by Robson (1973) for independent-subject designs, nine separate t tests were conducted. All of the tests were one-tailed in accordance with the predictions made. The first three t tests considered the difference between formal operational and concrete operational students at each instructional level. In accordance with the predictions, students in the formal operational group remembered more words in the conventional condition than did the concrete operational students in the conventional condition, T (30) = 2.51. No difference occurred in the number of words correctly recalled by the formal operational and concrete operational students in the sentence condition. This result supports the present hypotheses. Further, no differences occurred between the number of words recalled by the formal operational and concrete operational students in the repetition condition.

Table 7

Mean Number of Words Recalled as a Function of

Operational Level and Instructions

	Operational Level	
Instructions	Formal	Concrete
Repetition	35.31	33.06
Sentence	56.50	58.63
Conventional	44.63	33.31

A t test was conducted within each operational level and instructional condition. Formal operational students in the sentence condition remembered more words than formal operational students in the conventional condition, T (30) = 2.62, and in the repetition condition, T (30) = 4.50. The former finding does not support the present hypothesis that sentence (elaboration) instructions are not compensatory for formal operational students, but the latter result does support the hypothesis. Formal operational students in the conventional condition remembered more words than did the formal operational students in the repetition condition, T (30) = 1.73, $p < .05$. This result is in accordance with the prediction that repetition instructions hinder formal operational students.

Concrete operational students in the sentence condition remembered more words than concrete operational students in the conventional condition, T (30) = 6.02, and in the repetition condition, T (30) = 9.72. These results support the hypothesis that sentence instructions are compensatory for concrete operational students. No difference occurred between the number of words recalled by the concrete operational students in the conventional and repetition conditions. Concrete operational students, it can be argued in accordance with the hypotheses, spontaneously employ repetition strategies.

Natural study task. The number of correct responses for each student in the natural study task was calculated. A 2 x 2 analysis of variance, with the between-subject factors of operational level and sex, was conducted on the number of words correctly recalled. The analysis of variance summary table is presented in Appendix IV. This analysis indicated no significant outcomes.

Study Strategies

The study strategies employed by the students in the natural study situation were scored according to criteria based on Neimark (1976). The criteria for categorizing the strategies are presented in Appendix III. The strategies which each student was observed to employ were computed. The strategies which each student reported having employed were also computed. A male graduate student independently rated the observed and reported strategies according to the devised categories presented in Appendix III. These ratings were compared to those of the experimenter. A reliability of 88% resulted.

Fisher's Exact Probability Test (Courts, 1966) was employed to determine differences in the observed type of strategies employed by the formal operational and concrete operational students. The strategies were divided into two main categories of repetition and elaboration. These two categories are included in the criteria presented in Appendix III. The Fisher's Exact Probability Test indicated a significant outcome, $\underline{p}$ (1) = 5.69, $\underline{p} < .05$. The number and type of strategies observed are presented in Table 8. A second Fisher's Exact Probability Test was employed to determine differences in the type of strategies reported by the formal operational and concrete operational students. The results of this test were not significant. The number and type of strategies reported are presented in Table 9.

Sentences

The sentences generated during the study interval by the students in the sentence condition were scored five ways to determine differences in the quality and quantity of the sentences. First, the total number of sentences generated by each student was calculated. This scoring procedure was necessitated by the fact that although each student received 40 pairs of words, some did not produce a sentence for each pair. A 2 x 2 x 2 analysis of variance was conducted on the number of sentences produced. The between-subject variables were operational level and sex, and the within-subject variable was trials. The analysis of variance summary table is presented in Appendix IV. This analysis indicated no significant differences.

Table 8

Number of Formal Operational and Concrete Operational Students Showing Elaboration and Repetition Strategies

	Strategy	
Operational Level	Elaboration	Repetition
Formal	9	7
Concrete	5	11

Table 9

Number of Formal Operational and Concrete Operational Students Reporting Elaboration and Repetition Strategies

	Strategy	
Operational Level	Elaboration	Repetition
Formal	8	8
Concrete	9	7

Second, the mean number of words produced in the sentences was computed. A 2 x 2 x 2 analysis of variance was performed on the mean number of words contained in the sentences. The between-subject variables were operational level and sex, and the within-subject variable was trials. The analysis of variance summary table is presented in Appendix IV. No significant differences were indicated by this analysis.

Third, the percentage of the number of sentences which each student produced in the second study interval which was identical to those generated in the first study interval was determined. Two sentences were judged identical if the sentences produced were exactly alike or if only the verb tense, a possessive, or a preposition was changed. Sentences such as "The wife washed the dishes" and "My wife washed the dishes" were judged identical. Sentences such as "The girl wore the flower" and "The girl liked the flower" were judged as different. A female undergraduate independently rated 40 pairs of randomly selected sentences to determine if the pairs were identical or different. These ratings were compared to those of the experimenter. The reliability index was 90%. A 2 x 2 analysis of variance, with the between-subject variables of operational level and sex, was performed on the percentage of sentences produced which were identical on Trials 1 and 2. Arc sin transformations (Winer, 1971) were performed on the percentages prior to the analyses. The analysis of variance summary table is presented in Appendix IV. This analysis indicated a significant main effect of sex, $\underline{F}$ (1,28) = 7.80. The mean percentage for the males was 72% and the mean percentage for the females was 51%. Males produced more identical sentences on Trials $\underline{1}$ and $\underline{2}$ than did females.

The sentences were also scored for grammaticality. Sentences which included at least the two presented paired words and a verb were scored as grammatical, e.g., "The plant is on the chair". Sentences which included the two presented words but no verb were judged as ungrammatical, e.g., "The plant on the chair". Only six ungrammatical sentences were determined. Therefore, this scoring method was not pursued.

A fifth scoring procedure was devised which rated the structure of the sentences. The method is based on a linguistic model presented by Slobin (1971) and considers the composition of the sentences. The method for scoring the sentences is presented in Appendix III. A male graduate student independently judged 40 randomly selected sentences based on the method devised. These ratings were then compared to those made by the experimenter. A reliability of 92% was obtained. Two separate 2 x 2 x 6 analyses of variance, with the between-subject variables of operational level and sex, and the within-subject variable of sentence type were performed on the type of sentences which the students produced on Trial 1 and Trial 2. The analysis of variance summary tables are presented in Appendix IV. On Trial 1, a main effect of sentence type occurred, F (5,140) = 65.96. The means were: Sentence Type 1, 10.6; Sentence Type 2, 12.6; Sentence Type 3, .56; Sentence Type 4, 1.75; Sentence Type 5, 11.25; and Sentence Type 6, 1.2. The post hoc analysis indicated more Sentence Types 1, 2, and 5 than Sentence Types 3, 4, and 6. No other differences occurred. The analysis of sentence type on Trial 2 also indicated a significant main effect of type of sentence, F (5, 140) = 73.66. The means were: Sentence Type 1, 13.0; Sentence Type 2, 13.4; Sentence Type 3, .18; Sentence Type 4, .18; Sentence Type 5, 9.84; and Sentence Type 6, .84. The post hoc analyses indicated more Sentence Types 1, 2, and 5 occurred than Sentence Types 3, 4, and 6. No other differences occurred.

CHAPTER IV

DISCUSSION

Age and individual differences in performance on paired-associate tasks have been accounted for by Rohwer (1976) in the elaboration hypothesis. According to Rohwer (1976), some form of elaboration is essential to efficient storage in a paired-associate task. The effect of elaboration instructions on learning in a paired-associate task has been examined with a procedure employing three instructional conditions (Bobrow & Bower, 1969; Paivio & Yuille, 1969). Performance in conditions with elaboration instructions, i.e., instructions to generate a sentence connecting the presented pair of words, has been compared to performance in repetition conditions, i.e., instructions to repeat the paired words, and to conventional conditions, i.e., instructions to learn the word pairs. According to Suzuki and Rohwer (1969), elaboration instructions proved to be compensatory for young children and preadolescents as performance in the sentence condition was better than performance in the repetition and conventional conditions.

Propensity for elaboration has been postulated by Rohwer (1973) to develop with age, increasing significantly in adolescence. Rohwer and Bean (1973), however, reported that not all postadolescents demonstrated a propensity for elaboration. Rohwer (1976), therefore, concluded that differences within an age level for propensity for elaboration suggest that elaboration propensity is an age and individual difference phenomenon.

In accordance with the elaboration hypothesis, Rohwer et al. (1977) demonstrated age and individual differences in elaboration propensity. Postadolescents who displayed a high level of learning proficiency on a paired-associate task demonstrated a propensity for elaboration. A weak or minimal propensity for elaboration was demonstrated by preadolescents and postadolescents who had performed with a medium or low proficiency on a paired- associate task. These results were interpreted as evidence that the preferred mode of strategy for high proficiency postadolescents is elaboration and, for medium and low proficiency postadolescents and preadolescents, repetition.

In the present study, an explanation for the phenomenon of age and individual differences in the use of elaboration on paired-associate tasks was presented. An attempt was made to demonstrate that the operational structures underlying formal operational thought as presented by Inhelder and Piaget (1958) are sufficient for elaboration propensity. Neimark (1976) described formal operations as the ability to use the processes of integration and organization and to deliberately order experience. Elaboration involves integration and a systematic ordering of experience. Propensity for elaboration, it was hypothesized, may be affected by the attainment of formal operations.

In the present study, two main hypotheses were tested. First, it was theorized that formal operational ability is sufficient for elaboration propensity in postadolescents. Therefore, formal operational ability could be employed as an individual difference index with which to predict elaboration propensity. Second, formal operational postadolescents, it was postulated, should spontaneously employ elaboration strategies while concrete operational postadolescents must rely on rehearsal strategies.

The results of the study support the hypothesis that formal operational ability is sufficient for elaboration propensity in postadolescents. In accordance with the predictions, the formal operational postadolescents in the conventional condition displayed better memory performance than did the concrete operational postadolescents in the conventional condition. However, as predicted, the performance of the formal operational postadolescents and the concrete operational postadolescents in the sentence and repetition conditions was approximately equal. Support was also obtained for the hypothesis that the formal operational postadolescents' spontaneous mode of strategy is elaboration, since performance levels of the formal operational postadolescents in the conventional condition were better than those of the formal operational postadolescents in the repetition condition. Repetition instructions, it can be argued, interfered with the formal operational postadolescents spontaneous mode of strategy and hindered their performance. Concrete operational postadolescents, however, demonstrated equal levels of performance in the conventional and repetition conditions. This finding supports the hypothesis that the spontaneous mode of strategy for concrete operational postadolescents is repetition.

Sentence instructions were compensatory for postadolescents at both operational levels. Concrete operational postadolescents in the sentence condition, in accordance with the predictions, demonstrated better memory performance than the concrete operational postadolescents in the conventional and repetition conditions. Contrary to predictions, sentence instructions also proved to be compensatory for the formal operational postadolescents. Performance levels of the formal operational postadolescents in the sentence condition was better than the performance of the formal operational postadolescents in the conventional and repetition conditions.

The effect of sentence instructions on adults' performance in paired-associate tasks has not been consistently demonstrated. Rohwer (1976) argued that sentence (elaboration) instructions are not compensatory for adults. Bower and Winzenz (1970), Paivio and Yuille (1969), and Rimm, Alexander, and Eiles (1969), employing similar paired-associate procedures, however, reported that adults' performance in sentence conditions was better than adults' performance in conventional and repetition conditions. Elaboration instructions appear to facilitate the use of effective processing strategies (Craig & Tulving, 1975), and thereby enhance memory performance.

It is not surprising, therefore, that sentence instructions were also compensatory for the formal operational postadolescents in the present study. It can still be argued, however, that formal operational postadolescents demonstrate a propensity for elaboration. Although performance levels for the formal operational postadolescents in the sentence and conventional conditions were not equal as predicted, the formal operational postadolescents in the conventional condition did display better memory performance than did the formal operational postadolescents in the repetition condition.

One reason for the differences in performance of the formal operational postadolescents in the sentence and conventional conditions may have been a procedural one. In the present study, the students in the sentence conditions were instructed to repeat aloud the sentences which they had generated. They were forced, therefore, to use an elaboration strategy for each pair. The postadolescents in the conventional conditions wereinstructed only to learn the words as best they could. If the students in the conventional conditions had also been instructed to learn the words aloud, thereby perhaps forcing them to employ a strategy for each pair, performance levels may have been approximately equal.

A second reason for the differences in the performance of the formal operational students in the sentence and conventional conditions may have been an indexing one. Piaget and Inhelder (1958) have identified two levels of formal operational ability. Although the structures and operations of the two levels are similar, the Level II postadolescent is more efficient and spontaneous in employing formal operations. If the postadolescents in the present study had been indexed according to the two levels of formal operational ability, the Level II students may have demonstrated more of a propensity for elaboration.

Support for thehypothesis that formal operational ability is sufficient for elaboration propensity and can therefore be employed as an individual difference index for predicting elaboration propensity in postadolescents is provided by the results of the natural study situation. Formal operational postadolescents spontaneously employed more elaboration strategies than did the concrete operational students. However, the formal operational postadolescents did not report having used more elaboration strategies than did the concrete operational postadolescents. It appears from the interview questions that postadolescents at both operational levels may have employed strategies during the study interval that they did not perform aloud. This possibility is supported by the lack of a performance difference between the operational ability levels. The natural study situation procedures may not, therefore, provide a sufficiently sensitive method for investigating the spontaneous use of memory-related strategies. However, the findings of the observed elaboration strategy differences between the formal operational and concrete operational postadolescents indicate that formal operational postadolescents spontaneously employ elaboration strategies in natural settings more than did concrete operational postadolescents.

Analyses of the sentences produced by the formal and concrete operational postadolescents also supported the present hypotheses. Because no differences occurred in the type or quantity of sentences generated by the formal operational and concrete operational postadolescents, it can be argued that differences in the students' organization of semantic information did not exist (Bransford & Franks, 1976). Perhaps, differences in the memory performance of the formal and concrete operational postadolescents can be attributed to differences in cognitive structures and processes, not differences in organization of semantic memory.

Formal operational ability was successfully employed in the present study as an individual difference index to predict differences in elaboration propensity. As hypothesized, the development of formal cognitive abilities appears to parallel the development of elaboration propensity. The development of formal operational cognitive abilities may also be sufficient for the development of other efficient mnemonic strategies. The theory of intellectual development as hypothesized by Piaget (Piaget & Inhelder, 1969) appears to be a fruitful framework for investigating age and individual differences in the spontaneous use of elaboration and other mnemonic strategies. In the present study, the demonstration of an individual difference index which predicts differences in memory performance suggests that individual differences must also be considered in future memory research.

CHAPTER V

CONCLUSIONS

Propensity for elaboration has been hypothesized by Rohwer (1976) to account for age and individual differences in performance on paired-associate tasks. Elaboration propensity refers to the spontaneous association of two members of a pair by creation of an event or situation which joins the words. The construction of a sentence connecting the two words is an example of an elaboration strategy. According to Rohwer (1976), the use of elaboration techniques increases effective storage of information and thereby enhances retrieval of the information.

Rohwer, Raines, Eoff, and Wagner (1977) reported both individual and age differences in propensity for elaboration. Postadolescents (ages 16 to 17 years) who showed high learning proficiency on a paired-associate task demonstrated a propensity for elaboration. Preadolescents (ages 11 to 12 years) and postadolescents who performed with a medium or low proficiency on a paired-associate task demonstrated a minimal or weak elaboration propensity.

Although Rohwer and his associates (Rohwer & Bean, 1973; Rohwer et al., 1977) demonstrated individual differences in elaboration propensity in postadolescents, an explanation for such differences remained to be offered. Neimark (1976) argued that the use of well-developed, efficient mnemonic strategies reflects the development of formal operational ability. If this characterization is accurate, then propensity for elaboration should be predicted by the individual difference index of formal operational ability as described by Inhelder and Piaget (1958).

The present study investigated the relationship between propensity for elaboration in postadolescents and development of formal operational thought. An attempt was made to demonstrate that the operational structures underlying formal operational thought are sufficient for propensity for elaboration.

Two Inhelder tasks (Inhelder & Piaget, 1958), i.e., the Colorless Chemicals Task and the Pendulum Problem, were employed to assess formal operational ability. On the basis of their performance on the two tasks, postadolescents were assigned to the formal operational or concrete operational groups. The elaboration propensity of the formal operational and concrete operational postadolescents was examined with the procedures employed by Rohwer et al. (1977). Within each operational level, the postadolescents were assigned to one of three instructional conditions: conventional, repetition, and sentence.

The results supported the predictions. Formal operational postadolescents who received conventional instructions demonstrated better performance than concrete operational postadolescents who received conventional instructions. Formal operational postadolescents who received conventional instructions also demonstrated better performance than formal operational students who received repetition instructions. Repetition, it was argued, hindered the spontaneous elaboration strategy of the formal operational postadolescents. Concrete operational postadolescents, however, demonstrated equal performance levels in the conventional and repetition conditions. This result was interpreted as reflecting the use of repetition strategies which was hypothesized to be the concrete operational postadolescents' spontaneous mode of strategy. Contrary to predictions, sentence instructions proved to be compensatory for both formal and concrete operational postadolescents, i.e., performance levels of both formal operational and concrete operational postadolescents were better in the sentence condition than in the repetition and conventional conditions.

A direct examination of the spontaneous use of elaboration by formal operational and concrete operational postadolescents was also conducted. The postadolescents in the conventional conditions were given 40 additional pairs of words and were instructed to learn the pairs as best they could. The students were told to perform their study strategy aloud. The strategies employed by the students were recorded by the experimenter. After the test situation, the students were questioned about the strategies they had used. Formal operational postadolescents spontaneously employed more elaboration strategies than did concrete operational postadolescents. No difference occurred in the type of strategies reported by the students.

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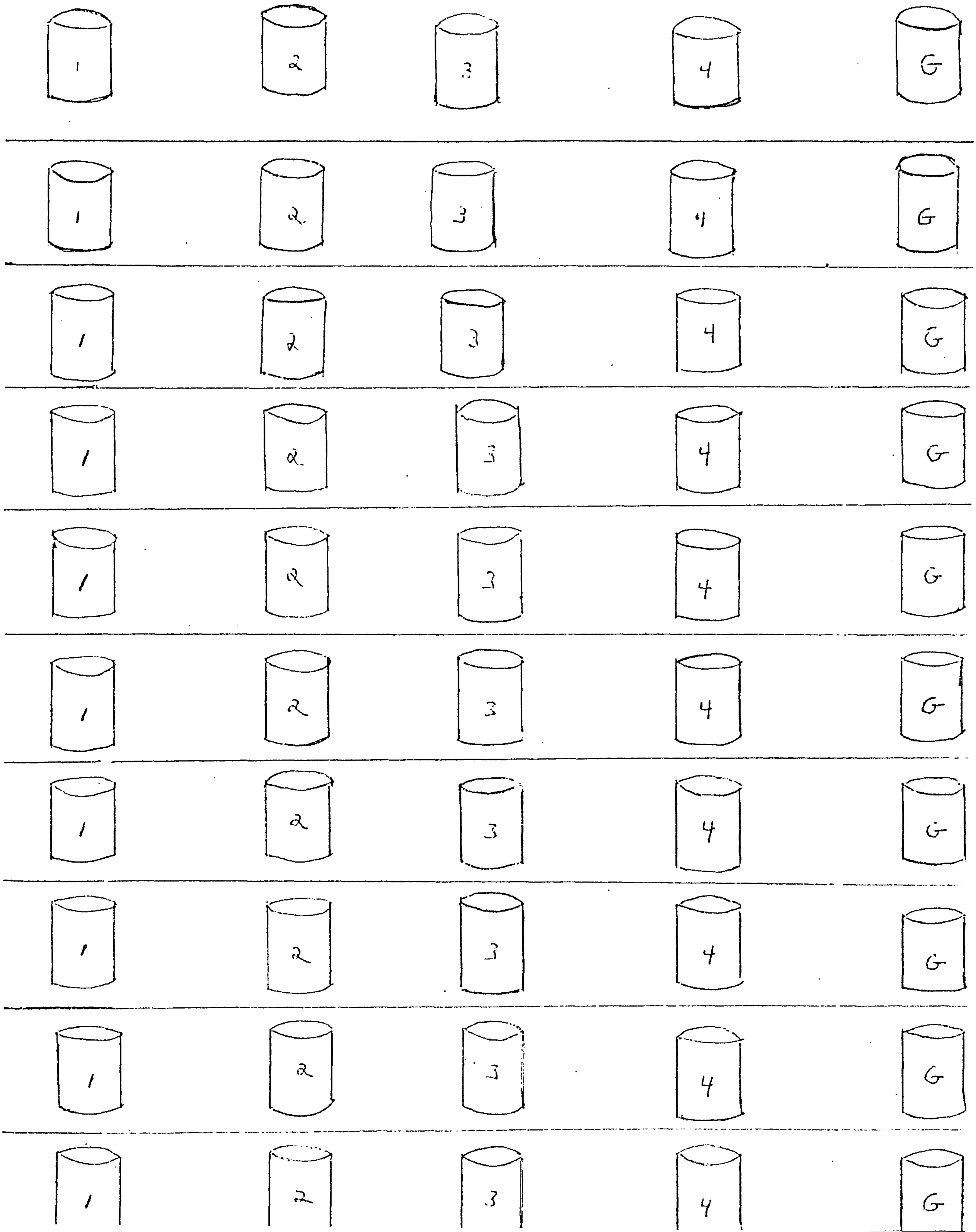
APPENDIX I

MATERIALS

Answer Sheet

Chemicals Task



List A

Order 1

baby - farm
poem - dream
movie - island
homes - bank
books - region
melody - church
jail - dust
lady - bread
yard - roots
band - office
party - leader
kids - items
blouse - model
pocket - style
shadow - corner
crops - snow
game - news
metals - soil
taxes - boat
army - fruit

doctor - collar
price - meal
shoes - rubber
artist - college
radio - jacket
mood - voices
nuts - pieces
nurse - tears
girl - flower
term - month
ring - gold
eggs - bear
horizon - acres
dirt - wheel
cake - secret
pencil - string
engine - plane
crowd - song
bird - fence
team - record

List A

Order 2

term - month
blouse - model
price - meal
homes - bank
cake - secret
radio - jacket
army - fruit
bird - fence
poem - dream
band - office
shoes - rubber
eggs - bear
jail - dust
nuts - pieces
crowd - song
game - news
yard - roots
dirt - wheel
girl - flower
kids - items
shadow - corner
engine - plane
books - region
mood - voices
pocket - style
movie - island
horizon - acres
artist - college
melody - church
crops - snow
ring - gold
baby - farm
nurse - tears
party - leader
lady - bread
team - record
doctor - collar
metals - soil
pencil - string
taxes - boat

List B

Order 1

capital - roof
essay - facts
horse - gift
sample - colors
drama - staff
wife - dish
enemy - grain
police - roads
digit - scale
nuns - dress
rain - pool
shirt - wind
data - chart
town - iron
trucks - foods
valley - cave
health - maid
giant - teeth
faces - pain
wagon - parade

forest - winter
nation - silver
walls - names
friend - visit
trains - glass
tools - oven
path - circles
animal - desert
tissue - cloth
bottle - mouth
muscle - jobs
desk - wood
card - guest
wine - lunch
trial - chamber
plant - chamber
youth - piano
cars - symbol
notes - sheets
ball - thumb

List B

Order 2

muscle - jobs
valley - cave
wife - dish
friend - visit
desk - wood
digit - scale
path - circles
sample - colors
plant - chair
shirt - wind
notes - sheets
essay - facts
forest - winter
town - iron
enemy - grain
wine - lunch
tools - oven
cars - symbol
rain - pool
tissue - cloth

ball - thumb
capital - roof
giant - teeth
card - guest
walls - names
youth - piano
data - chart
faces - pain
horse - gift
nation - silver
trucks - foods
bottle - mouth
trial - chamber
nuns - dress
drama - staff
trains - glass
wagon - parade
health - maid
police - roads

APPENDIX II

INSTRUCTIONS

Colorless Chemicals Task

I am interested in how people solve problems. Today, I will give you one problem and the next time I see you a second problem to solve.

Here are five glasses which are filled with five different kinds of liquids. Each of the liquids is colorless. A mixture of some of the liquids, however, produces a color. The glasses are labeled 1, 2, 3, 4, and g. Before you came in, I took some of the liquids from the glasses and put them into these unlabeled glasses. Now watch, I am going to place several drops from glass g into both of these unlabeled glasses. (The experimenter places the drops of potassium iodide into the unlabeled glasses.) The liquid in this glass (the experimenter points to the glass) turned yellow. The liquid in this glass (the experimenter points to the glass) remained clear. It will be your job to determine which mixture of the liquids causes the yellow color.

Here are several sheets with rows showing pictures of Glasses 1 through 4 and g. Rather than actually mixing the different liquids, I want you to circle all the mixtures you think you should try to solve the problem. For example, if you think you should try the mixture of the liquids in Glasses 1 and 2 to produce the color yellow, you would circle Glass 1 and Glass 2. (The experimenter circles these two glasses on the paper.) One row of glasses represents one mixture.

Do you understand what you are to do? Do you have any questions? Begin.

Colorless Chemicals Task

Continued

(If the student finishes before circling all of the possible combinations, the experimenter will prompt.) Are you certain you have circled all of the possible mixtures you should try in order to determine which mixtures produced the color yellow?

(After the student finishes, the experimenter will ask a question concerning how to provide proof for one of the liquid's involvement in the problem.) How would you go about determining if the liquid in Glass _4_ was involved in the production of the color yellow? Indicate by checking the mixtures that you would need to try in order to determine if the liquid in Glass _4_ was involved in producing the color yellow.

(After the student has appeared to have finished, the experimenter will prompt.) Are there any other mixtures you should try to determine if the liquid in Glass _4_ is involved in producing the color yellow?

Please do not discuss the problem or its solution with any of the other students.

The Pendulum Task

Today, I am going to give you a problem to solve. Here is a pendulum. Attached to the top hook is the string which can be lengthened and shortened like this. (The experimenter demonstrates how to lengthen and shorten the string.) Here I have four weights. The weights are 5 grams, 10 grams, 15 grams, and 20 grams. (The weights are shown to the student.) The weights can be attached to the string by using this bottom hook. A weight can be attached to the string and pushed hard or softly. (The experimenter attaches the 5 gram weight and pushes the pendulum in the two ways.) Also, the height of the release point can be changed. You can push the weight from a high point, a low point, or a medium point. (The experimenter demonstrates the different release points with the 5 gram weight.)

You are to experiment with the pendulum and determine what makes the pendulum swing faster or slower. You may use any length of the string, any of the weights, any height of the push, and any force of push that you wish. Do you have any questions about what you are to do?

While you are experimenting with the pendulum, I will be writing down what you are doing to solve the problem. Begin.

(When the student appears to be finished experimenting with the pendulum, the experimenter will ask questions concerning each of the four possible variables.)

Does the weight have anything to do with making the pendulum go faster or slower? How could you prove that?

The Pendulum Task

Continued

Does the force of the push have anything to do with making the pendulum go faster or slower? How could you prove that?

Does the length of the string have anything to do with making the pendulum go faster or slower? How could you prove that?

Does the height of the push have anything to do with making the pendulum go faster or slower? How could you prove that?

What is the solution to the problem?

(The experimenter will record all of the responses of the student.)

Please do not discuss the problem or its solution with any of the other students.

Paired-Associate Task

Conventional Condition

I am interested in how people learn. I am going to show you 40 cards one at a time. On each card will be printed two words. I want you to try to learn each pair of words as best you can. You will see each pair for 15 seconds.

After you have seen each pair one time, I will give you a test to see how well you learned the pairs. In the test, you will see the first member of the pair. You are to give the second member of the pair. Please say the word aloud so that I can record your answer. You will receive 5 seconds to respond to the first member of the pair. After you have responded to each of the 40 words, you will again study the pairs. A second test will then be given.

Do you have any questions?

Before we begin the task, we are going to try six pairs for practice. Remember you are to study the pairs as best you can so that you can give the second member of the pair when I test you. Let's begin. (The practice words are presented and the test of the practice words given.)

Now that you have tried a few pairs, do you have any questions?

We are going to begin the task. (The pairs are presented for study.)

This is the test part. Remember to answer aloud. You have 5 seconds to respond. (The test words are presented.)

Paired-Associate Task

Conventional Condition

Continued

We will now do the second study task. Remember to try to learn each pair as best you can. (The pairs are presented for study.)

This is the second test. Remember to answer aloud. You only have 5 seconds to respond. (The test words are presented.)

Paired-Associate Task

Repetition Condition

I am interested in how people learn. I am going to show you 40 cards one at a time. One each card will be printed two words. I want you to try to learn each pair of words as best you can. In order to learn the pairs, I want you to say each pair aloud as often as you can until I present the next pair. You will see each pair for 15 seconds.

After you have seen each pair of words one time, I will give you a test to see how well you learned the pairs. In the test, you will see the first member of the pair. You are to give the second member of the pair. Please say the word aloud so that I can record your answer. You will receive 5 seconds to respond. After you have responded to each of the 40 words, you will again study the pairs. A second test will be given.

Do you have any questions?

Before we begin the task, we are going to try six pairs for practice. Remember you are to repeat each pair aloud as often as possible. Let's begin. (The practice words are presented and the test of the practice words given.)

Now that you have tried a few pairs, do you have any questions?

We are going to begin the task. (The pairs are presented for study.)

This is the test part. Remember to answer aloud. You have 5 seconds to respond. (The test words are presented.)

Paired-Associate Task

Repetition Condition

Continued

We will now do the second study task. Remember to repeat aloud each pair until the next pair is presented. (The pairs are presented.)

This is the second test. Remember to answer aloud. You have 5 seconds to respond. (The test words are presented.)

Paired-Associate Task

Sentence Condition

I am interested in how people learn. I am going to show you 40 cards one at a time. On each card will be printed two words. I want you to try to learn each pair of words as best you can. In order to learn the pairs, I want you to make up a sentence joining the two words. For example, if the words were dog-lamp, you could say the dog knocked over the lamp. Say the sentence you make up aloud as often as you can until I present the next pair. You will see each pair of words for 15 seconds.

After you have seen each pair one time, I will give you a test to see how well you learned the pairs. In the test, you will see the first member of the pair. You are to give the second member of the pair. Please say the word aloud so that I can record your answer. You will receive 5 seconds to respond to the first member of the pair. After you have responded to each of the 40 words, you will again study the pairs. A second test will then be given. Do you have any questions?

Before we begin the task, we are going to try six practice pairs. Remember you are to study the pairs as best you can by making up a sentence joining the two words. Say the sentence aloud until I present the next pair. Let's begin. (The practice words and test words are presented.)

Now that you have tried a few pairs, do you have any questions?

Paired-Associate Task

Sentence Condition

Continued

We are going to begin the task. (The pairs are presented for study.)

This is the test part. Remember to answer aloud. You have 5 seconds to respond. (The test words are presented.)

We will now do the second study task. Make up any sentence even the one you used the first time. Say the sentence aloud until I present the next pair. (The pairs are presented for study.)

This is the second test. Remember to answer aloud. You only have 5 seconds to respond. (The test words are presented.)

Study Situation

We are going to do another task. This time, I am interested in how people study. I want you to pretend that you are studying for a test in school. Study the materials I give you just as you would at home or school.

I am going to give you 40 different pairs of words. You will receive all of the words at one time. Try to learn the pairs as best you can. You can use any method you want to learn the pairs. However, you must do your studying aloud so that I can record your methods. You will have 8 minutes to study the words.

The test will be just like before. You will be presented the first member of each pair. You are to give the second member. You will see each word for 5 seconds. You must give your answer within that time period.

Do you have any questions?

During the time you are studying the words, I will be writing down what you are doing. Remember to study aloud. I will tell you when the time is up.

Begin. (All of the words are given to the student.)

(After 8 minutes) Stop. (The cards are removed.)

We will now do the test. Please give your answers aloud. Remember you only have 5 seconds to respond. Do you have any questions?

Let's begin. (The words are presented.)

Study Situation

Continued

(After the test) What did you do during the study period to help you remember the words?

Did your strategy work? How?

Here is a pair of words you did not remember. (Experimenter shows a pair.) What did you do to study this pair? Why didn't your strategy work?

(The experimenter repeats the last two questions for several pairs of words.)

APPENDIX III

SCORING PROCEDURES

Scoring Procedures

Formal Operational Ability

In the characterization of formal operational ability, Inhelder and Piaget (1958) employed four levels of ability. Two of the levels are descriptive of concrete operational ability and two of formal operational ability. The levels presented by Inhelder and Piaget (1958) were used to assign the postadolescents to the formal operational and concrete operational levels. The students were assigned to the formal operational level if they scored at either of the two formal operational ability levels on both the Chemicals Task and the Pendulum Problem. Students were assigned to the concrete operational level if they scored at either of the concrete operational levels on both the Chemicals Task and the Pendulum Problem. Any student who scored at the formal operational level on one task and the concrete operational level on the second task was excluded from the study. A description of each of the four operational levels for the Chemicals Task and the Pendulum Problem is presented.

Chemicals Task

The two concrete operational levels are:

Substage IIA — The subject attempts to solve the problem by one-to-one correspondence of the liquids in Glasses _1_ through _4_ with _g_. No other combinations are considered. Proof for the problem cannot be given.

Substage IIB — The subject employs an n-by-n system, e.g., Liquids 1 and 2 and g. The subject does not employ a logical or systematic approach to the combinations. No systematic proof can be offered.

The two formal operational ability levels are:

Substage IIIA — The subject employs a systematic, complete n-by-n combinatorial system. After the solution has been discovered, the subject looks for proof.

Substage IIIB — The subject at this level demonstrates a more systematic, n-by-n combinatorial system which includes both solution and proof.

Pendulum Problem

The two concrete operational levels are:

Substage IIA — The subjects are able to order the differing lengths and the elevations serially. He/she can also judge the differences between the observed frequencies of swings objectively. However, the subject cannot accurately seriate the ordering of the weights. He/she does not manage to separate the four variables. Therefore, solution is by chance and accurate proof cannot be given.

Substage IIB — The subject can accurately order the effects of the weights. However, the four factors cannot be separated. Solution, therefore, is still by chance and accurate proof cannot be offered.

The two formal operational levels are:

Substage IIIA — The subject can, but does not spontaneously, separate the four variables. The approach to the problem is not systematic, but a solution and proof can be accurately given.

Substage IIIB — The subject can spontaneously separate the variables and exclude the inoperative factors. The subject employs the method of "all things being equal", i.e., he/she can vary a single factor while holding the other three constant. The approach to the problem is systematic and considers both proof and solution.

Criteria for Categorizing Sentence Type

<u>General Criteria</u>

Noun Phrase	Consists of a noun(s), adjective(s), article(s)
Verb Phrase	Consists of a verb(s), article(s), noun(s), adverb(s), adjective(s)
Verb	Consists of a verb(s) but no phrase
Prepositional Phrase	Consists of preposition, noun(s), article(s), adjective(s)
Auxilary Phrase	A noun phrase and verb phrase (verb) in addition to the main sentence

<u>Sentence Type</u>

1	Consists of a noun phrase and a verb phrase, e.g., "The wife broke the dish"
2	Consists of a noun phrase, verb, and a prepositional phrase, e.g., "The poem was in the dream"
3	Consists of a noun phrase, a prepositional phrase, a verb, and a second prepositional phrase, e.g., "The books on the region were in the library"

Criteria for Categorizing Sentence Type

Continued

Sentence Type	
4	Consists of a noun phrase, a prepositional phrase, and a verb phrase, e.g., "The metals in the soil are hot"
5	Consists of a noun phrase, a verb phrase, and a prepositional phrase, e.g., "The band is there in the office"
6	Consists of a noun phrase, a verb phrase, and an auxilary phrase, e.g., "I felt like I was running in circles on the path"

Criteria for Categorizing Strategies

<u>Repetition Strategies</u>	
Repetition	Repeats pairs once or several times
Repetition and Self-Test	Repeats pairs once or several times Tests self by covering first member of pair
Repetition Major, Not Sole Strategy	Repeats pairs once or several times Infrequently (less than 50% of pairs) employs an elaboration strategy
<u>Elaboration Strategies</u>	
Subjective Association	Joins two words by relating them to a personal experience
Sentence	Creates a sentence connecting the words
Relationship	Associates the words to a third event
Imagery	Creates a story or a scene in which the two words are present or related
Sentence and Repetition	Creates a sentence connecting the words Repeats pairs once or several times or Repeats sentence
Relationship and Repetition	Associates the words to a third event Repeats pairs once or several times or Repeats relationship

Criteria for Categorizing Strategies

Continued

Elaboration Strategies

Sentence and Relationship	Connects the words by creating a sentence and/or by associating the words to a third event
Sentence, Relationship, and Repetition	Connects the words by creating a sentence and/or by associating the words to a third event Repeats pairs once or several times or repeats sentence or relationship

APPENDIX IV

ANALYSIS OF VARIANCE SUMMARY TABLES

Table 10

Analysis of Variance Summary Table on the Number of Words Recalled as a Function of Operational Level, Instructions, Sex, List, List Order, and Trials

Source of Variance	df	MS	F
Operational Level (a)	1	44.08	.48
Instructions (b)	2	4152.88	22.80 **
Sex (c)	1	42.19	.46
List (d)	1	143.52	1.58
List Order (e)	1	200.08	2.19
Trials (f)	1	6030.08	616.35 **
a x b	2	49.25	.54
a x c	1	3.52	.04
b x c	2	116.83	1.28
a x d	1	58.52	.64
b x d	2	60.19	.66
c x d	1	8.33	.09
a x e	1	52.08	.57
b x e	2	95.19	.52
c x e	1	105.02	1.15
d x e	1	.19	.02
a x f	1	5.33	.54
b x f	2	53.01	5.42 **
c x f	1	13.02	1.33
d x f	1	17.52	1.79
e x f	1	.33	.03
a x b x c	2	3.54	.04
a x b x d	2	53.69	.59
a x c x d	1	10.08	.11
b x c x d	2	54.78	.60
a x b x e	2	446.10	4.90 *
a x c x e	1	157.69	1.73
b x c x e	2	41.01	.45
a x d x e	1	22.69	.25
b x d x e	2	156.14	1.71
c x d x e	1	.83	.01
a x b x f	2	8.38	.86
a x c x f	1	42.19	4.31 *
b x c x f	2	3.78	.39
a x d x f	1	58.52	5.98 *

Table 10

Continued

Source of Variance	df	MS	F
b x d x f	2	13.37	1.37
c x d x f	1	44.08	4.51 *
a x e x f	1	5.33	.55
b x e x f	2	1.03	.16
c x e x f	1	.52	.05
d x e x f	1	58.52	5.98 *
a x b x c x d	2	142.85	1.57
a x b x c x e	2	154.98	1.70
a x b x d x e	2	111.70	1.23
a x c x d x e	1	140.08	1.54
b x c x d x e	2	10.63	.17
a x b x c x f	2	2.64	.27
a x b x d x f	2	1.82	.19
a x c x d x f	1	8.33	.85
b x c x d x f	2	6.66	.68
a x b x e x f	2	24.10	2.46
a x c x e x f	1	1.02	.10
b x c x e x f	2	9.88	1.01
a x d x e x f	1	4.69	.48
b x d x e x f	2	18.91	1.93
c x d x e x f	1	12.00	1.23
a x b x c x d x e	2	9.00	.10
a x b x c x d x f	2	12.92	1.32
a x b x c x e x f	2	16.02	1.64
a x b x d x e x f	2	15.33	1.57
a x c x d x e x f	1	1.33	.14
b x c x d x e x f	2	67.81	6.93 **
s (abcde)	48	91.06	
a x b x c x d x e x f	2	1.90	.19
sf (abcde)	48	9.78	

$^{**}p < .01$
$^{*}p < .05$

Table 11

Analysis of Variance Summary Table on the Number of Words Recalled

As a Function of Operational Level, Instructions, and Sex

Source of Variance	df	MS	F
Operational Level (a)	1	384.84	1.97
Instructions (b)	2	4879.88	27.53 **
Sex (c)	1	6.51	.04
a x b	2	375.78	2.12 *
a x c	1	65.01	.37
b x c	2	102.26	.58
a x b x c	2	106.94	.60
s (abc)	84	177.27	

**$p < .01$
*$p < .20$

Table 12

Analysis of Variance Summary Table on the Number of Words Recalled in the Natural Study Situation As a Function of Operational Level and Sex

Source of Variance	df	MS	F
Operational Level (a)	1	7.03	.08
Sex (c)	1	42.78	.52
a x c	1	2.53	.03
s (ac)	28	82.89	

Table 13

Analysis of Variance Summary Table on the Number Of Sentences Generated as a Function of Operational Level, Sex, and Trials

Source of Variance	df	MS	F
Operational Level (a)	1	.29	1.00
Sex (c)	1	.29	1.00
Trials (f)	1	.12	1.31
a x c	1	.29	1.00
a x f	1	.85	.88
c x f	1	.47	.49
s (ac)	28	.28	
a x c x f	1	.47	.49
sf (ac)	28	.96	

Table 14

Analysis of Variance Summary Table on the Number Of Words in the Sentences Generated as a Function Of Operational Level, Sex, and Trials

Source of Variance	df	MS	F
Operational Level (a)	1	81.00	3.90
Sex (c)	1	9.00	.43
Trials (f)	1	169.00	1.32
a x c	1	33.06	1.59
a x f	1	95.06	.74
c x f	1	105.06	.82
s (ac)	28	20.76	
a x c x f	1	132.25	1.03
sf (ac)	28	128.20	

Table 15

Analysis of Variance Summary Table or the Arc Sin Transformations Of the Number of Identical Sentences Generated as a Function Of Operational Level and Sex

Source of Variance	df	MS	F
Operational Level (a)	1	.71	.004
Sex (c)	1	1.48	7.800 **
a x c	1	.24	1.282
s (ac)	28	.19	

**p $<$ .01

Table 16

Analysis of Variance Summary Table on the Type of Sentences Generated as a Function of Operational Level and Sex On Trial 1

Source of Variance	df	MS	F
Operational Level (a)	1	6.75	4.45
Sex (c)	1	2.08	1.37
Type of Sentence (f)	5	1023.98	65.96 **
a x c	1	2.52	1.66
a x f	5	4.21	.27
c x f	5	29.39	1.89
s (ac)	28	1.52	
a x c x f	5	6.18	.40
sf (ac)	140	15.52	

**$p < .01$

Table 17

Analysis of Variance Summary Table on the Type of Sentences Generated as a Function of Operational Level and Sex On Trial 2

Source of Variance	df	MS	F
Operational Level (a)	1	4.08	3.32
Sex (c)	1	2.08	1.69
Type of Sentence (f)	5	1136.15	73.67 **
a x c	1	1.02	.83
a x f	5	5.06	.33
c x f	5	14.03	.91
s (ac)	28	1.23	
a x c x f	5	7.52	.49
sf (ac)	140	15.42	

**p <.01