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The Interaction of Information-Handling and Affective Variables With Time of Feedback on Level of Mathematics Skills

by

CUTHBERT HORATIO C. JOSEPH

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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ABSTRACT

This study investigated:

1. the effects of the timing of providing test-results (item-by-item, end-of-test, and one-day delayed feedback) on the long-term retention of mathematics skills,
2. the effects of combining selected information-handling abilities (rehearsal proficiency and incidental-learning ability) and affective variables (preference for time of feedback and confidence in academic ability) with the time of feedback of test-results on mathematics skills, and
3. the accuracy of prediction of information-handling and affective variables on short-term retention and long-term retention of mathematics skills.

The participants in the study included 166 boys and 194 girls from 18 grade five classes in the Edmonton Public School District. Instruments used in the study included three forms of a mathematics achievement test, a digit-span task (designed to measure rehearsal proficiency), a selective attention task (designed to measure incidental-learning ability), the **Student's Perception of Ability Scale**, and a questionnaire designed to measure preference for time of feedback of test results.

The data revealed that, for short-term (next day) retention of mathematics skills, item-by-item feedback was superior to end-of-test and one-day delayed feedback, whereas when long-term (seven days) retention of mathematics skills was the instructional goal, one-day delayed feedback was superior to item-by-item and end-of-test feedback. The item-by-item and end-of-test feedback groups were not different with respect to long-term retention of mathematics skills.

A person's recency-rehearsal proficiency (i.e., ability to hold information in working memory) and confidence in her/his academic ability, when combined with the time of feedback, produced different levels of mathematics skill. Students who were high in academic self-confidence and high in recency-rehearsal proficiency displayed highest long-term retention in the item-by-item and the end-of-test feedback conditions, whereas students who were low in academic self-confidence and low in recency-rehearsal proficiency displayed highest long-term retention of mathematics skills when test results feedback was delayed for one day. On both the short-term and the long-term retention measures of level of mathematics skill, students whose

time-of-feedback preferences were met outperformed students whose preferences were not satisfied, even though students in the two preference groups showed similar levels of mathematics skill at the beginning of the experimental period. Remarkable differences were observed when the effect of satisfying students' feedback preferences was combined with that of time of feedback, and the differences were most significant at long-term retention. For girls in each treatment group, preference for time of feedback and academic self-confidence were the best predictors of short-term retention of mathematics skills; long-term retention of mathematics skills was best predicted by their level of primacy-rehearsal proficiency and academic self-confidence. The regression analyses did not reveal a clear and consistent pattern for boys in the three treatment groups. The results of the study were consistent with the view that the individual can influence her/his ability to remember meaningful material by using rehearsal strategies intelligently, and that affective parameters are crucial for an understanding of the individual's ability to retain meaningful material for a long period of time.

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1. INTRODUCTION AND THE PROBLEM

1.1 INTRODUCTION

Since the late sixties, researchers have been amazed by increasing evidence contradicting the view that learning occurs best when feedback on performance is given immediately. Several studies have reported that feedback delayed for one day is at least as effective as immediate feedback in influencing students' ability to retain meaningful material. (See Buckwald and Meager, 1974; More, 1969; Kulhavy & Anderson, 1972; Peeck & Tillema, 1979; Sassenrath, 1975; Sassenrath & Yonge, 1968, 1969; Sturges, 1969, 1972a, 1972b, 1978; Surber & Anderson, 1975). A proportionally large number of these investigations have even suggested that delayed feedback is superior to immediate feedback (Kulhavy & Anderson, 1972; More, 1969; Peeck & Tillema, 1979; Sassenrath, 1975; Sassenrath & Yonge, 1968, 1969; Sturges, 1969, 1972a, 1972b; Surber & Anderson, 1975). Other researchers (Beck & Lindsey, 1979; Kippel, 1974; Newman, Williams & Hiller, 1974; and Sheridan, 1980) have reported nonsignificant differences between the effectiveness of these two types of feedback; and two earlier studies (Sassenrath, Yonge & Shrabble, 1968; and White, 1968) have showed evidence of immediate feedback being more effective than delayed feedback.

Few patterns have emerged from these studies that differ in criterion measure, definition of immediate feedback, chronological age of the participants, and method of data analysis or experimental design. Yet, the concern to match test-results feedback parameters with test-item response characteristics in ways that optimize learning and retention requires a clear understanding of the differential effects of immediate and delayed feedback. Such an understanding might dictate important features of Computer Assisted Instruction. Some of these features might be error rate, feedback mode, motivational prompts, and the training of information-handling strategies that might influence students' ability to organize and store material to be remembered.

Several views have been proposed to explain the superiority of delayed feedback over immediate feedback. Kulhavy and Anderson (1972) and Surber and Anderson (1975) claimed that the individual does not readily forget his initial responses during the inter-trial feedback interval. The initial incorrect response perseverates, and inhibits learning of information about the correct response obtained from feedback. In simpler language, the selection of a response to a test item strengthens its connection with the stimulus question, creating a tendency to repeat it whenever the given stimulus is reintroduced. Where the initial response is wrong, the tendency to repeat it interferes with the learning of information from feedback about the correct response. All S-R connections weaken over time. Consequently, delayed negative feedback produces less conflict with previous responses than does immediate negative feedback. The delay is not an issue in the case of positive feedback where there is no competing response.

The findings reported by several studies (Kulhavy & Anderson, 1972; Sassenrath, 1975; Surber & Anderson, 1975; for example) seem consistent with the theory of interference. But the interference-perseveration hypothesis ignores the possibility that instructions to enhance, rehearsal and attention while the participant is learning the information from feedback might significantly influence the retention of the material to be remembered. Information-handling and affective variables such as rehearsal and confidence in academic ability seem, on the surface, to be important determinants of the depth at which to-be-remembered materials are stored. These variables may, in turn, influence the retention and retrieval of information.

Sturges' explanation can easily accommodate the influence of information processing variables such as rehearsal and stimulus elaboration. She claims that the delay interval is not the critical variable. More important is the student's alertness to cues available at feedback. In the immediate, item-by-item, feedback situation, participants seem to pay little attention to relationships between the stimulus question, the correct response, and the wrong alternatives, but, rather, note whether the answer they have selected is correct or incorrect and then move on to the next test item. This, she states, is not the case in the delayed feedback situation where participants perceive that they have enough time to note the relationships carefully. Her view seems to be supported by the finding that the superiority on long-term retention of delayed feedback over immediate feedback disappears when students in the immediate feedback condition are made to pay greater attention to the feedback cues, or when feedback is limited such that delayed feedback students have no additional cues with which to organize new material with previous learning (Sturges, 1972a, 1972b).

The rehearsal facilitation theory does not account for the fact that some studies (More, 1969; Peeck & Tillema, 1979; Sassenrath, 1968; Sturges, 1969, 1972a; Surber & Anderson, 1975) indicate that feedback delayed for 24 hours is superior to feedback provided immediately after the student has taken the test. In both of these situations, the student has enough time to note all the important feedback cues; yet feedback seems to differ in effectiveness from one condition to the next. Another inadequacy of the rehearsal facilitation theory pertains to the fact that immediate feedback and delayed feedback are equivalent in effectiveness on immediate retention but seem quite different in efficacy on delayed retention (Sassenrath, 1975; Sassenrath & Yonge, 1968, 1969). The recent study of Postman and Knecht (1983) also reported findings that seem inconsistent with Sturges' explanation of the delay-retention effect. The study examined the effects of encoding variability on retention in a series of three experiments. In Experiments 1 and 2, target words were presented to students three times, in either the same sentence or in three different sentences. Encoding variability failed to increase either free or cued recall of the target words, and it did not reduce long-term forgetting. In Experiment 3, the student was presented (three times) with class names and modifiers with or without imagery instructions. Modifiers either left the class names the same or changed them. Modifier variability showed no effect on either immediate or delayed retrieval of the class names. The researchers concluded that an increase in the number of retrieval routes was not a sufficient condition for improved recall. The inconsistencies revealed here seem to suggest that it is necessary to consider other variables of the feedback situation in order to arrive at a worthwhile explanation of the delay-retention effect (DRE).

In an attempt to arrive at a more parsimonious explanation of the DRE phenomenon, Joseph and Maguire (1982) introduced another parameter in the prediction equation. They tested the effects on mathematics skill level of immediate feedback and delayed feedback at various levels of self-concept of ability in reading. Whereas delayed feedback was the better feedback mode for students who were average or below average in self-concept of ability in reading, immediate feedback was more influential than delayed feedback with students in the highest reading self-concept category. This finding was discussed as suggesting the need for an explanatory retention model that accounts for variability in students' motivation and, possibly, information-processing ability. That is, the interaction of time of feedback with motivational and information-handling variables needs to be investigated so as to properly consider alternative hypotheses that speculate about the effects of differential affective states and cognitive abilities on learning and retention outcomes.

Since Kulhavy's and Anderson's explanation of the DRE focuses on competing responses that occur on the second trial of the test, an examination of the relationship between incidental-learning ability and the effects of time of feedback should provide evidence capable of strengthening or weakening their claim. The finding of a disordinal interaction between the timing of feedback and motivational variables such as confidence in academic ability, with individuals of high academic self-confidence deriving greater benefit from immediate than delayed feedback, would support Kulhavy's and Anderson's view.

Rehearsal proficiency might be another crucial information-processing variable for high level long-term retention. The individual who spontaneously rehearses information might use this strategy to keep details longer in his working memory, thus providing himself with enough time to develop meaningful connections between incoming pieces of information, as well as between the stimuli and similar material in storage. Since the probability of recall might be a function of the extent to which the individual has connected the information in question with cues of the stimulus, establishing a greater number of connecting links (called retrieval routes) with previous memory stores might enhance long-term retention and level of recall. Rehearsal could also be used to chunk or regroup several pieces of information together, another strategy that is likely to increase the number of retrieval routes (Craik & Lockart, 1972) and, consequently, the probability of recall. Practice of retrieving the to-be-remembered information might be yet another influence on delayed retention associated with rehearsal ability. An examination of the relationship between rehearsal proficiency and the differential effectiveness of immediate and delayed feedback on level of performance might be useful in assessing the worth of Sturges' explanation of the delay-retention effect.

As was suggested in the previous paragraph, students can re-address bits of information previously stored and reorganize or integrate them in ways that will facilitate their retrieval (Sassenrath, 1968). The student who likes the task or the treatment he is given might be the one most likely to re-address the problem situation and elaborate on his previous perceptions of it. Therefore, motivational variables such as the student's confidence in his ability or his enjoyment/disgust of the feedback mode with which he was treated might be critical in determining the effectiveness of a particular type of feedback.

1.2 THE PROBLEM

The present investigation was designed to examine the interaction of selected information-handling and affective variables with the effectiveness of three feedback modes on level of mathematics skill. A measure of mathematics skill level was taken on three different occasions. Different (parallel) forms of the mathematics test were used to measure initial performance level, short-term retention (STR), and long-term retention (LTR)of mathematics skills; so that the criterion of mathematics skills, rather than their recall of factual items. The feedback modes included knowledge of results provided at three different times. Students in one treatment group were informed as to whether their response to an item was correct or incorrect immediately after they had made it. This treatment was referred to as *item-by-item feedback*. In the second treatment group, test results were reported to each student immediately after completing the test. The term *end-of-test feedback* was used to describe this treatment group. Students in the *delayed feedback* treatment obtained test results feedback information one day after they took the test. For each treatment group, feedback included an indication as to whether each item-response was correct or incorrect, together with the item-stem (RW+S). The total number of items answered correctly was also provided on each trial of the test. Upon receipt of feedback, students were required to rework the mathematics exercise and rescore their answer sheets; they repeated this process until they correctly answered all test items. The testing-feedback process thus typified a classroom mathematics drill exercise for fifth grade students. The information-handling variables chosen were incidental-learning ability, as measured by a visual selective attention task, and rehearsal proficiency. These variables were assumed to be sensitive to individual differences in ability to learn and retain mathematics skills. The interactions of time of feedback with the students' self-concept of academic ability and preference for immediate feedback were also investigated, and the predictive accuracy of the information-handling and affective variables on mathematics skill level was examined after two intervals (one day and seven days) of retention. Important features of mathematics tests used in this study are described in Chapter 5. The data set included three measures of mathematics skill level as well as the information-handling variables (rehearsal proficiency and incidental-learning abilty) and the affective variables (academic self-confidence and preference for time of feedback) as covariates in a repeated measures analysis of variance and covariance design. The homogeneity of within cell regression estimates was central to the tests of significance of the interaction between time of feedback and the concomitants of achievement in mathematics.

1.3 THE RESEARCH QUESTIONS

Because of the delay-feedback paradigm used here, one consideration of the present study pertains to the relevance of the DRE to the learning and retention of mathematics skills. Although the delay-retention effect has been demonstrated repeatedly with multiple-choice items, few of these studies included mathematical concepts and skills. Furthermore, two of the studies that reported results contrary to the DRE used test items that included mathematical (White, 1968) and statistical (Sheridan, 1980) contents. White used a delay interval of three days rather than the conventionally used delay interval of one day. One interest was to find out whether the results from a conventionally used delay interval would be close to those obtained with meaningful, verbal material. Another category of questions pertains to the interaction of the feedback treatments' effectiveness with the information-handling and affective variables. The last three questions investigate the accuracy with which the information-handling and motivational variables predict the mathematics scores of Grade 5 students after different intervals of retention. The main research questions may be stated as follows:

1. Are the criterion line segments for the three treatment groups parallel? That is, are

the population profiles of the criterion means, plotted across the three occasions, similar for the treatment groups?

2. If the population mean profiles for the treatment groups are parallel, are they also on the same level? That is, do they coincide?

3. Do students in different feedback treatments differ in level of retention of mathematics skill even though they are similar in incidental-learning ability?

4. Do students in different time-of-feedback groups differ in level of retention of mathematics skills even though they are similar in rehearsal proficiency?

5. Is there any indication of a significant interaction between preference for immediate feedback and time of feedback on level of mathematics skill?

6. Are the effects, on mathematics skill level, of satisfying students' preferences for time of feedback significant?

7. How significant is the interaction of time of feedback with feedback-preference satisfaction on level performance in mathematics?

8. How significant is the interaction of confidence in academic ability with time of feedback on the retention of mathematics skill?

9. What is the best linear combination of the covariates that can be used to predict students' long-term retention (LTR) of mathematics skill? And what is its predictive accuracy?

10. Is the best linear combination of the covariates on the LTR test the same as that on the STR test? If these linear combinations are different, how do the covariates change with time in their influence on mathematics skill level?

2. FEEDBACK IN LEARNING AND RETENTION: THEORY AND RESEARCH

2.1 Definition of Feedback

The term *feedback* refers to a wide variety of information given to an individual in order to describe the adequacy or inadequacy of his response. Commonly used feedback treatments include *knowledge of results (KR), knowledge of correct response (KCR), and correctional reviews* that contain further information about the correct response. Especially with achievement tests, KR or KCR has been provided along with the item stem that may include the other alternative responses. KR has also been provided with cues that may guide the individual to the right answer.

Feedback as described above is supplied by the experimenter, teacher, or machine, and is, in this sense, extrinsic or external to the learner. But an individual usually has his own notions as to how well he has done a test or exercise. This notion may include his estimate of how much of the test he has done correctly as well as how well he has done relative to his expectations. Although extrinsic feedback may prompt a student to reexamine his feelings about his performance, his intrinsic notions are present and operative even when he is not provided extrinsically with a knowledge of his results (Annet, 1969). Much of test information feedback, then, is intrinsic to the learner, and experimenter provided feedback may be seen as mere extentions of the central feedback system to include an extrinsic loop that is additional to the learner's own notions of how well he did the exercise. Therefore, increments in performance level that seem to result from feedback treatments should be interpreted as gains that are over and above the influences of intrinsic knowledge of results.

2.2 The Influences of Feedback on Retention: reinforcement or information?

A massive accumulation of studies (Buss & Buss, 1956; Michael & Maccoby, 1961; Parkinson, 1964; and Sturges, 1964; for example) have been consistent in showing that feedback treatments enhance learning and retention in a wide variety of situations. It is generally accepted that repeated success or repeated failure has an enhancing or a deleterious effect on performance level. But researchers are in less agreement as to whether it is the informative nature of feedback or its alleged reinforcing capacity that influences performance level. Since the advent of teaching machines, operant psychologists (Holland & Skinner, 1961; Skinner, 1968) argued that telling a student his answer is *right reinforces* him, and serves to increase the probability that he will make the same correct response on a subsequent exposure to the stimulus. This view predicts that feedback, if it is to be effective, must be given immediately, for it is the immediate presentation of the reward that confirms the connection between the stimulus and the student's response. Consistent with this view is Renner's (1964) conclusion, from a review of the literature on delay of reinforcement with animals, that efficiency in learning and retention decreases with delay (usually in seconds) of reinforcement. Immediate feedback (according to Skinner, 1968) is thus used in programmed instruction to shape behaviour effectively and also to *maintain it in strength* (Skinner, 1968, p. 39).

Of course, one cannot fully reject the idea that feedback on some programme stimuli might be *satisfying* or *annoying* (Thorndike's definition of reinforcement) to some learners. But to assume that the instructional behaviour of most students is subject to the control of feedback might be to see the complex human cognitive system as being as simple as a rat's mentality, or to affirm that knowledge to a human is as food to a rat.

Research evidence has repeatedly challenged the notion that the influence of feedback on performance level can be explained within a reinforcement framework. (See Anderson, 1970; Anderson, Kulhavy & Andre, 1971, 1972; Annet, 1964, 1969; Smith & Smith, 1966; for example). Anderson et al (1971) treated subjects with *right only* and *wrong only* feedback conditions to computer controlled lessons. Students in both feedback conditions made about the same number of errors during learning but their levels of performance on the retention test were similar. The direction of the difference was actually in favour of the *wrong only* treatment group. This finding suggests that feedback does not have its greatest positive effect on correct responses, and that feedback about wrong responses does not necessarily affect performance level in a way that is detrimental; and these requirements are central to the reinforcement position.

The conclusion that feedback is not necessarily reinforcing has been confirmed by Kulhavy and Anderson (1972) and by Surber and Anderson (1975). Their experiments involved providing students with feedback immediately or one day after completing the test. Students who obtained the delay feedback treatment were just as likely as those in the immediate-feedback treatment to repeat, on the retention test, correct responses they had made on the initial test. This suggests that providing feedback immediately after a response (whether or not the feedback is satisfying) is not an important determinant of subsequent performance level. The students treated with delayed feedback in these studies actually outperformed those treated with immediate feedback since they were more likely to change their wrong responses on the initial test to the correct responses on the retention test. The researchers concluded from this finding that feedback appears to provide information or knowledge of results that helps an individual to correct his mistakes on a subsequent exposure to the test.

Shanon and Weaver (1949) were among the first to explain the influence of feedback on performance level in the context of an information-processing theory. Their model defines information in terms of the reduction of uncertainty. The information a given stimulus conveys is seen to be not so much a function of the stimulus itself as of the other messages that might have occurred instead. The informative value of a specific piece of feedback, then, depends on how many pieces of useful information that could have been sent in an evaluation or correction of the response. The feedback *right* following a response on a four-option multiple-choice item is more informative than *wrong* following an incorrect response. Whereas *right* reduces all uncertainty, the feedback *wrong* rules out only one of the four possible answers.

In support of the reduction of uncertainty theory, studies such as Bilodeau (1952, 1953), Bilodeau and Rosenback (1953), and Annet (1964) suggest that error information might be used strategically to locate the appropriate response rather than as a negative reinforcer. Feedback on wrong responses in these studies had the positive effect of reducing uncertainty and thus of guiding rather than inhibiting learning.

Another paradigm used to examine the reinforcing capacity of feedback involves withholding information from the participant systematically. This experimental technique is referred to as partial KR. It involves supplying knowledge of results (KR) in different frequencies, for example KR at the end of each trial, every other trial, or every fourth trial. Feedback frequencies may also include *blank trails*, which simply involve refusing to supply information where the subject would normally expect it.

A standard partial-feedback study was conducted by Bilodeau and Bilodeau (1952). The task involved pulling a lever through an arc of 33 degrees; and KR included a measurement (to the nearest degree) of the arc pulled with the words *too high* or *too low*, since the student was not told the size of the correct arc. Four treatment groups were used in this study. One group was given KR after every trial, another received KR after every third trial, a third group obtained KR after every fourth trial, and a fourth group was treated with the same type of feedback after every tenth trial. In each treatment group, participants continued to try at the task until they had ten trials with KR. An analysis of the number of errors in the ten trials that immediately followed the administration of feedback showed no difference between the treatment groups. The amount of learning accrued, therefore, seemed related to the absolute, rather than the relative frequency of feedback; a finding that contradicts the reinforcement principle and supports the information processing view of how feedback influences performance level. These findings were replicated by James and Rotter (1958) in a study that included measures of performance subsequent to the complete removal of KR. The way in which performance gains deteriorated did not seem to follow the reinforcement principle, the 100 per cent reinforcement gains being not significantly slower to extinguish than those of the 50 per cent reinforcement condition.

In the area of concept learning, the findings of studies of the influences of feedback similarly support an information-processing interpretation of the effect of feedback on learning and retention. Experiments in this area usually leave out either *right* or *wrong* from a series of feedback schedules, or give detailed results for some items and no feedback for others. Buss and Buss (1956) used geometric forms drawn in various colours and shapes on separate cards to examine the reinforcement versus information issue. The students were required to sort the cards by colour and then by shape independently of the other dimension. Feedback messages were typical of those used in concept learning studies. The results contradicted explanations posited by reinforcement theory. In search of consistency with the then popular trend of thought, the researchers proposed a reinforcement based explanation founded on the questionable assumption that *right* is only a weak positive reinforcer, whereas *wrong* is punitive. (The bulk of the empirical research that uses the S-R paradigm makes the opposite assumption, that *right* is a strong positive reinforcer whereas *wrong* is about neutral. (See Thorndike, 1933.)

Bourne et al (1967) reexamined Buss' and Buss' (1956) claims by systematically varying the proportions of trials in which *right, wrong,* and *no-KR* were supplied. When the number of trials on which feedback was given were held constant, differences between the effects of *right or wrong, nothing or wrong,* and *right or nothing* disappeared, suggesting that the students made similar use of the information whether it was presented in the form of negative or positive feedback. These findings contradict a reinforcement based explanation of the influence of feedback on performance level; but they raise questions about the exclusiveness of any interpretation based soley on information theory, since it was the proportions, rather than the absolute frequencies, that were related to performance level, and since no comment at times appeared to function like *right*. One should note that giving the individual no feedback does not prevent him from evaluating his own performance. He may reason that silence is equivalent to right since the teacher would have corrected him if he were wrong. This interpretation of the influence of blank trials may be seen as consistent with the view of information theory that performance level is influenced by additional information rather than the strength of the memory trace.

Summarizing

The findings of studies reviewed thus far seem contrary to a reinforcement based interpretation of the influence of feedback on retention and performance level. Rather, the findings are consistent with the view that the individual strategically uses information presented via feedback to confirm his correct responses or to improve upon errors he has made on a previous trial. When feedback follows a correct response it seems to tell the learner that his understanding of the material is adequate for the given requirement level, or his interpretation of the stimulus is correct. On the other hand, feedback on wrong responses to test items is used in a corrective manner. Consistent with this interpretation is the finding of Buss, Braden, Orgel & Buss (1956), Buss and Buss (1956), Buss, Weiner and Buss (1954), and Travers, Van Wagenen, Haygood, and McCormick (1964) that telling a student when he is wrong and correcting him yielded higher retention scores than confirming right answers. For the same reason, Anderson, Kulhavy and Andre (1971) treated students with feedback only on their errors, or gave them extra time when they made wrong responses, and found that these students did just as well as other participants who were given a more comprehensive feedback.

The evidence in this area of research supports the assumption that feedback helps when the individual uses the conjoint information to correct wrong responses. But it might be just as naive to think that negative feedback never detrimentally affects behaviour as it is to think that that is all it does. Such a conclusion would contradict the bulk of research that investigates the effects of repeated failure on performance level. (See Herold & Greller, 1977; Jacobs, Jacobs, Feldman & Cavior, 1973; Halperin, Snyder, Shendel & Houston, 1976; and Ilgen & Hamstra, 1972.) Besides, errors and correct responses have a remarkable tendency to perseverate to subsequent test trials whether or not feedback is available (Kulhavy & Anderson, 1972; Kulhavy & Parsons, 1972; Kulhavy & Swenson, 1975). This tendency might be indicative of learning that has taken place via S-R connections.

An alternative point of view that considers both the information-processing and reinforcement positions states that the extent to which an individual is helped or inhibited by negative feedback depends, at least in part, on his perception of his chances of succeeding on a subsequent trial. This perception determines level of motivation, which in turn dictates the degree of attention and concentration or effort allotted to the task. Low motivation might also function as a delimitor of incidental learning and the establishment of stimulus response connections. The finding of Joseph and Maguire (1982) that self-concept of academic ability significantly interacts with the effectiveness of two types of feedback is consistent with this view. But more extensive work needs to be done before one can assert with confidence that affective variables are critical for recall performance level.

2.2.1 Immediate versus Delayed Feedback and long-term retention

The law of effect requires that reinforcement closely follows the behaviour to be learned. Close temporal contiguity is necessary if the hypothesized automatic nature of reinforcement is to be upheld. If response strength is increased or maintained after an extended period of time between the reinforcer and the response, the operation of mediatory processes will have to be accredited with significance, and the law of effect would loose much of its worth as an explanation of how learning takes place. It is for this reason that research on the optimal time of providing feedback becomes relevant to the reinforcement versus information-processing issue. The ensuing discussion aims also at clarifying the worth of information-processing theory that sees the learner as an active processor of information rather than a passive recipient of S-R connections, as reinforcement theory would prefer to see him.

An increasingly large accumulation of studies have examined the relative efficacy of immediate and delayed feedback on both learning and long-term retention of verbal material. Generally, research efforts in this area have five components that can be represented schematically as follows:

T1----------Di---------FDBK----------Ri----------T2

where T1 is the initial test;

Di is the delay interval that may vary from 0 minutes (in the condition of immediate feedback) to days;

FDBK is performance feedback on T1;

Ri is the retention interval which may be minutes in the condition of immediate retention and days or weeks in conditions of delayed retention;

T2 is the postfeedback test that provides a measure of retention.

A study may include both immediate and delayed retention conditions by scheduling T2 for a random half of the T1 items to be immediately after FDBK, and T2 for the remaining T1 items to be at a later date.

Research efforts that use the delay-retention paradigm have been reasonably consistent in showing that individual's treated with delayed feedback retain meaningful material, on a long-term basis, better than do other individuals treated with immediate feedback. (See Buckwald & Meager, 1974; Kulhavy & Anderson, 1970, 1972; More, 1969; Peeck & Tillema, 1979; Sassenrath, 1975; Sassenrath & Yonge, 1968, 1969;

Sturges, 1964, 1969, 1972a, 1972b; and Surber & Anderson, 1975.) Materials used in these studies include French and German vocabulary words, prose passages, paired-associate learning, and multiple-choice items in subject areas such as psychology, science, and mathematics. The participants were mostly university students, but included school-aged children from junior and senior high school grades (Kulhavy & Anderson, 1972; Surber & Anderson, 1975), grade eight (More, 1969), grade five (Peeck & Tillema, 1979), and grade six (Sassenrath, 1972, 1975).

Studies that show immediate and delayed feedback treatments as being comparable in effectiveness (Beck & Lindsey, 1979; Newman, Hiller & Williams, 1974; Phye & Baller, 1970; and Sheridan, 1980) have used university students registered in psychology courses as subjects; whereas only one study (Sassenrath, 1972) that showed immediate and delayed feedback as being similar in effectiveness used school-aged children (390 sixth graders). It should be noted here that the immediate-feedback group of Sassenrath (1972) outperformed the delay-feedback group on the initial test ($p < .05$) and that the direction of the group difference remained the same on the retention test. But when Sassenrath re-analyzed the data of this study (Sassenrath, 1975) by using a criterion measure that was more sensitive than the number right score, the findings were strongly supportive of the delay-retention effect (DRE).

Some of the studies that used psychology students at university level and reported no significant main effect of time of feedback (Phye & Baller, 1970; Beck & Lindsey, 1979) deviated from the typical study in ways that might be important. For example, Phye and Baller provided students in the delayed feedback group with feedback after 48 hours, whereas 24 hours or less is the typical delay interval. In addition, the immediate KR treatment was really feedback delayed for 30 minutes. The length of the delay interval might be critical since a study that used a longer delay of 72 hours (White, 1968) found immediate feedback to be superior to delayed feedback on long-term retention. Furthermore, the feedback messages (which included questions plus distractors) of Phye and Baller were read to the students who were told the correct answer immediately after it was read. Thus the students in this study received test results feedback through both visual and auditory information channels. In spite of these possibly important ways in which the study deviated from the normal, the difference between the delayed and immediate feedback group means was in the predicted direction, $F(1, 72)=1.64$, although it was not significantly greater than zero.

In Beck and Lindsey (1979), 22 graduate students were divided into two groups of 11, such that the cell sizes may have been small (as in the case of Sheridan, 1980 where some cells included as few as 5 subjects). Immediate feedback took the form of a class discussion of the errors the same day, whereas delayed feedback took the form of a similar discussion one week later. Therefore, the delay interval of this study was one week, in contrast to one day used in the typical study. Also, the discussion gave the students extra time and motivation to correct their errors. The retention test included only items that were done wrongly on the initial testing occasion. A t-test of difference between independent groups showed the means as being similar. In the light of other findings of the DRE, the only conclusion that seems plausible here is that graduate students can benefit from an immediate discussion of their errors just as well as if this discussion takes place one week later; and this is so particularly where these students expect a subsequent, important test of the material.

Studies that report no difference in the effectiveness of immediate and delayed feedback treatments have all used psychology students at university level as subjects. Yet, it might not be very promising to survey the critical ways in which university level psychology students differ from other persons, since other unsystematic ways in which these studies differ from the typical ones make their findings fraught with interpretive problems. Two possibly critical ways in which university students differ from nonuniversity students might include self-concept of academic ability, and actual ability to handle (comprehend, integrate with previous knowledge) large portions of information in a short space of time. Another important difference might involve *guessing the hypothesis*. Psychology students with a background in operant conditioning might tend to be more confident than others about the relative value of having feedback immediately.

Not all investigations that use psychology students at university level report no difference between the effectiveness of immediate and delayed feedback. Sturges (1964, 1969) used volunteer university students registered in an introductory psychology course, and Sassenrath and Yonge (1968, 1969) used upperclass undergraduates registered in educational psychology. In all of these studies, the time of feedback main effect was very significant in favour of the delay-feedback treatment. When one compares the methodological details of these studies with those of investigations that report no difference between the two feedback treatments, fewer problems of interpretation seem to surface.

Explanations of DRE

Two competing views have been frequently cited as explanations of the delay-retention effect (DRE). On the one hand is Kulhavy's (1977), Kulhavy's and Anderson's (1972), and Surber's and Anderson's (1975) theory of interference-perseveration. The position postulates that initial wrong responses interfere proactively with the acquisition of correct responses when the student sees the feedback. But if individuals are given a chance to forget wrong responses, error perseveration and, consequently, interference will be reduced. A delay interval between the initial responses and the feedback allows students to forget their errors such that less proactive interference or response competition takes place in a delay-feedback situation than when feedback is provided immediately. An instructional procedure that delays feedback for one day should produce better retention than one that provides feedback immediately.

Interference perseveration can be explained in the language of information processing. In the immediate-feedback situation, T1 responses are not forgotten during the retention interval. Rather, they emerge to compete with the correct responses (obtained from feedback) when the participant is re-presented with the stimuli on T2. Thus, on the retention test, each item that was done wrongly now reference two, rather than one, long-term stores so that two responses compete equally well for the individual's attention. Response competition increases the probability of making an error on T2; as a result, level of performance will be low compared to that in an interference free situation. The condition is comparable to what Broadbent (1971, 1977) and Seaman (1980) refer to as an attentional failure. Here, the attentional selector switches back and forth between the response analyzers. The process results in confusion or a high probability error since both channel analyzers are similar in strength. In the delayed-feedback condition, response competition is less intense since the individual gets a chance to forget his initial wrong response before he obtains the correction from feedback. When he is presented with T2, the correct responses from feedback fire the dictionary units more strongly than do the analyzers associated with the wrong responses. In this relatively competition free situation, the individual is more likely to get the T2 items right.

An interference-perseveration explanation of DRE predicts that students treated with delayed feedback are likely to forget their initial wrong responses by Occasion 2, whereas students in the immediate feedback situation are likely to remember their wrong responses. This prediction provides one with a means of testing the validity of the interference-perseveration hypothesis. Kulhavy and Anderson (1972) and Surber and Anderson (1975) tested this prediction. Both studies involved providing test-results feedback to two groups of high school students, one obtaining feedback immediately while the other obtained test results feedback the following day. In both studies, all participants wrote the same test one week later. As was predicted, delayed-feedback students obtained higher scores on the retention test than did students in the immediate feedback condition, and were less able to identify the errors they made on T1. The researchers claimed that the findings supported the interference-perseveration hypothesis.

But interference theory tends to see the learner as being more passive than the current stage of information-processing theory would have him. (See Craik & Tulving, 1980; Eysenck, 1982; and Kail & Bisanz, 1982.) In addition, Peeck and Tillema (1979) reported findings that contradicted an interference-perseveration explanation of the DRE. Although the delayed-feedback students outperformed students in the immediate-feedback treatment ($p < .01$), both groups of students were equally capable of identifying errors they had made on T1. In other words, there was a substantial retention of the initial wrong responses, and this did not seem to prevent students from benefiting from the feedback. Rather, students within each group who had remembered their initial responses learned the correct responses from feedback even better than other students. The researchers concluded that remembering initial errors is not a necessary cause of low performance on a retention test, and that Kulhavy's and Anderson's interference-perseveration hypothesis is inadequate as an explanation of DRE.

The rehearsal-facilitation theory. Sturges' (1969, 1972a, 1972b) and Sassenrath's and Yonge's (1968, 1969) explanation of the benefits derived from delaying feedback has been referred to as a rehearsal-facilitation theory. The view states that the individual learns and retains more in a delayed than in an immediate feedback situation, because people respond differently to informative feedback when it is delayed than when it is presented after each item or immediately at the end of the test. In a delayed feedback situation, the individual perceives that he has enough time to process the material properly. He carefully notes both correct and incorrect options and makes fine-tuned discriminations between them; or he organizes the to-be-remembered material in a way that facilitates long-term retention.

Learning seems to be considerably less when feedback is presented immediately. Here, the student seems to note merely whether he is right or wrong and to ignore other information about the properties or characteristics of the correct responses. The theory therefore postulates that long-term retention is improved when both the characteristics of to-be-remembered stimuli and the timing of informative feedback allow subjects to identify and store relationships between the correct response and other incorrect alternatives. It expects that differences in the effects of immediate and delayed feedback would be most remarkable where cues to the right answer are provided with feedback of test results.

In an effort to confirm the rehearsal-facilitation theory, Sturges (1969) investigated the effects of two levels of delayed and two levels of immediate feedback of test results on retention. The four groups of undergraduate students were presented with a multiple-choice test of 38 factual items, and they received feedback immediately or 24 hours after completing the test. Feedback messages consisted of the stem and either all answer options with the correct answer (CA+) underlined, or the stem with the correct response underlined and all other options excluded (CA). The findings indicated that the 24 hour delayed feedback treatment resulted in superior long-term retention when the feedback included both incorrect and correct responses, but not when it contained the correct response option only. These findings seem on the surface to be consistent with the hypothesis that superior retention with delayed informative feedback is due to increased knowledge of alternative answers. But the removal of the incorrect alternatives also removed some of the cues (e.g. spatial position) from the feedback. Therefore, cues and alternatives are confounded, and the findings as stated so far are inconclusive.

The study was repilcated (Sturges, 1972a, 1972b) so as to overcome this confounding of additional cues with alternatives. The findings clearly support Sturges' position that superior retention with 24-hour delay of test-information feedback results from factors operative at or following the presentation of feedback. When informative feedback was presented in a form that required students in the immediate feedback group to respond to more than the correct alternatives at feedback, their retention improved and delayed feedback was no longer superior to immediate feedback.

One contradictory note is that the beneficial effect of delayed feedback was not observed on immediate retention (Sturges, 1969, 1972a; Sassenrath & Yonge, 1968, 1969). Sassenrath and Yonge (1969) speculated that this occurrence resulted from the fact that processing at feedback was not sufficient to promote better learning although enough to encourage further covert processing of the material during the retention interval. This interpretation, however, does not lend itself to easy confirmation. An alternative explanation is that the students used strategies that foster good long-term retention, and that these strategies do not influence immediate retention. This alternative explanation will be discussed further in Chapter 3 under the section that deals with rehearsal. Another possibility could be that immediate retention measures are characterized by ceiling effects that mask possible differences between the two groups at acquisition. Indeed most studies that include measures of immediate retention report group means that are quite high.

Summary and Conclusion

The assertion of Anderson and his associates that the DRE experimental design is analogous to the proactive interference (PI) paradigm seems to need further investigation. The theory sees the administration of the posttest as comparable to the presentation of feedback in a DRE study. When a person makes an error on the initial test, therefore, he strengthens an A-B connection that interferes with his ability to learn the correct A-C connection from feedback. But close scrutiny reveals some important differences between the situation in which the individual finds himself when he is correcting errors with the aid of test-information feedback and an A-B, A-C paradigm, although there are obvious similarities. For instance, it is doubtful whether the analytical processes involved in selecting an alternative as an answer to a test question is comparable to the processes of establishing an arbitrary A-B connection during the rote memorization of an initial list. The depth of processing and, consequently, the degree of learning required in these two situations seem different.

In addition, it should be noted that feedback includes both A-B, A-B and A-B, A-C paradigms at the same time, whereas this is not the case in an interference design. This difference makes it difficult to apply explanatory concepts such as response set interference and list differentiation to DRE studies, and these concepts are important to interference theory.

Finally, interference theory portrays the individual as a passive learner, acted upon by A-B and A-C connections that fight for supremacy within him. This framework is inconsistent with recent modifications of information-processing theory (Craik & Tulving, 1980) where the learner is seen to be very active in his use of strategies to control and differentiate between incoming stimuli and to integrate incoming material with previous knowledge. The alternative hypothesis of Sturges (1969, 1972a, 1972b) fits these recent modifications of information-processing theory more closely than the response-perseveration hypothesis of Kulhavy and his associates. But added emprical evidence is required to relate the important processes of learning and retention to data that reflect the DRE before one can be confident about the explanatory worth of these two theories. It is not very appealing to psychologists, at this stage of psychological enquiry, to consider the influence of different cognitive processes on the DRE, largely because these psychological processes have been too loosely defined. Consequently, studies that have investigated the interaction of time of feedback with the cognitive aptitudes of the individual are nonexistent. Some studies have examined possible effects of time of feedback with different feedback messages. Results from these studies may be worth looking at since feedback messages that are systematically different might require the use of different cognitive strategies for optimal learning. A significant interaction of time of feedback with type of feedback might therefore provide useful hints about the relevance of cognitive processes in explaining the delay-retention effect.

2.2.2 DRE with different feedback messages

Teachers and other educators aim at optimizing learning and retention of different types of curriculum material. To realize this goal, one needs to identify the important instructional variables for each type of message and curriculum content. Sturges (1964, 1969, 1972a, 1972b) has investigated the delay-retention effect under different feedback messages. Her 1972a study is most convincing. In this study, she demonstrated that the facilitative effect of 24-hour delay feedback upon seven-day retention varied with the form of the feedback. Twenty-four-hour delay test-results feedback was superior to 20-minute delayed feedback and zero minute delayed feedback on long-term retention when there was an immediate recall test and feedback took either of four forms: the correct answer, wrong answer options, and the item stem (R / W+); the correct and incorrect answer options only (R / W); and the correct answer only (R). When there was a recognition rather than a recall acquisition test, DRE occurred with variable (R / W or R) but not with redundant feedback; and when there was no acquisition (immediate retention) test, the DRE occurred when only a cue to the right answer (but not the correct answer itself) was supplied in feedback. These results seem to suggest that delayed feedback promotes good long-term retention when the feedback messages allow individuals to identify relationships among the stem, the correct answer, and the incorrect alternatives. An information-processing explanation of DRE is supported by these results.

Sassenrath and Yonge (1968, 1969) also investigated the delay-retention effect under different types of feedback messages. They treated undergraduate students with immediate and 24-hour delayed feedback. Half of the immediate feedback group was presented at feedback with the stem (quiz item) plus answer options and the correct answer option underlined (CA+). The other half of this group received only the answer options with the correct answer underlined (CA). Within each of these groups, half of the students were instructed about a retention test that should follow, whereas the other half were not. Students treated with delayed feedback were similarly divided into four subgroups. Thus delayed and immediate feedback treatments differed only with respect to the time of feedback. The design of the experiment was therefore 2(time of feedback) x 2(stem, no stem) x 2(set, no set).

Immediate and delayed feedback groups were not different on the initial test. They were similar also on the immediate retention test, the only significant effect being that of the stem/ no stem ($p < .001$). On the 5-day retention test, the means for feedback cues (stem, no stem) were again significantly different ($p < .001$). But significant mean differences were also observed for time of feedback ($p < .05$), and for retention set ($p < .01$). But none of the interactions was significant.

Sassenrath and Yonge (1969) replicated this study using a 2(time of feedback) x 2(stem, no stem) x 2(rights, rights+wrongs) design, and 311 upperclass men enrolled in introductory psychology as subjects. No significant difference was observed on the initial test, and at immediate retention. On the delayed retention test, delayed feedback was significantly better than immediate feedback ($p < .05$), and feedback without the stem (no stem but four alternatives, and no stem with right answer only) was significantly superior to feedback with the stem (stem and four alternative responses, and stem and right answer only). There was no significant difference between *rights* and *wrongs*. It should be noted here that the finding of *no stem* producing significantly higher retention scores than *stem* is exactly the opposite of the corresponding significant difference observed in Sassenrath and Yonge (1968). The researchers attributed the discrepant findings to differences in the feedback treatments themselves. When feedback was administered immediately after the entire test in Sassenrath and Yonge (1968), the stem plus the alternative answers produced better retention than alternatives only. In Sassenrath and Yonge (1969), however, when feedback was presented immediately after each item, the students did not have enough time to benefit from the additional information provided in the stem, which now served as a distractor rather than as an aid to long-term retention. One finds it puzzling, though, that the information overload in Sassenrath and Yonge (1969), created by including the stem in the feedback, did not produce a differential effect between the time of feedback groups at acquisition (immediate retention) but only at long-term retention. In other words, one would have thought that a distractor would have served to limit both acquisition and retention, and not just the latter. A lack of similar interaction effects was noted by Sturges (1969, 1972a), as pointed out above. But this finding was contrary to the expectation of the researchers. Thus, it leaves the nature of the interaction of cognitive processes with time of feedback as murky as it has ever been.

The study of Phye and Baller (1970) shines a glimmer on the time of feedback x type of feedback meaasge interaction. The study used messages that consist of either no distractors, three distractors, or seven distractors. The distractors were simply incorrect answer options. The results indicated a feedback form x level of feedback informativeness interaction, $p < .05$, suggesting that students in the 48-hour delayed feedback did best where the feedback provided more cues, and that 30 minute delayed feedback was more effective in the no distractor condition, in contrast to where clues or alternatives were presented with the feedback. The study supports the position that delayed feedback promotes better long-term retention by allowing students to process more of the information provided in feedback. But the clarity provided here is only an inkling.

Only one study that considers the DRE with tasks that vary in semantic requirements has been found. The study (Peeck & Tillema, 1979) investigated the delay-retention effect with tasks that required guessing, factual retention, and the making of inferences. Students either received no feedback, or feedback after 30-minutes or after one day. There was no significant difference between the time of feedback groups initially nor at immediate retention, suggesting that feedback affected the immediate retention of all types of material in the same manner. On the long-term retention test, delayed feedback, however, was superior to immediate feedback, and the feedback x type of test interaction was significant; even though there was no significant main effect for type of test.

2.3 Expectation of a Significant Delay-Retention Effect

Propositions of the present study, pertaining to the effectiveness of time of feedback on students' retention of mathematics skills may be stated as follows:

1. Do the line segments of mathematics achievement of three groups of students treated separately with *item-by-item, end-of-test, and one-day delayed feedback* of test results run parallel across three occasions?
2. If the population mean profiles for the treatment groups are indeed parallel, are they

also on the same level; that is, do they coincide?

These questions pertain to the effects of time of feedback on the retention of mathematics skills. In the first question, the treatment x occasion interaction is the important consideration; whereas the second question goes one step further to investigate whether the three treatments are really interchangeable.

The time of feedback x time (occasion) interaction was expected to be significant, reflecting the trend that information learned from an immediate feedback condition is characterized by a more abruptly declining retention curve than is similar material learned in a delayed feedback situation. The findings relevant here are those that examine the relative effects of immediate and delayed feedback on long-term retention. A large majority of these studies (Buckwald & Meager, 1974; Kulhavy & Anderson, 1972; More, 1969; Peeck & Tillema, 1979; Sassenrath & Yonge, 1968, 1969; Sturges, 1969, 1972a, 1972b, for example) support the view that delayed feedback is superior to immediate feedback in influencing the retention of meaningful material. These studies are methodologically cleaner and less fraught with interpretive problems than studies reporting no difference in the effects of immediate and delayed feedback. On the basis of the relevant findings, then, one would expect to find a significant treatment X time interaction, with delayed feedback being the most effective treatment for long-term retention.

3. REHEARSAL AND SELECTIVE ATTENTION: THEORY AND RESEARCH

3.1 Introduction

A conception of how information-handling strategies influence retention and recall performance level may be obtained from the basic postulates of two frequently referred to memory models. These are the *multistore* and *the levels of processing* models of memory. The multistore memory model was framed largely by the postulates of Atkinson and Shiffrin (1968). These theorists differentiate between the structural features of memory and observable strategies the memorizer uses to facilitate the acquisition, storage and retrieval of information. The various memory stores along with certain invariant processes comprise the structural components of the memory system. As such, structures are unmodifiable, like the hardware of a computer, and refer to aspects of memory that are not influenced by training. Optional strategies that the individual brings to bear on the task comprise the nonstructural component of memory. They are operations that allow the individual to select and store pertinent pieces of information and at the same time ignore other pieces of information that might be irrelevant as far as satisfying the current needs of the organism is concerned. Memory strategies were therefore referred to by Atkinson and Shiffrin (1968) as control processes. Control deficiencies are, by definition, trainable, whereas structural deficiencies are not.

Atkinson's and Shiffrin's distinction between structural and nonstructural components of the memory system is deceptively simple. Empirically, whether the young child's deficiency reflects structural or control failures relies on the effectiveness of training in the use of strategies. If training enhances strategic behaviour, control (or production) failures are implied. Unsuccessful training, on the other hand, suggests (however hazily) that a structural deficit is involved. One difficulty that emerges has to do with the fact that the ineffectiveness of training also raises questions about the appropriateness and/or adequacy of the training program itself. The inference that a performance deficit reflects a structural defect seems teneble only after all possible training procedures have been exhausted without success, a state of affairs that is unreachable. Another uncomfortable position is reached when training in the use of strategies is effective in an experimental situation but the performance gains do not transfer as expected to situations outside of the laboratory. It seems impossible to make convincing conclusions in these instances which have become quite numerous in the past decade.

Craik and Lockhart (1972) and Craik and Tulving (1975) have developed an alternative to the multistore memory model. Their *levels of processing model* deemphasizes structural features and defines memory in terms of the processes necessary to encode and comprehend incoming material to be remembered. Processing starts with the shallow sensory components of the system and progresses to deeper semantic levels. Whereas shallow levels of analysis consider only physical characteristics of the stimuli, deeper levels involve greater understanding and integration of the stimulus into existing cognitive structures. These include the recognition of patterns and relationships, and the elaboration and enrichment of the stimulus. Degree of retention reflects the level or depth at which the material in question has been processed.

There is some degree of circularity in the definition of depth or level of processing. Material that is deeply processed is predicted to be remembered effectively, but that which is remembered is alleged to have resulted from a deep level of processing. In other words, both degree of processing and level of recall are obtained from the same data. There have been recent modifications of the theory. (See Craik and Jacoby, 1975; Lockhart and Craik, 1976; and Jacoby and Craik, 1979.) But many concepts continue to be vaguely or globally defined, so that empirical verification or rejection of the theory is difficult.

In spite of the shortcomings, the multistore and levels of processing theories of memory serve as the basis of Sturges' rehearsal facilitation explanation of DRE. As does Sturges' explanation, the levels of processing theory sees the individual as an active memorizer, and explains variations in level of retention in terms of activities the individual carries out on the material at the time of acquisition. There is operational value in modeling memory related activities in terms of cognitive strategies the individual utilizes to effect learning. Such a formulation might emphasize how the individual uses his attention and different types of rehearsal to selectively encode, compare, recite, and retrieve some pieces of information and ignore others. This conception of memory leans heavily on the levels of processing view, even though it borrows terminology from the multistore framework. Thus, the differential use of rehearsal and attention strategies become focal. The present chapter proceeds to examine theory and research that relate rehearsal and selective attention with the acquisition, retention, and recall of information.

3.2 Attention in Information-Processing Theory

The term attention has remained a remarkably elusive concept, even though it has been studied closely since the early stages of psychological enquiry. There is no generally accepted definition or method of measuring attention, but a consistent feature of attentional research pertains to the selective aspects of information processing. Selective attention, in the context of information processing, refers to the degree to which one might choose to process specific sources of currently available information and ignore others. Selective encoding is a frequently used synonym whenever one wishes to focus on the more active aspects of the construct. Other cognitive processes (such as rehearsal, visualization, mental rotation, and memory search) may involve conscious, time-and-space consuming operations that are useful in explaining the individual's ability to focus his attention on particular objects. Nevertheless, attention is not equated with consciousness. Rather, it is primarily the selective properties of information processing that defines the mechanism as attentional. This measure of attention has been labeled *incidental-learning ability* (Epps, 1978).

Selected theories of attention will be reviewed in this section of the chapter. If mathematical models can be derived from these theories of attention, estimates of the parameters based on experimental data might be considered as quantitative measures useful in testing the fit of the models. The discussion proceeds by first describing selected models of attention and classifying them into one of three categories: one-filter serial coding models, attenuation and threshold models, and variable-filter, pertinence models.

3.2.1 One-Filter, Serial Coding Models of Attention

Several influential theories of attention attempt to model the internal representation of a stimulus as held in a sensory register {(such as iconic or echoic short-term memory (Broadbent, 1958)}. Representations at this stage are unprocessed, susceptible to the masking effects of subsequent stimulation, and decay rapidly. A number of models represent such coding processes as serial in nature with a sort of race between the decay and/or masking of information in the sensory register and the serial coding processes of the cognitive system.

Broadbent's (1958, 1971, 1977) proposition of a switch-like filter is one of the popular models of attention. He assumes that pieces of information entering the sensory channels proceed without restriction to the short-term memory (STM). The STM functions as a buffer, holding pieces of information for seconds. During this brief period, a selective filter allows one channel of information passage from STM to the central processor that is of a limited capacity. The filter is flexible and operates like a switch so that the individual can switch his attention from one information channel to another, provided that the remaining sources of information are not yet lost from STM. In this model, then, pieces of information are not analyzed for meaning until they reach the central processor, earlier selection being based purely on physical characteristics such as loudness, pitch, brightness and location in space. The central processor functions largely to select an appropriate response from among alternatives. Both stimulus selection and response selection draw from one attentional resource, and the energy required for accurate processing of information increases with the number of alternatives from which the appropriate response must be selected, as well as with the similarity of these alternatives. Parameters like frequency, recency, and strength of the mental impression are hypothesized to affect the probability of selection of a particular response.

Broadbent's theory was formulated on the basis of the results of many experiments. Typically, his subjects simultaneously heard a digit sequence like 6-3-7 in one ear and 5-8-2 in the other ear; but the subjects organized their recall by reporting all the digits heard in one ear first, and then one or two digits from the other ear.

Experiments involving the *Dear Aunt Jane Task* (Gray & Wedderburn, 1960; and Treisman, 1960) and shadowing (Treisman, 1964; Norman, 1969) report evidence that seems not to fit Broadbent's earliest model. In Gray and Wedderburn (1960) the participants may have heard the sequence *MICE-2-CHEESE* in one ear and *6-EAT-9* in the other ear. When asked to recall what they heard, the participants frequently recalled the stimuli in meaningful units (e.g, *MICE EAT CHEESE*). Furthermore, these participants were just as likely to recall items correctly when they alternated between ears to connect given information in a meaningful way as when they reported the items by spatial location. If selection was based purely on physical cues, the students would most likely report the digit-word sequence by ear. However, Broadbent's idea that the individual's cognitive system selects only some of the available information for storage or further processing remains almost unchallenged by subsequent research and theory of attention.

The many results supporting the notion that the individual does not use all the available information seem also to confirm the idea that the individual is limited in attentional capacity. Informally, we make this observation daily. There seems to be only a few activities an individual can do satisfactorily well at the same time he is doing something else. For this reason, attention is thought of as a limited resource, and is selective so that the individual can function as effectively as possible within the limits of his attentional capacity.

3.2.2 Selection by Differential Attenuation and Variable Thresholds

On the basis of findings that are inconsistent with Broadbent's earliest model of attention, Treisman (1964; 1971) postulates that information enters the system through a number of parallel channels that proceed without restriction to some part of the nervous system. These inputs are analyzed for crude physical properties such as loudness, brightness and pitch. From here on, the individual can act to attenuate the signal strength of the output from these analyzers, so that if he is instructed to listen to a female voice over one ear, all other output lines from the position analyzers pass on weakened signals. Thus an attenuator turns down the volume of unattended messages. The weakened messages together with the one unweakened message pass deep into the nervous system to the pattern recognizer that is comprised of a large number of dictionary units. Messages entering the pattern recognizer traverse up a logical tree with probabilistic nodes. The analyzer that reaches the foremost point of its dictionary unit fires, and the word is recognized by the observer. This firing of the dictionary unit seems to be synonymous with the conscious perception of the word.

The unattenuated message is usually the one to fire its dictionary unit first. But this is not always the case because of two important ways in which dictionary units differ.

Dictionary units vary in their thresholds that are themselves variable. Biologically and emotionally important signals (for example) have permanently lowered thresholds, so that these signals will frequently trigger their dictionary units even though their analyzer signals may have been attenuated earlier. Instruction and context serve to lower the thresholds of corresponding dictionary units. Also, the recognition of a signal will lower the thresholds of other signals that have occurred with it in the past.

Summarizing, Treisman postulated a two-stage model of attention. Selection is first made by attenuating analyzer signals and, later, by varying the thresholds of dictionary units that correspond to the messages. The unique contribution of Treisman's model of attention to this study pertains to its portrayal of the individual as actively controlling his attentional mechanisms. The learner can turn down the volume on some stimuli so as to turn it up on other stimuli. Also, the model accommodates the possibility that some stimuli can reach the response side of the system almost automatically, by hypothesizing a variable dictionary threshold. Stimuli that have been attended to previously, and responses that have been previously associated with these stimuli are seen to be preeminent in access to attention on subsequent occasions.

Clearly, locating the selective filter has been problematic for theorists. Experiments designed to confirm the various locations proposed in theory have reached contradictory conclusions (see Kahneman, 1973). On the one hand, Treisman's subjects recalled parts of a story presented in the unshadowed ear without increasing the number of shadowing errors, although they could not remember irrelevant information presented over the unshadowed ear. On the other hand, experiments from as early as Moray (1959, 1960) indicated that messages from the unattended ear are not analyzed for meaning even after they are re-presented up to thirty times. Bottleneck theories find it difficult to explain inconsistencies of this nature. Treisman's postulation of preliminary, preattentional tests is of limited worth in explaining these contradictions. The view suggests that a message that has already been analyzed for it's importance to the organism (or relevance to a problem in hand) has not been attended to as yet.

If only Broadbent's (1958) idea that the human's nervous system is limited in capacity is considered as factual, the apparent inconsistencies mentioned earlier could stem from differences in the tasks themselves. For example, if a shadowing task does not fully occupy the individual, he may selectively analyze messages fed through the unshadowed ear without making shadowing errors. The tendency to diversify attention when the material is familiar could also be explained by a theory that locates the bottleneck at no fixed position. Such a model would see attention as varying with the complexity or novelty of the task.

3.2.3 Selection by Relative Importance

In order to explain results that seemed contradictory to Triesman's theory of attention, Deutsch and Deutsch (1963, 1967), Deutsch (1970), Norman (1968, 1969) proposed modifications that would eliminate one of the filters of Treisman's model of attention. They located the lone filter somewhere between the original two postulated by Treisman (1964). Incoming information channels now proceed, without restriction, directly to the dictionary units. Here, each message is analyzed, but the strength of its output analyzer is proportional to the importance of its message to the organism. Signals that are more important to the organism fire their dictionary units more strongly, so that the most important stimulus captures the attention. Thus the Deutsch, Deutsch, and Norman model places the filter in the recognition system itself. Once it is attended to, a stimulus sets the criterion for other signals that may gain attention shortly after by redefining the pertinence of the remaining stimuli. As the general level of arousal increases, more and more signals are able to reach the response side of the system, as long as they are the most important at the moment they occur. Previous experience, context and instruction serve to modify the pertinence of incoming signals from the analyzers. This variable filter of the Deutsch, Deutsch and Norman model hardly eliminates the problem of locating the filter. More than anything else, the researchers' effort demonstrates the complexity of the human information processing system.

Neisser and Becker (1975) were among the first to discard the filter from their model of attention. They found that individuals could attend to either of two displays without hesitation, whereas filter models postulated that long practice would have been necessary to develop a filter for eliminating undesired signals. Their theory proposes that some aspects of selectivity is automatic, whereas others demand attention. The findings of Posner and Synder (1975a, 1975b; Neely, 1977; and Shiffrin & Schneider (1977) support this view. These findings suggest that automatic aspects of selectivity allow stimuli direct access to long-term memory (LTM) codes that include representations of meaning, sound, and visual form. For example, there might be a semi-automatic link between a given stimulus and similar material in storage. This is the basis of response competition. The view hypothesizes about situations where an individual is required to make a response (C) to a given stimulus (A) on Trial 2, when he had previously made another response (B) to this stimulus on Trial 1. The second presentation of A seems to reference B automatically, once the image of this response is still in memory. The individual is now prompted to attend to B and C before executing a response.

The limited capacity processor must be used to reference the LTM codes for stimulus-response connections that are less automatic (Klatzky, 1980), thus allowing the individual to compare the adequacy of an automatic response with the appropriateness of an alternative response. The activation of long-term memory codes draws from the capacity of the central processor and thus limits the individual's ability to discriminate between competing responses.

Hagen (1967, 1970) and Hagen and Kail (1975) preferred the terms *central and incidental processing* as descriptions of automatic and controlled ways in which individuals attend to stimuli. Central processing refers to instances where the object of attention is observed under central focus, whereas incidental learning is seen to occur under more peripheral vision or hearing. Eysenck (1982) prefers the terms *intentional and incidental* learning, since the term intentional seems to be more operational than central. Intentional and incidental learning can now be distinquished in terms of the use of prelearning instructions that either do, or do not, forewarn students about the retention test to be administered subsequently. In the central-learning condition, the participant is instructed to attend to particular stimuli. Learning that occurred without a motive was seen to result from peripheral attention and was labeled *incidental learning*. In the incidental-learning condition, instruction about an irrelevant orienting task serves to discourage participants from actively processing the material that will be tested. Any learning of this criterion, then, is assumed to be incidental. Research efforts that investigate selective attention by using a central-incidental learning paradigm will be discussed later in this chapter.

3.2.4 Research on Central Learning and Incidental Learning

The question as to whether central and incidental learning reflect mechanisms or processes that develop with age, or whether they represent scales along which people of all ages differ, has significance for this study. Initially, Hagen (1967, 1970) was concerned with the development of central and incidental learning. He reasoned that if the central-incidental learning tasks measured attentional variables, they should reveal findings consistent with the notion that as children grow older, they become more able to select task-relevant information for encoding. The children, 6 to 13 years of age, showed age-related increases in ability to retain information that they were instructed to remember (central learning). The learning of uninstructed pieces of information (incidental learning) did not vary systematically with age.

What is really responsible for these age-related gains in central learning? Do older persons use strategies intelligently to focus their attention on task-relevant details of the stimuli, or do the observed differences reflect growth in more basic attentional mechanisms? The first hint to an answer of this question comes from Hagen's (1967) finding that central-learning scores were positively correlated with incidental-learning scores among children at the younger age levels, but that these scores were negatively related among children who were 12 or 13 years of age. Hagen and West (1970) and Sabo and Hagen (1973) confirmed this trend among children (seven to 14 years old) and adults, and among eight-, 10-, and 12-year-old children. The different regression lines suggested that different processes were operative in the two groups. The studies that investigated this question (Druker and Hagen, 1969; Cutting, 1975; and Postman & Kruesi, 1977) were consistent in showing that older children repeated or covertly rehearsed the names of task-relevant stimuli, whereas young, nonrehearsing children were more passive when they attempted to learn the information. The experimental study of Sabo and Hagen (1973) confirmed the hypothesis that the use of encoding strategies is critical in intentional learning among rehearsing children. They allowed children to rehearse during a 10-second delay that was immediately after each presentation of a sequence of digits. The 12-year-old children showed a substantial increase in central learning, whereas 10-year-olds showed only a moderate increase, and the treatment had no effect on eight-year-old children. On the other hand, incidental learning declined with rehearsal activity so that 12-year-olds showed the greatest decrement in incidental-learning scores. Other examinations of counter hypotheses (Druker & Hagen, 1969; and Hagen & Kail, 1975) showed that young children's deficiencies at selectivity were not because they had difficulty analyzing the components of stimuli, and that age-related increases in selectivity were not confined to the use of the central-incidental learning tasks but were indeed a very pervasive phenomenon. It seems, then, that when individuals are instructed to learn say a list of items, they perform self-initiated, selective encoding operations on the items, and that their level of retention of central stimuli depends directly on the efficiency of the operations they choose to employ.

The finding that intentional learning is enhanced by the use of encoding strategies questions the idea that there are two types of learning, one occurring from focal attention and the other from peripheral hearing or view. It is possible that each learning, once it has occurred, was the focus of attention at a particular point in time. Incidental learning may have resulted from very brief focuses when the individual was distracted from the orienting task, whereas central or intentional learning may have occupied focal attention for longer periods (through the use of encoding strategies). Both types of learning are now placed on one continuum, and incidental learning has become an interesting phenomenon. (See Craik and Lockhart, 1972; Eysenck, 1982; Klatzky, 1980; Nelson & Vining, 1980; and Seaman, 1980.)

The new incidental-learning paradigm does not inform the participant that he is in a memory experiment until after the encoding phase has terminated. Rather, the approach uses various orienting tasks to insure encoding of the to-be-remembered items at a superficial, nonrehearsing level. This approach removes the temptation (characteristic of the intentional-learning condition) for individuals to ignore the experimenter's instruction and, instead, employ whatever encoding strategy they think would work best. The result is an experimental condition that is methodologically cleaner for comparing different kinds of encoding strategies involved in remembering, as well as for obtaining strategy-free measures of attention (in this case, incidental-learning ability). Research discussed hereafter use the incidental-learning paradigm in which participants perform different orienting tasks.

Schulman (1971) was one of the first to report that incidental learning was comparable to intentional learning when individuals in the latter condition were given a nonsemantic orienting task. His study revealed that even though intentional learning under a semantic orienting task was superior to incidental learning under a less semantic orienting task, intentional learning under the nonsemantic oreinting task was poorer than incidental learning, whether the orienting task was semantic or nonsemantic. In a replication of this experiment, Postman and Kruesi (1977) compared recall performance of children who had all performed a nonsemantic orientic task of rating the pleasantness of sound of words. One group of intentional learners performed no better than incidental learners; although another group of intentional learners, who were given much more emphatic instructions to learn the words, outperformed the incidental learners. Chow, Currie and Craik (1978) confirmed the finding of no difference between intentional and incidental learners when both were required to perform the same orienting task. The results were consitent with the earlier proposition that memory performance is determined far more by the nature of the processing activities than by the intention to learn per se.

Forgetting: by interference, or by decay.

Studies (Reitman, 1974; Shiffrin & Cook, 1978) have shown that when individuals do not rehearse items they are to attend to, the information is lost from short-term memory in seconds. In Shiffrin and Cook (1978), the longer the period of tone detection that intervened between the letter presentation and the test, the worse participants were at recalling the letters. The results were interpreted as indicating passive forgetting (decay) over time.

But both of these studies also showed evidence of interference. In Shiffrin's and Cook's study, performance at any detection interval was worse when five letters were presented than when four were presented, suggesting that the extra letter interfered with items that were presented earlier. Moreover, when the participants were asked to do mental arithmetic after signal detection ended and before recalling the letters, performance dropped drastically to virtually the chance or guessing level.

Klatzky (1980) concluded from a review of the literature that two factors determine, at different times, the degree of interference and extent of forgetting in short-term memory. One factor is the similarity of the distractor task and the material to be remembered, with greater similarity of these materials generating more interference. The other determining factor is the difficulty of the task. Thus in Shiffrin's and Cook's study, mental arithmetic interfered with the retention of letters, even though these materials seem not to be similar. A more general rule seems to be that the degree of interference is determined by the extent to which the distractor uses up the attentional space of the to-be-remembered task. Difficult tasks require more attention, and, consequently, displace more of the material that was previously the focus of attention. In the same vein, similar materials travel along the same information channels and are thus more likely to interfere with each other.

3.2.5 Attention in Discrimination Learning and Performance

Failures of Selectivity. Hearing your name in an unshadowed message, or seeing a bright, unexpected light will always be distracting. This is so because of characteristics of either the stimulus (e.g. familiarity, novelty, pitch, brightness, etc) or of the individual himself (e.g. curiosity, impulsivity, cognitive style, and cognitive immaturity). An interesting and relevant type of incidental learning seems to take place when one stimulus that was attended to previously distracts the observer from noticing details of newly introduced stimuli. In the language of learning theory, this phenomenon is referred to as proactive interference. The opposite inhibition of learning (retroactive interference) is possible also.

Stroop (1935) used a colour naming task to demonstrate that interference can be explained by the presence of more than one stimuli competing for the individual's attention in such a way that selective attending becomes difficult. The array treatments of his study included 100 colour names printed in black ink, 100 names printed in interfering colours (e.g. RED in blue ink), and 100 colour chips. In some conditions, participants were required to read the names as quickly as possible. The results showed reading colour names printed in interfering colours was just as fast as reading the same names in black ink. Interfering colours did not suppress reading rate. But significant impairments were found in other comparisons. Naming 100 colour chips took longer than reading the same number of colour names, as the participant had to determine the name for each chip before he could report it. The task of naming the colours was most disruptive when they spelled interfering colour words.

One possible explanation of these findings is that reading colour names printed in black ink is faster than naming colour chips; that is reading is faster than naming (Seaman, 1980). Reading colour names when they are printed in interfering colours, then, is not distracting because, before the ink colour is detected, the word has already been read. In the disruptive conditions, individuals were required to name the colour and avoid reading the words. But since it is easier to read than name colours (Hock & Egeth, 1970), participants had two possible responses in mind by the time they were ready to name the colour. Therefore, the condition presented was confusing since it fostered response competition: even though individuals wished to attend only to the colour of the ink, they could not ignore meaningful attributes of the stimuli to be obtained from reading the words (Kahneman, 1973).

Proactive interference explanations of the superiority of delayed feedback over immediate feedback could be similarly interpreted in the language of attentional failures. Proponents of filter models of attention find it difficulty to explain response competition. Treisman's model, where the thresholds of dictionary units are variable, suggests that when Stimulus A is recognized on Trial 1, a similar stimulus A* is likely to be recognized on Trial 2. But to explain response competition generated by previous stimulus-response connections that are similar to those the subject is now required to learn involves by-passing the central processor to access storage. The incidental-learning paradigm does better here by assuming that some stimuli will automatically reference information stored previously in long-term memory. But until a a model considers how an individual might use control processes such as rehearsal to influence his learning and retention, it seem inadequate or incomplete.

3.3 Rehearsal in acquisition, retention and recall

Verbal rehearsal constitutes a class of mnemonics that involve the repetitive vocalizing of the names of stimuli, whether overtly or covertly. At the simplest level, rehearsal takes the form of overt repetition of the name of a single stimulus. An intermediate form of rehearsal constitutes the cyclical naming of more than one stimulus, such that several of the items of a list are rehearsed simultaneously. A more advanced level of rehearsal involves generating associations among the stimuli and cumulatively rehearsing these groups defined by these associations or connecting links. In this way, retrieval of one of the stimuli facilitates the recall of others in that rehearsal set.

Proficiency in the use of rehearsal strategies is seen to be critical in the acquisition (or learning), storage (or retention), and retrieval (or recall) of school-aged children and adults. (See Atkinson & Shiffrin, 1968; Bjork & Jongeward, 1975; Craik & Lockhart, 1972; Craik & Watkins, 1973; Craik & Jacoby, 1978; and Darley & Glass, 1975.) Both the multistore memory model and the levels of processing model emphasize the importance of rehearsal ability. The multistore memory model postulates that rehearsal is comprised of a group of processes used by the individual to maintain information in a temporary or short-term storage, and to facilitate the movement of information between the short-term store and the more permanent long-term store. The levels of processing model, on the o[illegible] views rehearsal as a means of maintaining an item at a given level of the memory [illegible]s an instrument of intensive processing and elaboration. In both models, the role of rehearsal is seen to play two major roles, the first being that of maintaining information in working memory; the second involves functioning as a storage mechanism that provides further processing of the material to be remembered.

Several researchers (Bjork & Jongeward, 1975; Dark & Loftus, 1976) report that maintenance rehearsal is used to counter forgetting (decay in short-term memory) without the actual strengthening of the memory trace, whereas elaborative rehearsal leads to a more resiliant memory trace and better long-term storage. Findings have not always been consistent with this postulation. For example, Craik and Watkins (1973) reported that frequency of rehearsal facilitates short-term storage with no corresponding benefits in long-term storage, while other studies (Bjork & Jongeward, 1975; Dark & Loftus, 1976; and Darley & Glass, 1975) used a conceptually similar procedure to that of Craik and Watkins (1973) and reported strong evidence that both types of rehearsal enhance long-term retention. The findings of Bjork and Jongeward are typical of these studies. Their experiment involved presenting children with sets of six words that they were required to rehearse in a rote, cyclic fashion (i.e. maintenance rehearsal, or "primary rehearsal" as Bjork and Jongeward termed it, to correspond with primary memory).

Minutes later, these children were given similar sets of words to rehearse with the aid of meaningful associations (i.e. an elaborative rehearsal treatment, referred to by Bjork and Jongeward as "secondary rehearsal"). Following the presentation of the six words, there was a delay interval of 20-seconds, during which the child was required to rehearse the words as instructed. All the subjects were then given either a surprise free-recall test or a surprise recognition test of all the words they were rehearsing. In the recognition test, the child was required to select the words rehearsed from among a larger number of words that were not shown previously. The findings indicated that both types of rehearsal produced high recall on the initial test of short-term storage, although maintenance rehearsal was more effective than elaborative rehearsal. On the recall test given a few hours after the learning phase of the experiment, the rehearsal treatments were reversed in effectiveness, secondary rehearsal now being superior to primary rehearsal (Bjork's and Jongeward's terms). These results support the distinction commonly made between maintenance and elaborative rehearsal. Also, the distinction now seems to be more complex than was anticipated. Although secondary rehearsal was still superior to primary rehearsal on the recognition test, both treatments were associated with good long-term recognition; but this was not the case on the test of long-term recall. Similar observations were noted earlier by Woodward, Bjork and Jongeward (1973, 1974).

Together, the findings from the recall and recognition tests suggest that memory performance might be explained in terms of the type of rehearsal the individual brings to bear on the task, as well as in terms of the type of test he is given. Primary, maintenance, or cyclic rehearsal seems effective mainly for maintaining information in short-term storage, but it can produce some transfer to long-term storage. Elaborative rehearsal, on the other hand, seems less effective than a cyclic-rehearsal strategy for maintaining information in short-term memory, but more effective in transfering information to long-term storage in a way that facilitates retention and long-term recall.

An alternative explanation is that both elaborative and maintenance rehearsal transfer to-be-remembered material to long-term storage, but that the nature of the representations they produce can be quite different, and that this difference is a critical determinant of the probability of subsequent retrieval of the information stored. Since elaborative rehearsal is thought to require more inter-item connections than maintenance rehearsal, it follows that items stored by elaborative rehearsal will have more retrieval routes than items transferred to long-term storage by maintenance rehearsal. If one defines the strength of a memory trace (or depth of processing) as varying with the number of retrieval routes or semantic connections between the piece of information and other material in storage, then memory traces produced by elaborative rehearsal will be generally stronger than those resulting from maintenance rehearsal. Research efforts show consistently that recognition is more primitive than recall (Cohen & Greller, 1975), being able to occur from weaker memory traces or a minimal number of retrieval routes. Thus, even though elaborative and maintenance rehearsal might differ in the extent to which they foster long-term retention, they might be more similar in ability to produce long-term recognition, the strength of the memory trace being of little significance in the latter situation.

3.3.1 Relevant research using direct and inferential measures of rehearsal

Studies of rehearsal involve either direct or indirect measures of the construct. Direct measures of strategy usage usually involve the measurement of overt behaviour. Flavell, Beach and Chinsky (1966) used one of the best direct measures of rehearsal to investigate the age at which the different forms of the strategy first appear. The participants of this study included five- seven- and ten-year-old children. Circular arrays of pictures of seven common objects were the materials, three of which were identified on each trial as the ones to be recalled. After each presentation of the stimulus, there was a 15-second delay during which the experimenter recorded the child's lip movements, so as to measure any spontaneous verbal activity that might occur. During the delay interval, the child wore a space helmet that covered his eyes but exposed his lips. The visor was removed at the end of the delay interval and the child was asked to point to the to-be-remembered pictures. The relevant finding was that only two of the 20 five-year-olds showed signs of rehearsal during the delay interval whereas 17 of the 20 10-year-olds rehearsed spontaneously. Furthermore, a positive relationship was observed between the presence of lip movements and the total number of items recalled over the trials. This is the typical finding, and it has been replicated several times (Keeney, Cannizzo & Flavell, 1967; Hagen & Kail, 1973; Ornstein, Naus & Liberty, 1975; Cuvo, 1975). A review of the relevant studies indicates that five- and six-year-olds do not normally rehearse. Seven-year-olds rehearse sometimes, but when they do, their method of rehearsal is rudimentary. From 10 years to adulthood individuals become increasingly proficient in use of rehearsal strategies. Recall performance shows a remarkable increase with rehearsal ability in all instances.

It should be noted here that the lip reading technique is insensitive of the type or quality of rehearsal engaged in by the 10-year-olds. Had Flavell et al (1966) tested adolescents and adults, they would have noticed, a decline in verbalization with increasing age, a finding that reflects subvocalization or covert rehearsal, or rather the disappearance of overt rehearsal (Ornstein, Naus & Stone, 1977). One technique used with older subjects involves externalizing the strategy so that it can be measured directly (see Rundus & Atkinson, 1970; Rundus, 1971). But externalized measures of rehearsal are fraught with interpretive problems pointed out by Kail and Bisanz (1982).

Ornstein and his associates (Ornstein, Naus & Liberty, 1975; Naus, Ornstein & Aivano, 1977; and Ornstein, Naus & Stone, 1977) used direct observational techniques that involved measures of externalized rehearsal. In Ornstein, Naus and Liberty (1975), the researchers asked third- sixth- and eighth-graders to rehearse aloud during short intervals between the presentation and recall of objects. Control subjects (who were allowed to rehearse as they wished) were included at each grade level so as to overcome difficulties of interpreting measures from the externalized rehearsal technique. The serial position curves for the overt rehearsal and control groups were comparable at each grade level, even though control subjects recalled more items than children who were asked to rehearse aloud. Consequently, the researchers proceeded to analyze the rehearsal profiles of the children in the experimental group for qualitative differences that varied with age.

The results confirmed the earlier finding that recall performance level increased with age. More important was the finding of age-related changes in the primacy section of the serial position curves, although these differences were not significant in the later or more recent serial positions. Third graders showed virtually no primacy effect, their serial position curve being relatively flat over the prerecency positions. Sixth and eighth graders had U-shaped curves, with the primacy effect being slightly higher for eighth graders than for sixth graders. The finding of a primacy effect that increases with age has been reported earlier by Cole, Frankel and Sharp (1971), Kingsley and Hagen (1969), Philip, Atkinson, Hansen and Bernbeck (1964), Philip, Shiffrin and Atkinson (1967), Rundus (1971) and Rundus and Atkinson (1970). Subsequent replications (Naus, Ornstein & Aivano, 1977; Ornstein, Naus & Stone, 1977; and Ornstein & Naus, 1978, for example) appear in the literature quite frequently. The high degree of consistency of the primacy effect produces a reliable measure of rehearsal proficiency in the primacy score {(the number of digit positions correctly identified from iinitial positions of the sequence) (Kail & Bisanz, 1982; Seaman, 1980)}.

Direct measurement techniques have also been used to investigate the specific aspects of rehearsal that influence performance level. In two of these studies, Kingsley and Hagen (1969) and Ferguson and Bray (1976) induced children to learn a set of stimuli in one of the following ways: spontaneous rehearsal, overt labeling, covert labeling, repetitive labeling (in which students named the pictures and then changed all the names without rehearsing them). Only the rehearsal condition improved recall. The researchers speculated that rehearsal improved recall because it provided children with retrieval practice.

The position that rehearsal improves recall through the provision of practice in retrieving relevant details from memory predicts a direct relationship between rehearsal frequency and level of recall. The observational technique used by Ornstein and Liberty (1975) allows a test of this prediction by comparing measures of rehearsal frequency and recall performance level at various grade levels. Contrary to their expectation, Ornstein and Liberty found that rehearsal frequency was not highly related to recall performance level once the population was comprised of spontaneous rehearsers. The mean frequencies per rehearsal set (the number of digits or letters rehearsed before the cycle starts all over again) for the third-, sixth-, and eighth-graders (6.1, 6.4, and 6.2, respectively) were similar $p > .05$. The recall performance levels were, on the other hand, very different ($p < .01$), especially in the primacy section of the serial position curves.

Close observation of the patterns of rehearsal indicates that children of different ages were rehearsing in very different ways. Third-graders tended to rehearse each to-be-remembered item in a minimal combination with other items such that their average set size was just about 2.5 items. In contrast, children at Grades 6 and 8 had mean combinations of 4.0 and 4.5 items, respectively; an indication that these older children were more active rehearsers. Therefore, the important age-related changes in rehearsal that compare with the age-related increases in recall performance level, pertain to the extent to which items are rehearsed in meaningful groups or sets. This finding has been replicated several times in studies such as Naus, Ornstein and Aivano (1977), Ornstein, Naus and Stone (1977), and Ornstein and Naus (1978).

Of course, the number of times a list item is rehearsed might increase with the size of the rehearsal set (Rundus, 1971). Thus retrieval practice might be greater among individuals employing larger rehearsal set sizes. Therefore, data that support the levels of processing approach explanation (elaborative rehearsal) might also support the multi-store explanation (rehearsal frequency and retrieval practice) of the relationship observed between recall performance level and rehearsal ability. It should be noted that Ornstein and Naus (1978) held rehearsal frequency constant in simulated data from groups that differed in rehearsal set-size. The relationship between recall performance level and rehearsal set-size was still significantly positive, although this relationship was lower than when rehearsal frequency and rehearsal set-size were jointly related with level of recall. (The distinction made between young children's passive rehearsal strategy and the more active rehearsal of older children is synonymous with the distinction made earlier between maintenance and elaborative rehearsal. Indeed, third graders in the studies done by Ornstein and his associates, rehearsed in a passive, rote-like fashion, whereas older children rehearsed to-be-remembered items in a more active fashion.)

Studies that use an incidental-learning paradigm

Studies that use an incidental-learning paradigm to investigate the relationship between elaborative rehearsal and recall performance level examine differences in performance on structural and semantic orienting tasks. The semantic orienting task is assumed to process information at deeper levels (as does elaborative rehearsal) by allowing the individual to focus on the meaning and common characteristics of a group of stimuli. Structural orienting tasks, on the other hand, are seen to produce storage only at peripheral levels. The paradigm provides a useful test of the adequacy of the levels of processing model in explaining retention and recall.

A large number of studies (Hyde and Jenkins, 1969, 1973; Walsh & Jenkins, 1973; Craik & Tulving, 1975; Nelson & Vining, 1978; Darley & Glass, 1980; and Seaman & Murray, 1980) have reported that semantic orienting tasks produce higher levels of immediate recall than do structural orienting tasks. But Schulman (1974) has shown that forming semantic associations is not the whole story, since congruous statements such as *Is soprano a singer?* yield better recall than incongruous statements like *Is mustard concave?*. His children tend to pay attention to the former and ignore the latter statements, and this difference in attending seems to relate to level of recall.

Darley and Glass (1980) examined more fully the relationship between amount of rehearsal and recall probability in undergraduate university students. An incidental-learning paradigm, involving a visual search task followed by an unexpected recall test, was used to control the kind and amount of rehearsal. Theory (Atkinson & Shiffrin, 1968) about maintenance rehearsal predicts that recall probability is independent of target position in the search list; also, the incidental nature of the task should eliminate any primacy effect since neither the number of rehearsals a target receives nor the depth at which it is processed should depend on the serial position of the word in the list. The results indicated that serial (search-list) position of the target words was a significant determinant of recall probability, suggesting that even when rehearsal was simply a rote cycling of words, it increased the probability of recall over no rehearsal at all. This finding is consistent with the typical finding obtained from other experimental designs. (See Bjork & Jongeward, 1975; Cuvo, 1975; Kingsley & Hagen, 1969.) The findings of Craik and Watkins (1973) are, however, inconsistent with this trend. Darley and Glass (1980) proposed that the conflict between the findings of Craik and Watkins and those of other studies may be resolved if the critical factor is seen to be attention rather than rehearsal type. Using the argument that sometimes rote rehearsal does not demand attention, Darley and Glass concluded that the distinction between the kinds of rehearsal that do or do not facilitate retrieval from long-term store should not be drawn in terms of whether or not rehearsal is elaborative, but in terms of whether or not attending takes place during the execution of the strategy.

There seems be some worth in this explanation, notwithstanding Darley's and Glass's tendency to see attending as an all-or-none phenomenon. Stimuli that do not receive full attention, and are analyzed only at shallow sensory levels, might result in weak representations in memory. On the other hand, stimuli that are attended to fully, and are enriched by organizations that portray their associations with other materials in memory, might yield memory representations that are long lasting and more easily retrieved. But it is debatable as to whether the critical variable is the ability to attend selectively to pertinent stimuli or what this ability is used to do. One individual might choose to focus on physical characteristics of a single stimulus, whereas another of similar processing capacity might note conceptual categories within which several of the stimuli fall, and systematically reorganize the material into meaningful groups. This differential use of similar capacity might be related to level of recall. In sum, it might be important to differentiate between passive measures of attention, such as incidental-learning ability, and proficiency with rehearsal, even though efficient use of rehearsal strategies requires attentional energy.

3.3.2 Conclusion

What conception of information processing is gained from a review of theory and research in the areas of attention and rehearsal? In more traditional memory paradigms, traces and associations were the major theoretical concepts. The individual's acquisition, retention and retrieval of information were seen to be a function of the strength of associations and of their interrelations. The determinants of strength were also well known to be study time, recency, frequency (or number of repetitions), interference by associations involving similar or identical elements, and the like. However, Craik and Tulving (1980) held constant all of these important determinants of strength of associations and traces in a series of 10 experiments. The mental activity of the learner was the only thing manipulated. Yet, memory performance was dramatically affected by manipulations of the information-handling variables. This evidence is consistent with insights gained from the theory and research discussed in this chapter, and suggest that the ability of the learner to retain and retrieve meaningful material might be explained in terms of the strategies he uses to store the to-be-remembered material. The learner seems to be a processor of information, within the limits of his energy and attentional resource. Information-handling strategies such as rehearsal proficiency and incidental-learning ability seem to be able to explain level of learning and retention of meaningful material.

In the process of helping a child to correct his errors with the aid of informative feedback, what instructional variables are important if one intends to optimize learning and retention? How can one match test-item feedback parameters with test-item response characteristics in a way that promotes maximum long-term retention? An answer to this question requires an identification of how the main information-processing variables facilitate learning and retention of different messages or curriculum content. Kulhavy's and Anderson's view of the delay-retention effect implies a learning model of one critical parameter. The critical variable is the quantity of the material acquired or received by the learner. Learning might be measured in a quantitative way (i.e. by recall or recognition) in order to determine how much of the material was originally received. The main internal information-processing variable is the learner's attention, which include the related constructs (interference and response competition) that might detrimentally affect the individual's ability to selectively attend to the new material. The instructor merely has to manipulate variables such as rate and length of presentation, instructions to pay attention, and the like. In learning mathematics skills, for example, level of retention depends directly on how much is acquired; and one can increase acquisition by a slower rate of presentation, allowing more practice, or instructing the student to pay attention. But it was noted repeatedly that two groups of students provided with similar feedback after different delay intervals can be similar in acquisition of the information provided at feedback and yet significantly different on level of long-term retention of the information they acquired earlier. This finding seems inconsistent with the posits of a one-parameter model that sees the individual's attention as the lone critical variable of learning and retention.

A two-parameter model. An alternative model takes into consideration how much information is received, as well as the extent to which the learner organizes the material at input and integrates it with his previous knowledge. Of course, one might opt for a three-parameter model, the third parameter tapping how subjects vary in previous knowledge. But a two-parameter model seems most parsimonious for the present study. First, subjects in this study will all be at the same grade level, so that an assumption of a constant previous knowledge can be made. Second, degree of organization and integration of the new material with previous knowledge seems to consider already the existence of previous knowledge. That is, it seems reasonable to assume that degree of integration varies with any quantitative measure of previous knowledge. Furthermore, it is not the previous knowledge as such that is critical for retention of new material. Rather, it is the degree of organization of this new material with previous knowledge that is seen to be critical. It is this active reorganization and integration of the new material with previous learning that both reflects and fosters high level understanding, by revealing relationships between the various parts of the material, between each part and the whole, and between the whole object of interest and other material in storage.

By emphasizing the value of high level organization in addition to the amount of material acquired, the two-parameter model implies that learning should be measured both quantitatively and qualitatively. Thus, the finding that two groups of students are similar at immediate retention and yet different one week later on a long-term retention test can be easily explained by the two-parameter model. The obvious explanation is that the groups were different at immediate retention, and that a quantitative measure could not reveal this difference. A qualitative measure, on the other hand, is more likely to detect differences in the organization of the material; and these differences might be critical for high-level, long-term retention.

3.4 Expectation of the Interaction Effects of Time of Feedback With the Information-Handling Variables

Two research questions pertain to this area of the study. They may be stated as follows:

1. In providing students with mathematics test feedback, is there a significant interaction between time of feedback and incidental-learning ability?
2. Is there a significant interaction between rehearsal proficiency and time of feedback on mathematics skill level?

Incidental learning x time of feedback.

The first of these questions focused on the interaction of the student's incidental-learning ability with the treatments' influence on long-term retention. It was predicted that the relevant regression coefficient for immediate feedback would not be significantly higher than that for delayed feedback.

Theories such as Broadbent (1958, 1971, 1977) Deutsch and Deutsch (1963), Norman (1969, 1982), and Triesman (1964, 1971) suggest that selective attention is central to learning. Indeed these theories assume that learning results directly from selective attention. It has been reasonably assumed, also, that the material must be learned before it is retained, and that the deeper the learning the better the material will be retained. Also, some theorist (Kulhavy, 1977; Kulhavy & Anderson, 1972) posit that poor retention results when the to-be-remembered material interferes proactively with other material in storage. Recently, researchers such as Seaman (1980), Seaman and Murray (1980) and Anderson (1983) have been explaining interference in the language of information-processing theory. These theorists postulate that individuals who are high in selective attention can discriminate easily between *messages of similar intensities*, and are thus likely to arrive at right answers in a situation where the correct response and the distractors trigger long-term stores of similar trace strength. Such views imply a one-parameter model of learning, with the subject's attention as the lone critical determinant of acquisition. But several pieces of empirical evidence (Mayer, 1974; Mayer & Greeno, 1972; and Mayer, Stheil & Greeno, 1975, for example) report other evidence that is inconsistent with a one-parameter model of learning.

The relationship between learning and retention might be more complex than a one-parameter model seems to suggest, largely because *depth of learning* might be determined by more than mere passive attention (i.e. incidental-learning). Studies such as Sassenrath and Yonge (1968, 1969), Sturges (1969, 1972a, 1972b) and Peeck and Tillema (1979) have shown that two groups of students which are quite similar on the immediate retention (acquisition) of material presented at feedback can be quite different on the delayed retention test of the same material. Usually, students presented with test results under a delayed feedback condition obtain significantly higher long-term retention scores than those presented with immediate feedback. In addition, the recent evidence of Peeck and Tillema (1979), that students' memory of their initial wrong responses does not prevent them from benefiting from test results feedback is contrary to the prediction of the interference-perseveration hypothesis. On the basis of these pieces of evidence it is predicted that the measure of passive attention (incidental-learning abiity) employed in this study will have more to do with learning than with long-term retention. The ability might be a significant parameter of mathematics achievement on all occasions. But since all participants are expected to receive the feedback information, the effects of incidental-learning ability on level of long-term retention might be similar in all treatment groups. In sum, incidental-learning ability is expected to produce similar regression coefficients for the three feedback treatments.

Rehearsal proficiency x time of feedback.

The second question of this category investigates the interaction of the student's ability to use rehearsal strategies as storage facilitators with the effects of time of feedback. Mature rehearsers are expected to hold in mind relationships that lead to the selection of the right answers and the rejection of wrong answers and to use these relationships to update those concepts relevant to the test questions. In the immediate feedback situation, these relationships are expected to be still fresh in mind while the proficient rehearser is correcting his errors. The task of adequately updating concepts might be easier when the relationships have been recently studied, rather than on the following day when they are likely forgotten. Therefore, the highly proficient rehearser is expected to function best in an immediate feedback situation. Poor rehearsers, on the other hand, are expected to find the relationships associated with previously wrong responses distracting rather than informative while they are correcting errors (Hansen, 1974). Thus poor rehearsers provided with immediate feedback are expected to do worse than counterparts in the delayed feedback treatment. Theory and research that support this expectation are discussed extensively earlier in this chapter.

4. THE INFLUENCE OF SELECTED AFFECTIVE VARIABLES ON LEARNING AND RETENTION: THEORY AND RESEARCH

This chapter examines the influence of preference for immediate feedback and academic self-concept of ability on learning and retention of meaningful material. Research efforts that examine the interaction of preference for immediate feedback with the effectiveness of feedback modes are practically nonexistent. It is assumed that there is a direct relationship between children's stated preferences and their enjoyment of the objects in question. The first section of this chapter resorts to an examination of affect on learning outcomes.

4.1 Definition of Affect

The term *affect* has been used at two levels of meaning. At one level, affective experience can be interpreted as brief transitory states such as a pleasant or an unpleasant feeling. Activation or arousal has been classified as affect at this level. Stimulus characteristics such as novel, handy, prompt, and computer-like, are enough to activate observable changes in affect, which varies with neuro-physiological changes, whether they be internal or external to the organism. But although affect might be viewed as a mere product of neuro-physiological changes at one level, it seems plausible to see the construct as a personality dimension, characterized by a reliable, enduring nature, at another level of meaning. As a personality subsystem, affect might be indegenous to the living person. Neuro-physiological changes may amplify or attenuate affective states, causing particular aspects of this personality dimension to predominate for short periods of time (see Tomkins, 1962). But there might be some degree of stability and learned patterning that can be useful in understanding and predicting affective influences, within identifiable margins of error. It is at the second of these levels that affect is seen by some theorists (Izard, 1963; 1964, for example) to have relevance for an understanding of sustained, purposive behaviour such as interests and self-concept of academic ability. These studies indicate that important positive and negative affect may continue for extensive periods of time without change in activation.

An important distinction between preference for immediate feedback and academic self-concept has to do with the object on which the affect is focused.

Whereas preference for a feedback mode focuses the affect on features that define the learning condition, academic self-concept focuses the affect on the material to be learned. Preference for immediate feedback might be influenced largely by the individual's perception of the amount of fun derivable from features that define the learning situation, and, as such, is linked to the learning condition rather than to the learning itself. Self-concept of academic ability seems to be more closely related to the material to be learned or remembered. This difference between the two constructs might be important in understanding why they influence learning and retention differently. Another distinction between preference for a feedback mode and academic self-concept might be drawn in terms of the transitory enduring nature of the state or trait (whichever is relevant). Although preferences seem to be characterized by an enduring personality attribute, an individual's preference for a given feedback mode might be relatively transitory compared to his confidence in a subject area such as mathematics. Preferences might change with the amount of perceived fun or enjoyment derivable from the objects in question. But level of self-concept seems to be based more on a history of experiences and events, characterized by a pattern that tends to maintain itself by influencing the individual's perception of future events (Secord & Backman, 1976).

4.2 Affect on Learning and Retention

A stimulus that captures an individual's attention is alleged to initiate a chain or sequence of perceptual-cognitive responses, whether they be overt or covert. Affective responses triggered, might include the subjective experiences of the individual's history with similar stimuli, or novelties of the situation might be liked or disliked depending on the difficulties or discomforts they present the individual.. Both affective and cognitive systems are hypothesized to interact in determining the way the individual sees and feels about the stimulus. But, as researchers such Rosenberg (1963) conclude, it is practical to delineate the cognitive and affective components of the response at both the theoretical and empirical levels. This section of the chapter proceeds to examine research that attempts to explain the influence of affect on the individual's behaviour.

It has been proposed (Izard, 1964; Izard, Wehmer, Livsey, & Jennings, 1965) that the affective component is the primary motivational variable of learning and the related outcomes. Cognitive inputs such as clues and strategies may influence learning only by first altering the affective system. Possible alterations include amplifications or attenuations of ongoing affect, as well as instigations of competing or complementary affects. In support of postulations about the positive influences of affect on learning and retention, research evidence has been consistent in the finding of a significant main effect on learning outcomes between treatments that differ in terms of affect. (See Izard, 1959, 1960, 1963, 1964, Izard, Wehmer, Livsey & Jennings, 1965; Kleinsmith & Kaplan, 1963; Rosenberg, 1963; Tomkins, 1962.) Typically, the findings indicate that positive affect is associated with high recall levels and low recognition thresholds, whereas the opposite is typical for negative affect.

Explanations as to how positive and negative affect function to enhance and suppress learning outcomes still seem incomplete after several decades of researching. An early explanation of the enhancing effect of positive affect stems from a Freudian theory of repression. The theory postulates that memory stores associated with negative affect are difficult to retrieve because the individual's psyche undertakes protective measures to shutoff disturbing experiences from consciousness. As early as 1938 Sharp reported evidence that seems to support the repression hypothesis. His subjects recalled positive and neutral material significantly better than unpleasant material, even though 100% learning was ensured at the acquisition phase of the experiment. Further support of this position was provided by Worchel (1955). His study showed that once originally neutral words were associated with negative affective material, retention of these experimental associations were poorer than of neutral associations with these same words. Affective stimuli used in these studies were not carefully scaled; and important measures such as *learning time* and *retrieval or response time* were not considered. It is not possible to tell, then, whether subjects took longer to learn and recall stimuli associated with negative affect than stimuli associated with positive affect. The apparent enhancing influence of positive affect could have been due to a selective use of *control processes* such as attention and rehearsal, rather than to processes that are completely outside the individual's control.

In a series of five studies, Izard (1959, 1960, 1963) and Izard, Nagler, Randall and Fox (1965) used a continuous learning trials method to examine the influence of differential affect on learning and retention. The method involves taking control subjects through one learning trial beyond criterion, and comparing the recall scores of independent groups of experimental subjects with base values obtained from the control group to derive measures of retention. The result of these studies seem to support the attention-distractor hypothesis, as opposed to the repression hypothesis. Study I showed both positive and neutral picture labels as being learned at about the same rate, and that the rate of learning was significantly slower for negative affect pictures than for neutral and positive pictures.

It seems premature to conclude that the differential effects of positive and negative affect can be explained by the attention-distractor hypothesis until one has considered the effects on learning of positive affect treatments that are implemented as distractors. One expects learning under neutral affect conditions to be superior to learning under positive affect conditions where the affect stimuli are used as distractors. This hypothesis was examined in Study II. The study involved two levels of positive affect, together with a negative affect treatment. Affect pictures were scenes and faces of people that varied from attractively adorned female figures to badly deformed patients in hospital. The affect pictures were presented in one side of a cardmaster that remained open while cognitive stimuli were presented in the other side of the cardmaster two seconds later. All subjects were instructed to learn the labels of the cognitive stimuli. As the attention-distractor theory predicts, labels associated with the slightly positive affect pictures were learned significantly faster than labels associated with negative and positive affect pictures. There was no significant difference between learning rate in the latter two treatments, and the corresponding difference between the two positive affect conditions was statistically significant. Subjects seemed to take time-out from the learning task to view the positive affect stimuli for a second time. This explanation seemed to have been only part of the picture, however, since acquisition was not at its best in the negative treatment where subjects were least likely to reexamine the pictures. The subject's psyche could have activated a resistance to the intake of the diseased and badly deformed stimuli, and this resistance could have been transferred to the learning of the labels of these diseased and badly deformed figures pictured in the other side of the cardmaster.

Retention of the labels was contrary to expectation. For the 60 per cent learning condition, the negative affect pictures were associated with a significantly higher recall score than the positive and slightly positive affect conditions. The trend was similar for 100 per cent learning. The improper scaling of the affect stimuli was cited as a possible source of the contradictory results.

In Study III, much care was taken to select stimuli from four points of the affect scale. The four points were referred to as *extreme positive, moderately positive, moderately negative, and extreme negative* affect. Positive and negative pictures were matched for deviation from neutrality, and the cardmaster was used to present the stimuli such that exposure time and response time could have been studied as independent variables. The two-second exposure condition was associated with significant treatment difference, with moderately positive affect being significantly superior to extreme positive affect. None of the other mean differences was significant from zero. The four-second exposure condition was also associated with a significant treatment main effect, $p < .05$. Extreme positive affect was the worst condition, being significantly poorer than all of the other treatments. Moderately negative affect was associated with the highest treatment mean, but the difference reached significance only when it was compared with extreme positive affect. Thus far, then, the studies provide only partial support for the attention-distractor hypothesis.

Study V used a similar design and the same pictures as Study III; but neutral labels were used in Study V to separate the affect picture from the cognitive label. The results of this study were quite different from those observed in Study III, and were now consistent with findings observed in other affect inducement studies. Extreme positive affect was now significantly superior to all other treatments, whereas extreme negative affect was now clearly the worst. The difference between moderately positive and moderately negative affect was not significant, but all other mean differences reached statistical significance. This trend was observed among both the learning and the retention scores. A comparison of Study V with Study III, then, suggests that the attention-distractor hypothesis has relevance for a full understanding of the influence of affect on learning and retention. The only difference between these two studies involved a spatial separation of cognitive and affective stimuli in an effort to reduce the distracting influence of the affect pictures. This reduction of potential response confusion produced a dramatic change of results. Extreme positive affect, previously associated with poorest learning and retention, was now clearly the best condition for both learning and retention. But the distractability of the affect condition seems to be only part of the picture. The clear superiority of extreme positive affect over the more neutral conditions might be indicative of heightened arousal. In the same vein, extreme negative affect might be detrimental to learning because it depresses the learner. Although attention or selectivity might increase directly with arousal level and inversely with depression, fluctuations of attention might be mere indications of variability of a more basic cause of learning. Studies that investigate the relationship of students' enjoyment ratings of the learning experience with level of learning and retention seem necessary for a full consideration of counterhypotheses pertaining to the effects of affect on learning outcomes.

4.2.1 Summarizing

One wonders whether there are influences of affect that are separate from those that can be explained by cognitive variables such as attention and rehearsal. Studies conducted so far have not addressed this question, largely because of considerable confounding (and probably interaction) between cognitive and affective variables. Designs that consider the relationship between enjoyment ratings and visual attention measures might help to overcome this confounding and thus address the question of the separate effects of cognitive and affective variables on learning and retention.

The design undertaken in the present study seems to have the potential of considering the separate effects of cognitive and affective variables on learning and retention. The affective variables (preference for immediate feedback and self-concept of academic ability) used in this study are less confounded with cognitive measures such as incidental-learning ability and rehearsal proficiency than measures of affect used in the studies discussed in this section of the chapter.

Studies that examine the effects of preference for immediate feedback on performance in academic disciplines are practically nonexistent. In Joseph (1981), although there was a significant preference for immediate feedback, the interaction of the students' preferences with the effectiveness of immediate and delayed feedback was not significant at each of three occasions. A child's preference for a particular type of feedback might be influenced largely by the amount of perceived fun derivable from the feedback condition as well as by the familiarity of the condition to the learner. The attributes considered by the child seem quite unrelated to the type of skill or material he is required to learn. Given a learning situation he likes, the child's increased level of motivation might influence his level of initial learning. But since the characteristics of the learning situation are unrelated to the material to be remembered, they might be of little aid to his rehearsal of the material during the delay interval. Consequently, his preference for a particular feedback might be of limited assistance to him in his attempts to counteract the processes of forgetting. It seems likely, then, that the interaction of this measure of affect with time of feedback on mathematics skill level is not significant. At the same time, preference for immediate feedback is expected to reflect the students' enjoyment or appreciaton of the subject and, consequently, have significant effects on mathematics achievement level, irrespective of time of feedback.

4.3 The Influence of Academic Self-Concept on Achievement in Mathematics

4.3.1 Definition of Self-Concept

Research efforts in the area of self-concept have been plagued by conceptual and methodological problems pointed out in Scheirer and Kraut (1979), Shavelson, Hubner and Stanton (1976) and Wylie (1979). Yet there is some agreement that self-concept is the person's perception of himself/herself. The various percepts develop from one's interpretations of one's experiences with the environment. These interpretations are influenced particularly by one's attributions of one's behaviour (Bloom, 1976).

Self-concept theorists (Mead, 1934; Purkey, 1970; Shavelson & Bolus, 1982) state that people categorize the percepts they have of themselves. The self system is purported to be multifaceted, with the facets varying as the individual's activities and experiences. Although multifaceted, the construct is alleged to possess a hierarchy with perceptions of general behaviour at the base, proceeding to inferences about the self in subareas such as scholastic achievement. It is on this basis that studies such as Boersma and Chapman (1977), Brookover, Patterson and Thomas (1964) and Shavelson and Bolus (1982) include measures of general self-concept as well as self-concept of academic abilities such as mathematics and reading/spelling. At each level, the construct is seen to include both descriptive and evaluative elements reflected in statements such as *I find division fun, I am a smart kid, I do poorly in school subjects,* and *I am good at attacking new words.* Lastly, the self-concept is seen to be differentiable from related constructs such as achievement and ability (Brookover et al 1964, 1967). Therefore, the construct is hypothesized to add to the predictability of performance level after variance due to mathematical ability has been accounted for.

4.3.2 Research on Academic Self-Concept and Achievement in School

Research efforts have been generally supportive of the definitive characteristics of self-concept. The body of research that examines the structural relations of this construct is voluminous. No attempt is made to discuss this body of research here. The reader is referred to reviews of the relevant literature found in Bloom (1976) Lynch, Gregen and Noreem-Hebelson (1981), Purkey (1970), Shavelson, Hubner and Stanton (1976), Scheirer and Kraut (1979) and Wylie (1979). Research evidence reviewed will be limited to the influence of self-concept of academic ability on academic achievement.

Several reviews (Bloom, 1976; Purkey, 1970; Scheirer & Kraut, 1979; and Shavelson, Hubner & Stanton, 1976) have cited evidence that children's feelings and self-percepts are closely related to learning and performance in school. The findings referred to here include correlational data from longitudinal and cross-sectional studies (Brookover, Thomas & Patterson, 1964; Brookover, Erickson & Joiner, 1967; Epps, 1969; Reckless, Dinitz & Kay, 1957). With respect to performance in mathematics, the coefficients tend to be in the region of .30 to .40. For example, Brookover et al (1967) reported an average correlation (from 4 studies) of .37 among boys and .31 among girls of junior high school grades, after controlling for individual differences in mathematical ability. The corresponding correlations reported by Jordon (1981) were .40 and .31 among boys and girls, respectively. But there is an abundance of contradictory results that question the reliability of the relationship. (See Bettschen, Winne & Wideen, 1977; Prendergarst & Binder, 1975; Scheirer & Kraut, 1979; and Shavelson, Hubner, & Stanton, 1976.) As pointed out by Brookover, Erickson, and Joiner (1967) and Bloom (1976), the murkiness of the relationship between academic self-concept and achievement seems to stem largely from conceptual problems. The large number of available self-concept scales differ in focus on the various aspects of the construct. Frequently used measures of self-esteem and general self-concept include few items of academic self-concept, and focus more on physical and social aspects of the self. The poorest and weakest effects of students' self-perceptions on level of mathematics achievement have been reported by studies that use these general measures of self-concept. On the other hand, studies that report strong positive relationships between self-concept and academic achievement (Brookover et al, 1964; Reckless et al, 1957, 1972; Rogers et al, 1978; Strang, Smith and Rogers, 1978; and Boersma, Chapman and Battle, 1979, for example) include measures of students' self-perceptions with respect to specific academic subjects such as mathematics and reading/spelling. Also, low, zero-order, positive correlations between general self-concept and achievement measures were obtained in the latter studies (Brookover et al, 1964, 1967; Boersma et al, 1979; Jordon, 1981; Rogers et al, 1978; Strang et al, 1978); but when the academic dimension of self-concept was accounted for, the usual low but positive association between general self-concept and school achievement drops to a position of nonsignificance from zero. It seems reasonable, then, to expect a positive relationship between students' self-perceptions of their ability to do specific academic subjects (such as mathematics) and their performance level in these subjects. Academic self-concept might function to influence level of motivation and perseverance in school tasks. Students with positive self-perception of academic ability might invest more effort in completing learning tasks, use their errors as clues rather than as objects of frustration, and derive more fun or enjoyment from doing the tasks than students of low self-perceptions.

Although the evidence indicates some agreement of a positive relationship between academic self-concept and achievement, support of a causal predominance between these two constructs is less clear. Brookover et al (1964, 1967) and Shavelson and Bolus (1982) concluded that self-concept is causally predominant over level of achievement; Calsyn and Kenny (1977) reanalyzed data from the studies of Brookover and his associates, using a cross-lagged panel correlational analysis, and concluded that self-concept is an outcome of achievement rather than an intervening variable; and Shavelson and Stuart (1981) argued that causation is probably reciprocal between the two personality systems. Generally accepted theoretical models for examining the causal predominance of concomitant constructs are yet to be formulated. Path analysis models frequently incorporate correlation coefficients from two or more studies that use different self-concept scales on population groups that might differ in important ways. This inadequacy categorizes as suspect both the correlation matrices involved and the results reported. Cross-lagged panel correlational analysis (as used by Calsyn & Kenney, 1977) seems to have much potential as an appropriate causal model; but the intervention programme required between Time 1 and Time 2 makes the approach unattractive to researchers in search of inexpensive models. It takes much time and coordinated effort to change expectations and conjoint behavioral patterns of all persons that comprise the social milieu of a large sample of students. Finally, none of these models seems to allow adequate tests of the hypothesis that the causal direction between self-concept and achievement changes at different stages of the individual's psychic development and experience with the environment.

Laboratory studies that examine the relationship between academic self-concept and achievement level include preschool children (Cicirelli & Westinghouse Learning Corporation, 1979; Gray, 1974; Gray & Klaus, 1970), primary grade children (Stallings, 1975; Stallings & Kaskowitz, 1974; Stebbings, St. Pierre, Proper, Anderson & Cerva, 1977), and junior high school students (Dinitz & Kay, 1957; Reckless & Dinitz, 1972; Brookover, Thomas and Patterson, 1964; Brookover, Erickson, and Joiner, 1967). Studies that include children of elementary grades will be of central focus, since the present study also include children at an elementary grade level.

The Follow Through Planned Variations Project included elementary school children from several American states. Stallings and Kaskowitz (1974) evaluated the degree of implementation of seven model programmes involving 342 classrooms. The degree of implementation of a model was judged on the basis of behavioral observations that considered materials used, activities followed, and interaction patterns of the classroom participants. The theoretical models differed in emphasis on the development of positive self-concept within the classroom. At one extreme was the behavioral learning approach that emphasized the identification and structured teaching of specific skills, along with the use of immediate positive reinforcement for strengthening the correct response. Self-concept changes, if they occur at all, are seen by this model to be a consequence of success. The contrasting position of the open classroom model stressed the development of positive self-concept as a necessary prerequisite of improved level of performance.

The results of standardized tests revealed differences among programme sponsors favouring the behavioral or basic skills models on both academic achievement and level of self-concept as measured by the *Coopersmith Self-Esteem Inventory* (Stebbins et al, 1977), although preliminary tests showed similar differences only on the achievement tests in mathematics and reading (Stalling & Kaskowitz, 1974). Thus this massive study that combined results from several cites scattered across the United States does not support the assumption of the open classroom education theorist, that the child's internal developmental needs, including the development of a positive self-concept, must be the basis for educational progress. Contrary to this prediction, the more highly structured models that approached the behavioral ideology were associated with improvements in both academic achievement and self-esteem.

One criticism of this project pertains to its deviation from the most sensitive model of self-concept, namely, the social comparison model. With respect to self-concept in the classroom, between class differences might not be significant, whereas within class differences might be substantial (Joseph, 1975; Rogers et al; 1978, Strang et al; 1978). Rogers and his associates (for example) found only trivial between-class differences in self-concept of ability in reading. The corresponding differences for mathematics reached statistical significance, but only at a low level ($p < .05$). Within-class differences, on the other hand, were significant at the .01 level for reading and at the .0001 level for mathematics. A design that uses class as the unit of analysis, then, might be incapable of tapping important within-class differences in self-concept.

The open classroom theorists, ideolized in Follow Through, assumed a positive relationship between academic achievement and general self-concept. This assumption lacks the consistent support of empirical evidence cited earlier in this chapter. The results of the project may have been closer to expectation if the open models had focused on academic self-concept rather than on general self-esteem, since studies that include both of these self-concept measures (Bloom, 1976; Boersma, Chapman, & Battle, 1979; and Brookover et al, 1967; for example) have been consistent in showing a stronger relationship between academic self-concept and academic achievement than between general self-concept and achievement. But in spite of the potential worth of these suggestions for further research, it seems unlikely that the persistent failure of self-concept enhancement studies to produce substantial and durable gains is attributable to faulty methodology alone. Too many studies, that include a wide variety of models, have been unsuccessful to uphold the view that important changes were been masked merely by insensitive measures and inadequate experimental designs. One cannot conclude, then, that self-concept is a necessary prerequisite of learning. One can state with greater confidence that self-concept (especially of academic ability) and achievement are positively related, and the coefficients tend to be highest when performance in mathematics is the criterion. Based on this observed relationship, it is expected that the measure of academic self-concept, employed in this study, will account for a significant portion of the variance in the retention of mathematics skills.

4.4 Expectation of the Interaction of Time of Feedback With Selected Affective Variables

Research questions that pertain to this area of the study may be stated as follows:

1. Does preference for immediate feedback interact significantly with time of feedback of mathematics test results?
2. Do students who are provided with test results feedback at a time they prefer retain the feedback better than students whose preferred feedback times are not met?
3. Does academic self-concept interact significantly with time of feedback of mathematics test results?

Preference X time of feedback.

Studies such as Kaplan and Pascoe (1977) and Zillmann, Williams, Bryant and Wolf (1980) have reported a significant positive relationship between students' enjoyment ratings and level of performance in academic subjects. This finding is consistent with the commonly held view that if young children enjoy what they are doing, they will pay keen attention to the task and do it well. But students seem to consider several factors of the learning condition when they are stating preferences, making a casual link between preference for time of feedback and long-term retention quite complex. Possible causal links between these two constructs is made even more hazy by the tendency for highly mathematical students to do better than other students in their class whether or not their feedback preferences are met.

The only evidence on the status of the interaction of preference for immediate feedback with time of feedback (Joseph, 1981) reported nonsignificant effects ($p > .10$). Students may be considering several attributes of the feedback modes while they are deciding on their preferences for time of feedback. Some of these attributes might include *what they consider the usual or customary delay interval, the length of the feedback delay interval, and what they consider a reasonable feedback mode that can be provided with minimal disruption of the typical classroom time table.* It would be interesting to know whether any of these attributes interact significantly with time of feedback.

Informative feedback might be seen to have rewarding attributes by some individuals, with tasks such as solving mathematics problems (even though the rewarding influence of feedback seems to be inseparable from its informativeness, Annett, 1969). Given that delayed feedback promotes better long-term retention than immediate feedback, students who are intuitively aware of this fact might prefer to know their results at the end of the test or one day after completing the test, rather than while they are doing the test (i.e., item by item). Children seem to be low in awareness of their memory capabilities (Ritter, 1978; Salatas & Flavell, 1976; Kelley, Scholnick, Travers & Johnson, 1976); but by fifth grade, students begin to discern many of the situational factors that might influence their ability to recall items from a paired-associate learning task (Bisanz, Vesonder, & Voss, 1978). Therefore, Grade 5 students might begin to doubt their ability to benefit optimally from item-by-item informative feedback and, consequently, show a slight preference for delaying the information. The more mature memorizers are likely to be the ones to discern which situational variables will aid their memory (Kail, 1979), and thus prefer delayed feedback in contrast to immediate feedback.

But these are also the students who will use their superior rehearsal ability to process information quickly and, in this way, do better than others in an immediate feedback situation. Students who prefer to have the feedback immediately, then, are likely to be only a subset of the high performers. If it is rewarding to anyone, it is the student with the right answers who will find feedback most rewarding. This is likely to be the case whether students are provided with item-by-item, end-of-test, or one-day delayed feedback. It seems reasonable to assume, also, that the motivational influence of preference, by itself, has trivial effects on students' ability to organize and integrate material for storage, the influence of transitory affective states pertaining more to associative rather than integrative strategies (Kulhavy, 1977; Hansen, 1974). Therefore, preference for immediate feedback is expected to influence the three feedback treatments similarly.

Academic self-concept x time of feedback interaction.

Another affective concomitant of achievement is academic self-concept. Research evidence (Brookover, Erickson, & Joiner, 1967; Epps, 1969; Reckless & Dinitz, 1957; Rogers, Smith, & Strang, 1978; Strang, Smith, & Rogers, 1978; for example) suggest a clear relationship between measures of academic self-concept and achievement in school subjetcs such as mathematics, reading and spelling, after individual differences in mathematical ability has been accounted for. The observed correlations of subscales such as self-concept of ability in mathematics and self-confidence in academic ability with achievement in mathematics tend to be substantial (Boersma, Chapman, and Battle, 1979; Strang et al., 1978). Although there has been much doubt with respect to the validity of a causal link between self-concept and achievement (Calsyn & Kenney, 1977; Scheirer & Kraut, 1979), the existence of a significant positive relationship between these variables has received wide acceptance. On the basis of the trend of a positive relationship between acdemic self-concept and academic achievement, the prediction that academic self-concept will account for a significant proportion of the variance in the mathematics achievement measures is expected to find support.

With respect to the interaction effects of academic self-concept with time of feedback, it may be assumed that students who are confident about their academic ability are positive at the onset of their approach to a mathematics question prepared for their grade level. They [illegible] that they can do the task and are probably eager to meet the challenge. In attacking the problem, they first eliminate the choices that are obviously wrong, and then select from the remaining alternatives the answer that is probably right. The response they select is the one they place highest in a response hierarchy of the alternatives presented with the question. If the response chosen is wrong, highly confident students may become a bit incensed about having missed the question, but dismissed this disappointment with an undivided attention to the feedback information, comparing it with the response hierarchy developed in their minds. These students should find the correction of errors and the learning of the new information easiest in an immediate feedback situation. The response hierarchy is still in mind when the student is required to correct his error. Tied with this response hierarchy are the various reasons for crediting or discrediting each possible response. Once the correct answer is found, the student integrates the relationships associated with this response and the question into a new concept which serves to update her / his relevant propositional logic.

Since the task of consulting all relationships is easiest when they have recently been studied, the higher probability of success in an immediate feedback situation should serve as an added boost rather than as a frustration to the confident student. Subsequent attempts at similar tasks (e.g., on a retention test) are likely to be met with increased zeal and the feeling that *I can do it*. In short, the confident student is expected to benefit most from immediate informative feedback.

It may be assumed that students of low confidence in academic ability approach the mathematics task in doubt; they use associational rather than integrative strategies (Sternberg, 1971) when selecting an answer. If they select the right answer, the association between the question and the answer selected is confirmed, and the selection of this response to the question on a subsequent occasion becomes even more probable. When students of low academic self-confidence select a wrong answer, they search among the alternatives provided for a second answer and make another association of the newly selected alternative response with the test question. Little attempt is made to integrate information pertaining to the various selection of alternative answers into one concept that include the updated rules for reaching the right answer. Instead of one propositional logic, there are several memory stores, each involving the test question connected to one of the alternative answers. In an immediate feedback situation, all associations are made at roughly the same time, and are thus of similar trace strength. Competition between these various responses is therefore likely to take place on subsequent attempts of the test, especially when incorrect response associations re-emerge to the forefront (Kahneman 1973). In the delayed feedback situation, initial incorrect stimulus - response associations are quite submerged by the second day when the correct associations are made. Relationships that led to the selection of the wrong response have faded also, such that they are not distracting to the learner when he is focusing on the right stimulus response association. Therefore, it is expected that students of low academic self-concepts will perform best under the conditions of delayed feedback, whereas immediate feedback will be the optimal feedback mode for the confident and highly integrative student.

4.4.1 Expected predictive accuracy of the covariates of retention of mathematics skill

Having discussed theory and research on both the information-handling and affective variables, the question of how these variables combine to predict mathematics skill level can be fruitfully considered. The research questions that are pertinent to this section of the study may be stated as follows:

1. What is the best linear combination of the information-handling and affective variables that can be used to predict level of retention of mathematics skill? And, what is its predictive accuracy?
2. Is the prediction equation for short-term retention of mathematics skill similar to the equation for long-term retention of these skills? If they are not similar, in what way do the parameters change in influence with time?

Theory and research discussed in Chapter III suggest a clear relationship between rehearsal proficiency and both depth of storage and level of retention. Long-term rete[illegible]rial is generally assumed to be influenced by level of storage. Th[illegible]arsal proficiency used in this study are expected to be si[illegible] predic[illegible] term retention of mathematics skills.

The influence of measures of passive attention, such as incidental-learning ability, seem to be quite confounded with the effects of other information-handling variables as well as with the effects of the affect variables. But studies such as Schulman (1971) and Postman and Kruesi (1977) (that use an incidental-learning paradigm) suggest effects of incidental-learning ability that are separate from other information-handling strategies. Although research evidence does not suggest a clear relationship between measures of passive attention and long-term retention, there has been much theorizing about the relationship of attention and acquisition. The haziness lies in the connection between measures of initial learning and retention. Theories of central processing (Anderson et al, 1971; Norman, 1969) have suggested a direct relationship between level of acquisition and level of delayed recall. But research has consistently shown that two groups of persons can be quite similar on an acquisition test and yet different one week later on a delayed-retention test of the same material (See Chapter II for the relevant research). Research evidence discussed in Chapter III has associated the influence of passive measures of attention with acquisition but not with long-term retention of the material learned (Nelson & Vinning, 1980, Postman & Kruesi, 1977; and Schulman, 1971); whereas rehearsal proficiency had more to do with level of storage and, consequently, long-term retention (Bjork & Jongeward, 1975; Guvo, 1975; Darley & Glass, 1980; Nelson & Vining, 1978; Schulman, 1974). On the basis of these findings, it was expected that incidental-learning ability (a pasive measure of attention) would account for less of the total variance in the delayed-retention scores than would rehearsal proficiency, and that the status of these two predictors would be reversed on the short-term retention test.

Research evidence (Izard, 1960, 1963, 1964; Izard et al, 1965; Kaplan & Pascoe, 1977; Worchel, 1955; Zillmann, et al, 1980) has reported a consistent relationship between treatments of affect and level of performance on cognitive tasks. These studies have involved a wide variety of experimental designs and tasks that include affective stimuli as well as humor treatments and enjoyment ratings. But indications of a clear relationship have been less consistent in the few studies that have attempted to partial out the influences of information-handling variables from effects of affect. One reason for the observed inconsistencies could be that affective influences on learning and retention vary from one sample group to another. In the present study it would be interesting to compare the influences of preference for immediate feedback and academic self-concept among boys and girls.

Academic self-concept and other confidence related variables are expected to account for a significant portion of the variance in the achievement measures. Theory and research discussed in the second section of Chapter IV support this expectation. Although causal relationships between academic self-concept and mathematics achievement might be unreliable, studies have consistently reported positive relationships between these two variables (Brookover, Erickson, & Joiner, 1967; Jordon, 1981; Rogers, Strang, & Smith, 1978; and Smith et al, 1978. The relationships identified have been quite significant after individual differences in ability have been accounted for. Other research evidence summarized by Kulhavy (1977) Izard et al (1965) and Rozenberg (1963) have indicated an interaction between affective measures such as confidence, state anxiety and trait anxiety and long-term retention. Students who are confident in what they are doing usually talk about their work and readdress aspects of the tasks that presented them with difficulties in an earlier trial. These efforts usually serve to recode relationships and concepts that were wrongly grasped, and to ensure high performance on the long-term retention test. Therefore, it is expected that academic self-concept would account for significant portions of the variance at short-term retention and also at long-term retention.

The lack of research efforts and theory that map relationships between students' preference for time of feedback and their learning and retention of academic skills makes it difficult to state clear expectations of the predictive accuracy of preference variables used in this study. It is generally believed that meeting students' preferences that pertain to a learning situation can transfer positive effects to the learning of the stimuli themselves. When students feel satisfied, comfortable, or excited about a particular situation, it is believed that they will be more vigilant and attentive to the stimuli, and thus increase their *time on task*. The added time spent on the task is likely to result in increased learning outcomes. But it seems crucial that the conditions that engender the affect be closely related to the material to be learned (Kaplan & Pascoe, 1977; Zillmann, Williams, Bryant & Wolf, 1980). It is not clear how closely related the features of the motivational object should be to the stimuli to be learned. It would be interesting to know whether preference for time of feedback possesses features that are likely to generate affect that will result in improved learning and retention of an academic skill.

5. METHOD

5.1 The Population and the Sample of Students

The population of the present study was comprised of Grade 5 students in the Public School District of the City of Edmonton. Only students who were considered as being capable of coping in the regular class stream were included in this population. Students placed in special classes because they were limited in English language were exempted from the sample.

To select a sample of classes, schools were chosen at random from a complete list of elementary schools in the Edmonton Public School District. Principals of schools were questioned about possible involvement in the study, and encouraged to discuss the matter with their Grade 5 teacher(s). Each teacher decided whether the students in her/his class would participate in the study. In cases where the teacher or the school principal preferred to have the students exempted, the same procedure was followed to obtain class replacements.

Twenty Grade 5 classes were selected as participants in the study. Two of these classes were used to pilot the instruments of the study. The remaining 18 classes were randomly assigned to one of three treatment groups that were defined by the time of feedback variable. One treatment group, consisting of six classes, was labeled *item-by-item feedback,* since students in this group obtained immediate feedback regarding their responses to each item of a mathematics achievement test. The second treatment group was labeled *end-of-test feedback* since participants in this group obtained their test results as soon as they completed the entire test. Participants in the third group, referred to as the *delayed feedback* group, received their test results one day after taking the test.

5.2 The Instruments and Administration

The instruments used in this study included mathematics achievement tests, game-like activities designed to measure incidental-learning ability and rehearsal proficiency, and questionnaires that required students to indicate their preferences for immediate feedback on mathematics achievement tests, as well as their self-perceptions in school subjects such as mathematics and reading/spelling.

5.2.1 The Mathematics Achievement Instrument

Three forms of a mathematics achievement test were used both to measure performance level and to serve as a means of instruction through the correction of students' errors. The test domain was obtained from the *Elementary Mathematics Curriculum Guide (Alberta Education, 1982).* Test items were chosen from three areas of mathematical content: concepts, operations, and problem solving skills. Each of these broad areas was divided into subdomains from which the test items were constructed. Item facets employed include content, item format, operations, and important item features unique to each area of content. From each subdomain, items were generated in sets of three with the aid of computer programs. Item format, operation, and content were held constant for each set of three items, so that items differed across the testforms only in terms of the numbers used.

5.2.2 Preliminary forms and field testing of the mathematics achievement tests

One hundred and eight test items were constructed by randomly sampling items from each row of the item domain (see Appendix A). These items were collated into three booklets and distributed to 10 Grade 5 teachers and two graduate students specializing in mathematics education at the University of Alberta. Each teacher/specialist was asked to rate each test item for its relevance to the the Alberta Grade 5 mathematics curriculum, its suitability as a problem for the Grade 5 student in the second term of the school year, and for appropriateness of item format and syntax (related to decimals and remainders of division problems). Each rater was also required to specify whether the requisite skills for item solution were mainly conceptual, operational, or problem solving. Feedback from the raters was used to improve the definition of the test domain, as well as to exclude content that was unlikely to be covered by the second term of the school year.

Sixty items in the mathematics achievement test were field tested using 44 students in two classes. Of interest was the ability of each item to discriminate between high and low performers and to correlate positively with the total test score. Each item was also required to be challenging in terms of level of difficulty for Grade 5 students. For each test item, the number of student requests for further explanation of what was required was also noted. Difficult words and confusing phrases were replaced or clarified on subsequent testforms. All items selected for the final forms of the mathematics tests were characterized by positive discrimination indices, positive item with total testscore correlations, and difficulty levels between 0.20 and 0.75.

5.2.3 The final testforms

The final testforms were selected so that only the numbers included in an item differed from one testform to another. The content, format, and other important features of the test items were as specified in the test blueprint. Each testform included 30 four-option, multiple choice items. (See Appendix B.)

Item analyses of the Occasion 1 responses of participants showed the test items as being characterized by positive discrimination indices and positive point-biserial correlations. One item from Testform 1 and two items from Testform 2 showed point-biserial correlations that were nearly zero, and Testform 3 included one item with a negative point-biserial coefficient that was not significantly different from zero. These test items indicated positive relationships with the total test-score on subsequent occasions. All other correlations were within the satisfactory range of .20 to .60. Also, the difficulty levels (proportions of students passing the items) were quite satisfactory. For Testform 2, 26 of the 30 difficulty levels were evenly distributed between 0.22 and 0.71; two of the difficulty levels of the remaining test items were between .10 and .18, whereas the other two were between .81 and .83. For Testforms 1 and 3, 28 of the 30 difficulty levels were evenly distributed between .20 and .75 with the indices for the remaining two items on either side of this range. Table 5.1 displays the means and standard deviations of the three testforms.

Table 5.1

Means and Standard Deviations of the Initial Responses to the Testforms

Testform	n	Mean	S.D.	S.E.	Alpha	Kristof-Alpha
Form 1	115	13.391	4.815	.449	.752	----
Form 2	131	13.473	5.033	.440	.774	----
Form 3	113	14.628	4.689	.441	.736	----
Total	359	13.810	4.875	.256	----	.830

NOTE:

1. Cronbach-alpha measures the internal consistency of a test instrument.
2. Kristof-alpha estimates the similarity of three or more parallel forms of a test.

The distribution of scores on each testform was approximately normal, ranging from 4 to 27, 4 to 26, and 6 to 25 for Testforms 1, 2, and 3, respectively.

5.2.4 Reliability and equality of the testforms

The mathematics achievement test was designed to include tasks from three areas of mathematics. Therefore, measures of internal consistency were expected to be lower than those usually obtained from homogeneous instruments. Cronbach alphas of .752, .774 and .736, were observed for Testforms 1, 2, and 3, respectively. Bearing in mind the heterogeneous nature of the test, these measures were considered acceptable and reasonably equal. Test-retest, zero-order correlations observed between subgroups of the sample were also acceptable. The following intercorrelations between the three testforms were obtained using the data from the students (n = 113) who wrote Testform 3 first: $r_{12} = .747$, $r_{13} = .730$, and $r_{23} = .725$.

Not only were the observed relationships between the testforms acceptable, they seemed also to be quite similar, suggesting that the testforms were of equal reliability. It was decided on this basis to proceed with further tests of the equality of the three testforms.

The lack of a control group that responded to all forms of the test before receiving feedback made it difficult to apply Wilks' (1946) multivariate test of the equality of means, variances, and covariances, or Votaw's (1948) multivariate test of compound symmetry. Although the variances and covariances of the achievement measures were expected to be rather stable from Occasion 1 to Occasion 3, the mean scores were expected to undergo considerable change from one occasion to another. It was decided to use the Occasion 1 testform means and to test their similarity with the aid of a 1-way analysis of variance. Table 5.2 displays the ANOVA test of differences between the testform means at Occasion 1.

Table 5.2

Significance of Differences Between the Testform Means at Occasion 1

Source	df	Sum Sq.	F-ratio	Prob.of Sig.
Between Groups	2	110.68	2.3459	.097
Within Groups	356	8398.44		
Total	358	8509.12		

Tests of the homogeneity of variances

Bartlett - Box		F = 0.3108	p = .733
Cochrans	C = (max var / sum var)	= 0.3593	p = .687

As may be noticed from Table 5.2, the observed between-groups F-value of 2.346 is less than the critical $_{.95}F(2, 356)$ of 3.87, suggesting that differences between the means of the testforms were not significant at the .05-level. The variances of the testforms were quite similar; the probability values of a Type 1 error were greater than 10 per cent.

The means and other data reported in Table 5.1 were used to compute the average variance (**s**), average mean (**M**), average correlation (**r**), and the variance of the testform means (**v**). Wilks' (1946) L_{mvc} was computed to simultaneously test the hypotheses that all means are equal, all variances are equal, and all covariances are equal. Estimates of the intercorrelations between the testforms were obtained from the average correlations observed among the various sample groups. The observed L_{mvc} was .7395. (See Table 5.3.) The value of $-N \log_e L_{mvc}$ was 15.768, which was between the $_{.05}\chi^2_{(6)}$ and the $_{.01}\chi^2_{(6)}$ critical values of 12.5916 and 16.8119; this suggested that a second series of tests was necessary.

The formula used to compute L_{vc} may be obtained from Gullicksen (1950) or Wilks (1946). The observed value of L_{vc} was .98235, and of $-N \log_e$ .98235 was .948. This value was considerably less than the $_{.05}\chi^2_{(4)}$ and the $_{.01}\chi^2_{(4)}$ critical values of 9.49 and 13.28, respectively, suggesting that all three variances and all three covariances of the testforms may be considered equal.

Table 5.3

Tests of the Equality of Means, Variances, and Covariances of Three Mathematics Achievement Tests

Source	Observed Values	Critical Values .05-level	Critical Values .01-level	df
L_{mvc}	.740	.813	.739	6
$-N \log_e L_{mvc}$	15.768	12.592	16.812	6
L_{vc}	.982	.855	.803	4
$-N \log_e L_{vc}$	.948	9.494	13.283	4

NOTE:

1. $-\underline{N}\ln L_{mvc}$ and $-\underline{N}\ln L_{vc}$ are distributed as chi squares with degrees of freedom (k / 2)(k+3) - 3 and (k / 2)(k+ 1) - 2, respectively, where N is larger than 63 and k (the number of testforms) is equal to 3.

In place of a test of compound symmetry, one may compare the predictive validities of the three testforms by looking closely at their relationships with other variables used in this study. Table 5.5 indicates that the three testforms show similar relationships with the various measures of incidental-learning ability, rehearsal, and academic self-concept. On the basis of the tests of equality of variances and covariances and the measures of internal consistency and test-retest reliability, the three test forms may be considered parallel.

5.2.5 Administration of the mathematics testforms

A **3M Model 550 Electronic Test Scorer** was used to provide students in the end-of-test feedback and one-day delayed feedback groups with the results of their achievement tests. It was easy for students to score their responses on this machine; the answer sheet was simply fed through the scorer. The use of the scorer allowed prompt reporting of the test results. Information provided by the scorer included a red dash beside each incorrect answer as well as the total number of questions answered correctly.

The tests were administered to students in their regular class groups. Figure 5.1 illustrates how the three testforms were used with the eighteen classes over three test sessions (called occasions).

Figure 5.1

Interchangeable Use of Mathematics Testforms in 18 Classes Over Three Occasions

OCCASION / TESTFORM	Occasion 1	Occasion 2	Occasion 3
Testform 1	C_{13}, C_{14} C_{22}, C_{24} C_{31}, C_{34}	C_{11}, C_{16} C_{25}, C_{26} C_{35}, C_{36}	C_{12}, C_{15} C_{21}, C_{23} C_{32}, C_{33}
Testform 2	C_{11}, C_{15} C_{23}, C_{25} C_{32}, C_{35}	C_{12}, C_{14} C_{21}, C_{22} C_{31}, C_{33}	C_{13}, C_{16} C_{24}, C_{26} C_{34}, C_{36}
Testform 3	C_{12}, C_{16} C_{21}, C_{26} C_{33}, C_{36}	C_{13}, C_{15} C_{23}, C_{24} C_{32}, C_{34}	C_{11}, C_{14} C_{22}, C_{25} C_{31}, C_{35}

NOTE:

1. C refers to class being observed.
2. The first subscript (1 to 3) stands for *treatment group*.
3. The second subscript (1 to 6) stands for *class number* (in that treatment group).

In each treatment group, two classes responded to Testform 1 on Occasion 1, two other classes responded to Testform 2 on Occasion 1, and the remaining two classes responded to Testform 3 on this occasion. This interchangeable use of the testforms was employed also on Occasions 2 and 3. A different form of the achievement test was administered to a class on each occasion so that no student took the same testform twice.

A time schedule of the three occasions for each treatment is displayed in Figure 5.2. The experimental period was nine days long for students in both the item-by-item feedback and end-of-test feedback groups and eleven days for students in the one-day delayed feedback group. From this figure (Figure 5.2) one may note the time when each instrument was administered to a particular treatment group.

The item-by-item feedback treatment group.

Students in the item-by-item feedback group followed the test instructions as the investigator read them aloud. To do the test, participants read each question carefully and worked the sum on rough paper in order to find which one of four alternative answers was correct. They then indicated their response to a test question by shading one of the letters, *a, b, c, or d* of the four answer options. To find out the appropriateness of an answer to a test item, the student erased the crayon paste beside the letter which he/she shaded to see whether an "r" or a "w" was beneath it. If an "r" appeared, this indicated that the response was correct; a "w" indicated that the response was wrong. Whenever the participant selected a wrong answer, he was required to do the item again, or to search for the right answer. Students in all classes were encouraged to question the designated correct alternative if they did not understand why it was right (or wrong). As soon as all of the right answers were found, participants checked their answer sheets for the total number of questions which were answered correctly on the first attempt. This involved counting all answer spaces in which only one of the four crayon pastes was removed. Participants then wrote this number at the foot of their answer sheets.

All procedures from Occasion 1 were used again on Occasion 2, held on the following day. Occasions 1 and 2 involved writing two different forms of the mathematics achievement test. At the end of Occasion 2, participants were provided with a verbal summary of common errors made by their class.

<u>Figure 5.2</u>

Time Schedule of The Instruments and Occasions for Each Feedback Treatment Group

DAY TREATMENT	Day 1	Day 2	Day 3	Day 4		Day 9	Day 11
Item-By-Item	Occasion 1 Taking test Correcting test 90 MINUTES	STR Occasion 2 Taking test Correcting test 90 MINUTES	Measuring Incid. learning Self-concept Preference Rehearsal 60 MINUTES	Seven-day Interval	Retention	LTR Occasion 3 Taking test Correcting test 60 MINUTES	
End-Of-Test	Occasion 1 Taking test Correcting test 90 MINUTES	STR Occasion 2 Taking test Correcting test 90 MINUTES	Measuring Incid. learning Self-concept Preference, Rehearsal 60 MINUTES	Seven-day Interval	Retention	LTR Occasion 3 Taking test Correcting test 60 MINUTES	
1-Day Delay	Occasion 1 Taking test 60 MINUTES	Correcting test Incid. learning 60 MINUTES	STR Occasion 2 Taking test 60 MINUTES	Correct test Measuring: Self-concept Preference, Rehearsal 60 MINUTES	Seven-day Interval	Retention	LTR Occasion 3 Taking test, Correcting test 60 MINUTES

The third form of the mathematics achievement test was administered on Occasion 3. Contrary to the procedures followed on the first two occasions, participants completed the entire test before scoring their answer sheets with the aid of the electronic scorer.

The end-of-test feedback treatment.

Students in the end-of-test feeback group responded to one of three forms of the mathematics test on Occasion 1. They followed the test instructions on the front page of the test booklet while the investigator read them aloud. Participants then did two sample questions and recorded their answers on the sample mark sense answer sheet to ensure an understanding of how to record their answers on the answer sheet. The students were then shown how to feed their answer sheets through the scorer. They were told that they should verify their answers with the scorer as soon as they were finished all 30 questions. After scoring the responses, each participant was advised to replace the selected alternative for the incorrect items and to rescore the responses with the aid of the scorer. Participating students repeated this exercise until they correctly answered each item. They could ask for assistance on their second or third attempt at questions they found difficult.

Occasion 2 was held on the following day. Using the same procedures as in Occasion 1, participants took a different form of the mathematics test, scored their responses with the aid of the scorer, and corrected their incorrect choices as has been done the previous day. This procedure was repeated one week later, on Occasion 3, when participants were required to write the third form of the mathematics test.

The delayed feedback treatment.

The delayed feedback treatment differed from the end-of-test feedback treatment only with respect to the time when feedback was provided. Whereas end-of-test feedback students were allowed to score their answer sheets immediately after they had finished the test, the answer sheets and test booklets for participants in the delayed feedback group were collected and then redistributed the following day. For Occasions 1 and 2, these students did not score their answer sheets and correct their errors until one day after they had written the mathematics test. Unrelated exercises (such as a word puzzle) were given to students who finished their corrections with time to spare. The amount of time students in the one-day delayed feedback group took to correct their errors was comparable to the time taken by students in the end-of-test feedback group. Occasions 2 and 3 were held one day and one week, respectively, after feedback was issued on the previous occasion. Occasion 2 took the same format as Occasion 1; but on Occasion 3, delayed feedback students wrote the mathematics test and scored their responses the same day.

5.2.6 The Incidental-Learning Ability Scale

A selective attention task was used to obtain a measure of the student's incidental-learning ability. Each stimulus for the orienting task included a familiar animal (for example: bird, fish, goat, lamb, lion, monkey, pig or zebra) and a two-digit number (such as 28, 36, 38, 44, 47, 51, 57 or 62) that always appeared with that animal. The eight animals and eight numbers were put together in sixteen pictures, each of which contained an animal and a number. In half of the pictures, the number appeared directly above an animal and, in the other half, the number was directly below the animal. An animal was always paired with the same number. The pictures were mounted on black and white slides. Twelve random sequences of six pictures comprised the twelve-item orienting task. (See Appendix C.) No animal occurred more than once in a sequence; the animal appeared above the number in three of the set of six pictures in a sequence and below the number in the other three pictures.

The orienting task required participants to keep track of the sequence in which the animals and numbers appeared. At the end of the sequence, one number was selected and shown on the screen a second time. Participants were required to circle, on their answer sheet, the position of the sequence in which this picture had appeared.

Administration of the scale.

The *Student's Incidental-Learning Ability Scale* was administered to all students in the participating classes after Occasion 2. (See Figure 5.2 for a time schedule of the administration of all of the instruments.) Instructions were written on the first page of the answer sheet. The student followed these instructions as the investigator read them aloud. Each participant was also required to do two sample questions. The instructions read to the participant may be obtained from Appendix C.

Each picture in a sequence was exposed for 2 seconds. The criterion picture was exposed for 15 seconds, during which time the students indicated their responses.

Incidental Learning. At the end of the orienting exercise, each examinee was asked to recall i) all the numbers and ii) the names of all the animals. After answering these two questions, each participant was given a list of the eight animals. Each animal in the list was paired with a row of four numbers. Two of the numbers in the set were included in the criterion pictures, whereas the other two numbers were not included in the orienting exercise which the students had just completed. One of the four numbers was the number that always appeared with the animal included in the row. From each row of four numbers, participants were required to circle the correct number that always appeared with the picture of the animal beside the set of numbers.

Scoring. Scores obtained from the orienting phase of the instrument included the total number of positions of pictures that were correctly identified. The 12 items in the orienting task indicated difficulty levels that varied from .300 to .781. Nine of the twelve difficulty levels were between the narrower range of .464 and .656. For the total group, the result of the 12 item task was a mean of 6.914, a variance of 5.377, and a standardized alpha of .534. The item-by-total test score correlations were all positive. Central-learning scores correlated significantly with total digit-span scores ($p < .0001$) and with mathematics achievement ($p < .001$). As expected, central learning was uncorrelated with incidental learning of the numbers ($p = .221$).

The incidental-learning tasks correlated positively with one another, as well as with mathematics achievement. On the other hand, performance on tasks that required participants to recall the names of animals were uncorrelated with performance on items that involved numbers only, as well with mathematics achievement. Incidental-learning scores for the total group ranged from 0 to 13, with a mean of 5.8 and a variance of 7.435. The item-with-total test score correlations for the crucial items ranged from .230 to .424.

5.2.7 The Rehearsal Proficiency Scale

Rehearsal proficiency was measured with the aid of a digit-span task comprised of fifteen sets of seven one-digit numbers. The seven numbers in each set were randomly arranged and recorded, at one-second intervals, on an audio tape; the audio tape was used to standardized the instrument.

Administration.

This instrument was administered after Occasion 2 to all students in the participating classes. (See Figure 5.2.) Instructions provided with the administration of the instrument are included in Appendix D.

The fifteen items of this scale had difficulty levels ranging from .352 to .832. Eight of the difficulty levels were below .50 whereas the other 7 were between .50 and .832. All items correlated positively with the total score. The distribution of the scores was close to normal with a mean of 8.20, a variance of 7.18. Of the eight items that referenced the first three serial positions, six had difficulty levels that were less than .500, whereas five of the seven items that referenced the last three serials positions showed difficulty levels that were greater than .500. This heterogeneity was expected. The standardized alpha coefficient was .576.

Scoring.

Two scores were extracted from this scale. The first score was computed from the number of correct responses associated with the first three serial positions. This score was referred to as the individual's primacy-rehearsal score. The second score obtained from this scale was the number-correct score associated with the last three serial positions. It may be referred to as the recency-rehearsal proficiency score. The primacy and recency scores were positively related to each other ($r = .30$), and to the total score ($r = .821$ and .784, respectively). They were both positively related to visual central-learning ability ($r = .383$ and .181, respectively), and to mathematics achievement ($r = .258$ and .221, respectively). As expected, the recency-rehearsal scores showed a significant relationship with the incidental learning of numbers ($p < .0001$), whereas the primacy-rehearsal scores were uncorrelated with this measure of incidental-learning ability ($p > .411$). See Table 5.5.

5.2.8 Preference for Time of Feedback

The student's preference for time of feedback was measured with the aid of a questionnaire. In Section A of this instrument, students were presented with paired comparisons of different delay-feedback modes. The types of feedback included in the instrument were: Item-by-item feedback, end-of-test feedback, three-hour delayed feedback, one-day delayed feedback, and one-week delayed feedback. All possible pairs (e.g., 1st feedback mode with 2nd feedback mode, 1st with 3rd, 1st with 4th, 1st with 5th, 2nd with 3rd, etc.) were included in the presentation.

Administration.

The preference for time of feedback questionnaire was administered to all students in the participating classes after Occasion 2. (See Figure 5.2.) For each paired comparison of two types of feedback, the student was required to shade the box beside the type of feedback that was closer to his preference. The instructions read to the participants are included in Appendix E.

In Section B of this instrument, participants were required to rank order the five feedback modes according to their preferences, by putting 1st in the box beside the type of feedback liked best, 2nd in the box beside the type of feedback liked second best, and so on.

Scoring.

A multidimensional, dual scaling technique (see Nishisato, 1980) was used to obtain scales along which the students' preferences could be significantly differentiated. Also, this technique was used to compute scale values for the five feedback modes and scores for each participant on each of the scales.

Three scale dimensions were required to account for the different ways in which participants responded to the *Preference for Time of Feedback Scale*. For each of the three scales, the pattern of stimuli weights were examined so as to label the scale according to how it discriminated between the students' ratings of the five feedback modes. (See Figure 5.3 and Table 5.4 for a graph and a display of the three sets of scale weights for the five feedback modes.) Scale I seemed to differentiate between participants in terms of the time of feedback they considered customary. This scale accounted for 44.4 per cent of the total variance. The ability of the scale to discriminate between the subjects was significant, the chi-square (df=360) being as high as 664.56, and $(ETA)^2$ (the maximum correlation ratio, i.e., SSbet./SStotal) being .422. Scale II differentiated between participants in terms of their preferred length of delay of feedback. It accounted for 30.9 per cent of the total variance in the raw scores. Both the associated chi-square of 447.21 and $(ETA)^2$ of .351 were significant suggesting that the scale differentiated between the students' preferences. The pattern of stimuli weights for the thrid scale does not lend itself to easy labeling. One-day delayed feedback and item-by-item feedback obtained high positive and low positive weights, respectively; whereas three-hour delayed feedback and one-week delayed feedback obtained high-negative and low-negative weights. Since students realized that it was possible to provide item-by-item feedback with the aid of a computer, and that a teacher can complete the hand scoring of a test by the next day, the third scale was seen as reflecting what the students felt was a feasible or reasonable time for providing test results feedback. Therefore, the scale was labeled *feasibility*. This scale was orthogonal to the other two scales and accounted for an additional 13.4 per cent of the total variance. The associated chi square of 187.27 and the maximum correlation ratio (.232) were significantly larger than zero; this indicated that the scale significantly differentiated between participants (N = 358) who responded to the questionnaire. The three scales accounted for a total of 88.7 per cent of the total variance in the raw scores. The three sets of scale values for the five feedback modes are included in Table 5.4; Figure 5.3 illustrates a plot of the scale values for each stimulus in a three dimensional space defined by the scales.

Normalized scale scores with a mean of zero were generated for each participant, such that a participant was given three scores (one on each of the three scales or dimensions of reduction). These subject scores were used in the analyses reported in Chapter 6.

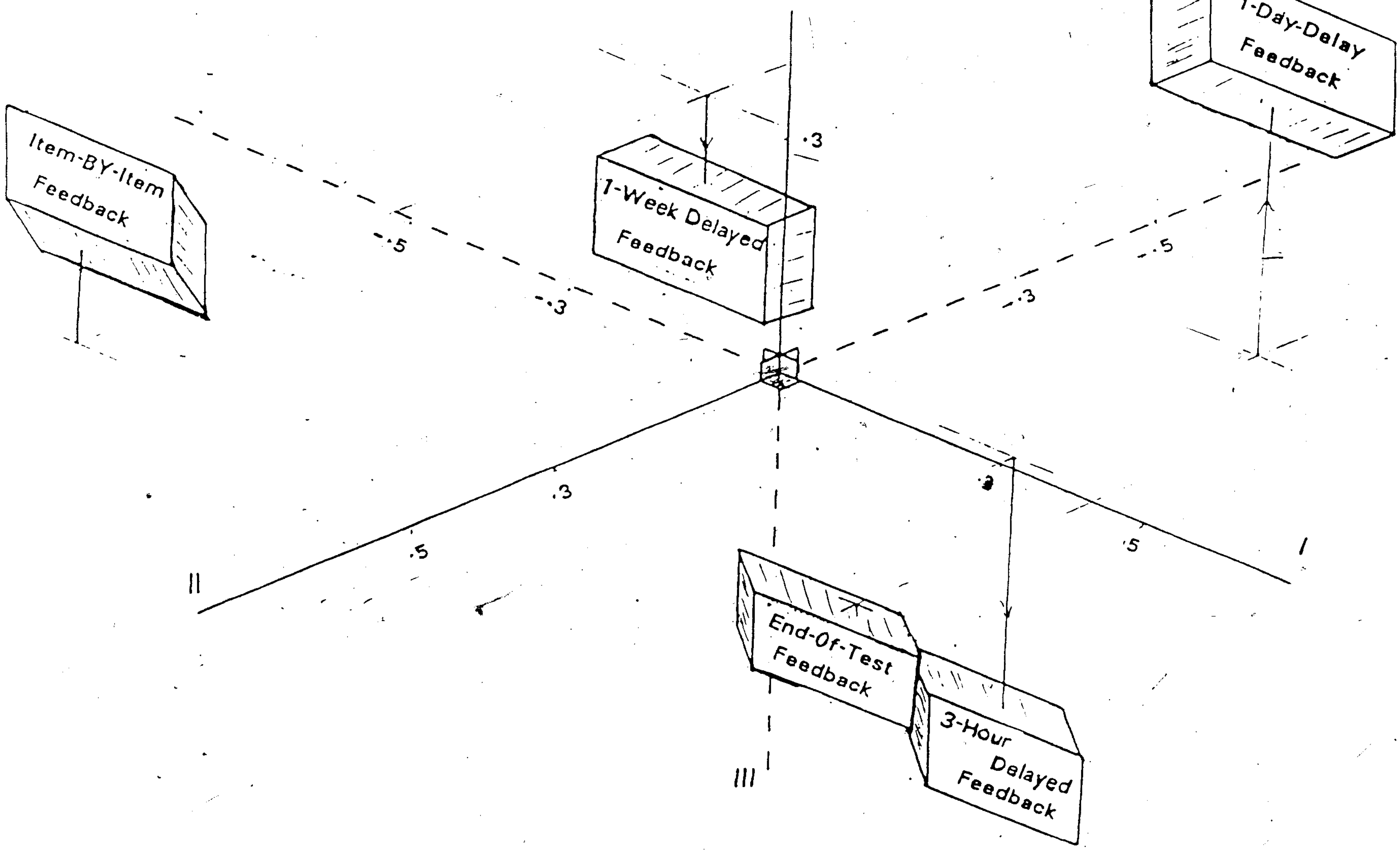
Table 5.4

Weighted Vectors for Hypothesized Feedback Modes on Three Solutions

Feedback Mode / Solution	Soltn 1	Soltn2	Soltn3
Item-by-Item	-.503	.468	.123
End-of-Test	.433	.339	-.017
3-Hour Delayed	.292	-.061	-.338
1-Day Delayed	.300	-.344	.352
1-Week Delayed	-.522	-.402	-.120

Figure 5.3

Preference for Time of Feedback: Scales I, II, & III



5.2.9 The Academic Self-Concept Scale

Self-concept of academic ability was measured with the aid of the **Student's Perception of Ability Scale (SPAS)** which was designed by Boersma and Chapman (1977). The instrument was designed to scale school-related self-perceptions of students in Grades 3 to 6. The scale consists of seventy short statements that students usually use to describe their performance at school. Examples of these statements are: *I always understand everything I read, All new words are easy for me to spell, My teacher thinks I write poor stories, I am a smart kid*, and *I always get everything in arithmetic right*, etc. Being measures of academic self-concept, subscale scores of the SPAS show roughly zero correlation with measures of general self-concept (obtained from instruments such as the *Piers-Harris Children's Self-Concept Scale* (Piers, 1969) and, at the same time, demonstrate good predictability of achievement measures (Boersma, Chapman, & Maguire, 1979). Pearson correlations among the subscales and between the subscales and the full scale suggest that the six subscales of the instrument are reasonably independent of each other, and that they measure a common construct - the Cronbach alpha for the full scale being as high as .915.

Administration

The Student's Perception of Ability Scale was administrated towards the end of Occasion 2. Each student was provided with a copy of the instrument. They were asked to follow the printed instructions while the investigator read them aloud. In brief, the instrument requires participants to read each statement carefully and to shade one of the adjacent spaces, **YES** or **NO**, depending on whether or not they think the statement is true. Students were encouraged to respond to all statements and not to shade both YES and NO. The students' responses were scored according to the key provided with purchase of the instrument.

Three of the subscales of the SPAS showed substantial positive Pearson correlation with achievement in mathematics. These subscales were Self-Concept of Ability in Mathematics, Self-Concept of Ability in Reading/ Spelling, and Confidence in Academic Ability. Scores on the mathematics self-concept and the reading/spelling self-concept subscales obtained from the total sample of 360 Grade 5 students were very negatively skewed, the modal score being the highest possible score in both instances. Scores on the Confidence subscale, on the other hand, were reasonably normal in distribution with a mean score of 4.37. (The highest possible score on this subscale was 10.0.) Therefore, the Confidence subscale was considered as a covariate in analyses reported in Chapter 6. Correlations between this measure of affect and other variables included in the study may be obtained from Table 5.5.

5.3 Criterion Validity of the Instruments

This section presents the intercorrelations between variables included in the data set of the present study. The data set includes three measures of mathematics achievement, primacy-rehearsal, recency-rehearsal, incidental learning of numbers, two subscales of the Students Perception of Ability Scale, and three dimensions of preference for immediate feedback. The intercorrelations of these variables are displayed in Table 5.5. It was expected that each variable would correlate significantly with the mathematics achievement measures.

Except for the relationship between incidental-learning ability and primacy-rehearsal, where the relationship was expected to be about zero, information-handling variables correlated more highly with one another than with the affective variables. Recency-rehearsal correlated significantly with incidental-learning ability (r = .16) and with academic self-confidence (r = .13). The corresponding correlations (r = .01, and r = .07) for primacy-rehearsal proficiency were not significant at the .05-level. But the correlation of primacy-rehearsal with mathematics achievement (r = .29) was not less than correlation of recency-rehearsal with mathematics achievement (r = .26). This pattern of correlations was expected.

Table 5.5

Pearson Correlations Between Mathematics Achievement and Information-Handling and Affective Variables

Variables	Mth1	Mth2	Mth3	ILA	Pmcy	Rncy	M.sc	Cdnc	Prf1	Prf2	Prf3
Math1	1.00	$.71_1$	$.71_1$	$.16_2$	$.26_1$	$.22_1$	$.26_1$	$.23_1$	$.07_5$	$.10_4$	$-.14_3$
Math2	$.71_1$	1.00	$.68_1$	$.21_1$	$.26_1$	$.15_3$	$.30_1$	$.24_1$	$.09_4$	$.08_5$	$-.17_1$
Math3	$.71_1$	$.68_1$	1.00	$.21_1$	$.29_1$	$.26_1$	$.37_1$	$.26_1$	$.11_4$	$.14_3$	$-.13_3$
ILAnm	$.16_2$	$.21_1$	$.21_1$	1.00	$.01_5$	$.16_2$	$.15_3$	$.04_5$	$.11_4$	$-.03_5$	$-.04_5$
Prmcy	$.26_1$	$.26_1$	$.29_1$	$.01_5$	1.00	$.30_1$	$.10_4$	$.07_5$	$.04_5$	$.03_5$	$-.10_4$
Rcncy	$.22_1$	$.15_3$	$.26_1$	$.16_3$	$.30_1$	1.00	$.19_2$	$.13_3$	$.20_1$	$-.01_5$	$-.10_4$
M.sc	$.26_1$	$.30_1$	$.37_1$	$.15_3$	$.10_4$	$.17_2$	1.00	$.41_1$	$.02_5$	$.09_4$	$.00_5$
Cnfdnce	$.23_1$	$.24_1$	$.26_1$	$.04_5$	$.07_5$	$.13_3$	$.41_1$	1.00	$.04_4$	$.05_5$	$-.13_3$
Prfsl1	$.06_5$	$.09_4$	$.11_4$	$.11_4$	$.04_5$	$.20_1$	$.02_5$	$.04_5$	1.00	$.11_4$	$-.21_1$
Prfsl2	$.10_4$	$.08_5$	$.14_3$	$-.03_5$	$.03_5$	$-.01_5$	$.09_4$	$.05_5$	$.11_2$	1.00	$-.14_3$

NOTE:

1. $_1$ means significant beyond the .0001 level,
2. $_2$ means significant beyond the .001 level,
3. $_3$ means significant beyond the .01 level,
4. $_4$ means significant beyond the .05 level,
5. $_5$ means not significant at the .05 level.

6. THE RESULTS

It may be remembered that this study was undertaken to explore the findings suggesting that delayed feedback of test information is superior to immediate feedback in influencing the retention of meaningful material. The study investigated:

1. the relevance of the delay-retention effect for the learning of mathematics skills,
2. the interaction of selected information-handling variables with the effects of time of feedback on mathematics achievement,
3. the interaction of selected affective variables with time of feedback on mathematics achievement, and
4. the best linear combinations of the information-handling and affective variables for explaining both learning and retention of mathematics skills.

Three treatment groups were included in the study. These treatments were referred to as: *item-by-item feedback (I-by-I)*, *end-of-test feedback (E-O-T)*, and *one-day delayed feedback (DELAYED)*. A total of 18 classes of Grade 5 students were randomly assigned to the three treatment groups; so that six classes, including both males and females, were in each treatment group.

6.1 Considerations of External Validity

Concerns regarding the external validity of the study led to investigations of the interaction of treatment effects with the sex of participants as well as with special features of their class groups. Analyses that pertain to these consideratrions are included in the first four tables in this chapter.

Table 6.1 displays the means and standard deviations of males and females in each treatment group. To test the sex *x* treatment interaction and the sex main effects, orthogonal transformations of the mathematics achievement scores on the three occasions were used as three dependent variables in a 2-way multivariate analysis of variance. The three feedback treatments and the students' sex (males, females) were used as the between subjects factors of this analysis. Table 6.2 presents a summary of the analysis of variance.

Table 6.1

Mathematics Achievement Means and S.D.'s of Males and Females in Each Treatment

Feedback Group		Occasion 1		Occasion 2		Occasion 3	
Item-by-Item fdbk	N	Mean	S.D.	Mean	S.D.	Mean	S.D.
Males	52	14.7	5.0	18.9	5.4	17.0	5.7
Females	68	13.1	3.9	17.7	5.2	15.6	5.2
End-Of-Test fdbk							
Males	57	13.3	5.3	16.3	7.1	15.3	6.9
Females	63	14.9	5.1	15.9	5.9	16.6	6.4
DELAYED fdbk							
Males	57	13.1	5.1	16.9	6.2	17.9	6.5
Females	62	13.8	4.8	16.8	5.1	18.3	5.7

NOTE: meaning of frequently used abreviations.

1. I-by-I = Item-by-item feedback;
2. E-O-T = End-of-test feedback;
3. DELAYED = one-day delayed feedback;
4. fdbk = feedback;
5. O, Occasn = Occasion;
6. T, trt, or trtmnt = treatment.

Table 6.2

ANOVA of Treatment x Sex x Occasion Effects on Level of Mathematics Skill.

Source of Variation	SS	df	MS	F	Prob.
Treatment	131.350	2	65.675	0.862	.423
Sex	.699	1	0.699	0.009	.924
Trtmnt x Sex	248.435	2	124.387	1.633	.197
Sbjcts Within Grps	26886.435	353	76.166		
BETWEEN OCCASIONS					
OCCASION	2332.22	2	1166.118	126.704	.000
Trt x Occasion	506.60	4	126.650	13.761	.000
Sex x Occasion	28.38	2	14.187	1.542	.215
Trtmnt x Sex x Occsn	49.21	4	12.302	1.337	.255
Occ x Subj Wthn C	6497.60	706	9.203		

It may be observed from Table 6.2 that the treatment x sex, sex x occasion, and treatment x sex x occasion interactions are all not significant. This suggests that treatments had similar effects on both males and females. Consequently, the sex stratification variable was removed from subsequent analyses of variance.

6.1.1 The interaction of class variables with the treatments

The six classes in each treatment group were categorized according to the relative positions of the class means on the mathematics achievement test. This categorization was used as a fixed factor in a 2-way (class x treatment) multivariate analysis of variance on the transformed mathematics scores for the three occasions. The means and standard deviations for high and low classes are displayed in Table 6.3, and the analysis of variance in Table 6.4.

Table 6.3

Means and S.D.'s of Classes Categorized as High or Low in Mathematics Skill

		Occasion 1		Occasion 2		Occasion 3	
I-by-I fdbk	N	Means	S.D.	Means	S.D.	Means	S.D.
Low Class	65	12.35	3.11	17.26	5.41	15.23	5.06
High Class	55	15.56	5.19	19.35	5.00	17.29	5.77
E-O-T fdbk							
Low Class	69	12.54	4.77	14.26	4.66	13.64	5.45
High Class	51	16.25	5.02	18.59	6.64	19.12	6.83
DELAYED fdbk							
Low Class	71	12.13	4.56	15.93	5.61	17.08	5.99
High Class	48	15.50	4.86	18.42	5.41	19.69	5.96

Table 6.4

ANOVA of The Class x Time of Feedback Effects on Mathematics Skill Level

Source of Variation	SS	df	MS	F	Prob.
Treatment	131.35	2	65.67	0.961	.384
Class Level	2797.00	1	2797.00	40.923	.000
Treatment x Class	212.17	2	106.09	1.552	.213
Treatment Within Grps	24126.74	353	68.35		
OCCASIONS: (Within Subjects Effects)					
Occasion	2332.217	2	1166.11	126.867	.000
Treatment x Occsn	506.60	4	126.65	13.779	.000
Class x Occasion	11.53	2	5.76	0.627	.535
Trtmnt x class x Occsn	74.41	4	18.60	2.024	.089
Occ x subj wthn class	6489.24	706	9.19		

Table 6.4 indicates that the *class x treatment x occasion, class x occasion, and class x treatment interactions* were all not significant. This suggests that the significant *treatment x occasion interaction* effects were pervasive over class levels defined by performance in mathematics. Other class related differences (such as whether classes were taught by school principals or by regular class teachers, or whether classes were taught by male or female teachers) proved not to be significant. Therefore, it was decided to abandon the design that uses class as the unit of analysis in favour of a more powerful design that uses subjects as the unit of analysis. The latter design allows larger degrees of freedom and, consequently, more reliable conclusions.

6.2 The Effects of Time of Feedback

The influence of time of feedback on mathematics skill level was investigated with the aid of a 2-way analysis of variance repeated measures design. Time of feedback was considered a fixed factor with three levels, whereas occasions was considered as the repeated measures factor of three levels. (The score distributions met the assumptions required for a clear interpretation of the ANOVA model. See Chapter 5.) The means and standard deviations are displayed in Table 6.5, and the analysis of variance is summarized in Table 6.6.

The mathematics achievement means for the three treatment groups were similar at Occasion 1 {$F(2, 356) = .497$, $p = .609$}. The summary of the analysis of variance displayed in Table 6.6 shows the main effects of these treatments (the time of feedback factor) as being similar over the three occasions; the observed F-value of 0.861 is less than both critical limits { $_{.95}F(1, 2) = 18.51$ and the Box $_{.95}F(2, 4) = 6.94$ }. The *treatment x occasion interaction* was significant ($p < .0001$). This suggests that the feedback treatments had different effects on the retention of mathematics skill.

An examination of differences between the within cell means shows item-by-item feedback as being superior to both end-of-test feedback and one-day delayed feedback on short-term (one day) retention: Scheffe multiple comparisons showing F-observed (2, 1068) values of 3.070 and 2.849 for the Occasion 2 (I - E) and the (I - (E + D)/2) mathematics achievement mean scores. These F-values were significant at the .01-level and .05-level, respectively. The DELAYED minus E-O-T mean difference was not significant at the .10-level. Significant differences were also observed between the mean scores at Occasion 3. On this occasion, the mean score for the one-day delayed feedback group was significantly higher than the end-of-test feedback group mean ($p < .01$) and the item-by-item feedback group mean ($p < .05$). Scheffe multiple comparisons F(2, 1068) were 2.837 and 3.138 for the (DELAYED minus I-by-I) and (DELAYED minus E-O-T) feedback mean differences. This finding confirms previous conclusions that one-day delayed feedback is superior to item-by-item and end-of-test feedback on the LTR of meaningful material (Sturges, 1972a). The difference between the mean scores for item-by-item feedback and end-of-test feedback was not significant at the 0.1-level. The significantly higher LTR mean score for the delayed feedback treatment (than for item-by-item and end-of-test feedback treatments) suggests that the DRE has relevance for the learning of mathematics skills.

Table 6.5

Means and Standard Deviations of Mathematics for the Treatment Groups

Treatment	Occasion 1		Occasion 2		Occasion 3		
	Mean	SD.	Mean	SD	Mean	SD.	n
I-by-I fdbk	13.8	4.5	18.2	5.3	16.17	5.5	120
E-O-T fdbk	14.1	5.2	16.1	6.4	15.97	6.6	120
DELAYED fdbk	13.5	5.0	16.9	5.6	18.13	6.1	119
Total	13.8	4.9	17.1	5.9	16.75	6.2	359

Table 6.6

ANOVA of Time of Feedback on Level of Performance in Mathematics

Source of Variation	SS	df	MS	F	Prob.
BETWEEN SUBJECTS	27267.38	358			
Treatment effects	131.21	2	65.60	0.861	.424
Subj Within Grps	27136.00	356	76.23		
WITHIN SUBJECTS	9414.00	718			
Occasion effects	2335.51	2	1167.76	126.450	.000
Trtmnt x Occsn	507.06	4	126.76	13.727	.000
Occsn x subj wthn grps	6575.25	712	9.24		

Figure 6.1

The Occasion x Time of Feedback Interaction on Level of Performance in Mathematics

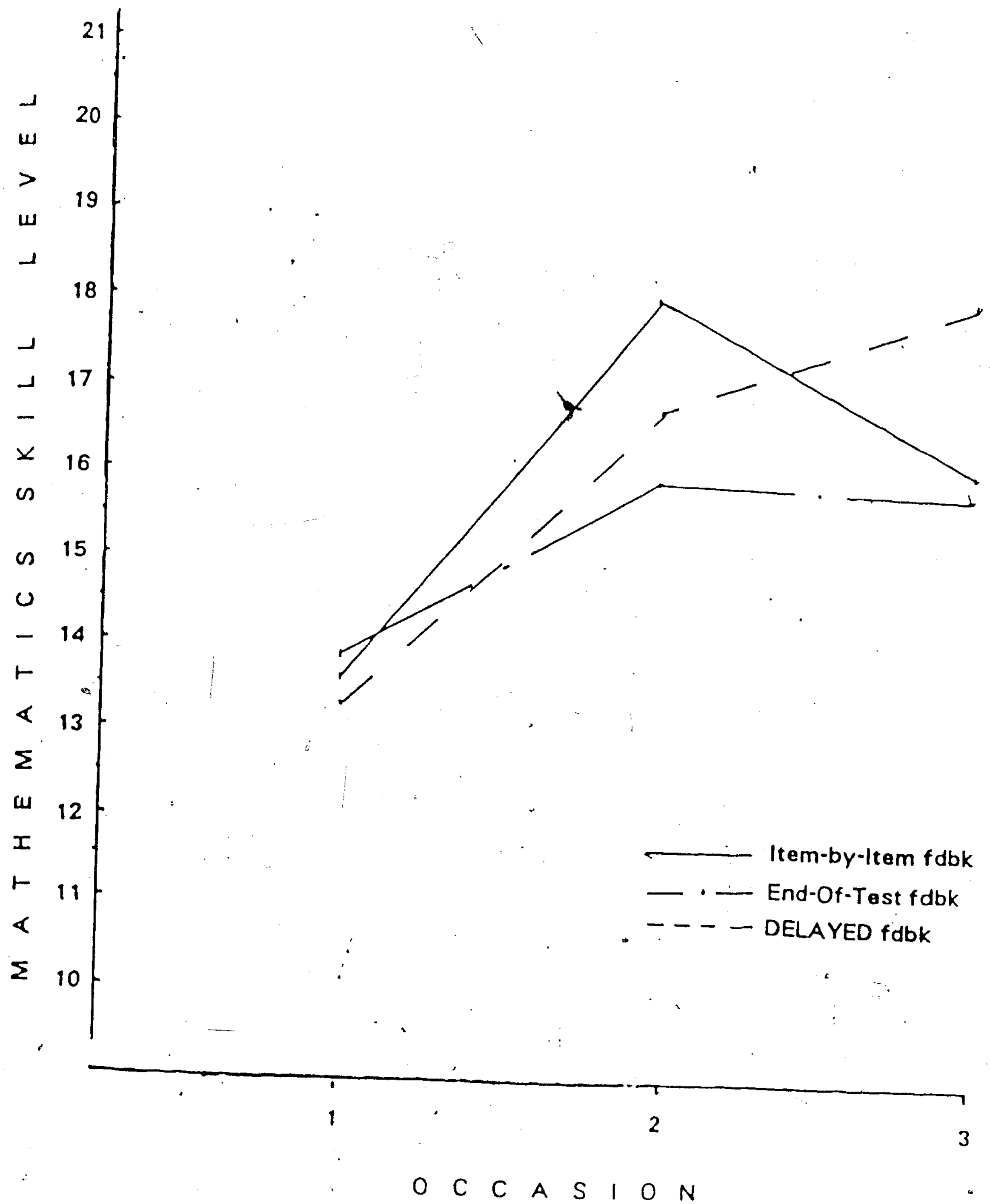


Table 6.7

Scheffe Multiple Comparisons of Differences Between the Treatment Means at Occasions 2 and 3

Group Contrast	Difference	F	Sig.
	Occasion 2		
I - E	2.117	3.070	**
I - D	1.284	1.860	NS
I - (E+D)/2	1.702	2.849	*
E - D	0.833	1.206	NS
	Occasion 3		
D - I	1.959	2.837	*
D - E	2.167	3.138	**

NOTE:

1. .01-level critical $F(2, 1068) = 3.040$
2. .05-level critical $F(2, 1068) = 2.449$
3. .10-level critical $F(2, 1068) = 2.145$
4. I means item-by-item feedback treatment group
5. E means end-of-test feedback treatment group
6. D means one-day delayed feedback treatment group.

6.3 Interaction of Time of Feedback with Selected Information-Handling Variables

Two scores were derived from the digit-span task to measure rehearsal proficiency. One score summarized participants' recall performance on items that sampled initial serial positions, and as such were referred to as the *primacy-rehearsal score*. The *recency-rehearsal score* described the participant's recall performance on items that referenced final serial positions. Both scores were seen as measures of rehearsal proficiency since the participant was required to rehearse all digits presented before any position was referenced. Primacy rehearsal involved retrieving recently processed items from storage, whereas recency rehearsal was seen to involve holding or recycling bits of information. Both measures of rehearsal proficiency were expected to influence achievement in mathematics as well as to interact significantly with time of feedback. They involve active mental processing and are theorized to influence depth or breadth of storage.

Incidental-learning ability was seen as a relatively passive measure of cognitive mediation, since the critical learning took place while participants were actively engaged in a distracting orienting task. This orienting task occupied the learner in a continuous rehearsal task, such that learning of the crucial stimuli took place at a nonrehearsing level. Therefore, incidental-learning ability was expected to have a similar influence on learning and retention, and, consequently, not to interact significantly with time of feedback.

Several analyses of covariance were used to measure the interaction of each information-handling variable with the effectiveness of the feedback modes. (The score distributions met the assumptions required for clear interpretations of the analysis of covariance model. See Chapter 5.) The analyses are summarized in Tables 6.8 to 6.9.

Table 6.8 indicates that the primacy-rehearsal regression estimates for the three feedback treatments were similar on Occasion 2 ($p > .10$), although the regression coefficient (0.43) for Item-by-Item feedback seemed quite different from the other two regression estimates. (1.15 for End-of-Test and 1.11 for Delayed feedback). The estimates were most similar on Occasion 3, where the coefficients were expected to be significantly different. The hypothesis of a significant interaction between primacy-rehearsal proficiency and time of feedback was therefore rejected. Primacy rehearsal ability showed a significant effect upon mathematics skill level ($p < .00001$), on both the short-term and the long-term retention scores. But these effects were similar for students in all three treatment groups, suggesting that the effects of time of feedback on mathematics performance does not interact with primacy-rehearsal ability. Several alternative explanations of these results will be discussed in a subsequent section of this chapter.

Table 6.8

Primacy-Rehearsal x Time of Feedback Interaction on Level of Mathematics Skill

Source / Feedback	I-by-I	End-of-Test	Delayed
Primacy rehearsal (Mean)	3.867	3.983	3.546
	Occasion 2		
Math achievement (Mean)	18.216	16.100	16.933
Variance (wthn gp)	20.188	41.486	31.826
Regression constant	16.548	11.514	13.012
Regression estimate	0.432	1.151	1.106
Regression homogeneity test	F(2, 353) = 1.971; p = .1410		
Primacy rehearsal effect	F(1, 353) = 29.892; p = .0000		
	Occasion 3		
Math achievement (mean)	16.175	15.976	18.134
Variance (Wthn grp)	29.944	43.965	37.152
Regression constant	11.748	12.044	14.637
Regression estimate	1.145	0.985	0.986
Regression homogeneity test	F(2, 353) = 0.095; p = .9100		
Primacy rehearsal effect	F(1, 355) = 36.683; p = .0000		

The interaction of recency-rehearsal with time of feedback on mathematics skill level is summarized in Table 6.9. As with primacy-rehearsal, recency-rehearsal indicated similar regression coefficients for the three treatment groups on Occasion 1 ($p > .329$). The three coefficients were similar on Occasion 2 ($p > .10$). However, by Occasion 3, the three regression estimates were significantly different at the .05-level, suggesting that recency-rehearsal proficiency interacted significantly with time of feedback. The regression estimate was smallest (0.38) for delayed feedback, and similarly steep (1.12 and 1.52) for the item-by-item and end-of-test feedback modes. This finding suggests that whereas high and low recency-rehearsal students profited from delayed feedback, only highly proficient recency-rehearsal students benefited from item-by-item and end-of-test feedback. Figures 6.2 and 6.3 display graphs of the interactions for short-term and long-term retention.

Table 6.9

Recency-Rehearsal x Time of Feedback Interaction on Level of Mathematics Skills

Source/Feedback	Item-By-Item	End-Of-Test	Delayed
Recency-rehearsal (mean)	4.017	4.450	4.378
		Occasion 2	
Math achievement (mean)	18.216	16.100	16.933
Variance (within grp)	28.188	41.486	31.826
Regression constant	17.701	11.479	13.835
Regression estimate	0.128	1.038	0.708
Regression homogeneity test	$F(2, 353) = 1.878$; $p = .1544$		
Receny-rehearsal effect	$F(1, 355) = 9.654$; $p = .0020$		
		Occasion 3	
Math achievement (mean)	16.175	15.967	18.134
Variance (within grp)	29.944	43.965	37.152
Regression constant	11.374	9.218	16.455
Regression estimate	1.195	1.516	0.383
Regression homogeneity test	$F(2, 353) = 2.944$; $p = .0540$		
Recency-rehearsal effect	$F(1, 355) = 25.689$; $p = .0000$		

Figure 6.2

Recency-Rehearsal x Time of Feedback Interaction on Short-Term Retention of Mathematics Skills Level

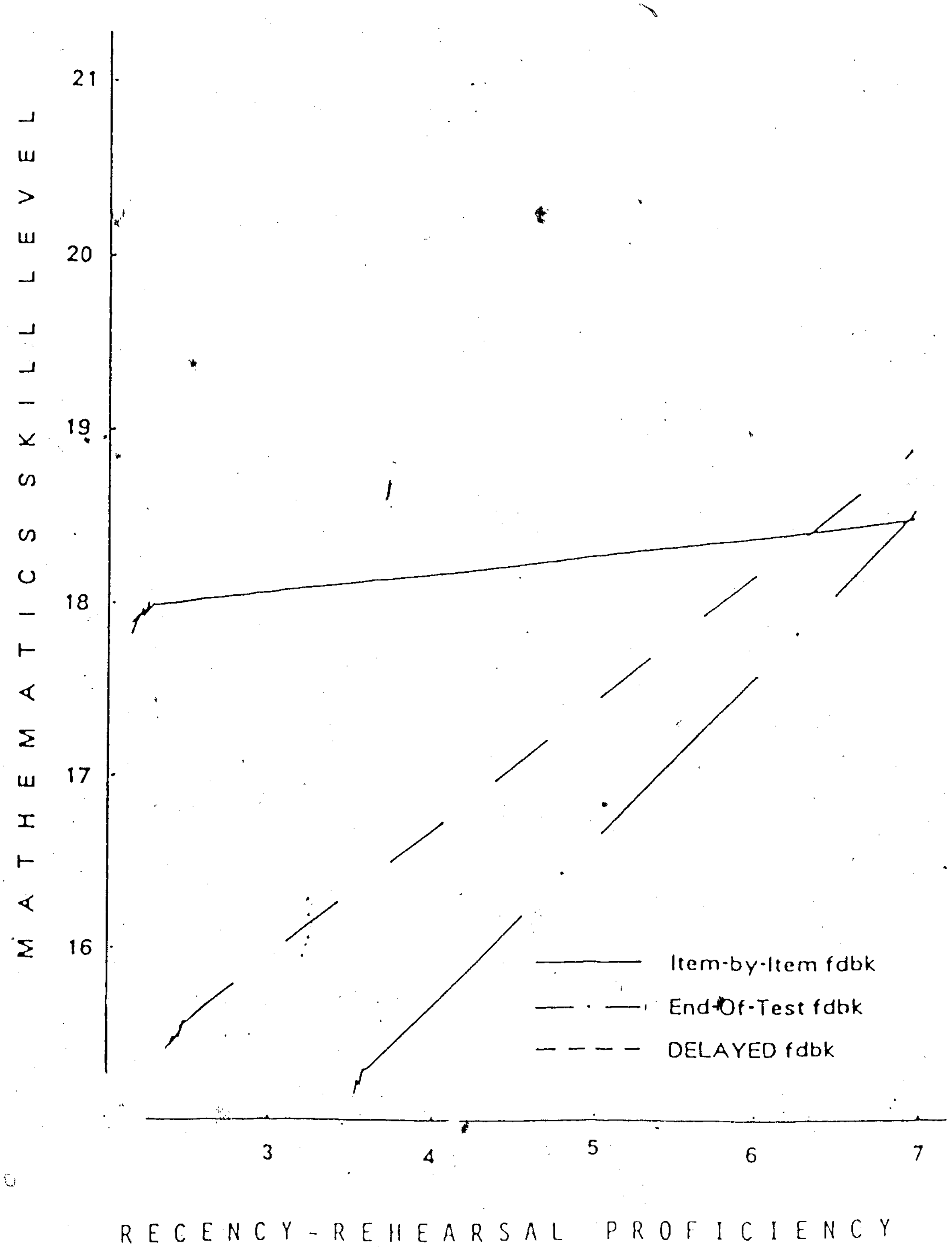
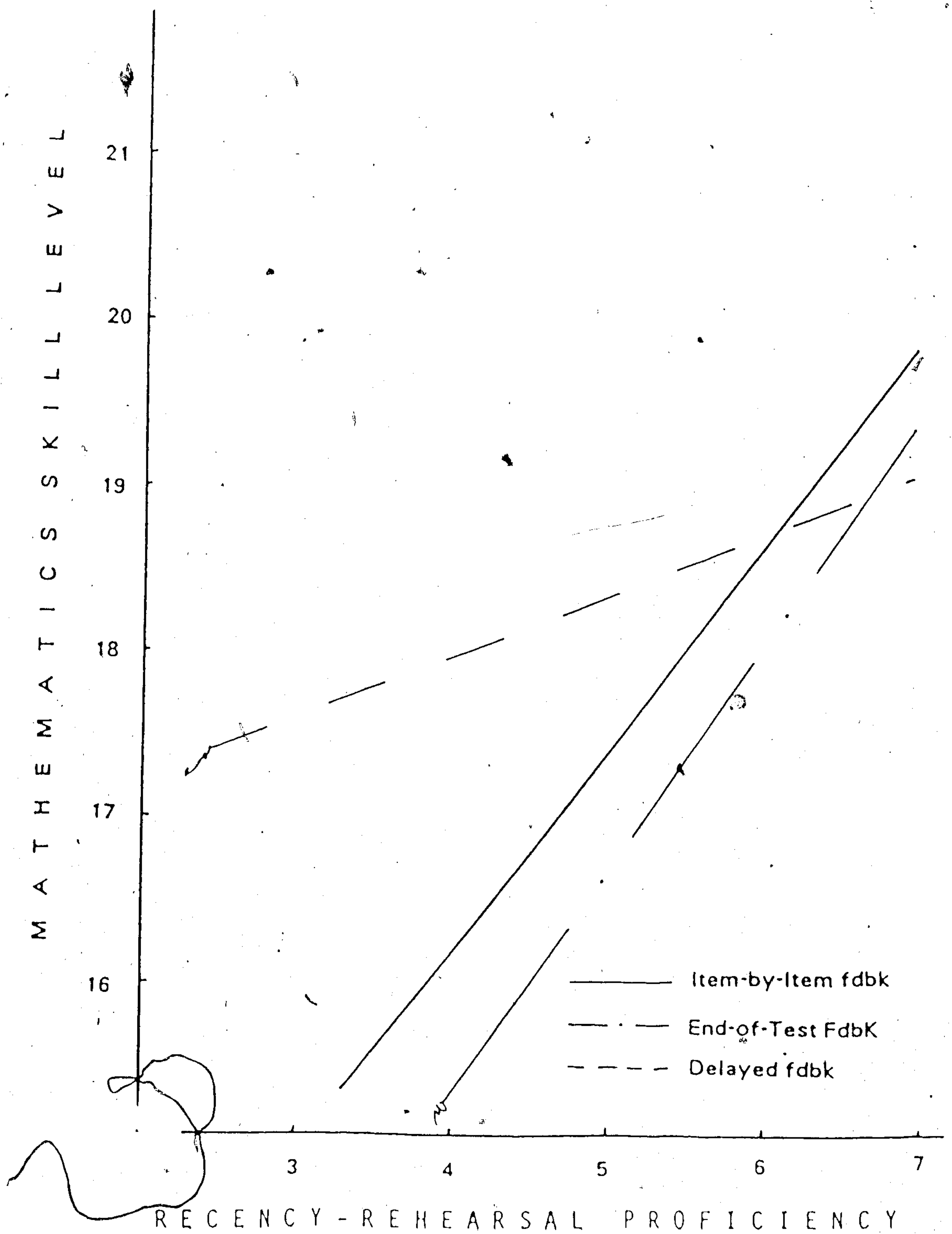


Figure 6.3

Recency-Rehearsal x Time of Feedback Interaction on Long-term Retention

Mathematics Skills Level



The interaction of incidental-learning ability with time of feedback. The interaction of incidental-learning ability with time of feedback was not significant. On each occasion, the regression estimates for the three treatment groups were quite similar ($p > .10$), suggesting that the interaction of this measure of attention with time of feedback was not significant. (The regression coefficients for the treatment groups on both short-term and long-term retention are reported in Table 6.10). This finding supports the hypothesis of nonsignificant interaction effects of time of feedback and incidental-learning ability on mathematics skill level.

Table 6.10

Incidental-Learning Ability x Time of Feedback Interaction on Mathematics Skills Level

Source/Feedback	Item-by-Item	End-of-Test	Delayed
Incidental-Learning (mean)	5.733	5.500	6.034
		Occasion 2	
Math achievement (mean)	18.216	16.100	16.933
Variance (withn grp)	28.188	41.486	31.826
Regression constant	16.018	12.246	14.774
Regression estimate	.383	.701	.358
Regression homogeneity test	$F(2, 353) = 0.794$; $p = .4530$		
Incidental-Learning effect	$F(1, 355) = 15.499$; $p = .0001$		
		Occasion 3	
Math achievement (mean)	16.175	15.967	18.134
Variance (withn grp)	29.944	43.965	37.152
Regression constant	13.178	12.469	16.369
Regression estimate	.523	.634	.298
Regression homogeneity test	$F(2, 353) = 0.508$; $p = .6024$		
Incidental-Learning effect	$F(1, 355) = 15.324$; $p = .0001$		

6.4 The Interaction of Selected Affective Variables with Time of Feedback

This section examines the interaction of selected affective variables with time of feedback on mathematics skill level. The chosen variables of affect include preference of time of feedback and confidence in academic ability. Theory and research that directly examine the interaction of preference of time of feedback with the time of feedback of mathematics test results are practically nonexistent. Therefore, it is difficult to state with confidence any clear expectations of these interactions. The literature, reviewed in Chapter 4, suggests that transitory, affective states induced by the presence of affective stimuli influence both learning and retention (see Izard, 1965). But the only study that directly examines the interaction of students' preferences with time of feedback (Joseph, 1981) reports nonsignificant effects which were difficult to explain, since another measure of affect (academic self-concept) showed significant interaction effects for the same sample of students.

Pertaining to the efects of meeting students' preference for time of feedback the commonly held view is that students stand to benefit more from a learning situation that meets there preference than from one that is contrary to their wishes. This view predicts significant interaction effects between satisfying students' preferences and time of feedback. Confidence in academic ability, in contrast to preference for immediate feedback, relates directly to the material to be learned, rather than to the learning condition, and as such was expected to directly influence the learning of the material. Besides, students who were of high academic self-confidence, or who were happy about their performance in school, seemed more likely than others to talk about the test questions and to rehearse or readdress the mathematics problems during the retention interval. Therefore, confidence in academic ability was expected to be significantly associated with different within treatment regression estimates on the Occasion 3 measures of mathematics achievement.

Tests of the interaction effects of preference for immediate feedback with time of feedback involved several analyses of variance and covariance. Two of the preference scales were used as covariates of mathematics achievement at Occasions 2 and 3. Table 6.11 summarizes results that pertain to the first dimension of the preference scale; the pattern of stimuli weights that define this scale seems to reflect the students' feelings about feedback modes that are generally being used in class. Therefore, the scale was labeled *what is customary*. This dimension loaded positively on end-of-test, one-day delayed, and three-hour delayed feedback (with no significant differences between these scale values), and loaded negatively on item-by-item and one-week delayed feedback. This dimension accounted for 44.7 per cent of the variance in the preference responses and correlated .09 with mathematics achievement.

Table 6.11

Within Treatment Regression Estimates of Preference of Time Feedback: Scale I

Source / Feedback	Item-by-item	End-of-Test	Delayed
Preference (mean)	.090	.094	.102
		Occasion 2	
Mathematics Achievement	18.217	16.042	16.933
Regression Constant	18.100	13.834	17.019
Regression Estimate	1.298	23.589	-0.848
Regression Homogeneity Test		$F(2, 352) = 3.216$;	$p = .0410$
Preference Effects		$F(1, 354) = 3.314$;	$p = .0695$
Treatment Effects		$F(1, 354) = 4.418$;	$p = .0127$
		Occasion 3	
Mathematics Achievement	16.175	15.908	18.134
Regression Constant	15.487	14.064	18.319
Regression Estimate	7.667	19.700	-1.814
Regression Homogeneity Test		$F(2, 352) = 1.844$;	$p = .1601$
Preference Effects		$F(1, 354) = 3.478$;	$p = .0630$
Treatment Effects		$F(1, 354) = 4.406$;	$p = .0129$

The test of homogeneity of the within cell regression estimates shows the three coefficients as being similar at Occasion 3 [$F(2, 352) = 1.844$; ($p > .10$)], suggesting no significant interaction between preference for time of feedback and time of feedback on level of mathematics skill. The corresponding regression estimates were, however, significantly different at Occasion 2 {$F(2, 352) = 3.216$; $p < .05$}, even though they were not significantly different at Occasion 1 {$F(2, 352) = 2.671$; $p > .05$}. This finding suggests that the principal component of the students' preferences for immediate feedback interacted significantly with the influence of the feedback treatments on the short-term retention of mathematics skill. However, these interaction effects were not significant one week later on the long-term retention test. The relatively steep regression estimate associated with end-of-test feedback is indicative of a higher preference/mathematics achievement relationship for this treatment group than for the other treatment groups, since the three groups were of similar variance ($p=.222$) on the Occasion 2 criterion scores as well as on the preference scores.

The second dimension of the students' preferences reflected the attribute of length of delay of feedback. Item-by-item feedback had the highest positive scale score, whereas one-week delayed feedback was at the extreme negative pole. This component accounted for 30.9 per cent of the total variance in the students' expressed preferences; and it had a correlation of .10 with mathematics achievement. The within cell regression estimates associated with this dimension of the students' preferences were similar on all three occasions. The observed $F(2, 352)$ values were 1.355 ($p > .10$) on Occasion 2, and 1.448 ($p > .10$) on Occasion 3. This finding of no significant interaction is consistent with the results of Joseph (1981). As expected, also, the influence of the length of delay dimension of the students' preference showed highly significant effects on mathematics achievement at Occasion 3 {$F(1, 354) = 8.634$; $p < .01$}, although these effects were not significant on earlier occasions. The significant effects of this dimension of preference on mathematics achievement is consistent with the time of feedback effects on long-term retention reported earlier.

The effects on STR and LTR of having feedback preferences satisfied.

From each of the three treatment groups, students who preferred to have their test results either after each item, at the end of the test, or one day after taking the test were categorized into two groups: students who got their preferences satisfied were put into one group, whereas students whose preferences were not met fell into the other group. Using the 299 students who preferred to have their test-results feedback at either of these three times, a two-way ANOVA was conducted on the mathematics achievement scores for each of the Occasions 2 and 3. Both factors (treatment and preference satisfaction) were considered as being fixed. The means and standard deviations for each preference group are displayed in Table 6.12, and the analysis of variance results are reported in Table 6.13.

The results indicated low interaction effects between *preference satisfaction* and *time of feedback* for short-term retention of mathematics skill {$\underline{F}(2, 293) = 2.318$; $p = .10$}, and highly significant interaction effects for long-term retention {$\underline{F}(2, 293) = 5.557$; $P < .01$}. On both occasions, all of the interaction occurred between the end-of-test and delayed feedback groups: [{$\underline{F}(1, 293) = 4.541$; $p < .05$} for short-term retention, and {$\underline{F}(1, 293) = 11.114$; $p < .001$} for long-term retention]. An examination of the Occasion 2 cell means showed that, whereas end-of-test feedback students whose preferences were *not* satisfied performed poorly relative to end-of-test feedback students whose preferences were satisfied, these two *preference-met* groups for the delayed feedback treatment were characterized by similar levels of performance in mathematics. This pattern of cell means was even more pronounced at Occasion 3.

The preference main effect was significant at both Occasion 2 {$\underline{F}(1, 293) = 6.442$; $p < .01$} and Occasion 3 {$\underline{F}(1, 293) = 3.886$; $p < .05$ }. On both of these occasions, students whose preferences were met outperformed those students whose preferences were not satisfied; but the difference in performance seemed less remarkable at long-term retention than at short-term retention.

Table 6.12

Means and SDs of Students Who Got Their Feedback Preferences Met

		Occasion 2		Occasion 3	
Treatment	**N**	**Mean**	**S.D.**	**Mean**	**S.D.**
Item-by-Item fdbk	**94**				
Pref.Met	16	18.56	5.89	14.94	5.52
Pref.Not.Met	78	18.03	5.53	16.21	5.39
End-of-Test FdbK	**104**				
Pref.Met	50	18.36	6.88	18.50	6.84
Pref.Not.Met	54	14.56	5.66	14.09	5.80
Delayed fdbk	**101**				
Pref.Met	25	17.44	6.93	18.20	6.45
Pref.Not.Met	76	17.03	5.26	18.65	5.85
TOTAL	**299**	**16.93**	**6.15**	**16.78**	**6.13**

Table 6.13

The Effects on STR and LTR of Meeting Students' Preference for Time of Feedback

Source of Variation	SS	df	MS	F	Prob.
			Occasion 2: (Short-Term Retention)		
Treatment	**148.593**	**2**	**74.296**	**2.150**	**.118**
T1(I - D)	44.644	1	44.644	1.292	.257
T2(E - D)	103.949	1	103.949	3.008	.084
Pref.Met	**222.617**	**1**	**222.617**	**6.442**	**.012**
Treatment x Pref.Met	**160.191**	**2**	**80.095**	**2.318**	**.100**
T1 x Pref	3.287	1	3.287	0.095	.758
T2 x Pref	156.904	1	156.904	4.541	.034
Within Cells	**10124.847**	**293**	**34.556**		
			Occasion 3: (Long-Term Retention)		
Treatment	**396.917**	**2**	**198.459**	**5.624**	**.004**
T1(I - D)	322.106	1	322.106	9.127	.003
T2(E - D)	74.812	1	74.812	2.120	.146
Pref.met	**137.148**	**1**	**137.148**	**3.886**	**.050**
Treatment x Pref.Met	**392.216**	**2**	**196.108**	**5.557**	**.004**
T1 x Pref	0.000	1	0.000	0.000	.999
T2 x Pref	392.216	1	392.216	11.114	.001
Within Cells	**10340.100**	**293**	**35.290**		

Academic self-confidence x time of feedback interaction on mathematics skill level.

Three subscale measures of SPAS were considered in the selection of a useful academic self-concept measure. Two of these subscales, *Self-concept of Ability in Mathematics* and *Self-Concept of Ability in Reading/Spelling,* produced, scores that were highly skewed. In both of these subscales, the highest score was associated with the highest frequency. Scores on the *Confidence* subscale were distributed normally between 0 and 10 with a mean of 4.37. On the basis of the distribution of its scores and of its relationship with the achievement measures for the Grade 5 students studied, the Confidence subscale was used as a covariate in analyses described in this secton.

The interaction of confidence in academic ability with time of feedback was investigated with the aid of covariance analyses. Table 6.14 displays the regression estimates for each treatment group on the short-term and long-term retention scores taken at Occasions 2 and 3.

Table 6.14

The Interaction of Confidence in Academic Ability with Time of Feedback on Mathematics

Source / Feedback	Item-by-Item	End-of-Test	Delayed
Confidence (mean)	4.47	4.26	4.32
		Occasion 2	
Mathematics achievement (mean)	18.22	16.10	16.93
Variance (within group)	28.19	41.49	31.83
Regression constant	16.10	10.46	15.36
Regression estimate	0.47	1.33	0.36
Regression homogeneity test		$F(2, 353) = 3.898$; $p = .0212$	
Confidence effect		$F(1, 355) = 20.779$; $p = .0000$	
		Occasion 3	
Mathematics achievement	16.17	15.97	18.13
Variance (within group)	29.94	43.97	37.15
Regression constant	12.98	9.72	17.13
Regression estimate	0.72	1.47	0.23
Regression homogeneity test		$F(2, 353) = 5.199$; $p = .0061$	
Confidence effect		$F(1, 355) = 23.807$; $p = .0000$	

The within-treatment regression estimates associated with the interaction of confidence in academic ability with time of feedback were as expected. The coefficients obtained on Occasion 2 (0.474, 1.325, and 0.358) were significantly different at the .05-level, suggesting that confidence in school subjects influences short-term retention of mathematics skills. The regression estimates for the three feedback groups were more dissimilar by Occasion 3; they were significantly different at the .01-level.

Figure 6.4

Academic Self-Confidence x Time of Feedback Interaction on Short-Term Retention of Mathematics Skills

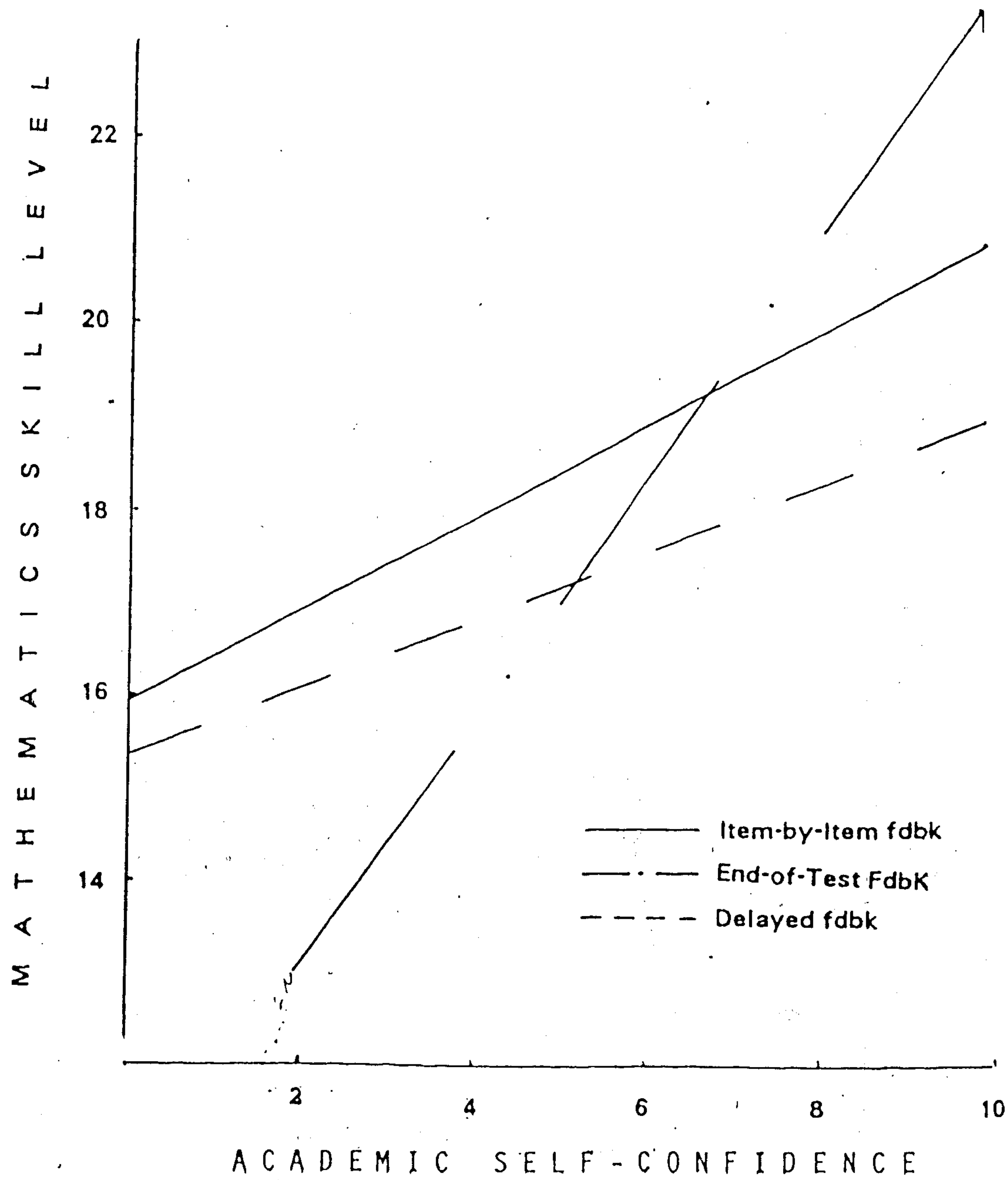
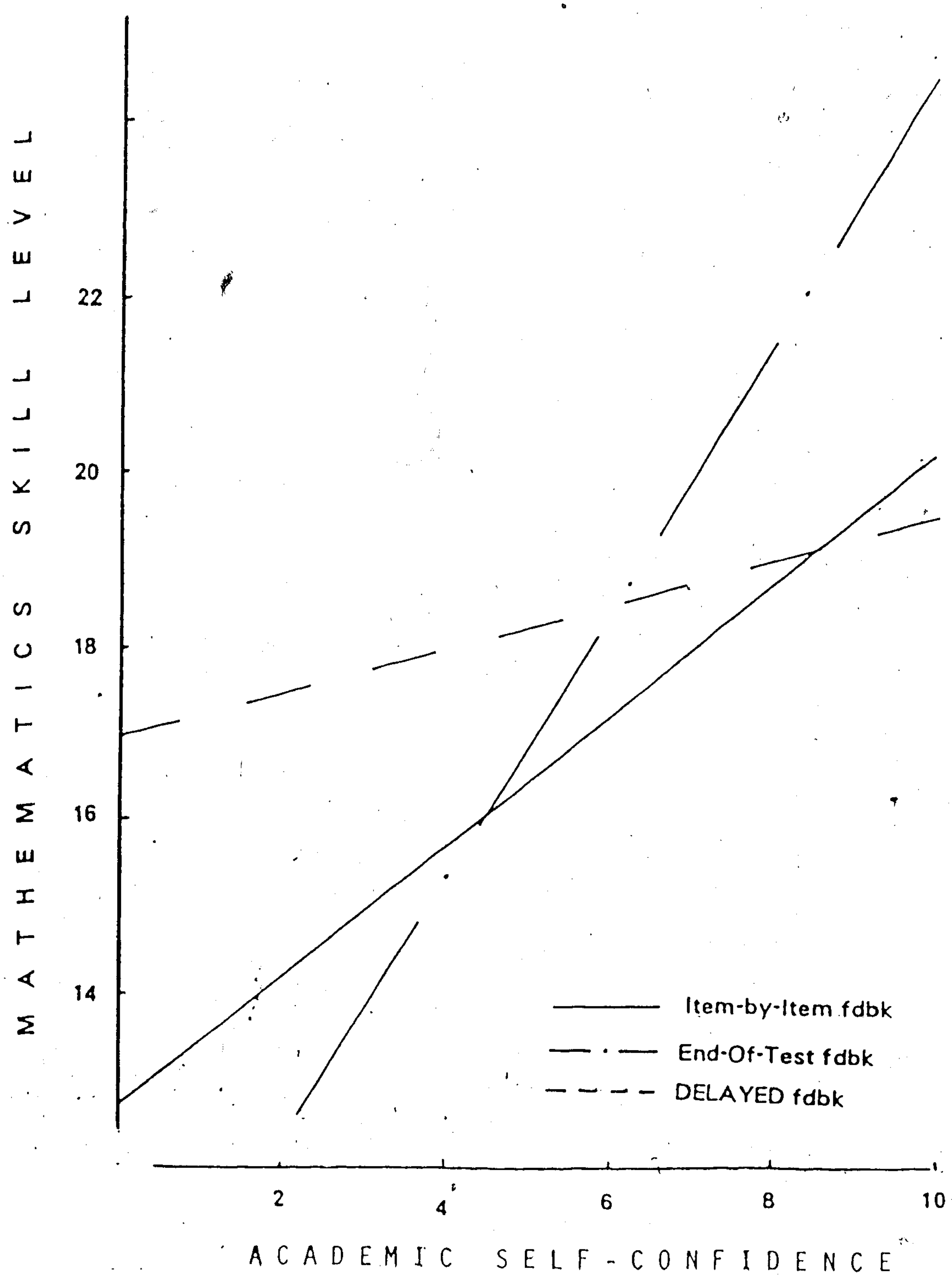


Figure 6.5

Academic Self-Confidence x Time of Feedback Interaction on Long-Term Retention of Mathematics Skills



This finding suggests that confidence in academic ability interacted significantly with the influence of the feedback treatments on the long-term retention of mathematics skill. Figure 6.5 displays a graph of the interaction. The flattest regression line was associated with delayed feedback, suggesting that the effect of this feedback mode on the retention of mathematics skill was similar for students at opposite ends of the confidence scale. This was not the case for item-by-item and end-of-test feedback where the regression lines were relatively steep, suggesting that students of greatest confidence in academic ability benefited most from end-of-test and item-by-item feedback treatments, in contrast to one-day delayed feedback. The latter feedback mode, on the other hand, seemed better than the immediate feedback treatments for students of low academic self-confidence.

6.5 Predicting Short-Term and Long-Term Retention of Mathematics Skill

This section examines the predictive accuracy of combinations of information-handling and motivational variables on the short-term and long-term retention of mathematics skills. The students' mathematics achievement scores at Occasion 2 and Occasion 3 were used as measures of short-term retention and long-term retention, respectively, in stepwise regression analyses. The independent variables of the regression equations included incidental-learning ability, primacy-rehearsal proficiency, recency-rehearsal proficiency, confidence in academic ability, and the three aspects of the students' preference for time of feedback. The students' mathematics achievement scores at Occasion 1 were included in these equations to account for variability due to previous knowledge in mathematics. In this way, mathematics achievement at Occasion 1 was used to partial out variance due to individual differences in mathematics from the short-term retention and long-term retention measures of mathematics skill level. Separate analyses were made for each sex within each treatment group, since significant treatment effects on the criterion were observed at Occasion 2 and Occasion 3 and boys and girls were expected to differ on the affective variables.

6.5.1 Predictive equations of STR and LTR of mathematics skill among girls

Short-term retention.

For girls within each treatment group, the regression analyses that pertain to short-term retention of mathematics skill are displayed in Tables 6.15 and 6.16. It may be observed from these tables that, once individual differences in mathematics were accounted for, the most predictive variables of mathematics skill level were: confidence in academic ability for the end-of-test feedback group {$F(1, 58) = 6.992$; $p = .01$} and preference of time of feedback for the delayed feedback group {$F(1, 59) = 12.462$; $p < .001$}. In the item-by-item feedback group, the F-ratios for confidence in academic ability {$F(1, 59) = 2.426$; $p > .10$} and preference of time of feedback {$F(1, 59) = 3.024$; $p < .10$} were both relatively large, although they were not significant at the .05-level. Information-handling variables were less predictive than the affective variables, and only in one instance did a measure of rehearsal {primacy rehearsal: $F(1, 58) = 5.537$; $p < .05$} emerge as a significant predictor of girls' short-term retention of mathematics skill. Since the trend was identifiable in all treatment groups, the STR results for the pooled sample of girls are reported in Table 6.17. The prediction equation for the entire sample of girls shows the affective variables, preference for time of feedback and confidence in academic ability, as the predictors of short-term retention of mathematics skill that were significant at the .05-level.

Table 6.15

Selected Predictors of STR of Mathematics Skills Among Girls Treated With E-O-T Feedback

Predictor	B	S.E. of B	BETA	F	Prob.
Math 1	0.744	0.099	.636	56.169	.000
Confidence	0.641	0.242	.221	6.912	.011
Primacy	0.601	0.255	.172	5.537	.022
Constant	-0.637	1.505		0.179	.674
	$R = .847$, $R^2 .717$, $\underline{F}(3, 58) = 48.884$; $p < .0001$				
Incid. Learning	0.182	0.169	.082	1.171	.284
Preference.1	5.942	6.932	.068	0.735	.395
Preference.3	-2.806	4.300	-.050	0.426	.517
Preference.2	-0.695	4.225	-.013	0.027	.870
Recency	0.015	0.345	.004	0.002	.965
	$R = .857$, $R^2 .735$, $\underline{F}(8, 53) = 18.353$; $p < .0001$ Change-in-$\underline{F}(4, 53) = 0.726$; $p = .607$.				

Table 6.16

Selected Predictors of STR of Mathematics Skills Among Girls Treated With Delayed Feedback

Predictor	B	S.E. of B	BETA	F	Prob.
Math 1	0.773	0.085	.728	83.456	.000
Preference.3	-7.726	2.993	-.206	6.662	.012
Constant	6.319	1.240		25.968	.000
	$R = .806$, $R^2 = .649$, $\underline{F}(2, 59) = 54.547$; $p < .0001$.				
Incid. Learning	-0.119	0.177	-.054	0.456	.503
Preference.2	-5.209	4.466	-.107	1.360	.249
Confidence	0.013	0.242	-.004	0.003	.958
Primacy	0.321	0.229	.121	2.000	.163
Recency	-0.205	0.252	-.071	0.666	.418
Preference.1	9.623	7.379	.120	1.701	.198
	$R = .821$, $R^2 = .674$, $\underline{F}(8, 53) = 13.695$; $p < .0001$				

Table 6.17

Selected Predictors of Short-Term Retention of Mathematics Skills Among Girls

Predictor	B	S.E. of B	BETA	F	Probblty
Math1	0.729	0.062	.623	138.218	.0000
Preference.3	-7.461	2.382	-.158	9.811	.0020
Confidence	0.440	0.150	,155	8.588	.0038
Constant	4.866	0.950		26.237	.0000
$R = .731$ $R^2 = .534$ S.E.= 3.743. $F(3, 188) = 71.752$					
Primacy	0.319	0.169	.102	3.533	.0610
Recency	-0.210	0.191	-.061	1.212	.2742
Incid.Learning	0.048	0.107	.022	0.190	.6636
Preference.2	-0.067	2.407	-.001	0.001	.9979
Preference.1	-0.420	4.261	-.005	0.010	.9217

$R = .738$; $R^2 = .545$; S.E. = 3.749. $F(8, 183) = 27.345$; $p = .0000$;

Change-in-F(5, 183) = .861; $p = .5085$.

Long-term retention of mathematics skill.

For girls within each treatment group, the results that pertain to long-term retention of mathematics skill are displayed in Tables 6.18 and 6.19. As expected, rehearsal proficiency was a significant predictor in each treatment group; primacy-rehearsal proficiency was significant for the item-by-item feedback group {$F(1, 63) = 11.772$; $p < .001$} whereas recency rehearsal was included in the equations for the end-of-test feedback group {$F(1, 58) = 4.482$; $p < .05$} and the one-day delayed feedback group {$F(1, 53) = 3.078$; $p < .10$}. Confidence in academic ability was also a significant predictor of girls' long-term retention of mathematics skill for the item-by-item feedback group {$F(1, 63) = 8.825$; $p < .01$} and for the end-of-test feedback group {$F(1, 58) = 7.316$; $p < .01$}; but it was not significant for the delayed feedback group {$F(1, 53) = 1.048$; $p > .10$}.

Table 6.18

Selected Predictors of Long-Term Retention of Mathematics Skills Among Girls Treated With Item-By-Item Feedback

Predictor	B	S.E. of B	BETA	F	Prob.
Math 1	0.775	0.109	.582	50.705	.000
Primacy	0.938	0.274	.282	11.772	.001
Confidence	0.675	0.227	.249	8.825	.004
Preference.2	7.360	3.192	.189	5.318	.024
Constant	-1.243	1.837		0.458	.501
	$R = .770$, $R^2 = .529$, $F(4, 63) = 22.916$				
Preference.3	0.341	4.615	.007	0.005	.941
Preference.1	-0.653	6.720	-.010	0.009	.923
Incid. Learning	0.147	0.169	.079	0.759	.387
Recency	0.387	0.340	.118	1.296	.260
	$R = .780$, $R^2 = .608$, $F(8, 59) = 11.426$; $p < .0001$ Change-in-$F(4, 59) = 0.587$; $p = .688$				

Table 6.19

Selected Predictors of LTR of Mathematics Skills Among Girls Treated With E-O-T Feedback

Predictor	B	S.E. of B	BETA	F	Prob.
Math 1	0.700	0.128	.552	30.055	.000
Confidence	0.813	0.301	.259	7.316	.009
Recency	0.776	0.366	.180	4.482	.039
Constant	-1.029	2.039		0.254	.616
	$R = .795$, $R^2 = .631$, $F(3, 58) = 33.109$; $p < .0001$				
Incid. Learning	0.800	0.214	.033	0.141	.709
Preference.3	-1.385	5.446	-.023	0.065	.800
Preference.2	2.301	5.352	.039	0.185	.669
Preference.1	1.164	8.780	.012	0.018	.895
Primacy	0.236	0.360	.062	0.430	.515
	$R = .799$, $R^2 = .638$, $F(8, 53) = 11.681$; $p < .0001$ Change-in-$F(5, 53) = .198$; $p = .962$				

The results pertaining to long-term retention of mathematics skills for the pooled sample of girls are reported in Table 6.20. The same trend of results was clearly demonstrated in the pooled sample of girls.

Table 6.20

Selected Predictors of Long-Term Retention Of Mathematics Skills Among Girls

Predictor	B	SE of B	BETA	F	Probblty
Math 1	0.795	0.069	.629	132.371	.0000
Primacy	0.453	0.176	.134	6.615	.0109
Confidence	0.371	0.163	.121	5.228	.0238
Constant	2.265	1.102		4.228	.0411

R = .727, R^2 = .529, S.E. = 4.063,

Change in F(2, 188) = 6.239; p = .002 F(3, 188) = 70.386.

Preference.1	4.419	4.583	.053	0.930	.3362
Preference.2	3.906	2.589	.078	2.777	.1330
Incidental Lrnng	0.205	0.115	.091	3.139	.0781
Preference.3	-0.369	2.697	-.007	0.019	.8914
Recency	0.131	0.205	.036	0.744	.3894

R = .741, R^2 = .548, R^2-adj. = .529, S.E. = 4.043.

Change of F(5, 183) = 1.569; p = .1710; F(8, 183) = 27.774; p = .0000

6.5.2 Predictors of retention of mathematics skills among boys

Short-term retention of mathematics skills

For boys in each treatment group, the results did not consistently support the expectation that incidental-learning ability pertains to acquisition or short-term retention and rehearsal proficiency to long-term retention of mathematics skills. Although incidental-learning ability was a significant predictor of short-term retention of mathematics for boys treated with delayed feedback {$F(1, 53) = 12.462; p < .001$}, it was not significant for boys treated with item-by-item feedback { $F(1, 42) = 2.729; p = .106$}, nor for boys treated with end-of-test feedback {$F(1, 48) = 0.482; p > .10$}.

Long-term retention of mathematics skills.

Primacy rehearsal was a significant predictor of long-term retention of mathematics skills for boys treated with item-by-item feedback { $F(1, 48) = 5.764; p < .05$}; but it was not significant for boys treated with end-of-test feedback {$F(1, 48) = 0.011; p > .10$} nor delayed feedback {$F(1, 48) = 0.331; p > .10$}. Similarly, recency rehearsal was not predictive of the boys' long-term retention of mathematics skills. Also, no identifiable pattern of significance was observed for the affective variables. Therefore, the proposition that rehearsal proficiency is predictive of long-term retention of meaningful material among boys was not consistently supported.

6.6 Summary and Discussion of the Findings

The findings of the present study regarding feedback of test information on achievement support the hypothesis that one-day delayed feedback is more effective than item-by-item or end-of-test feedback for long-term retention of mathematics skills. This finding is consistent with results reported by several other studies (Sturges, 1972a, 1972b; More, 1969; Peeck & Tillema, 1979), that delayed feedback is generally superior to immediate feedback on the long-term retention of meaningful material. The present findings extend the realm of the delay-retention effect to the learning of curriculum-related mathematics skills by children in Grade 5.

The finding of a delay-retention effect with respect to the learning of mathematics skills is contrary to that of an earlier study (White, 1968) that used multiple-choice mathematics items with Grade 5 children. Whereas the results of the present study suggest that delayed feedback is superior to immediate feedback modes, White (1968) reported that immediate feedback students outperformed delayed feedback students. The finding of the present study is in closer agreement with the emerging trend of results on DRE with other types of meaningful material.

Differences between these results and those of White (1968) could have stemmed from two sources. Firstly, White used a feedback delay interval of seventy-two hours rather than the commonly used interval of twenty-four hours. The length of the delay of feedback seems to be crucial since More (1969) suggests that the delay interval for optimal retention is somewhere between three hours and twenty-four hours. More reported that ninety-six hours delayed feedback was ineffective compared to one-day delayed feedback. Secondly, Whites' immediate feedback treatment encouraged cheating; this aspect clouds the validity of his findings. The possibility that the participants in his study cheated was discussed extensively by White. The fact that participants of this study worked on their own, in test-like conditions during their first attempt at each testform, may have made the results of the present study less fraught with interpretive problems. Mention should be made of Joseph (1981) who also investigated the relevance of DRE for the learning of mathematics skill, and, like the present study, reported a significant treatment x time interaction. In Joseph's study, however, the treatment groups were significantly different on Occasion 1 and remained so on Occasion 3. A plot of the cell means indicated parallel graphs for the immediate (end-of-test) and delayed feedback groups. Unfortunately, the existence of initial group differences on Occasion 1 makes any interpretation of the treatment effects difficult. In the present study, the comparability of the treatment groups allows clearer interpretation of the effects of time of feedback on long-term retention of mathematics skill.

6.6.1 Differences between Item-by-Item and End-of-Test feedback treatments

The finding of no significant difference between the performance levels of end-of-test and item-by-item feedback groups on long-term retention was contrary to results reported by Sturges (1978). Two competing explanations may be provided for the present results. One is that differences between item-by-item and end-of-test feedback are entirely trivial (and unreliable). Two previous studies (Sturges, 1972a; and Sturges, 1978) included both item-by-item and end-of-test feedback treatments, but their relative effects were contrasted in only the latter study. Further research might be required to assess the reliability of the difference between the effectiveness of these two types of feedback.

An alternative explanation of the finding of no difference between the achievement scores of the two groups is that item-by-item and end-of-test feedback treatments are indeed different in effectiveness and that the present finding is a result of other important differences that characterized the two learning conditions. One probable important difference pertains to the extent to which the treatment conditions employed in the present study facilitate the use of cognitive strategies. The investigator observed the tendency of students in the item-by-item feedback group to erase check marks they made beside incorrect alternatives, and to retrace check marks they made beside correct answer options, so as to let the correct answers stand out from the wrong ones. Yet, when these students were required to tally their wrong responses to the test, they included all wrong response alternatives that were selected. A similar strategy used by some students in the item-by-item feedback group involved shading all referenced "w"s and leaving the "r"s exposed. These strategies could not have been used effectively by students in the end of test and delayed feedback treatments.

A seemingly important difference between the item-by-item and the end-of-test feedback treatments pertains to the extent to which the treatments allowed easy access to the test questions. Whereas students in the item-by-item feedback treatment looked back and forth from the answer sheet to the test questions, end-of-test feedback students tended to look at wrong responses made on earlier attempts to answer the test item, and to use these errors as the prime source of information for the new response. The latter strategy seems to allow relatively little understanding as to why an answer is correct or incorrect. Since letters associated with the correct answers changed randomly from one testform to another, the comparing of answer sheets strategy was less effective for high performance on subsequent occasions than the back and forth eye-movements typical of item-by-item feedback students. The fact that item-by-item feedback students did better on the short-term retention test written on Occasion 2 is consistent with the second alternative explanation.

The indication that different treatments allowed students to use different strategies on Occasions 1 and 2 is also consistent with the superiority of item-by-item feedback over end-of-test and one-day delayed feedback for short-term retention. The higher achievement scores on the short-term retention test, then, could be attributable to differences in the use of strategies the treatments allow rather than to differences in time of feedback. In sum, the item-by-item feedback condition (in which students use one answer sheet for both the initial attempt and the correction of errors) seems to allow the use of more efficient recoding strategies than do other learning conditions where more than answer sheets are referenced while correcting wrong test responses. Strategies used in greater frequency by the item-by-item feedback group include back and forth eye-movements from the wrong responses to the test items, and the tactile and visual cue of making bold all correct selections. End-of-test and one-day delayed feedback students, unlike item-by-item feedback students, were excited by the total score and the size of the total-score gains. The total score could not serve as a distractor to item-by-item feedback students since they were allowed to consider the total score only after they had found the right answer to all thirty questions. Differences between the feedback treatments on the short-term retention test, then, may be explainable by treatment differences that are unrelated to time of feedback.

6.6.2 The interaction of selected information-handling and affective variables with time of feedback

Findings of the present study discussed in this section may be summarized as follows:

1. Recency-rehearsal proficiency interacted significantly with time of feedback on level of mathematics skill, whereas incidental-learning ability and primacy-rehearsal proficiency did not interact significantly with time of feedback.
2. Confidence in academic ability was associated with within-treatment regression estimates that were significantly different on both short-term and long-term retention of mathematics skills. Preference for time of feedback, on the other hand, did not interact significantly with time of feedback.

3. Students whose feedback preferences were met outperformed students whose feedback preferences were not met. Also the combined effect of meeting students' feedback preferences with that of time of feedback was significant especially on the long-term retention of mathematics skills.

In all instances where significant differences were observed, one-day delayed feedback was associated with relatively flat regression estimates; this suggests that delaying feedback for one day might help to counteract processes that serve normally to delimit the perfomance level of students who are low in the abilities in question. But delaying feedback for one day might also prevent highly confident students from using very efficient coding strategies that seem to foster high-level, long-term retention of meaningful material.

Why recency-rehearsal and not other information-handling variables?

An answer to this question relies heavily on distinctions commonly made between recency-rehearsal and other information-handling strategies. Distinctions are clearest between recency-rehearsal and incidental-learning ability. As a rehearsal process, recency-rehearsal involves active recital of to-be-remembered material, with the intent to store or hold the various bits of information in memory. Whether covert or overt, the definitive characteristic of rehearsal, then, lies in the individual's intent to store or keep the to-be-remembered material in mind, and his execution of a systematic, repetition strategy to accomplish this end. With respect to incidental-learning ability, the student is unaware that the material will be tested. Since he is fully engaged in an orienting task while the to-be-tested material is reduntantly exposed, the learning of this crucial material takes place at a nonrehearsing or incidental level. Therefore, incidental-learning involves passive attention compared to the active repetition and recoding of information in a rehearsal learning situation.

The finding of a significant *recency-rehearsal x time of feedback* interaction and, at the same time, nonsignificant *incidental-learning x time of feedback* interaction might be reflecting an important difference between feedback learning conditions. This difference pertains to the extent to which the feedback conditions allow active processing of items to be remembered. The feedback treatments might not differ remarkably in the extent to which they allow participants to acquire and store the information at a peripheral level. Where errors have recently been made, it might be necessary to hold the corrections (or new pieces of information) in mind for a while in order to ensure high level, long-term retention of the corrections. Therefore, a critical difference between immediate and delayed feedback learning conditions might be the extent to which they allow the learner to rehearse and thus actively process the material to be remembered, rather than merely seeing or hearing the new information. This view is consistent with learning theories proposed by Thorndike, Pavlov, and Hull (see Hilgard & Bower, 1983) that reinforced repetition strengthens the memory trace, as well as with Anderson's and Bower's (1974) theory of *propositional encoding*. The latter position is consitent with recent extensions of information processing theory that the active learner can represent recently learned information to himself, that the propositional form is updated with each new presentation, and that a recent presentation might include information gone unnoticed in earlier presentations.

All counter hypotheses with respect to the different interaction effects of primacy- and recency-rehearsal with time of feedback cannot be eliminated at this stage of the research. In explaining these findings, one of two alternative positions might be taken. The first position argues that the findings of a significant *time of feedback x recency-rehearsal proficiency* interaction and of nonsignificant *time of feedback x primacy-rehearsal* interaction is valid and reliable. For support, the position resorts to distinctions made between these types of rehearsal in theory. Recency- and primacy-rehearsal are frequently referred to as Type I and Type II rehearsal (Craik & Lockhart, 1972; Rundus, 1977; Nelson, 1977; Woodward, Bjork, & Jongeward, 1973). Type I rehearsal is used to maintain information in short-term memory, and is measured best by performance in the last serial positions of a digit-span task (Ornstein, 1977; 1978; Rundus, 1971; 1977). Type II rehearsal (also called coding rehearsal by Rundus, 1977) results when the individual intends to transfer the material to long-term storage. The learner usually performs more extensive analyses of the stimulus material when using Type II rehearsal. Such extensive analysis might involve systematically linking digits together (e.g. by order, and in three-then-four, telephone-number-like patterns). This type of rehearsal proficiency is measured adequately by performance in the primacy serial positions of a digit-span task (Bisanz, 1982; Ornstein, 1977; 1978).

Researchers (such as Woodward, Bjork, & Jongeward, 1973, 1975) have shown that both types of rehearsal promote long-term storage of meaningful material, but that Type I rehearsal is more effective for high performance on recognition tests whereas Type II rehearsal is better when the retention test involves recall. Other important distinctions made by Das (1982), Rundus (1977), and Ornstein (1978) state that whereas recency rehearsal requires a search of working memory for the appropriate response, primacy-rehearsal proficiency involves retrieving bits of information that have been recently stored in long-term memory. The former involves the ability to hold bits of information in mind, whereas primacy-rehearsal resorts to the use of efficient search operations for high performance.

The significant time of feedback x recency-rehearsal and the nonsignificant time of feedback x primacy-rehearsal proficiency may now be interpreted in the light of these distinctions. The findings discussed here seem to suggest that immediate and delayed feedback learning conditions differ more with respect to opportunities of holding the crucial relationships or stimuli in mind than with respect to opportunities for retrieving these bits of information, once they are stored. Individual differences in ability to search memory and to hold information in mind might be both critical for high performance on a long-term retention test, but only the latter ability might be able to differentiate clearly between the performance of students provided with immediate feedback and students provided with delayed feedback. Where feedback is provided immediately, high performance on a long-term retention test might require that information be held in mind for awhile until new relationships are adequately integrated with related material already in storage. This, indeed, is the position of Anderson's and Bower's (1974) propositional encoding theory. Individuals presumably form propositions about to-be-remembered material; and, especially where errors have recently been made, time is required to adequately update the propositional form after each presentation of new material. This interpretation is inconsistent with the view of Kail and Hagen (1979) and Rundus (1971) that rehearsal improves long-term retention merely because it provides the individual with retrieval practice. On the other hand, it is consistent with Ornstein's and Aviano's (1977) view that it is the size of the rehearsal set that is critical for good long-term retention.

These researchers partialled out rehearsal set-size from rehearsal frequency scores and found that the previously very significant relationship between rehearsal frequency and level of long-term retention had reduced to near zero. Rehearsal set-size, then, might be the critical variable. Individuals who are proficient at holding information in mind might normally link more bits of information together such that the task of handling or holding the information is made easier.

An alternative explanation of a significant recency-rehearsal x time of feedback interaction and yet a nonsignificant primacy-rehearsal x time of feedback interaction is that individual differences in ability to search memory for recently stored material can account for much of the variance of long-term retention of meaningful material, irrespective of time of feedback. Consistent with this view is the finding of the present study that primacy-rehearsal is the significant predictor of long-term retention of mathematics skills among girls after individual differences in mathematical ability have been removed. The important question is whether high level long-term retention under one type of feedback condition requires more of a particular type of rehearsal ability than do other feedback learning conditions; in other words, whether immediate-feedback learning conditions limit the use of a type of rehearsal that is critical for high level long-term retention. It is possible that even though retrieval of recently stored information influences performance on a long-term retention test, none of the feedback treatments really prevented students from retrieving information they had learned; mediatory cognitive processes may take place on what was learned anytime during the retention interval. More critical for high level long-term retention seems to be how much information was taken in or really understood when the feedback was presented. This is indicative of the finding of similar within treatment regression estimates for primacy-rehearsal, and heterogeneous regression estimates for recency-rehearsal proficiency. Confirmation of this finding is necessary before the alternative hypothesis of trivial interaction between primacy-rehearsal proficiency and time of feedback should be credited. More sensitive measures of rehearsal proficiency might reveal different interaction effects. Subsequent studies might include measures of rehearsal obtained from longer delays between the end of a sequence of numbers and the probe of a particular serial position.

Interaction of affective variables with time of feedback on mathematics skill level

The present study reports a significant effect of confidence in academic ability x time of feedback interaction on level of mathematics skill, and, at the same time, nonsignificant interactions between time of feedback and the dimensions of preference for immediate feedback. The pattern of the within cell regression estimates for the confidence x time of feedback interaction indicates that whereas students at the various levels of confidence benefited when feedback was delayed, it was largely the highly confident student who benefited when feedback was provided immediately. This was the case especially on the measures of long-term retention where the regression estimates (of 0.715, 1.468, and 0.233 for the item-by-item, end-of-test and one-day delayed feedback groups, respectively) were significantly different at the .01-level. The finding of a flat regression line for delayed feedback students and relatively steep regression lines for immediate feedback treatments is consistent with the results of Joseph (1981), that another subscale of academic self-concept interacted significantly with time of feedback on level of performance in mathematics. (The findings of the earlier study could not have been replicated more closely here, since self-perceptions of ability in reading/ spelling were all very high in this sample of students. By Grade 5, most students seem to become less concerned about their ability to read relative to how they felt about themselves when they were at earlier grade levels.)

An important difference between immediate and delayed feedback modes might be the extent to which the students involve their self-concept of academic ability while studying the feedback information. The disordinal interaction suggests that students who are high in academic self-confidence learn and retain best from immediate feedback conditions.

The occurrence of lower performance levels for highly confident students treated with delayed feedback than highly confident students treated with item-by-item feedback (whereas the opposite is true for low-confidence students) supports the interpretation that high- and low-confidence students differ in their approach to mathematics tasks. Highly confident students might be attempting to keep in mind the various relationships between several of the answer options and the item stem and, consequently, function best in an immediate feedback situation where all of these relationships have recently been studied. The task of recalling all of these relationships when the right answer is reported might be more difficult in a delayed feedback situation than in an item-by-item feedback condition. Low-confidence students, on the other hand, might wish to ignore relationships that lead to wrong answers and study those that are directly related to the correct response (after the right answer is known), and might do this best when the relationships that lead to wrong answers are forgotten. Their memory stores would include relationships that tell *why the correct answer is x* rather than both *why the correct answer is x as well as why it is not y.* The lower performance levels for highly confident students treated with delayed feedback than for similarly confident students treated with item-by-item feedback might be reflecting limitations of ability to include both types of relationships in the propositional logic of concepts necessary for reaching the right answers when test-results feedback is delayed.

Preference for time of feedback. The effect of the interaction of the student's preference with time of feedback on long-term retention was not significant for each dimension of the preference scale; but significant interactions were observed at short-term retention for Scale 2 and at Occasion 1 for Scale 3. The pattern of results obtained here does not lend itself to simple theoretical explanation.

The students considered three attributes of the feedback modes in making their preferences. Two of these attributes seemed (from an examination of the pattern of stimuli weights on each solution or dimension) to be: the usual/unusual nature or feasibility of the time of feedback, and the length of the feedback delay interval. These attributes seem quite different from the components of academic self-perceptions. Differences between the interactions observed for preference for time of feedback and for academic self-confidence can be easily explained in terms of the unique attributes of each construct.

On both the short-term retention and long-term retention tests, clear effects were observed for having one's preference satisfied; and the combined effects of the *preference satisfaction* and *time of feedback* factors were significant especially on the long-term retention of mathematics skills. The interaction effects of the preference satisfaction and time of feedback factors were most remarkable between the end-of-test and one-day delayed feedback groups. Indeed, the difference in mathematics performance between these two treatment groups was carried by the preference-met factor. In other words, whereas it did not matter whether or not students treated with delayed feedback got their preferences satisfied, end-of-test feedback students whose preferences were not met performed poorly compared to those whose preferences were satisfied. The effects of *preference satisfaction* and the interaction of *time of feedback x preference satisfaction* were not confounded with mathematical ability since, at Occasion 1, the groups were similar ($p > .10$) on both the treatment and the preference satisfaction factors as well as on their interaction effects.

6.6.3 The regression analyses

For girls within each treatment group, the regression analyses revealed a consistent trend. The affective variables of preference for time of feedback and confidence in academic ability were significant predictors of short-term retention of mathematics skills, after controlling for individual differences in mathematical ability. In the end-of-test feedback group, rehearsal proficiency was also predictive of short-term retention, but its influence was superceeded by the students' self-confidence. The affective and information-handling variables were reversed in their predictability of long-term retention of mathematics skills, rehearsal now being more heavily weighted than academic self-confidence. These findings support the proposition that rehearsal proficiency has relevance for an understanding of long-term retention of meaningful material, and reliance on an information-processing framework for explaining the delay retention effect. But contributions of variables of affect to the predictive accuracy of the regression equations were reliable even after variance attributable to information-handling variables had been accounted for. This finding suggests that any adequate explanation of learning and retention of mathematics skills among girls should include the influence of parameters of affect in addition to information-handling or cognitive variables.

For boys, the results were not clear. Incidental-learning ability was significant ($p < .001$) for predicting short-term retention of mathematics skill in the delayed feedback group, and primacy rehearsal was significant ($p < .05$) in the prediction equation of long-term retention for boys treated with item-by-item feedback. But the results in other instances did not strongly support the proposition that incidental-learning ability is predictive of short-term retention, whereas rehearsal pertains to long-term retention. The limited number of boys in each treatment group may have been one reason for the finding of unreliable regression coefficients. The standardized regression coefficients frequently approached significance and were relatively large. But individual differences in mathematical ability accounted for most of the variance in the various regression equations.

7. CONCLUSIONS AND IMPLICATIONS

The conclusions should be of interest to educationists concerned with matching test item feedback parameters with test item response characteristics in order to optimize the learning [illegible] retention of mathematics skills. One caution is that the study involved Grade 5 stud[illegible] the Edmonton Public School District) who may have been in the process of developing their proficiency with rehearsal strategies. For students who are more mature (or less mature) rehearsers, the interaction of rehearsal proficiency with time of feedback might be quite different. Therefore, the findings are limited to Grade 5 students. Replications of the study at other grade levels are required before the results can be justifiably applied to children in other age groups.

7.0.1 The relevance of DRE for the learning of mathematics.

In examining the relevance of the delay-retention effect (DRE) for the learning and retention of [illegible]tics skills, the results showed three feedback treatments (item-by-item [illegible]nd-of-test feedback, and one-day delayed feedback) as being associated wi[illegible]mean profiles over the experimental period of 10 days. *Item-by-item fe[illegible]as found to be superior to end-of-test and one-day delayed feedba[illegible]or sho[illegible] (next day) retention,* whereas *one-day delayed feedback was signific[illegible]y be[illegible] than other types of feedback for long-term (seven-day) retention.* The findi[illegible] of si[illegible]ficantly higher long-term retention of mathematics skills for one-day delayed fe[illegible] than for item-by-item and for end-of-test feedback supports the propositio[illegible]he delay-retention effect has relevance for the learning and retention of mathematics [illegible]lls. It should be remembered that the criterion pertained to participants' ability to ret[illegible]mathematics skills which they had grasped (or understood). Test items used on Occa[illegible]n 1 were not re-presented; rather, on Occasions 2 and 3, participants were required [illegible] respond to test items that were parallel to the initial ones. Therefore, the finding of the superiority of delayed feedback over immediate feedback seems to have relevance for the retention of knowledge previously grasped. Significant differences observed here may be more attributable to the influence of affective than of cognitive paramet[illegible]nce all students were allowed to rework questions done wrongly until they did them correctly. The more dramatic interaction observed between time of feedback with the affective variables (academic self-confidence and preference satisfaction) than with the cognitive variables (incidental-learning ability, primacy rehearsal, and recency rehearsal) is consistent with an interpretation that credits the influence of extra-cognitive parameters on the retention of mathematics skills. The fact that delayed feedback students did better than others on Occasion 3, even though this was not the case on earlier occasions, makes inadequate interpretations of the delay-retention effect that assumes a purely linear relationship between acquisition and retention of meaningful material.

The superiority of item-by-item feedback over end-of-test feedback for short-term retention of mathematics skills was thought to result from the use of additional strategies that this treatment encouraged students to use in the item-by-item feedback group. Some of these strategies included: erasing wrong selections, retracing right answers, and back-and-forth eye movements between the answer sheet and the question booklet. The transfer of short-term retention gains from Occasion 2 to Occasion 3 was not enough to offset the superiority of one-day delayed feedback in influencing long-term retention.

7.0.2 The interaction of information-handling and affective variables with time of feedback on level of mathematics skills.

Effects of the interaction of the treatments with information-handling and affective variables were investigated. One information-handling variable (incidental-learning ability) was seen as a measure of alertness or passive attention; the others (primacy rehearsal and recency rehearsal) involved much student effort and concentration. Primacy rehearsal involved retrieving information that was recently stored, whereas recency rehearesal involved the ability to hold bits of information in mind. *Recency rehearsal interacted significantly with the effectiveness of the treatments on long-term retention of mathematics skills, although this was not the case on two earlier occasions. Other information-handling variables (incidental-learning ability and primacy rehearsal) did not interact significantly with the three treatments.* It seems, then, that holding the material in mind for a while is necessary for high level long-term retention, especially when the information is to be used to correct errors made previously. Although both ability to retrieve information just after it is stored and incidental-learning ability might be important for high level long-term retention, these information-handling strategies showed similar significant relationships with all treatment groups. Therefore, they do not differentially effect immediate and delayed feedback

The affective variables.

Confidence in academic ability interacted significantly with the feedback treatments at Occasion 2 and also on the long-term retention of mathematics skills (measured on Occasion 3). With respect to long-term retention, end-of-test feedback seemed best for students (73 out of 359) in the highest self-confidence category, whereas feedback delayed for one day promoted the best long-term retention among students of low or average confidence. In the end-of-test feedback learning condition, confident students might be using a hierarchy of response alternatives to assist them in correcting their errors, particularly since the hierarchy and the various relationships between each answer option and the question stem seem to be still clear in their minds. Confident students might be using these relationships to adequately update their propositional logic of those concepts which are necessary to find the right answers. Thus, they retain corrections of test results feedback better in an item-by-item feedback situation, where the various relations have been recently studied, than in a delayed feedback situation where some of these relationships may have been forgotten when the right answers were presented. Students of low academic self-confidence seem to find the mass of available information distracting (Hansen, 1974), and, consequently, do better in a delayed feedback situation where much of this information is forgotten. The present finding of a significant interaction between academic self-confidence and time of feedback on level of mathematics skill is consistent with Kulhavy's (1977) information-processing conceptualization of how learning takes place under various feedback conditions, as well as with Hansen's (1974) report of relationships between trait anxiety and long-term retention of curriculum material.

The finding of significant interaction between time of feedback and both recency-rehearsal proficiency and confidence in academic ability suggests that the three feedback conditions differ in the extent to which they facilitate the use of strategies commonly used by students who are high in recency-rehearsal proficiency and confidence in academic ability. Recency rehearsal has been theorized to reflect short-term memory capacity; and a consistent relationship has been identified between short-term memory capacity and long-term storage (Este, 1982). But it is not clear how students who are high in short-term memory capacity differ from students of low short-term memory in the use of coding strategies. This issue seems to merit further research. Once these differences are identified, interest might be directed to the training of students who are deficient in short-term memory capacity.

7.0.3 Predicting retention of mathematics skills.

The affective variables were more important for girls than boys. Once individual differences in mathematical ability were accounted for, the girls' preference for time of feedback and confidence in their academic abilities were the significant predictors of short-term retention of mathematics skills; for long-term retention, the significant parameters were rehearsal proficiency and confidence in academic ability.

Although the findings of significant interactions with the test results feedback treatments support Kulhavy's (1977) proposition that confident students enhance their performance level by taking advantage of their superior short-term memory capacity. This explanation seems to be only part of the picture. Especially among girls, confidence in academic ability seems to account for portions of the variance in mathematics achievement that are separate from variance accounted for by cognitive variables such as rehearsal-proficiency and incidental-learning ability. This finding seems to merit further research effort. A research paradigm that incorporates the possibility of loss of information through repression and interference along with the information-processing framework might prove to be useful in subsequent research efforts.

7.1 Suggestions For Further Research

The results of the investigation indicated a number of parts that future research might fruitfully undertake:

1. The finding of significant preference satisfaction x time of feedback interaction on mathematics skill level seems to have much potential for classroom application, and as such, merits further investigative effort. Very little research has examined the influence of students' feedback preferences on their performance level. Therefore, confirmation of the findings of the present study seems to be the next logical step. One needs to survey the relevance of the results for other subject areas and with other population groups before the reliability of the findings can be properly estimated.
2. One is curious to know how the present findings of significant interactions of time of feedback with information-handling variables and confidence in academic ability apply to young children who have not begun to use rehearsal strategies spontaneously. An examination of the interaction of time of feedback with information-handling strategies used by young children might provide useful information here. Critical information-handling strategies for young children might include eye movements and components selection ability.
3. The significant interactions of time of feedback of mathematics test results with recency-rehearsal proficiency and also with the affective variables of confidence in academic ability and preference satisfaction might be indicating important considerations for the matching of test-item feedback parameters with test-item response characteristics. Experimental efforts might further investigate the pay off, in terms of improved long-term retention, of meeting students' feedback preferences, as well as of placing high-confidence and low-confidence students in learning conditions that seem to promise greatest rewards for effort.
4. Enhancing variables of affect, such as self-confidence and preference for time of feedback, seem to promise improvements in mathematics performance level among girls. For girls' short-term retention of mathematics skills, the critical affective variables were preference for time of feedback of test results and confidence in academic ability; and for long-term retention (which is usually the educational goal),

effort might be best spent enhancing primacy-rehearsal ability and confidence in academic ability. This finding seems to merit further research. Subsequent research efforts might be experimental in nature, or they might seek confirmation of the finding in other age groups. Also, one is curious to know whether variables of affect such as confidence in academic ability and preference for time of feedback is predictive of mathematics skill level in other samples of girls.

5. Proponents of information-processing models of learning might be interested in reconsidering the finding that confidence in academic ability significantly contributed to the prediction of mathematics skill level after variance due to rehearsal proficiency had been accounted for. Attempts to replicate this finding might include information-handling variables not included in the present study. Alternatively, a research paradigm that credits theories about the repression of storage associated with negative affect might survey the long-term retention of information of varying relationships with measures of participants' self-confidence.

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APPENDIX A: THE BLUE PRINT OF THE MATHEMATICS ACHIEVEMENT TESTS

The domain of the achievement test includes mathematical concepts, operations and problem solving skills taught at the Grade 4 and early Grade 5 levels in the public schools of Edmonton. The important features of the blue print of the test are specified in the following description of the test domain.

7.1 Frequently Used Abreviations

H(C,) - horizontal, canonical arrangement -

indicates that the problem should be presented as follows:

632 + 4 = ___, 632 - 4 = ___, 632 X 4 = ___, 632 4 = ___.

H(,Nc) - horizontal, noncanonical arrangement -

indicates that the problem should be presented as follows:

___ + 4 = 632, ___ - 4 = 632, ___ X 4 = 632, ___ 4 = 632.

or 4 + ___ = 632, 632 - ___ = 4, 4 X ___ = 632, 632 ___ = 4

V(C,) - vertical, canonical arrangement -

indicates that the problem should be presented as follows:

632	632	632	4) 632
+400	-400	X 4	

V(,Nc) - veritcal, noncanonical arangement

indicates that the problem will be presented as follows:

400	632	158
+ -----	- -----	X -----
632	400	632

F find, find the missing element (e.g. the missing number)

I identify, (e.g., which one, in which one, select)

R round, requiring the rounding of rational numbers (e.g. numerical answers to the nearest whole number, tenth, or hundredth.

E write whole numbers or rational numbers in expanded notation or vice versa.

7.2 Description of the Test Domain

Op.	Format	Content	Important Features	Replacement Scheme	Wght
E	words/ numbers	numbers to 9.999	multiples of 10 excluded	transformations: numbers to words.	1
I	sketches	Simple geometric figures	similarities and differences	vary number of sides and size of angles.	1
I	graph	Locating points;	1st quadrant.	Well known places.	1
F	H(C)	Dividends to 999	equivalent quotients	Multiples of 10 only.	1
I	Words H	place value 99.9 to 99 999.9	less than or larger than	Adding 1, 10 or 100.	1
I	Words H	Place value .001 to .09	hundredths and thousandths	fractions to decimals	1
I	H(C)	Zero and identity	four operations	1-digit numbers	1
I	numeric	Simple fractions such as 1/2, 1/5, 3/4.	largest/smallest	same numerator or same denominator	1
I	Graphic	Decimals: tenths and hundredths	10 columns per figure 10 squares per column	Shade whole squares	1
R	numeric	.01 to 99.99	to the nearest whole number/ tenth	given numbers or answers of simple operations	2
-	V(,Nc)	Minuend to 9 999	With regrouping		1
X	H(C,)	Product to 9 999	With carrying	Two-digit multipliers	1
	H(C,)	Dividends to 999	Without remainders	1-digit divisors	1
	H(C,)	Dividends to 999	With remainders	1-digit divisors	1
+	V(,Nc)	Sum to 99 999.99	Three addends	4 to 6 digit numbers	1
-	H(C,)	Minuend to 99 999.99	With regrouping	Sum to mult. of 100	1
+	H(C,)	Sum to 99.99	With regrouping	Three terms	1
X+-	H(C,)	Sum to 999	X with + or -, 2 terms	1-digit factors	1
X	H(C,)	product to 999.99	mult. of 10 product	1-digit, whole nmbr multiplier	1
-	Story	Minuend to 9 999	1-step, regrouping	Involving a known workman	1
X-	Story	Product to 999	2-step, regrouping	Involving common objects	1
X+	Story	Product to 999	2-step, 1 mult. of 10	Involving common activity	1

	Story	Dividend to 999	1-step, 1-digit divisor	Involving common objects	1
F	Story	Selective Comparsn	1-step, 1 redundancy	Frequently used objects	1
X	Story	Product to 99999.99	1-digit multiplier	Currency	1
	Story	Geometric sequence	Given mult. + one term	Provide previous term	1
+-	Story	Short Grocery bill	Making change $2 to $10	Two terms	1
X+	Story	Short grocery bill	Payments, $2 to $5	Three terms	2

APPENDIX B: THE MATHEMATICS ACHIEVEMENT TESTS

MATHEMATICS ACHIEVEMENT TEST

GRADE 5

FORM 1

NAME: ____________________

SCHOOL: ____________________

SEX: __________ GRADE: ______ AGE: ______ YEARS, ______ MONTHS

DATE: ____________________

CUTHBERT H. JOSEPH

THE UNIVERSITY OF ALBERTA

EDMONTON, ALBERTA

1. DIRECTIONS

This exercise includes 30 mathematics questions selected from math content you have been taught already. You should find the exercise interesting and useful.

FOUR (4) different answers are provided for each question. CHOOSE THE ONE ANSWER THAT YOU THINK IS CORRECT. ON THE ANSWER SHEET, FIND THE ROW THAT HAS THE SAME NUMBER AS THE QUESTION. Then, use your pencil to SHADE THE ANSWER SPACE (a, b, c, or d) THAT MATCHES THE ANSWER YOU HAVE CHOSEN.

Here are two sample questions. The first one is answered for you.

SAMPLE QUESTIONS

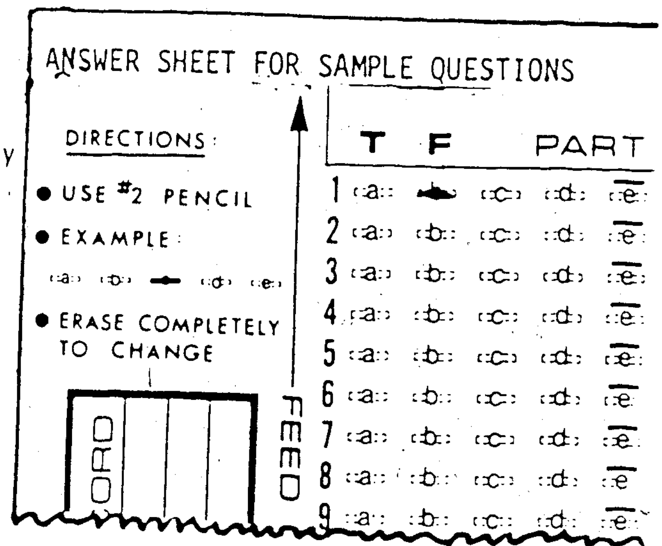
1. Harry has 1 apple. Bob has 2 apples. How many apples do Harry and Bob have altogether?

a) 2

b) 3

c) 4

d) 5



The correct answer is "3"; that is *choice b*. Therefore, *b*, in the first row of the ANSWER SHEET for the SAMPLE QUESTIONS, is shaded to show this.

2. ADD 2
+2

a) 2

b) 3

c) 4

d) 5

SHADE *c* IN ROW 2 of the ANSWER SHEET for the SAMPLE QUESTIONS to show that 4 is the correct answer of SAMPLE QUESTION #2.

1. 9.372 is read as

   a) 9 thousands and 372 ones

   b) 9 and 372 tenths

   c) 9 and 372 hundredths

   d) 9 and 372 thousandths.

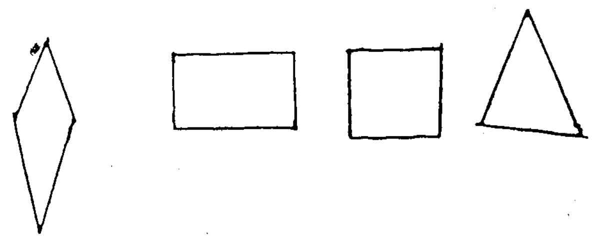
2. Here are four figures in mathematics. Select the figure that is most different from the others

   a) Kite

   b) Rectangle

   c) Square

   d) Triangle.



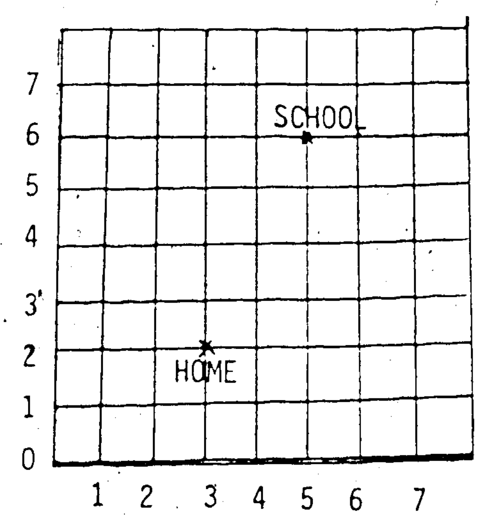
3. Which one of the following answers inlcudes the correct co-ordinates for <u>both</u> HOME and SCHOOL?

   a) HOME (3,2); SCHOOL (6,5)

   b) HOME (3,2); SCHOOL (5,6)

   c) HOME (2,3); SCHOOL (6,5)

   d) HOME (2,3); SCHOOL (5,6)



4. Which one of the following is equal to 9 ÷ 3 ?

   a) 900 ÷ 300

   b) 900 ÷ 30

   c) 900 ÷ 3

   d) 90 ÷ 300

5. Select the number that is 1 larger than 999.9

   a) 999.91

   b) 1 000.0

   c) 1 000.9

   d) 1 999.9

6 Which one of the following numbers is equal to 46 / 1000 ?

a) 46 000

b) 0.46

c) 0.046

d) 0.00046

7. In which one of the following is ? greater than zero?

a) 9 - 9 = ?

b) 9 X 0 = ?

c) 0 ÷ 9 = ?

d) None of these.

8. In which one of the following sets of fractions is 1/6 the largest fraction?

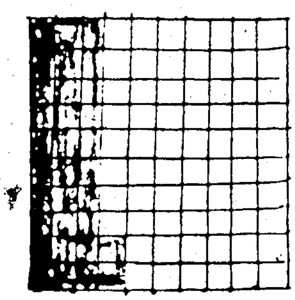
a) 1/3, 1/4, 1/5, 1/6;

b) 1/3, 1/6, 1/9, 1/12;

c) 1/6, 1/8, 1/10, 1/12;

d) 5/6, 4/6, 3/6, 1/6;

9. Write the decimal that tells what part of the square is shaded:



a) 32.0

b) 3.2

c) 0.32

d) 0.23

10. Which one of the following numbers is closest to 1 ?

a) 1.9

b) 1.37

c) 0.85

d) 0.7

[illegible] following numbers is closest to 0.14 X 8 ?

c) 1 1

d) 110

12. 3[illegible]57 (Find the missing number.)

- ? ? ? ?

374

a) 4 231

b) 3 583

c) 3 483

d) 2 483

13. Multiply 3 467 X 58

a) 201 086

b) 45 071

c) 27 736

d) None of these.

14. Divide $9\overline{)4\,590}$

a) 51

b) 501

c) 510

d) 5010

15. Divide $7\overline{)5\,882}$

a) 84 r 2

b) 840 r 2

c) 84.2

d) 840.2

16. Find the missing addend (number) of the following addition sum

```
  2 754.73
     67.21
+ ? ? ?.? ?
  3 384.93
```

a) 562.99

b) 563.09

c) 6 206.87

d) None of these.

17. Subtract 889.89 from 9 000.00

a) 8 111.21

b) 8 110.11

c) 110.21

d) 110.11

18. ADD the following numbers: 0.735 + 0.47 + 16.1

a) 943

b) 0.943

c) 17.205

d) 17.305

19. 151 X 3 + 151 X 2 = ___?___

a) 302 X 5

b) 453 - 302

c) 755

d) None of these.

20. Multiply 52.38 X 5

a) 26.19 b) 261.9

c) 2 619 d) None of these.

21. A postman has 374 mails to deliver. 98 of the mails are Christmas cards. If all the other mails are letters, then how many letters does the postman have to deliver?

a) 472 letters

b) 324 letters

c) 286 letters

d) 276 letters

22. A classroom has 13 rows of chairs with 9 chairs in each row. FOUR chairs were removed from the classroom. How many chairs remained?

a) 26 chairs

b) 113 chairs

c) 117 chairs

d) 121 chairs

23. Harry runs 55 meters per minute for 3 minutes. Then, he walks another 100 meters. How many meters did Harry run and walk altoether?

a) 155 meters

b) 165 meters

c) 265 meters

d) 465 meters

24. Linda filled 7 boxes with 1 064 apples. If all the boxes are of the same size, then how many apples did she pack in each box?

a) 109 apples

b) 150 apples

c) 152 apples

d) 7 448 apples

25. In Mary's handbag are 1 pen WITHOUT ink and 3 other pens WITH ink. How many pens must Mary take out of her handbag before she can be sure that she has a pen with ink?

a) 1 pen

b) 2 pens

c) 3 pens

d) 4 pens

26. Tickets for the FLAMES vs FLIERS hockey game were sold at $5.00 each. 9 460 people bought tickets for the game. How much money was collected?

a) $47 300.00

b) $47 000.00

c) $45 300.00

d) $1 892.00

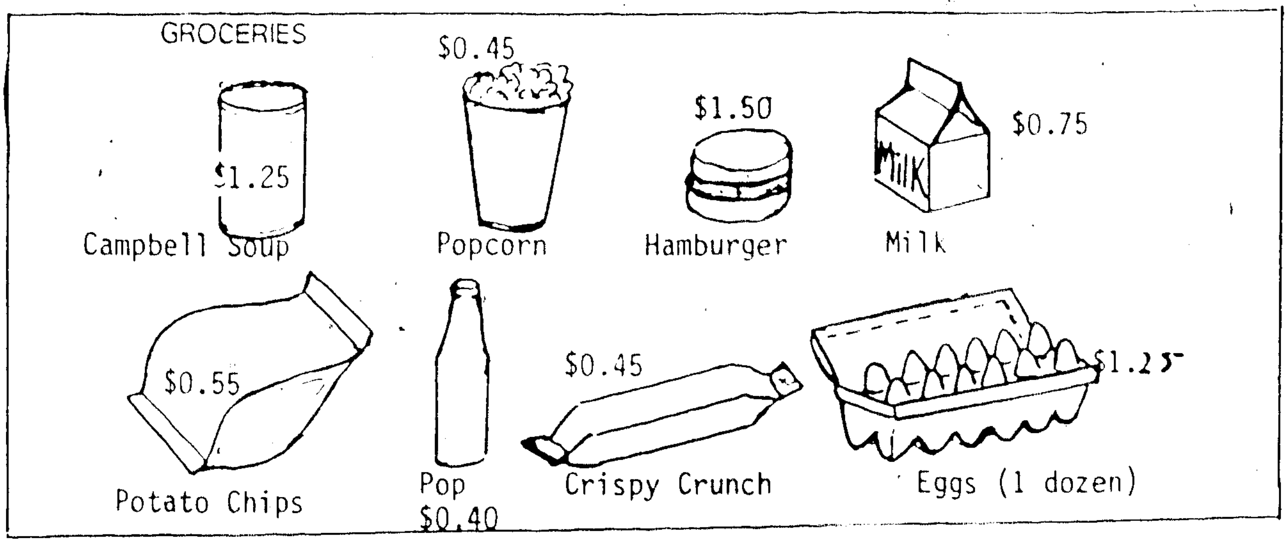
27. Tommy's father doubles Tommy's monthly allowance everytime Tommy has a birthday. Tommy is now 8 years old, and his monthly allowance is $50.00. How old was Tommy when his monthly allowance was $25.00 ?

a) 4 years old

b) 5 years old

c) 6 years old

d) 7 years old



28. Bob is buying 1 Hamburger and 1 milk from a $5.00 bill. How much change should he get back?

a) $2.75

b) $2.50

c) $2.25

d) $2.00

29. Jane is buying 1 Popcorn, 1 Pop, and 3 packages of Chrispy Crunch. How much should she pay?

a) $1.30

b) $1.75

c) $2.20

d) $2.30

30. Olivia is buying 2 bags of Potato Chips, 2 Campbell Soups, and 1 dozen Eggs. How much should she pay?

a) $4.85

b) $4.30

c) $3.60

d) $3.05

MATHEMATICS ACHIEVEMENT TEST

GRADE 5

FORM 2

NAME: ____________________

SCHOOL: ____________________

DATE: ____________________

SEX: __________ GRADE: __________ AGE: ________, ________
YEARS MONTHS

CUTHBERT H. JOSEPH

THE UNIVERSITY OF ALBERTA

EDMONTON, ALBERTA.

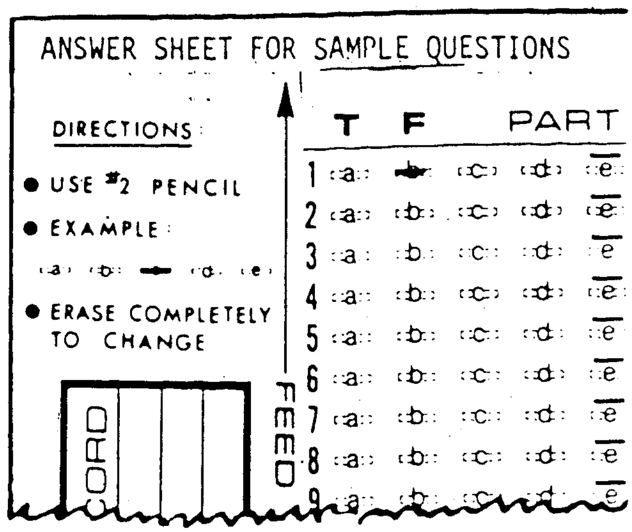
1984

2. DIRECTIONS

This exercise includes 30 mathematics questions selected from math content you have already been taught. You should find the exercise interesting and useful.

FOUR different answers are provided for each question. CHOOSE THE ONE ANSWER THAT YOU THINK IS CORRECT. ON THE ANSWER SHEET, FIND THE ROW THAT HAS THE SAME NUMBER AS THE QUESTION. Then, USE PENCIL TO SHADE THE ANSWER SPACE (a, b, c, or d) THAT MATCHES THE ANSWER YOU HAVE CHOSEN.

Here are two sample questions. The first question is answered for you.



SAMPLE QUESTIONS

1. Harry has 1 apple. Bob has 2 apples. How many apples do Harry and Bob have altogether?

   a) 2

   b) 3

   c) 4

   d) 5

The correct answer is *choice b*. Therefore, *b*, in the first row of the ANSWER SHEET for the SAMPLE QUESTIONS, is shaded to show this.

2. ADD $\begin{array}{r} 2 \\ +2 \\ \hline \end{array}$

   a) 2

   b) 3

   c) 4

   d) 5

The correct answer is "4". Therefore, SHADE *c* in ROW 2 of the ANSWER SHEET for the SAMPLE QUESTIONS to show that "4" is the correct answer to SAMPLE QUESTION #2.

1. 8.479 is read as.

   a) 8 thousands and 479 ones

   b) 8 and 479 tenths

   c) 8 and 479 hundredths

   d) 8 and 479 thousandths

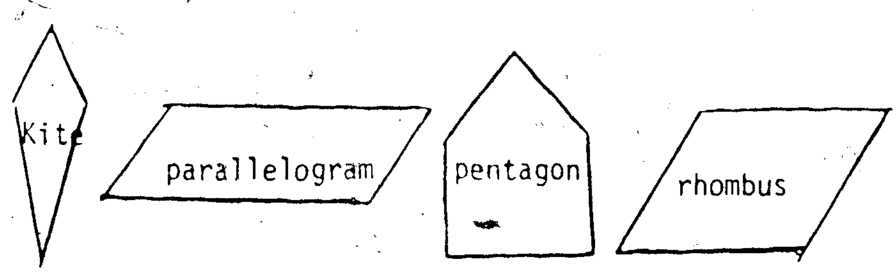
2. Look closely at each of the following figures, and then select the figure that is most like a square.

   a) Kite

   b) parallelogram

   c) pentagon

   d) rhombus



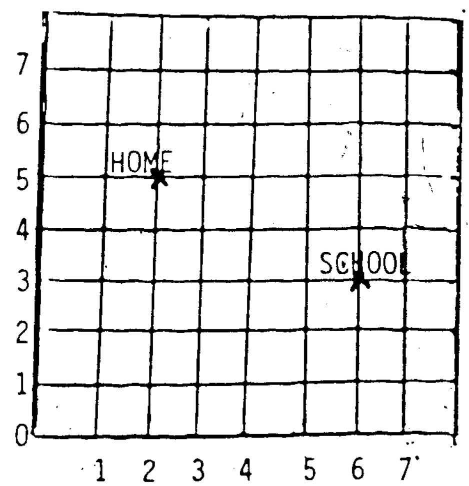
3. Which one of the following answers includes the correct co-ordinates for both HOME and SCHOOL?

   a) HOME (2,5), SCHOOL (3,6)

   b) HOME (2,5); SCHOOL (6,3)

   c) HOME (5,2), SCHOOL (3,6)

   d) HOME (5,2); SCHOOL (6,3)



4. Which one of the following is equal to 8 ÷ 2 ?

   a) 800 ÷ 200

   b) 800 ÷ 20

   c) 800 ÷ 2

   d) 80 ÷ 2

5. Select the number that is 1 larger than 9 999.9 :

   a) 9 999.91

   b) 10 000.0

   c) 10 000.9

   d) 19 999.9

6. Which one of the following numbers is equal to 37 / 1000 ?

a) 37 000

b) 0.37

c) 0.037

d) 0.00037

7. In which one of the following numbers is ? greater than zero?

a) 8 - 8 = ?

b) 8 X 0 = ?

c) 0 ÷ 8 = ?

d) None of these.

8. In which one of the following sets of fractions is 1 / 8 the largest fraction?

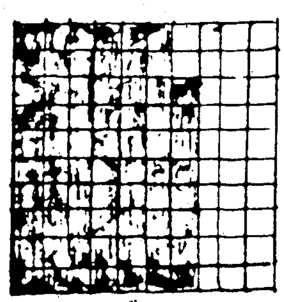
a) 1 / 4, 1 / 6, 1 / 8, 1 / 12;

b) 1 / 8, 1 / 9, 1 / 10, 1 / 12.

c) 1 / 4, 1 / 5, 1 / 6, 1 / 8,

d) 7 / 8, 5 / 8, 3 / 8, 1 / 8

9. Write the decimal that tells what part of the sqaure is shaded.



a) 68

b) 6.8

c) 0.86

d) 0.68

10. Which one of the following numbers is closest to 1 ?

a) 1.8

b) 1.25

c) 0.89

d) 0.7

11. Which one of the following numbers is closest to 0.13 X 9 ?

a) 1

b) 2

c) 12

d) 120

12. 27 564

-? ? ? ? ?

682

a) 28 246

b) 27 882

c) 26 982

d) 26 882

13. Multiply 3 570 X 46

a) 164 220

b) 35 700

c) 21 420

d) None of these

14. DIVIDE $9\overline{)6\,327}$

a) 73

b) 703

c) 730

d) 7030

15. $7\overline{)6\,862}$

a) 980 r 2

b) 98 r 2

c) 980.2

d) 98.2

16. Find the missing addend (number) of the following sum.

    2 583.52
       54.02
    + ? ? ? ?.? ?
    3 277.75

a) 640.21 b) 740.21

c) 2 637.54 d) 5 915.29

17. Subtract 19 000.99 from 20 000.00 .

a) 1 999.11

b) 1 999.01

c) 999.01

d) 99.01

18. ADD the following numbers: 0.463 + 0.39 + 14.2 = ____

a) 0.644

b) 0.995

c) 15.053

d) 644.0

19. 140 X 3 + 140 X 2 = __?__

a) 280 X 5

b) 420 - 280

c) 700

d) None of these

20. Multiply 26.15 X 8

a) 20.92 b) 209.2

c) 2092 d) None of these.

21. A postman has 367 mails to deliver. 89 of the mails are Christmas cards. If all the other mails are letters, then how many letters does the postman have to deliver?

a) 456

b) 322

c) 288

d) 278

22. A classroom has 14 rows of chairs, with 8 chairs in each row. FIVE chairs were removed from the classroom. How many chairs remained?

a) 27

b) 107

c) 112

d) 117

23. Mary runs 300 meters to the swimming pool. Then she swims for 10 minutes at the rate of 14 meters per minute. How many meters did Mary run and swim altogether?

a) 160 meters

b) 314 meters

c) 440 meters

d) 1 700 meters

24. Carmen is packing 18 848 sardines in 8 boxes of the same size. How many sardines must she pack in each box?

a) 216

b) 2 306

c) 2 356

d) 150 784

25. Kathy has 10 WHITE socks and 20 RED socks in a drawer. How many socks must she take out of the drawer before she can be sure that she has TWO socks of the SAME COLOUR ?

a) 3

b) 4

c) 5

d) 11

26. For the Eskimos vs Rough Riders football game, 17 357 tickets were sold. If each ticket was sold at $8.00 each, then how much money was collected?

a) $138 856.00

b) $138 456.00

c) $136 456.00

d) $2 169.62

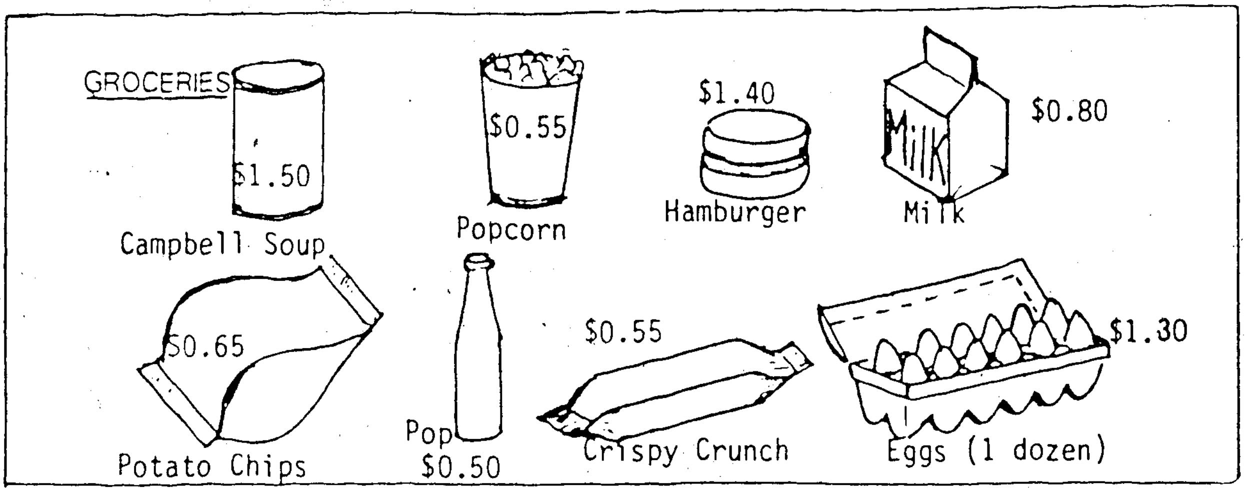
27. The number of bacteria on a piece of meat doubles in number every hour. It takes 12 hours for a piece of meat to be completely covered with bacteria. How long does it take a piece of meat to be half covered with bateria?

a) 6 hours

b) 8 hours

c) 10 hours

d) 11 hours



28. Bob is buying 1 Hamburger and 1 Milk from a $5.00 bill. How much change should he get back?

    a) $3.80

    b) $2.80

    c) $2.20

    d) $2.00

29. Jane is buying 1 Popcorn, 1 Pop, and 3 packages of Crispy Crunch. How much should she pay?

    a) $1.60

    b) $2.15

    c) $2.70

    d) $3.25

30. Olivia is buying 2 bags of Potato Chips, 2 Campbell Soups, and 1 dozen Eggs. How much should she pay?

    a) $3.45

    b) $4.10

    c) $4.95

    d) $5.60

MATHEMATICS ACHIEVEMENT TEST

GRADE 5

FORM 3

NAME: ______________________________

SCHOOL: ______________________________

DATE: ______________________________

SEX: __________ GRADE: ______ AGE: __________ YEARS, __________ MONTHS

CUTHBERT H. JOSEPH

THE UNIVERSITY OF ALBERTA,

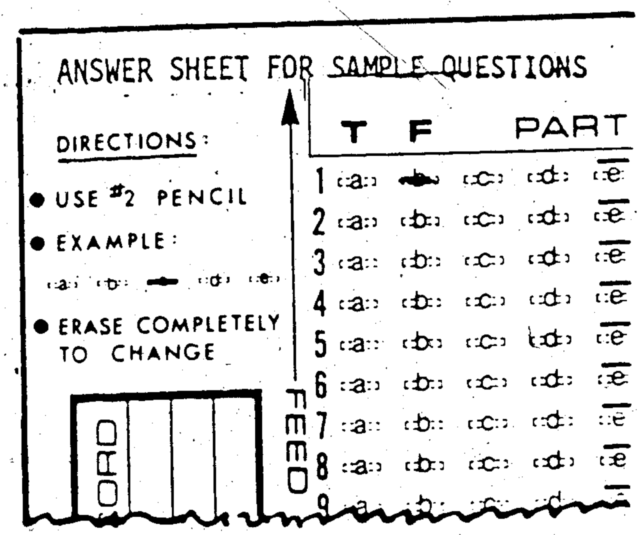
EDMONTON, ALBERTA.

3. DIRECTIONS: Form 3

This exercise includes 30 mathematics questions selected from math content you have been taught already. You should find the exercise interesting and useful.

FOUR (4) different answers are provided for each question. CHOOSE THE ONE ANSWER YOU THINK IS CORRECT. ON THE ANSWER SHEET, FIND THE ROW THAT HAS THE SAME NUMBER AS THE QUESTION. Then, use pencil to <u>SHADE THE ANSWER SPACE (a, b, c, or d) THAT MATCHES THE ANSWER YOU HAVE CHOSEN.</u>

Here are two sample questions. The first one is answered for you.



<u>SAMPLE QUESTIONS:</u>

1. Harry has 1 apple. Bob has 2 apples. How many apples do Harry and Bob have altogether?

   a) 2

   b) 3

   c) 4

   d) 5

The correct answer is "3"; that is *choice b*. Therefore, *b*, in the first row of the ANSWER SHEET for the SAMPLE QUESTIONS, is shaded to show this.

2. ADD 2 +2

   a) 2

   b) 3

   c) 4✓

   d) 5

SHADE *c* in ROW 2 of the ANSWER SHEET for the SAMPLE QUESTIONS to show that "4" is the correct answer of SAMPLE QUESTION #2.

1. 5.836 is read as:

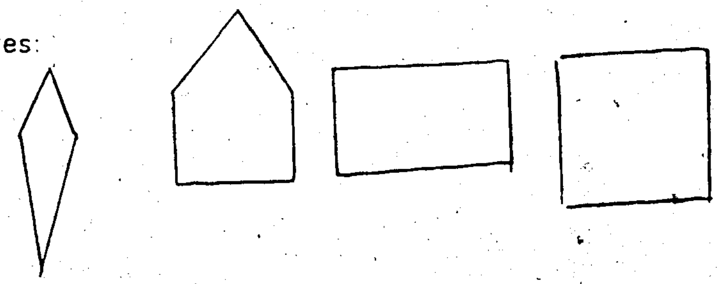
a) 5 thousands and 836 ones

b) 5 and 836 tenths

c) 5 and 836 hundredths

d) 5 and 836 thousandths

2. Look carefully at the sides of each of these figures. Select the figure that is most different from all the other figures:



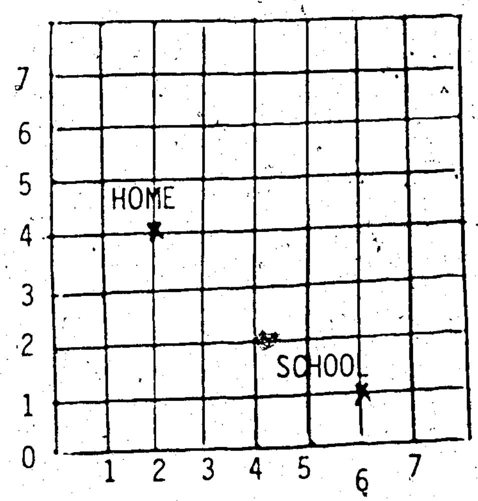
a) Kite

b) Pentagon

c) Rectangle

d) Square

3. Which one of the following answers includes the correct co-ordinates for both HOME and SCHOOL



a) HOME (2,4); SCHOOL (1,6)

b) HOME (2,4); SCHOOL (6, 1)

c) HOME (4,2); SCHOOL (1,6)

d) HOME (4,2); SCHOOL (6, 1)

4. Which one of the following is equal to 10 ÷ 2 ?

a) 1 000 ÷ 2 000

b) 1 000 ÷ 200

c) 1 000 ÷ 20

d) 1 000 ÷ 2

5. Select the number that is 1 larger than 7 999.9

a) 7 999.91

b) 8 000.0

c) 8 000.9

d) 8 999.9

6. Which one of the following numbers is equal to 69 / 1000 ?

a) 69 000

b) 0.69

c) 0.069

d) 0.00069

7. In which one of the following is ? greater than zero?

a) 4 - 4 = ?

b) 4 X 0 = ?

c) 0 ÷ 4 = ?

d) None of these.

8. In which one of the following sets of fractions is 1 / 5 the largest fraction?

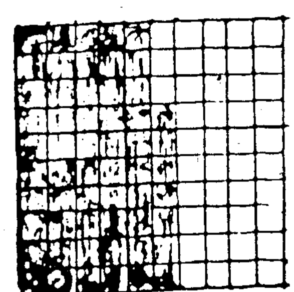
a) 1 / 2, 1 / 3, 1 / 4, 1 / 5;

b) 1 / 3, 1 / 5, 1 / 7, 1 / 9;

c) 1 / 20, 1 / 15, 1 / 10, 1 / 5;

d) 4 / 5, 3 / 5, 2 / 5, 1 / 5;

9. Write the decimal that tells what part of the square is shaded:



a) 57.0

b) 5.7

c) 0.75

d) 0.57

10. Which one of the following numbers is closest to 10 ?

a) 10.7

b) 10.43

c) 9.68

d) 9.6

11. Which one of the following numbers is closest to 0.15 X 7 ?

a) 1

b) 2

c) 10

d) 100

12. 43 254 (Find the missing number)

\- ? ? ? ?

783

a) 44 037

b) 43 471

c) 42 571

d) 42 471

13. Multiply 6 735 X 64

a) 431 040

b) 67 350

c) 26 940

d) None of these.

14. DIVIDE 8) 8 240

a) 13

b) 103

c) 130

d) 1030

15. DIVIDE 8) 5 124

a) 640 r 4

b) 64 r 4

c) 640.4

d) 603

16. Find the missing addend (number) of the following sum:

```
  3 671.39
     74.21
+ ? ? ?.? ?
  4 103.51
```

a) 357.91

b) 358.91

c) 3 729.01

d) 7 849.11

17. Subtract 13 899.99 from 14 000.00

a) 211.11

b) 111.11

c) 111.01

d) 100.01

18. ADD the following numbers: 0.397 + 0.28 + 13.8

a) 0.563

b) 0.925

c) 14.477

d) 563

19. 160 X 3 + 160 X 2 = ?

a) 320 X 5

b) 480 - 320

c) 800

d) None of these.

20. Multiply 13.45 X 8

a) 10.76

b) 107.6

c) 1076

d) None of these.

21. A postman has 354 mails to deliver. 96 of the mails are Christmas cards. If all the other mails are letters, then how many letters does the postman have to deliver?

a) 450 letters

b) 342 letters

c) 268 letters

d) 258 letters

22. A classroom has 16 rows of chairs with 7 chairs in each row. FOUR chairs were removed from the classroom. How many chairs remained?

a) 27 chairs

b) 108 chairs

c) 112 chairs

d) 116 chairs

23. Megan sprints around the 250 meter track 3 times, and then she walks around the same track ONCE. How many meters did Megan run and walk altogether?

a) 1 250 meters

b) 1 000 meters

c) 750 meters

d) 500 meters

24. Ron must drive 2 912 kilometers to his new home. He has 8 days to get there. How many kilometers must he drive each day to get to his new home just on time?

a) 351 kilometers

b) 364 kilometers

c) 3 604 kilometers

d) 23 296 kilometers

25. If you have 10 BLUE marbles and 20 RED marbles in a bag, how many marbles must you take out of the bag before you can be sure that you have two marbles of the same colour?

a) 3 marbles

b) 4 marbles

c) 5 marbles

d) 11 marbles

26. The Edmonton Oilers and the New York Islanders reached the finals in the 1983 hockey season. 23 403 persons bought tickets for one of the games. If the cost of each ticket was $7.00, then how much money was collected for this game?

a) $ 163 821.00

b) $ 143 821.00

c) 141 821.00

d) $3 343.29

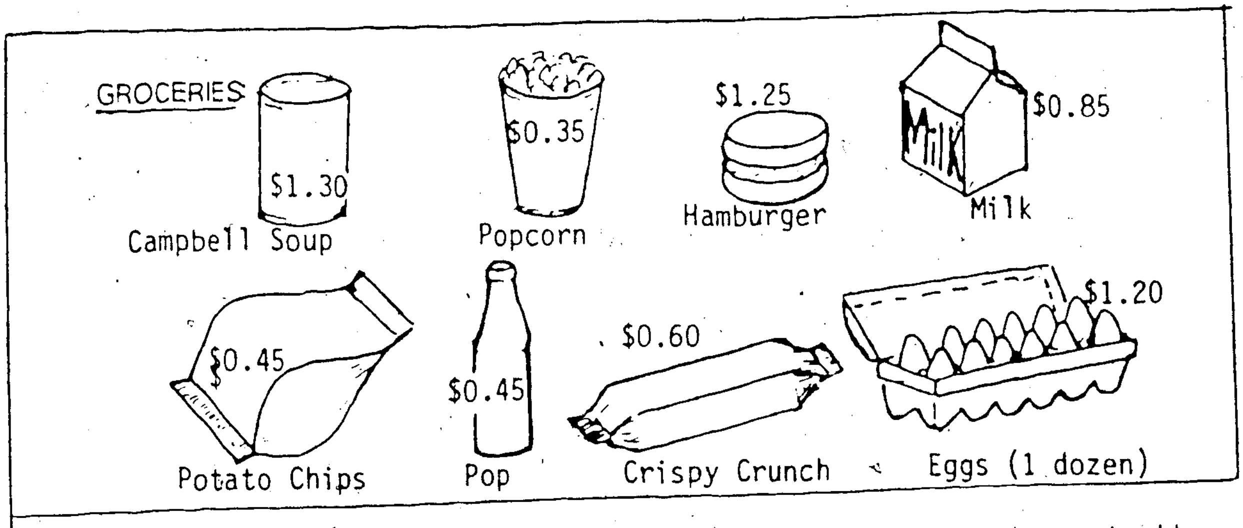
27. Susan's clothing allowance doubles every time Susan has a birthday. Susan is now 12 years old, and her clothing allowance is $ 100.00 dollars. How old was Susan when her clothing allowance was $50.00?

a) 6 years

b) 9 years

c) 10 years old

d) 11 years old



28. Bob is buying 1 Hamburger and 1 Milk from a $5.00 bill. How much change should he get back?

a) $3.00

b) $2.90

c) $2.10

d) $2.00

29. Jane is buying 1 Popcorn, 1 Crispy Crunch, and 3 Pops. How much should she pay?

a) $1.40

b) $1.85

c) $2.30

b) $4.20

30. Olivia is buying 2 bags of Potato Chips, 2 Campbell Soups, and 1 dozen Eggs. How much should she pay?

a) $5.90

b) $4.70

c) $4.25

d) $2.95

APPENDIX C: THE INCIDENTAL-LEARNING ABILITY SCALE

THE STUDENT'S ATTENTION SCALE

(ANSWER SHEET)

NAME: ______________________ B/G: ____ GRADE: ________

SCHOOL: ______________________ DATE OF BIRTH: __________, ______
month year

DIRECTIONS:

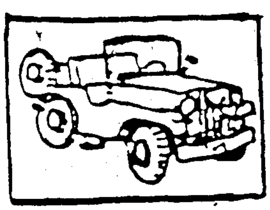
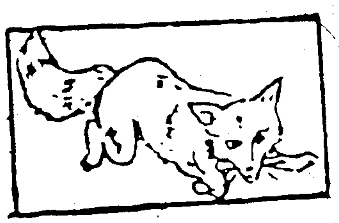
You are about to take part in a memory game that children your age seem to enjoy.

You will be shown a few series of pictures.. KEEP TRACK OF THE SEQUENCE IN WHICH THE ANIMALS AND THE NUMBERS APPEAR, since you will be asked WHICH POSITION IN THE SERIES A PARTICULAR ANIMAL APPEARS.

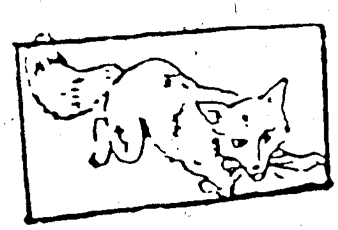
The Rules of the Game:

Let us learn the rules of the game by doing a few SAMPLE EXERCISES.

1. Look carefully at the set of pictures below:

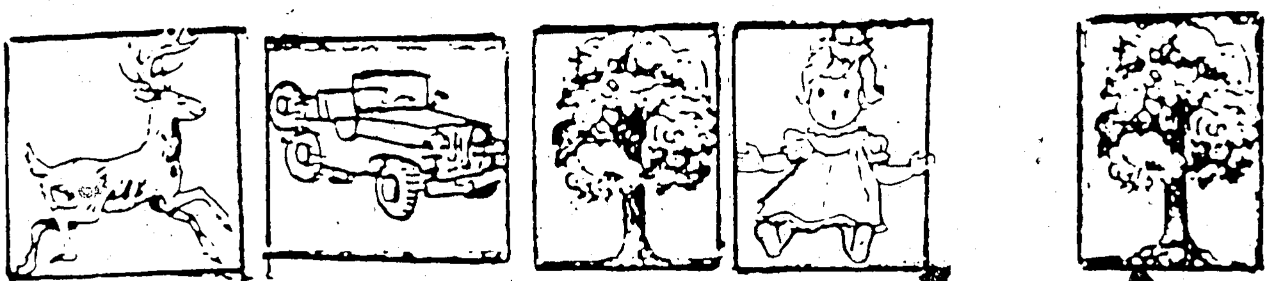




One of them is selected:



ON THE ANSWER SHEET FOR THE SAMPLE ITEMS, CIRCLE THE NUMBER 1st, 2nd, or 3rd that correctly describes the position of this picture in the series. DO THIS NOW. You should have circled <u>2nd</u>, since the FOX is the second picture in the series.

2. Let us do the second practice example. Four pictures are in this series, as you can see below:



Try to do this example without my help. DO IT NOW, on the sample sheet. You should have circled 3rd, since the tree is the third picture in the series.

3. The pictures in the game will be shown on slides. The next sample exercise illustrates how a series of slides will look.

READY with a beep	099	HORSE	DEER	091	MOUSE	END with a low-pitched sound	091
	FOX	109	019	OWL	910		OWL

You should circle 4th here, since OWL is in the fourth picture.

Now, we will play the game using the slide projector to show the pictures. SIX SLIDES are in each series. You should circle 1st, 2nd, 3rd, 4th, 5th, or 6th, depending on the position of the picture selected from that series.

BE SURE TO PAY ATTENTION TO THE SEQUENCE IN WHICH THE ANIMALS APPEAR.

ANSWER SHEET FOR THE SAMPLE ITEMS

1.	1st	2nd	3rd.	
2.	1st	2nd	3rd	4th.
3.	1st	2nd	3rd	4th.

ANSWER SHEET
(Intentional Learning)

Name:

SET	POSITION						
A.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
B.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
C.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
D.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
E.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
F.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!

NOW, YOU ARE ABOUT TO START SET "G". ARE YOU INDICATING YOUR ANSWERS ALRIGHT?

G.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
H.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
I.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
J.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
K.	1st,	2nd,	3rd,	4th,	5th,	6th.	PENCILS DOWN!
L.	1st,	2nd,	3rd,	4th,	5th,	6th.	

THE STUDENT'S ATTENTION SCALE

(Incidental-Learning Ability).

SHEET ONE

1. Each slide had a number and a picture of an animal. WRITE ALL THE NUMBERS SHOWN IN THE PICTURES, IN ANY ORDER. Put a comma after each number. Write only those numbers you can recall by yourself.

7, 57, 62, 28, 38 37

2. On the lines below, WRITE THE NAMES OF ALL THE ANIMALS IN THE PICTURES YOU JUST SAW. In order to play the game fairly, YOU SHOULD WRITE ONLY THOSE NAMES YOU CAN REMEMBER WITHOUT LOOKING AT ANYONE ELSE'S PAPER!

GOAT, LAMB, LION, MONKEY, PIG, FISH
ZEBRA

Did you expect this test ? [ ] or [ ] .
yes, NO

PLEASE GIVE THIS SHEET TO YOUR TEACHER BEFORE YOU RECEIVE THE NEXT ONE!

THE STUDENT'S ATTENTION SCALE

(Incidental-Learning Ability)

NAME: ____________

SHEET TWO

Here are the names of all the animals that were shown on the slides. They are in alphabetical order. Beside each animal is a set of numbers. Each set of numbers includes the ONE number that always appeared with the animal beside it. For each set of numbers, CIRCLE THE NUMBER THAT ALWAYS APPEARED WITH THE ANIMAL BESIDE IT.

DUCK	(58, 57, 47, 38.)
FISH	(61, 51, 44, 36.)
GOAT	(57, 51, 47, 28.)
LION	(62, 58, 44, 38.)
MONKEY	(64, 54, 44, 36.)
PIG	(63, 38, 36, 26.)
SHEEP	(62, 57, 36, 26.)
ZEBRA	(51, 47, 28, 26.)

3

7 - 1 = 6

9

DID YOU WRITE YOUR NAME ON THE FRONT PAGE OF THIS BOOKLET?

PLEASE WRITE YOUR NAME ON THIS SHEET ALSO.

V. Good

I HOPE YOU ENJOYED THIS EXERCISE. YOU WILL GET YOUR RESULTS TOMORROW.

APPENDIX D: THE REHEARSAL PROFICIENCY SCALE

THE STUDENT'S REHEARSAL PROFICIENCY SCALE

(ANSWER SHEET)

NAME:____________________ SEX:____ GRADE:____

SCHOOL:____________________ DATE OF BIRTH: Year____, Month____

DIRECTIONS:

We are going to do a short memory exercise. This is how it begins: I will read a list of numbers which you will try to remember. When I am finished with each set of numbers, I will repeat one of the numbers a second time. You will be asked to remember where this number occurred in the set of numbers. Was it the 1st, 2nd, 3rd, 4th, 5th, 6th, or 7th number in the set? You must indicate the correct position by CIRCLING the appropriate number on the answer sheet.

Let us do two sample exercises.

SAMPLE EXERCISES:

1. If I were to say the numbers: 3 7 4 and then ask you in what position the number 7 occurred, YOU WOULD CIRCLE 2nd, because 7 is the second number in this set. DO THIS ON THE ANSWER SHEET ON THIS PAGE.
2. Now, if I were to say the numbers 3 5 9 2 and then ask you in what position the number 2 occurred, YOU WOULD CIRCLE 4th.

ANSWER SHEET FOR SAMPLE ITEMS

1. 1st, 2nd, 3rd.
2. 1st, 2nd, 3rd, 4th.

C H Joseph

(TURN OVER)

1984

The numbers in this game will be presented on an audio tape. LISTEN CAREFULLY! Be sure to USE THE ANSWER SHEET BELOW to indicate your answers.

ANSWER SHEET

SET	POSITION						
A.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
B.	1st	2nd,	3rd,	4th,	5th,	6th,	7th.
C.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
D.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
E.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.

CHECK TO SEE IF YOU HAVE JUST RESPONDED TO SET "E". THE NEXT SET IS "F".

F.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
G.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
H.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
I.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
J.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
K.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
L.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
M.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
N.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
O.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.

YOU SHOULD HAVE JUST RESPONDED TO SET "O". THE NEXT SET IS "P".

P.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
Q.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.
R.	1st,	2nd,	3rd,	4th,	5th,	6th,	7th.

APPENDIX E: THE PREFERENCE FOR IMMEDIATE FEEDBACK SCALE

THE STUDENT'S PREFERENCE FOR IMMEDIATE FEEDBACK SCALE

NAME: ______________________ B or G: _____ GRADE: ____

SCHOOL: ______________________ BIRTHDATE: __________, ______.
month year

IMAGINE yourself with the opportunity to go to school in several different countries. The teachers in each of these countries differ with respect to when they give students their test results. We will refer to these imaginary countries as COUNTRY A, COUNTRY B, COUNTRY C, and so on. FOR EACH COUNTRY, SHADE ONE OF THE BOXES to indicate how you would like to have your test results reported, if you were going to school in that country.

1. In COUNTRY A, students are told whether their answer was correct or incorrect either

☐ IMMEDIATELY AFTER DOING EACH TEST QUESTION,

or ☐ IMMEDIATELY AFTER FINISHING THE ENTIRE TEST.

2. In COUNTRY B, students are told whether their answer was correct or incorrect either

☐ IMMEDIATELY AFTER DOING EACH TEST QUESTION,

or ☐ THREE HOURS AFTER finishing the test.

C Joseph '84

3. In COUNTRY C, students are told whether their answer was correct or incorrect either

[ ] IMMEDIATELY AFTER DOING EACH TEST QUESTION,

or [ ] THE NEXT DAY.

4. In COUNTRY D, students are told whether their answer was correct or incorrect either

[ ] IMMEDIATELY AFTER DOING EACH TEST QUESTION,

or [ ] ONE WEEK AFTER finishing the test.

5. In COUNTRY E, students are told whether their answer was correct or incorrect either

[ ] IMMEDIATELY AFTER FINISHING THE ENTIRE TEST,

or [ ] THREE HOURS AFTER finishing the test.

6. In COUNTRY F, students are told whether their answer was correct or incorrect either

[ ] IMMEDIATELY AFTER FINISHING THE ENTIRE TEST,

or [ ] THE NEXT DAY.

7. In COUNTRY G, students are told whether their answer was correct or incorrect either

[ ] IMMEDIATELY AFTER FINISHING THE ENTIRE TEST,

or [ ] ONE WEEK AFTER finishing the test.

8. In COUNTRY H, students are told whether their answer was correct or incorrect either

☐ THREE HOURS AFTER finishing the test,

or ☐ THE NEXT DAY.

9. In COUNTRY I, students are told whether their answer was correct or incorrect either

☐ THREE HOURS AFTER finishing the test,

or ☐ ONE WEEK AFTER finishing the test.

10. In COUNTRY J, students are told whether their answer was correct or incorrect either

☐ THE NEXT DAY

or ☐ ONE WEEK AFTER finishing the test.

THE STUDENT'S PREFERENCE FOR IMMEDIATE FEEDBACK SCALE

(SECTION B)

Use the numbers 1st, 2nd, 3rd, 4th, and 5th to indicate how you would prefer to be told how well you did on a mathematics test. WRITE 1st IN THE BOX BESIDE THE ONE YOU LIKE BEST, 2nd IN THE BOX BESIDE THE ONE YOU LIKE SECOND BEST, and so on.

☐ IMMEDIATELY AFTER DOING EACH TEST QUESTION;

☐ IMMEDIATELY AFTER FINISHING THE ENTIRE TEST;

☐ THREE HOURS AFTER FINISHING THE TEST;

☐ THE NEXT DAY;

☐ ONE WEEK AFTER FINISHING THE TEST.

DID YOU REMEMBER TO WRITE YOUR NAME, SCHOOL, AND GRADE ON THE FRONT PAGE OF THIS TEST BOOKLET?

HOPE YOU HAD FUN DOING THIS EXERCISE

```
$SIGNON CHCJ PRIO=L RETURN=EDUC COPIES=15 PACKAGE=LOOSE PAPER=XK
Batch,Low,Internal/Teaching,Research
 Last signon was: 15:43:35
 User "CHCJ" signed on at  20:05:56 on Wed Oct 24/84
$r new textform scards=abstr(1,9) spunch=*print*
TEXTFORM Version 1.50
20:05:59
```