The Efficacy of Improving Fundamental Learning and Its Subsequent Effects on Recall, Application and Retention

by

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ABSTRACT

In post-secondary introductory courses there is a knowledge base that must be learned before proceeding to advance study. One method to learn such fundamental material has been the mastery paradigm (Bloom, 1956). Using this approach, students learn a particular knowledge unit until they achieve a predetermined accuracy criterion, for example, 90% correct, on a post-learning test. Lindsley (1972) broadened the definition of mastery learning to include response rate (i.e., responses per minute) and called it 'fluency'. The response rate has not generally been considered in the traditional demonstration of mastery within the academic setting.

Empirical research to date has focused solely on the effects of either approach without any direct comparisons. There was only one published report comparing the effects between the two approaches (Kelly, 1996). In the present study, two single-subject experiments were conducted using a computer program called Think Fast to deliver factual information covering introductory behavioral psychology concepts.

In Experiment 1, a within-subject design was used to control the number of learning trials, instructional set, and the experimental presentation sequence (n=9). This design consisted of multiple learning units and instructions. Group, subgroup and individual descriptive analyses revealed that posttest achievement was higher for items learned to both Accuracy and Speed than Accuracy. In analyzing the change in retention from immediate recall to scores obtained after a 30-day absence, learning was more resistant to extinction for concepts that had previously been learned to Accuracy and Speed rather than Reading or Accuracy.

Furthermore, retention decreases were examined statistically and there was one significant result in Session 1 and two in Session 2. In Session 1, under the Accuracy condition, subjects recalled 25.5% fewer items after a 30-day absence, $t(8)=5.33$, $p<.01$. A decrease of 12.2% for posttest items learned under the Accuracy and Speed condition

was not significant, $t(8)=2.05$, $p>.05$. In Session 2, significantly fewer (Recall 2) posttest items were remembered after a 30-day absence for both experimental conditions, $t(8)=5.08$, $p<.01$ (Accuracy) and $t(8)=3.82$, $p<.01$ (Accuracy and Speed). All other group retention comparisons were not statistically significant.

In Experiment 2, a between-subject design was used to replicate the effects of Experiment 1, but this time each subject received only one set of instructions ($n=6$). The effects of this simplified research design resulted in no significant differences between learning to both Accuracy and Speed in comparison to Accuracy. Other factors that affected learning included subjects' baseline ability and the extent of their interest in the study. These factors determined whether or not subjects followed the learning instructions and, to varying degrees, affected their subsequent posttest performance. The study concluded with educational implications and suggestions for further research.

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Chapter 1

The Research Problem

For many years, instructors have used mastery learning in educational and other learning settings (see Bloom, 1956; Kulik, Kulik, and Bangert-Drowns, 1990; Levine, 1985). The primary component of this approach is that students are instructed to learn a particular knowledge domain, skill or objective until they achieve 80-100% correct as measured by a post-learning test/evaluation. Other components of mastery learning include breaking the material into discrete units and allocating students as much time as required to prepare for tests. During tests students demonstrate mastery, usually with an accuracy criterion set by the instructor. If students are experiencing difficulty reaching the criterion then corrective feedback, additional instruction or an intervention is provided. Students must reach the learning goals (criterion) of each unit or chapter before advancing to subsequent material. These are the main elements of mastery learning. In short, learners are considered to have "mastered" the learning of some particular information after meeting an accuracy correct criterion.

Recently, several researchers in human performance have argued that the rate of response should also be factored into the mastery equation. This created a new definition called fluent performance (Binder, 1988; Johnston and Layng, 1992, 1994; Lindsley, 1972). They have argued that in most "real-world" situations, those considered to be "masters" of a given field (e.g., teachers, and doctors) are able to provide accurate responses at a rapid rate. For example, a teacher who answers a student's question quickly or a doctor who can immediately diagnose an illness are both examples of persons who have mastered their field.

It is sometimes difficult for teachers to determine when students have become experts or 'mastered' a given content area, skill or learning objective. The problem with using the conventional method of mastery evaluation is that the top 10% -20% on the normal distribution of grades would have "mastered" the material without consideration of their response rate. It is possible for two students to achieve the traditional definition of mastery even though one may have required double the time to respond than another. One may ask if both subjects have similarly mastered the content and to what extent their learning differs in terms of retention over time and application in other more complex situations.

Binder (1988) defined quick and accurate performance as true "mastery" in a content area. He is one of many researchers who have used the term *fluency* to redefine mastery learning. He equated the term fluency as being the combination of accuracy and speed. His research findings in human performance demonstrated that learners who were required to become fluent in industrial settings were better able to perform in the presence of distraction, retain newly acquired skills and apply the newly learned skills to other situations than workers who were not fluent (Binder, 1988). Nevertheless, can fluency be applied to learning factual material in order to enhance post-learning performance in terms of retention and application? To date, no definitive study has answered this question. This was the main focus of the following experiments.

First, a comprehensive analysis of the components of mastery and fluency learning was conducted. Relevant research articles were also investigated (Chapter 2). Second, several research questions were considered and two experiments were designed to answer these questions. Essentially, an experiment conducted using computer software developed by Parsons (1984; 1994) was used to deliver stimuli to examine the efficacy of the main components of the two approaches, namely learning to an accuracy (mastery) and learning to response rate criteria (fluency learning).

Purpose

The primary purpose of the study was to examine the effectiveness of accuracy (mastery) and response rate (fluency learning) delivered by a computer and measured by post-learning recall, retention and application tests. The stimulus material was fundamental psychological facts taken from a post-secondary textbook. The post-learning measurements assessed acquisition, recall, retention, and application. Johnson and Layng (1994) considered these outcomes to be critical achievement measures (p. 183). Adults were targeted as participants because the focus was on enhancing post-secondary learning.

The field of learning is enormous with many quantitative and qualitative research issues (e.g., learning styles, motivation, memory, and information learning vs. knowledge). Even the definition of learning is varied from one theoretical position to another. In an attempt to maintain a clear focus and minimize confounding variables this study was designed to investigate the primary component of the mastery and fluency learning approaches only. Behavior analysis, cognitive science and the constructivist approach were used to pinpoint where this study fits theoretically. The selection of posttests was based upon the research findings of Johnson and Layng (1994), who found that the distinguishing feature between accuracy and the combination of accuracy and speed was that "...accuracy, unlike fluency (accuracy and speed), rarely predicts whether performance will be retained, endure, transfer to more complex situations, combine with other repertoires under the same contingencies or remain stable during distracting conditions" (p. 183). The following is a list of research questions that were used to shape the design of the experiments.

The Research Question

The purpose of this study was to compare the effects of two learning instructions--learning to Accuracy and learning to Accuracy and Speed--to determine which produces the greatest achievement as measured by recall, retention and application tests.

Subsidiary Questions

1. Does the requirement of learning to accuracy and speed produce quantitatively and qualitatively superior posttest performance (e.g., recall, retention, application) than learning to an accuracy?

2. To what extent does learning without an accuracy or accuracy and speed requirement (i.e., reading) increase subsequent performance on posttests such as recall, application and retention?

3. Is there a relationship between subjects' interest in the study content and posttest performance?

Definition of Terms

1. Deliberate practice – A term used by Ericsson, Krampe and Tesch-Romer (1993) to describe highly effortful and intense practice of a particular skill.

2. Learning to Accuracy – A term used to describe learning instructions whereby subjects responded to each item slowly and accurately. This was the main component extracted from the Mastery approach.

3. Learning to Accuracy and Speed – A term used to describe learning instructions whereby subjects responded to each item as quickly and accurately as possible. This was the main component extracted from the Fluency approach.

4. Think Fast – Software developed by Parsons (1984; 1994) to enable students to learn facts and concepts by typing or saying answers to stimulus material. The software resembled a flashcard and provided immediate corrective feedback as well as accuracy and response rate information.

5. Think Fast Trial – One set of Think Fast cards constituted a deck. Going through each card of a deck was counted as one trial.

6. Think Fast Session – Completing all the trials of an assigned experimental condition was called a session.

7. Exemplar – An example of human behavior presented in written format.

8. Mastery Learning - A form of learning that focuses on students reaching a certain goal, regardless of how long it requires them to do so. Specifically, the information to be learned is broken down into units and subjects work at their own pace. A test is provided

at the conclusion of a unit and a predetermined achievement goal, usually 80% or greater, must be attained.

9. Precision Teaching – A branch of behavior analysis that bases "educational decisions on changes in continuous self-monitored performance frequencies" (Lindsley, 1992).

10. Fluency - A term used by precision teachers to redefine mastery learning. Students are required to reach both accuracy correct (i.e., percentage correct) and response rate (i.e., correct per minute) criteria. The time required to reach fluency criteria is dependent upon the student.

11. Response rate – Used to describe a performance measurement of count per minute. For example, the number of correct responses made divided into the time required. Often referred to simply as *rate*.

Chapter 2

Review of the Literature

Mastery Learning

Mastery learning is a teaching approach that helps all students in a class to fully achieve a common set of instructional objectives regardless of the learning time required (Bloom, 1956). "Mastery learning accomplishes its goal by doing three things: allowing students different amounts of time to reach instructional objectives; providing additional or remedial instruction for students who do not master objectives quickly; and, organizing the curriculum into discrete units" (Seifert, 1991, p. 349). Each of these can be taught and evaluated separately from the others.

Mastery learning takes the relationship between time and achievement into consideration. Whereas, conventional teaching arrangements allocate a fixed amount of instructional time and allow students' achievement levels to vary according to aptitude. Mastery learning affords subjects the amount and kind of instruction individually needed in order to achieve a fixed set of objectives (Bloom, 1956; Kulik, Kulik, and Bangert-Drowns, 1990; Levine, 1985; Seifert, 1991). In the Mastery situation, teachers devote extra time to students who take longer to reach objectives or students spend more time independently. Users of the approach assume that, given enough time and appropriate help, virtually all subjects will master the instructional objectives set (Keller, 1968). For example, if a requirement was to learn 100 definitions, then all students would attain this criterion and the grading would be based on this threshold, regardless of the time needed. In contrast, in the traditional teaching situation, students would differ in the number of definitions learned as a result of their aptitude and learning time. That is, some students would do well and others would not. In mastery learning, this variability would be replaced by a "...uniformly high level of performance for all." (Kulik, Kulik, and Bangert-Drowns, 1990, p. 266).

In order to address flexibility in learning time, the Mastery approach offers extra instruction, called corrective instruction, for students who take longer to reach instructional goals (Bloom, 1976). Corrective instruction may come in the form of individual tutorials or small group instruction tailored to remedy the shortcomings. It is provided as 'extra help' to aid the student in reaching the learning objectives of one unit before advancing to the next.

To make the corrective instruction effective, Mastery learning also requires that teachers organize the curriculum into discrete units, each focused on a specific set of learning objectives (Seifert, 1991, p. 351). This approach focuses teachers' initial instruction more clearly, helps them monitor subjects' progress and eases the design of tests based specifically on the curriculum unit. These advantages, in turn, help teachers plan corrective instruction that is appropriate and helpful. The following is a summary of the vast research literature in mastery learning with a focus on recent studies.

Durnin and Yildiran (1987) designed a study to measure the effects after combining mastery learning and creative activities on children's achievement levels. The primary reason for using Bloom's mastery learning approach was that it improved learning about one standard deviation greater than traditional methods (Bloom, 1976). These researchers randomly assigned 110 sixth grade Turkish students into five groups, (the treatment and teachers were also randomly assigned). Each group was coded. Section A received mastery learning methods and objectives as well as creativity methods and objectives. Section B received mastery learning objectives and methods only. Section C received creativity methods and objectives. Teachers in Sections A, B, and C were provided with objectives and instructions. Section D received content and creativity objectives but the teacher did not receive any instructions. Section E received no treatments or instructions. Three units from second language instruction from English for a Changing World (1976) were used as the topic of study. Sections A and C received creativity training in the form of teacher modeled diverse responses and dialogues after which subjects were instructed to construct their own dialogues. Students in Sections A and B were administered unit tests with criterion levels set at 80% for sentences written correctly in English and 90% on items based on information from the book. The teachers were instructed to proceed at a rate suitable for their class. Sections A, C and D finished in nine days and Sections B and E finished in ten days. Upon completion of the three units, all sections received a summative test which included measures such as content, creativity, dialogue completion, dialogue inventiveness, story precision and story inventiveness. Two-way analysis of variance was used along with post-hoc tests using the Scheffe method. The statistical analysis performed indicated that the effects of mastery learning method and teaching for creativity were additive and were supported with both controls (p. 284). Mastery learning used in Sections A and B outperformed Sections C, D and E across all measures, $t(105) = 6.21$, $p<.001$. Students from sections who received creativity training performed better on creativity tests than those who did not. The results supported the authors' main hypothesis that using a combination of creativity objectives and methods in language lessons and requiring mastery performance significantly increased learning and also increased creative achievement to a superior level.

Kulik, Kulik, and Bangert-Drowns (1990) performed a meta-analysis on the effectiveness of mastery learning programs. A total of 108 studies were used in the analysis. Seventy-two studies used Keller's Personalized System of Instruction (PSI), (Keller, 1986) and the remaining 36 used Bloom's Learning for Mastery (LFM) approach (Bloom, 1976). The outcome measures for all but five of the studies involved post-learning examination performance. Of the remaining studies, 96 reported that mastery learning resulted in positive effects. The average effect size of all 103 studies was 0.52. This indicated a moderate statistical significance. The authors concluded that mastery learning was effective because "...the average subject in a mastery learning class performed at the 70th percentile (equivalent to a Z score of 0.52), whereas the average subject in a class taught without a mastery requirement performed at the 50th percentile (Kulik, Kulik and Bangert-Drowns, 1990, p. 271).

Liefeld and Herrmann (1990) conducted an experiment with 49 post-secondary students enrolled in a third year one-semester course in communication management. Of these students, 24 were assigned to a seminar-discussion group with no mastery-testing criterion while the remaining 25 were assigned to a mastery-testing group. Another class consisting of 65 third-year students who had not taken the course served as the control group. The course readings were broken into 12 units and a computer-administered test was developed for each unit. Each test consisted of 20-items of multiple-choice, true-false and fill-in-the blank questions. Students attended lectures, studied and read course material until they felt ready to take a unit test delivered via the computer program. When students achieved mastery (80%) they received a congratulatory message from the program and continued with the next unit of reading. "The seminar-discussion group achieved a high mean score on the posttest (pretest=14.54, posttest=20.79). The mastery testing group achieved a significantly greater improvement in their posttest mean scores (pretest=13.28, posttest=37.08) (p. 23)." Furthermore, the improvement scores of the mastery-testing group were four times greater than the seminar-discussion group. The control group did not improve and their mean pretest (12.94) and posttest (11.86) scores were not significantly different than the pretest scores of the seminar-discussion and mastery-learning groups. The authors concluded that mastery-learning produced better undergraduate learning than lecturing or participatory seminars. They encouraged other researchers to replicate and extend their study.

Ritchie and Carr (1992) presented a discussion paper critiquing the use of Mastery learning when instructing children in mathematics. They identified some undesirable results of the Mastery learning approach. In one case, children who were interviewed after using self-paced mastery learning erroneously believed that mathematics was a "...game whereby one had to guess the answers found in the answer key" (p. 193). Also, in criterion-referenced mastery tests, "...cheating has actually been documented" (p. 193). It seemed the criterion placed pressure on the students to achieve at a particular rate and some children resorted to unconventional means in order to reach the score that was expected. In addition, Mastery assessment encouraged "...rote memorization of information in a form which may never be used again by the student " (p. 193). Use of only formal tests for mastery learning results in limited feedback for the students, that is, a grade. There is a lack of information about misconceptions and the nature of the subjects' error. Furthermore, these authors suggested that the mastery approach made students overly-concerned with grades, reduced their levels of risk-taking and did not help to develop subjects' own knowledge of their understanding (metacognition) (p. 197). Currently, mastery assessment testing does not distinguish between whether a student uses advanced or primitive strategies. In terms of a paper and pencil mathematics tests, such assessments did not measure how the students problem-solved outside the classroom (i.e., real-life mathematics). The authors concluded that such tests may only indicate results and not understanding.

Ritchie and Carr (1992) proposed that a constructivist approach be used. The constructivist approach affords psychological well being in the face of the students discovering that there are gaps in their knowledge. Learners would be conceptualized as persons who actively constructed their knowledge. Using this theoretical basis, assessment tests would not be used to evaluate need for further instruction; rather, the students would be empowered to evaluate their own learning needs. Moreover, the learner would be encouraged to reflect upon what they have learned. The authors stated that "...critical modes of thinking are brought into play" (p. 198). Feedback is provided to assist active learning. For example, subjects may be asked to identify the kinds of mathematical problems that they cannot do, and to isolate where their difficulties arise" (p. 198). Students would be encouraged to speak out loud during problem solving and investigate their own errors. The authors claimed that this approach would provide teachers with data during the learning process rather than at the end, as is the case with conventional mastery assessment. Reliance upon conventional mastery assessment focuses learning on expositions, repetition and hinders intuitive ideas and discovery learning. In turn, teachers may not assess subjects beyond surface learning and mechanical skills.

Palardy (1993) examined five major mastery learning assumptions. He concluded by reporting that mastery learning can be done and was being used in educational settings with positive effects on achievement and student attitude. While he speculated that mastery learning seemed "...ill-suited to dealing adequately with many aspects of learners' social, emotional and high-order cognitive lives" (p. 305), he also believed it held "...great promise as a systematic framework for teaching and learning certain items, such as multiplication, word skills, social studies facts, and letter writing" (p. 305).

Some research has demonstrated that higher-order cognitive questions enhanced cognitive processing (Rickards and Divesta, 1974), increased recall (Frase and Schwartz, 1975), recognition (Ryan and Pfeifer, 1979) and creativity (Torrance, 1988). Mevarech and Susak (1993) wanted to extend these findings by using two methods of differing origin in combination to enhance children's questioning skills. One was cooperative learning and the other was a cognitive mastery learning approach. In cooperative learning groups, children were afforded the opportunity to participate actively, which acted to motivate their participation and learning. However, there was sometimes a lack of sufficient means to systematically diagnose performance and provide corrective feedback. Mastery learning, however, was used to diagnose subjects' level on skills, as well as teach, practice skills and provide the corrective feedback that helped generate complex cognitive skills. The authors divided 271 third and fourth grade subjects into one of four groups. These groups were designated either cooperative learning, mastery learning, cooperative-mastery learning or control. The researchers hypothesized that the cooperative-mastery learning approach would outperform the other groups in generating higher-order cognitive questions, achievement and creativity. In order to measure these behaviors, three instruments were used. First, a question skills instrument (Berlyne and Frommer, 1966) was used to elicit questions. Students were shown a picture, asked to generate questions and then administered a short story. Generated questions were rated using Bloom's taxonomy (1956); analysis, synthesis and evaluative questions were scored as higher cognitive questions. Second, the Torrance (1988) Test of Creativity Thinking was used to measure creativity. Third, teachers of the classes constructed a 20-item multiple-choice test on the three-month curriculum content. The three instruments were used for the pretest and posttest. Content, learning time and instructional schedule were all equalized and only the specific instructional strategies differed. Analyses of covariance were conducted on the subjects' responses to the instruments. A significant treatment main effect was discovered. Students in the mastery learning group and the cooperative-mastery learning groups generated significantly more higher-order cognitive questions than their counterparts in the cooperative learning group who, in turn, generated significantly more questions than the control group (p. 201). In terms of creativity, ANCOVA indicated that there were significant differences on fluency (the number of relevant responses) and flexibility (the number of different approaches used in producing ideas for improvement) between the mastery-cooperative learning, mastery learning and cooperative learning groups but not between the cooperative learning and control groups (p. 201). No significant differences were found between the groups from the achievement scores. The authors summarized three findings. First, prior to any intervention, these third and fourth grade students generated mainly lower cognitive questions. After exposure to the mastery questioning method on its own or within a cooperative setting, their ability to generate higher-order cognitive questions increased substantially. Second, creativity also increased through the use of approaches to generate higher-order cognitive questions. The mastery questioning approach used individually or in a cooperative group setting did not effect achievement on the content. Finally, the authors concluded that the mastery questioning approach improved students' thinking skills.

Malehorn (1994) discussed the need for better methods of assessment. He speculated that grades were "misleading and incomplete at best; and at worst they were inhibiting and traumatizing" (p. 324). He profiled ten assessment methods, which provided more information than the one statistic 'grade'. They included: multiple marks, contracted learning, mastery learning, credit/no credit, checklist, anecdotal records, pupil profile, dossier, peer evaluation and self-evaluation. In terms of mastery learning, he advocated the use of criterion-referenced materials to provide subjects with concrete learning goals. With this approach there is also the opportunity to continue efforts "...without penalty until these expectations are fulfilled" (p. 323). Malehorn surmised that grades simply hinder students' motivation and effort to learn more than any other school element (p. 324).

Palardy (1994) presented a discussion article on the state of elementary education based upon his own observations, readings and discussion. He acknowledged that he had no statistical evidence to support his claims and that a lot of progress had occurred within the educational system, but claimed that there have been "...six giant steps backward" (p. 395). These problems included the improper use of behavior modification in the classroom, increased emphasis in reading instruction on decoding skills, the definitional change of individualized instruction, the use of absolute Mastery learning instead of relative Mastery learning, the movement away from self-contained, heterogeneously grouped classes to departmentalized, homogeneously grouped classes and the move away from educating the 'whole child', instead, concentrating on their 'intellect' (p. 396-397). In terms of the use of Mastery learning, Palardy did not discredit the mastery approach but rather the way in which it had been used in classrooms. He suggested that the biggest problem was with *absolute* mastery criteria. Brighter students learn material that others cannot, even when the latter are given an extraordinary length of time. Using *absolute* mastery criteria does not always translate to all students being able to learn. Palardy noted that not knowing what to do with these children was a problem learning proponents have not dealt with successfully (p. 396). Furthermore, those brighter students who progress rapidly through material may end up with 'nothing to do'. He suggested that mastery criteria be set relative to each individual's ability. "On the one hand, slow children are not challenged beyond their capacity, and on the other hand, bright children are expected to work and to live up to their potential" (p. 397).

Lai and Biggs (1994) orchestrated an experiment to determine if students biased towards a surface or deep approach to learning reacted differently to a mastery program. Five Grade 9 Biology classes served as subjects. Three classes (n=95) were assigned to the experimental condition using the Learning for Mastery approached outlined by Block and Anderson (1975). With this approach, each learning unit was teacher presented and students moved through at a uniform pace controlled by the teacher; struggling subjects were given extra tutorial. Two classes (n=64) were taught using the usual expository approach. Prior to any intervention, all subjects were administered the Learning Process Questionnaire and classified into surface (n=58), deep (n=73) or non-biased (n=28) learners. All subjects were tested on four occasions. The Learning for Mastery approach resulted in statistically significant higher test scores. When comparing between learning bias types, the surface and deep biased experimental group performed much better than the control group counterparts. The non-biased subjects in the control group performed marginally better than the non-biased subjects under the experimental mastery group. It is noteworthy that when the surface and deep biased learners' test scores were plotted from test to test, the researchers discovered that "...scores of the surface learners improved sharply from Tests 1 to 4, while the scores of the deep learners, initially higher than those of the surface learners on Test 1, steadily declined, finishing over 10 points lower than the surface learners on Test 4." In order to understand this discovery, eight surface and eight deep biased subjects were interviewed. Surface learners found that they could pass by 'sheer diligence' and were positively motivated by the mastery approach while deep learners claimed the continual testing was tedious. The researchers concluded that

"...under mastery learning, deep and surface learners increasingly diverge in both performance and attitude...surface learners did better from unit to unit and deep [learners] got worse" (p. 20-21). They called mastery learning into question when a quantitative criterion was used because this resulted in lower cognitive level outcomes and may "turn off the more promising students" (p. 22). However, it was possible to use a qualitative criterion such as authentic testing, partial credit, phenomenography or SOLO taxonomy which promoted high level processing and complex, higher-order outcomes.

Ritchie and Thorkildsen (1994) examined the role of accountability in a mastery learning program. They considered accountability to be a daily or regular learning goal which determined progression and pace through a course of material. They wanted to determine if students' knowledge of accountability was related to academic achievement. A well-documented program titled Mastering Fractions was used as the learning material. Subjects were 96 fifth-grade students with little exposure to fractions. Subjects were randomly assigned to either an experimental or control condition. Those in the experimental condition were told that they were participating in a mastery learning program. Their responses to tests would determine their routing through the material. Subjects in the control group were not informed that they were learning with a mastery program. A criterion-referenced fraction test was administered following the program.

Test scores between experimental and control groups differed by a standardized mean difference effect size of 0.67 for adjusted scores. This supported the claim that knowledge of learning with a mastery program resulted in increased academic achievement. The authors speculated that achievement was due to the knowledge of the mastery program and their awareness that quiz results determined their progression and remediation of the instructional material. In other words, these subjects had a specific goal to learn and perceived that their actions controlled their learning progression. The authors challenged critics of mastery learning programs who considered that achievement using mastery programs was a function of more time spent due to remediation. They concluded that improved achievement was a result of learner accountability.

Senemoglu and Fogelmann (1995) conducted an experiment to explore the role of prior learning and subsequent achievement. A mastery learning approach was used to teach an undergraduate education course on curriculum development and instruction; this course was considered to be less sequential than usual. In a sequential course, previous learning facilitates the learning of subsequent content in a particular series; without the prior experience subsequent learning goals cannot be mastered. The course prerequisite was either educational psychology, philosophy or sociology. Ninety subjects were randomly assigned to one of three groups. In the control group, subjects were pretested using the Cognitive Entry Behavior test (CEB). Thereafter, the instruction was conventional. That is, they were given a course outline, reading list, lectures and some workshops as the teaching method. These subjects received formative tests at the end of each learning task but no feedback on "...how any lack of learning related to the behavioral objectives" (p. 61). At the end of the term, a summative test was used as a posttest. In Experimental Group 1, subjects were also pretested with the CEB, but gaps in prerequisite learning were retaught by teachers and small group work. The CEB was readministered to determine mastery of the prerequisite learning. Thereafter, the remainder of the course was conventionally taught. They also received the same pattern of formative test after each learning task and a summative posttest identical to the control group. In Experimental Group 2, the subjects were pretested with the CEB test and received additional instruction to enhance their prerequisite learning identical to Experimental Group 1. As well, they were provided with feedback and correction after each formative test. If the majority of subjects had not learned a particular component, the teacher would provide remediation using a different approach. These subjects were also presented with the same formative and summative testing protocol. The different pretest scores between the three groups were not statistically significant. Using an analysis of covariance, the authors found that the achievement scores of the second experimental group were significantly higher than the first experimental group and the control group. Experimental Group 1 subjects scored significantly higher than the control group. Enhancing prerequisite learning had a positive effect on achievement. The additional use of the feedback/corrective procedures resulted in the achievement of superior scores for Experimental Group 2, relative to the other two groups. The authors concluded that when prerequisite knowledge is increased and feedback/correction is used, (even in a less sequential course at the university level), there is a significant increase in the level of learning relative to conventional teaching methods, and "...the effects tend to be cumulative" (p. 63). This underscored the importance of mastering prerequisite material.

Hokoda and Fincham (1995) conducted an exploratory study to identify the link between family socialization and children's problem solving styles. Specifically, they studied 3rd grade students and their mothers during a series of solvable and insolvable tasks. The Intellectual Achievement Responsibility Scale and observations of their behaviors were used to identify 21 subjects from an initial sample of 113 subjects as having either mastery (11 pairings) or learned helpless (10 pairings) motivational patterns. Each pairing of mother and child were told that they had up to 5 minutes to complete the tasks which included: 1) block designs, 2) anagram tasks, 3) gridlocks and 4) compound words. Three of the four tasks were unsolvable. The authors wanted to observe whether mothers of mastery children were more sensitive to their children's ability beliefs. Three questions were used to guide the study. First, are mothers' uses of teaching strategies related to their children's motivational patterns? Second, are mothers of mastery children more responsive than mothers of helpless children when their children ask for help? Third, what maternal behaviors directly precede children's displays of helpless behaviors? Verbatim interactions during each task were analyzed and categorized by the following attributional statements: affect, quitting vs. persistence, teaching strategies, feedback and five other behavior codes. Two independent research assistants coded the interactions and Cohen's alpha was used to determine agreement of coding inputs. Examination of the results indicated that mothers of mastery children not only made more attributions of their children's high ability and positive affect statements but also increased teaching statements during the difficult tasks and increased direct-control teaching while working on insolvable puzzles than the learned helpless children's mothers (p. 378). The mothers of helpless and mastery children differed in key ways that are considered to promote children's achievement orientation. For example, mothers of mastery children were more likely to ignore negative statements made by their children and instead offered a teaching strategy whereas mothers of helpless children reciprocated their children's negative affect which promoted a helpless response by the child. Also, mothers of helpless children did not adapt their teaching responses "...as a function of the solvability of the tasks..." (p. 384). Furthermore, when helpless children asked for help, their mothers were more likely to give no feedback than mastery mothers. It appeared that when mothers modeled helpless behaviors their children became passive and unproductive during the unsolvable tasks. In terms of maternal behaviors that preceded children's displays of helplessness, mothers who suggested quitting elicited quitting from their children. Similarly, mothers who made mastery performance-goal statements elicited the same from their children. The study showed the importance of motivation in relation to achievement. Specifically, it demonstrated that mothers can influence their children by the way they structure task goals and that "...goals are important in determining achievement motivation in children" (p. 384).

Bergin (1995) examined the differences between mastery learning goal situations and competitive goal situations. He hypothesized that high-ability subjects would score similarly in both mastery and competitive goal learning situations. However, he also thought low-ability subjects using the mastery goal approach would perform better than their counterparts under the competitive approach. Fifty-one undergraduate education students served as subjects (7 males and 44 females). The subjects were randomly assigned to either a competitive or mastery situation. Those assigned to the competitive situation were instructed to "...study the passage as though [they] were trying to beat all the other subjects in the class" and those assigned to the mastery situation were instructed to "...study the passage as though [they] were really trying to learn the material so [they] could use it (p. 306). Both groups read an identical 978-word text outlining children's writing as the stimulus material. Grade point average was measured using a self-reported 4-point scale. This was used to rank subjects' ability. All students were tested two days after presentation of the reading material. Learning was measured in two ways. One measure was simply free recall; the subjects were asked to write down everything they could using pen and paper. The responses were rated for importance. The other measure was a 10 item multiple-choice test with questions regarding content and specific details. The author reported that both high and low ability subjects' scores did not differ significantly on the multiple-choice test. In contrast, the high-ability subjects scored significantly better than the low-ability subjects did in the competitive situation. A similar pattern was found for the recall task but the scores were not statistically significant. Bergin concluded that the mastery goal situation resulted in greater learning among subjects of low ability than the competitive situation did with similar ability subjects. The results also supported past research findings that mastery learning situations are more adaptive for effective learning.

Madhumita and Kumar (1995) presented 21 brief guidelines for effective instructional design. They were directed towards those who designed computer software, video, or other printed instructional material for distance education or self-learning packages. The authors wanted to perform a synthesis of the educational theories and findings to form the guidelines. The authors claimed that one major flaw with 'guideline' literature has been that previous authors focused on one theoretical orientation--such as behavioral, cognitive, or neurophysiological--and they felt that a "...single theory only explained one dimension of human learning" (p. 58). Moreover, the issue was often clouded by critiques on the subject and related theories. Indeed, others purposely combined theories to articulate useful guidelines that work in application. Two guidelines relevant to Mastery learning included the division of complex tasks into smaller learning units and that such a technique be used to ensure the achievement of critical tasks.

Ross and McBean (1995) investigated the effects of different pacing contingencies in university courses using the Personalized System of Instruction (PSI) whereby 80% or better mastery of each unit was required before advancement to the subsequent unit. Four sections of classes were used with 81, 83, 30, and 46 subjects in each respective section. In course A, a variable interval (VI), fixed interval (FI) and variable interval (VI) sequence of testing was used throughout the learning of 15 units of material. In course B, VI, FI and VI sequence was used and a VI schedule in courses C and D. The test-taking schedule was manipulated by setting deadlines corresponding to the reinforcement schedule. For example, in a VI schedule multiple deadlines were set and tests were taken after a variable number of units were completed; whereas, in an FI schedule, subjects only took one review test after a series of unit learning. If subjects missed a test deadline they would only be credited with 80% of the unit grade upon completion. The authors reported that rates of test taking were more uniform during the VI components in courses A and B (similar to spaced practice effects) than FI components. The latter tended to produce a test-taking scallop, whereby test taking started at a lower level until the nearing of the review tests where rates increased, similar to 'massed practice'. Furthermore, rates of test taking showed the least variability under the VI condition for courses C and D. Ross and McBean concluded that multiple deadlines be used in a PSI course to maintain test-taking behavior.

Many years of research in mastery learning has resulted in evidence that the approach can be effective. Recent research has demonstrated that mastery learning resulted in greater recall than a competitive learning situation when used along with daily goals to teach fractions (Bergin, 1995). Also, subjects with daily goals solved more fractions than subjects learning the same program but without accountability goals (Ritchie and Thorkildsen, 1994). When the mastery approach was used with feedback/correction, learning was superior to conventional teaching methods (Senemoglu and Fogelmann, 1995), improved higher-order thinking skills (Mevarech and Susak, 1993), and, when combined with creative elements, enhanced creative writing among subjects learning English as a second language (Durnin and Yildiran, 1987). Hokoda and Fincham (1995) demonstrated that there was a link between family socialization and children's problem-solving styles. Mothers of children who modeled a mastery approach to problem-solving were more likely to ignore their children's negative statements and offered alternative approaches for solutions. Mothers of children who exhibited learned helplessness statements and behaviors were more likely to be passive and modeled quitting. This study illustrated the importance of learners' interest and motivation in relation to achievement.

Fluency

Precision Teaching. The fluency approach adds response rate to the learning equation. The combination of accuracy and speed defines fluency. Other components of the Precision Teaching methodology include goal setting, regular and frequent monitoring of performance and making instructional adjustments based on students' performance. Using Precision Teaching procedures, educators became subjects "...of the pupil's behavior, carefully analyzing how the behavior changes from day to day and adjusting the instructional plan as necessary to facilitate learning" (White, 1986, p. 522). Lindsley (1990) described several tenets of Precision Teaching:

1.The behavior of the subject should be used to determine the effectiveness of instruction.

2.Achievement should be measured directly and continuously monitored (daily performance assessment).

3.The use of rate of response (e.g., number of correct answers per minute) is the standard measure of behavior.

4.Charting of performance can be used to study performance patterns.

5.Descriptive and functional definitions of behavior and processes are used.

Lindsley (1972) introduced Precision Teaching to the educational audience. The focus was to define the language used with the approach. Precision Teaching developed from operant conditioning research conducted in laboratory studies. However, the 'producers' of this method were really the teachers and children. "The teacher knows best if we are talking about teacher behavior, but the child knows best if we are talking about child behavior" (p. 2). Lindsley described the main parts of the approach. First, the term frequency was used instead of rate as it was not immediately apparent to the lay public that it meant "numbers of behaviors divided by the time it took to count it" (p. 2). Second, the cumulative recorder was used in the form of self-charting. Lindsley studied 'inner behavior' by having behavers chart their own performance on a continuous basis to monitor whether their frequency was increasing or decreasing. In this way, it was possible to determine the effectiveness of rewards. Some other language changes that he felt were necessary included the term 'steep and shallow slopes' from the cumulative record. Instead, the words celeration and deceleration were used. The logarithmic scale was also rejected in favour of the 'multiple-divide' scale. It has now been updated and is referred to as the standard celeration chart. Still other changes included 'baseline' instead of 'operant level' and 'behaver' replacing 'subject'. The name itself was changed from 'free operant conditioning' to Precision Teaching to denote that the procedure was focused on precision. The term 'pin point' was also adopted in place of target behavior. At this early stage of Precision Teaching, Lindsley was determined to simplify the language into basic English so that any teacher or behaver could use the approach to report and monitor their own behavior.

Since that time, studies have shown that subjects who learn to fluency criteria are better able to apply the learned concepts than subjects with no fluency requirement. McDade, Rubenstein and Olander (1983) tested the relationship between frequent testing and application of learned concepts in essay questions. Six undergraduate subjects who enrolled in a senior level psychology course at Jacksonville State University served as subjects. Subjects were required to become fluent with the ideas of several theorists by responding to a minimum of 10 questions per minute with 80% accuracy and successfully passing a review test before moving to other theorists. Subjects were evaluated according to their identification of basic concepts, terms, and definitions associated with particular theorists. The other evaluation component was the composition of an essay. A descriptive analysis of these data was performed. As the number of correct concepts on the frequency testing increased the number of correct concepts on the essay questions also increased. The authors concluded that fluency testing of the concepts resulted in the subject responding quickly and accurately. As well, fluency testing facilitated subject use of those concepts on essays. In sum, not only did the subjects apply the concepts better as they identified them fluently, but they also used them more concisely. As well, since there was no control group, time spent on fluency training cannot be compared to time spent on conventional or other methods.

One article supported the effectiveness of fluency but found no significant differences between a computer or study card learning medium. McDade, Austin and

Olander (1985) conducted a study to compare two frequency-based testing formats. One was the precision teaching technique of Say, All, Fast, Minutes, Each, Day, Shuffled (SAFMEDS). A card deck of at least 100 questions per unit was used. The other format was a computer-generated frequency based testing program which selects items and their alternatives at random from a test item pool of at least 100 items per unit. There were fifteen learning units. Both contained identical material. Thirty-three senior undergraduate subjects at the Jacksonville State University participated. Fifteen were from the Psych 410 course and eighteen from the Psych 335 course.

The Findley forced-choice procedure was used to ensure that testing was given to all subjects in both formats. "Each class was treated as a separate study using non-parametric comparisons for dependent samples, since sample sizes were small. Then the classes were combined into one group, using parametric conditions for dependent samples" (McDade, Austin and Olander, 1985, p. 50). In Psych 335 and Psych 410, the majority of subjects scored their best performances on SAFMEDS, with scores of 77% and 87% respectively. However, the data analysis revealed that "...the highest and best performances were no different in either testing format" (McDade, Austin and Olander, 1985, p. 50). Only one subject in each class used more trials on SAFMEDS than on computers. Fourteen of fifteen subjects in Psychology 410 used the computer past mastery while only ten used SAFMEDS past mastery. In Psychology 335 all eighteen subjects used SAFMEDS past mastery. Since the number of attempts to mastery did not vary in either formats, the authors concluded that both formats resulted in high fluency for both classes.

Olander, Collins, McArthur, Watts, and McDade (1985) compared traditional versus Precision Teaching methods as they related to the retention of material learned after eight months. Eighteen nursing students who were enrolled in Biology 360 were randomly assigned to either a precision taught or traditionally taught method. Traditional methods included two class lectures of 1.5 hours each. Subject performance was measured by an essay exam given after every two chapters and a comprehensive final exam. Precision taught subjects proceeded at their own pace without lectures. They responded to study cards and were required to answer eight correct cards at 80% mastery before progressing to new material. Subjects charted their performance daily and their performance was measured using ten questions for each chapter. There were six chapters to be learned. Eight months later, all subjects were given a retention test which consisted of 1) definition and explanation of thirty-six terms and, 2) the use of six key concepts in an essay. The precision taught subjects were 1.83 times more accurate and 1.85 times more fluent than traditionally taught subjects. Surprisingly, these precision taught subjects also did 1.46 times better than traditionally taught subjects on an essay exam that utilized the concepts (Olander, Collins, McArthur, Watts and McDade, 1986). This study showed that precision taught subjects retained what was learned eight months previously much better than traditionally taught subjects based upon the less structured achievement format of essay exams. This study did not compare fluency training with the mastery training approach.

Binder and Bloom (1989) applied fluency building technology to promote product knowledge for banker trainees. Fluency was defined as a combination of accuracy plus speed or second nature performance that is without hesitation or error (p. 17). Traditional banker training does not allow salespersons enough practice and training to respond "...fluently to potential customers' statement of needs, signals and questions" and sales opportunities may be missed (p. 18). The training procedure consisted of a pretest, a three-step process using Fluency Cards, informal roleplays, and a 2-hour focused coaching session allowing participants to verbally state product facts and match products and services to meet customers' needs. A posttest was administered upon the completion of the training, usually after four weeks. Forty-seven trainees at the Shawmut Bank and nine trainees at the First American Bank participated. All participants showed dramatic improvements in correct responses per minutes to Fluency Cards and decreased errors/skipped items. Their response time in terms of picking up on customers' cues or signal phrases and matching a product or service improved by decreasing from 8.0 seconds to 3.69 seconds at the Shawmut Bank and from 9.23 seconds to 3.93 seconds at the First American Bank. Anecdotal evidence from the training manager and other sales managers were that trainees had better product knowledge than commercial bankers with several years of experience. Observations of trainees' performances also showed that, in face to face customer interactions, quick and knowledgeable responses likely gained sales that would have otherwise been missed. The authors stated that there was a huge potential for the fluency paradigm to improve training and increase bottom-line results in the private sector.

Binder (1990) presented three instructional technologies as capable of solving America's 'basic skills crisis' (p. 32). These were Precision Teaching, Direct Instruction and the Personalized System of Instruction. He speculated that the reason these methods were not widely used was because researchers in these areas had not successfully marketed their work. Binder referred to the *Project Follow Through* study in the early 1970's as the demonstration of the effectiveness of these methods. This project was a federal review panel that examined, researched and reported on the effectiveness of various instructional methodologies to teach 'basic skills'. Precision Teaching is "based on daily practice and direct measurement of skills, charting performance on the Standard Chart and participation in education goal-setting and decision-making by students based on their charted learning pictures" (p. 32). A key component of Precision Teaching was that true mastery was 'fluency' a combination of accuracy plus speed of performance. Binder made the point that true mastery of any skill is performed almost second nature or automatic without hesitation or errors. Direct Instruction consists of brief, carefully sequenced teaching sessions with small groups of students. Carefully selected examples and individualized error-correction procedures are used (p. 33). Personalized System of Instruction (PSI) consists of small units of course material which students learn by study guides consisting of questions, exercises, and comments to guide students' study, as well as quizzes (p. 33). Students progress at their own pace and take a quiz to demonstrate mastery of each unit. If students pass the quiz at a high level (e.g., 90%) they proceed to the next unit. If they do not, then student proctors provide feedback and suggestions for re-study. Binder felt that educators and researchers focused too much on social problems outside the control of teachers such as drugs at school, single-parent families or excessive media influence, instead of effective instructional methods

Downs and Morin (1990) presented two methods for improving reading fluency and an outline for implementing these methods. They noted that past research has demonstrated that students with reading hesitations, decoding and pronunciation difficulties were often identified as having 'comprehension' problems. Two methods have been used to improve reading fluency. One is called Repeated Readings. Students orally reread prose until a predetermined fluency level is reached, usually over 200 words per minute (wpm). The purpose of Repeated Readings is to provide the practice necessary to make decoding automatic, thus enabling the reader to concentrate on comprehension (p.39). The other method is called Neurological Impress Method (NIM). Students read prose orally along with a teacher. The teacher ensures a quick pace (150-200 wpm) by having students read in time to the tracking of her/his finger along the text. The authors detailed an eight-step plan to conduct either method with slow readers. Step 1 involves identifying students who require an intervention through direct observation and measurement of their oral reading rate. Those who read fewer than 80 wpm or made frequent errors or hesitations were identified. Step 2 involves explaining the procedure and benefits to the student to encourage participation and commitment. Step 3 involves implementing either the Repeated Reading or NIM method along with reassurances and reinforcement for close approximations during the reading. Step 4 is a remedial step for very slow readers and gives students another opportunity for practice and success. Step 5 is a one-minute timing procedure. Students read for one minute and the teacher scores the number of correct and incorrect words emitted. Step 6 is a reinforcement step. Students also count the number of words read and the teacher praises the effort and provides corrective feedback for any words that may have been difficult. Step 7 is simply charting these data on a standard celeration chart. Step 8 is a reminder to repeat the process the next day with new reading. The authors concluded that this procedure has improved reading fluency rapidly for students from elementary school through high school.

Bell, Young, Salzberg and West (1991) carried out an experiment to teach four subjects (who had failed the driver education class) the written maneuvers portion of the Utah driver education curriculum. This curriculum consisted of labeling driving sequences such as turns and parking movements. Subjects were all 16 years old and currently in a driver education class. A multiple-baseline design was used to sequence the learning of three maneuvers. Subjects advanced to the next maneuver after meeting the present maneuver's learning criterion. A baseline measure was conducted by giving five minutes to write down everything they could about each maneuver (p. 46). The treatment consisted of peer tutoring, direct instruction and precision teaching. Each subject was paired with a peer tutor (ages 16-18) and all but one of the tutors had tutoring experience. These peer tutors were given 40 minutes of direct instruction training whereby they were presented with a checklist and instructed to "...model, test, retest; to acknowledge correct responses; to use the correction procedure of interrupt, model, test; and to begin the timings with the subject in the writing position and end the timings in one minute" (p. 46).

Diagrams of each maneuver were used and subjects were asked to recall each instruction and draw the position of the car in that particular maneuver. Subjects spent 10 minute sessions with tutors. In order to promote automatic responding and generalization of skills, subjects were timed for one minute each day during which they wrote as much about each maneuver as they could until they reached a criterion of 112 correct responses per minute with no errors. This procedure was consistent with the precision teaching approach (p. 47). The training occurred over 25 school days. The descriptive data analysis illustrated that during baseline all subjects responded inaccurately or at near-zero rates. Peer tutoring resulted in immediate increases in correct responding for all subjects

(p. 49). It took Subjects 2, 3 and 4, between eight and thirteen 10-minute sessions to reach criterion on all maneuvers. Subject 1, required 21 peer tutoring sessions to meet the criteria on the maneuvers. In the regular driver education class, written maneuver tests were administered on eight occasions. From Tests 1 to 4, the four subjects in this study scored zero on every occasion except a score of 30% correct by Subject 1 from Test 4. The intervention was delivered after classroom Test 5 and by Test 7 all subjects who received this treatment scored 100% correct on all written maneuvers. In comparison, their 54 classmates scored an average of 93% correct on the same test and the class average never exceeded 87% correct. Subjects 2, 3 and 4 passed the course along with 66% of the class. Subject 1 required more time to master the remainder of the driver education material. The authors concluded that "...peer tutoring, direct instruction and precision teaching could be used to teach secondary content areas with learners and tutors with variable entry-level skills" (p. 50).

Schoen and James (1991) used the principles of Precision Teaching to systematically evaluate a subject's disruptive behavior and then decrease it, and increase academic learning time. After a behavioral analysis of the situation (which included manipulation of antecedent variables and consequences) did not decrease disruptive behavior to an acceptable level, a self-recording system and behavior contract was employed. The subject was a Grade 5, 11 year-old male with IQ scores within the normal range. At baseline, he called out an average of 34 times daily. Two approaches were tried before the principles of Precision Teaching were implemented. The first approach involved three changes to the classroom. First, since the subject was more likely to call out when he was close to the teacher, the seats were arranged into a 'U'-shape with the subject at the back end of the configuration.

In the second approach, the communication cubes were provided to students and they were asked to expose the appropriate side of the cube when they needed help, were finished, were working or needed to use the bathroom. This procedure was used to decrease unnecessary and unproductive dialogue. Students who committed two or fewer infractions of the classroom rules were informed they could write "no weekend homework" on an index card while other students submitted blanks cards. All the cards were put into a bag and if a card with a no homework message appeared, then all students would be exempt from homework. Even with the group contingency in place and some peer pressure applied to the disruptive subject, 'call outs' did not decrease over the first week. As a result, another approach was taken. The message cube was replaced with a classroom meeting, role-play and written note. The students discussed the problems of calling out and role-played a problem-solving situation involving a disruptive call-out. A written note was also placed on each student's desk as a reminder not to call-out. The group-reward contingency was replaced with a homework pass given to each person with no rule infraction during the week. Unfortunately, this meant that the subject never earned a pass and his call-outs remained at a rate of 20 per day.

The third approach employed a self-recording system and a behavior contract instead of the meeting, role-playing and written reminder note. The subject was encouraged to keep track of and record the times he called out. The subject requested that he be rewarded with a homework pass if he made fewer than seven call-outs daily. This procedure worked and the callouts were minimized; the classroom was no longer disrupted during the day. The authors were aware that the combination of the three approaches may have heightened the subjects' awareness of the problem and served to facilitate the acceptance of self-monitoring. They also noted that having a daily rather than weekly homework contingency may have been more effective by providing immediate consequences. The Precision Teaching principles employed in this study were: behavior measured directly and continuously; response rate quantified behavior; charting performed by the subject; instructional procedures continuously evaluated for effectiveness; and focus on skill building (not simply the elimination of the undesired behavior).

Johnson and Layng (1992) described behavior analysis as a selectionist science and discussed how such a framework could be used to "...investigate changes in behavioral repertoire over time" (p. 1475). In contrast, the mainstream theoretical framework has been the structuralist approach "...which emphasizes investigating knowledge structures and processing" (Skinner, 1987). Two main components of a selectionist approach include generative instruction and fluency. The authors describe generative instruction as focusing on "...effective teaching to establish key component skills and their underlying tool elements to fluency" (p. 1476). Furthermore, fluency with respect to these newly learned tool skills can "...recombine in new ways that correspond to the higher level complex skills shown by experts" (p. 1476). The authors noted that Haughton (1972) defined fluency "as the rate of performance that makes skills not only useful in everyday affairs but also remembered even after a significant period of no practice". Of particular importance was that rate of performance included both the time and count dimensions of measurement. The authors outlined a broad collection of research that was used to develop the generative instruction and fluency learning systems at both the Morningside

Academy in Seattle, Washington and the Malcom X College in Chicago, Illinois. Essentially, the fluency concept was used to build true mastery of tool skills. Through several research initiatives the authors demonstrated that fluency of tool skills resulted in greater subsequent achievement where more complex skills were required. For example, building fluent responses to simple multiplication facts resulted in increased performance in double-digit computation (p. 1480). One student's initial performance rate on component tool skills (multiplication and math facts) was 70 per minute and 15 per minute on double-digit multiplication facts. Building her component skills to 100 per minute resulted in subsequent performance of 50 correct digits per minute on double-digit skills, without any practice on the latter. The authors also distinguished the fluency concept from automaticity and overlearning. The latter two were defined as repetition or practice beyond accuracy whereas fluency included the rate of performance, typically measured as a response per minute and required learning to a rate which ensured later retention, endurance, application and performance.

The authors concluded with an elaboration of the selectionist approach as it related to educational implications. Similar to evolutionary theorists, selectionist theorists must look to variation, selection and retention to build better educational practices. Variants that meet environmental requirements are said to be selected and the selection process is not necessarily limited to the fittest organism but rather organisms with changes best 'fitted' to their environments (p. 1487). If applied to the educational environment, the selectionist approach advances that variants be 'fitted' to educational practice. Moreover these changes must be maintained through a concept such as fluency in order to build educationally beneficial behaviors from a solid foundation of repertoires.

Lindsley (1992) updated the findings of the 23 major precision teaching discoveries that had resulted from 20 years of examining standard celeration charts. He used the mnemonic mediator, PRACTICED MUSIC REAPS FUN, for easy recall. "PRACTICED helps recall the eight important features of practice that were discovered by precision teachers. Practice must be **P**articular, **R**apid, have **A**ims and be added to the curriculum, be **C**ounted by the learner, have 1-minute **T**imings, be **I**nformed, be **C**harted, be **E**rror-full, and done **D**aily. MUSIC helps recall the four basic counterintuitive rules of performance discovered by precision teaching. Performance lives in a **M**ultiply world-not add. Maximizing performance requires **U**nique conditions-not common. Performance is always **S**pecific to the learning situation-not generalized. All performance features are **I**ndependent-not dependent. Performances are pushed by **C**onsequences, not pulled by cause. REAPS lists the performance results produced by fluency. **R**etention, greater **E**ndurance, generalization to **A**pplication, **P**erformance aims for teaching and **S**tandards for aims and evaluation. FUN covers three additional performance goals. **F**luent performance generates interest in searching for **U**nderstanding and there is **N**o time for cheating. Lindsley concluded with a summary of the effectiveness of the Morningside Academy in Seattle, Washington, established in 1980. This is a school which combines fluency with direct instruction to teach children with attention and learning problems. Students generally gain two to three grade levels per year of study and achievement is based on State produced examinations.

Daly and Cooper (1993) enlisted the participation of 29 inservice teachers from elementary or secondary level programs in learning disabilities and 34 preservice undergraduate seniors majoring in special education. The researchers wanted to

"...determine if preservice and inservice teachers were satisfied consumers of Precision Teaching technology and if they used their Precision Teaching skills after the course was over...(p. 317). Both groups developed competencies in basic Precision Teaching skills, including charting, using data to make instructional decisions, and developing fluency with content areas. The authors considered the quantity and quality of Precision Teaching training to be comparable between the two groups. The main measurement was a 9-item questionnaire asking whether teachers were satisfied with Precision Teaching as a method. They were also asked whether they used Precision Teaching, after completing the course, either in the classroom or during subject teaching (p. 319). At the conclusion of the course, the teachers were given the questionnaires. For both groups, 76% of the participants responded to the survey. Fifty-nine percent of the inservice teachers used Precision Teaching with at least one subject since the completion of the course while the preservice teachers reported 50% usage. Both groups used the method to teach math facts, oral reading, spelling, sight vocabulary, geography, writing and science vocabulary (p. 319). There was opportunity for comments from the teachers. Both groups made statements which supported Precision Teaching as a socially valid instructional technique and all reported that it was worth learning. They believed that "... Precision Teaching offered effective classroom instructional application" (p. 323). The most common reason for not using the method was that their sponsor teachers (mentors) did not support using the approach. It is standard practice in special education classrooms to develop knowledge at the acquisition level only but fluency development was not a typical educational objective. The authors stated that many teachers did not use the standard celeration charting procedure properly. This charting procedure provided the teacher with data on subjects' progress. They felt that regular and frequent use of chart-based instructional decisions were essential to being a Precision Teacher.

Johnson and Layng (1994) have conducted numerous studies using the elements of Precision Teaching to assist children with learning and behavior problems. They have been able to help these subjects attain 1.6 to 3.9 grade-levels within one academic year in areas such as reading, language arts and math. They offered the new definition of mastery put forth using the Precision Teaching model. That is, true mastery should consider rate of response as well as accuracy of response. They observed that "...criterion frequency predicts that behavior will be retained after significant periods of no practice, will endure over extended periods, will be easily applied in more complex situations and will be stable in the face of distractions" (p. 183). They reported that the discovery of the benefits of frequency based criterion has "...led many Precision Teachers to abandon goal setting and competency defining by norm-based frequency criteria [fluency]" (p. 183) and, instead. focus on rates of responding that ensure retention, endurance, transfer, and stability.

Kelly (1996) conducted a series of experiments in order to analyze the functional effects of mastery with and without a fluency requirement, on learning maintenance. Her three experiments employed a counterbalanced single-subject design. In Experiment 1, a five-year old child with mild mental retardation was taught to ‘see and say’ words. After an initial baseline measurement, the child was instructed to perform until both accuracy and response rate criteria (fluency measures) were attained. Next, the child was asked to ‘see and say’ a different set of words and the baseline performance data were recorded. Then, the child had to perform until he attained an accuracy criterion (mastery measure) with these new words. All three measures--baseline, fluency and baseline, mastery--were repeated again resulting in an ABACABAC sequence. Tabulation of the post-treatment results revealed that average fluency scores (*M*=47.9 % correct per minute) were superior to the mastery scores (*M*=17.4 % correct per minute). After time away (up to 194 days) from the experimental sessions, the subject was probed by presentation of the same sight-words. For words learned under the mastery condition, this subject posted an average score of 17.4 % correct compared to an average of 47.7 % correct for responses learned under fluency criteria. Clearly, fluency scores were superior. The author conducted Experiment 2 in order to rule out 'order effects'. Two five-year old children with identified learning disabilities participated in this next study. The treatment sequence was counterbalanced across subjects. Subject 1 experienced the ACABACAB sequence while Subject 2 was administered the ABACABAC sequence. Subject 1 recalled an average of 24% correct under the mastery conditions and 33.7% under the fluency conditions. Subject 2 recalled an average of 33.6% correct under the mastery conditions and 34.9 % correct under the fluency conditions. In both cases, post-treatment scores were not significantly different. However, differences were observed when maintenance of learning was measured. The same maintenance probe procedure from Experiment 1 was used for this study. Subject 1 maintained performance of words learned under fluency conditions (*M*=44.9% correct) better than the mastery conditions (*M*=11.8 % correct). The author surmised that when controlled for order effects, the results were similar to Experiment 1. She recognized that there were small but possibly significant differences in instructional time between the treatments. For example, Subject 1 received 1.2 minutes of instruction during the first mastery session and 1.8 minutes of instruction during the first fluency session, resulting in 36 more seconds of instruction under the fluency condition.

Experiment 3 sought to control for these instructional time differences. Two six-year olds identified as learning disabled participated in this study. This time, both subjects progressed through treatments in the same order: ABADABAD. The main difference was that each mastery instructional session time (D) matched the preceding fluency instructional time (B). In essence, D sessions were yoked for time with B sessions. Results were similar to both preceding experiments. Subject 1's average scores after the mastery condition with controlled instructional time was 15.1% correct and 30.3% correct after the fluency conditions. When the maintenance probe procedure was used, words learned under the fluency criteria (*M*=26.3% correct) produced better results than the time-controlled mastery sessions (*M*=0% correct). Subject 2's average scores after the mastery condition with controlled instructional time was 14.6% correct and 29.43% correct after the fluency conditions. Again, when the maintenance probe procedure was used, words learned under the fluency criteria (*M*=23.2% correct) produced better results than the time-controlled mastery sessions (*M*=8% correct). The author recommended using mastery with fluency (rate) requirement to maintain sight words learned by children with learning disabilities.

Precision Teacher literature has found that accurate and rapid rates of responding deliberately conducted for short durations lead to greater retention, endurance, application, performance and stable learning than no response rate requirement. For the most part, these studies lacked a comparison with the accuracy approach used in mastery learning and rate used in fluency learning (accuracy and speed per minute). In all but one case, time spent on each experimental condition was not controlled to rule out the effects of differing practice exposure per experimental condition.

Active Learning

Numerous studies have demonstrated the efficacy of activity in the learning situation. Active responding is a behavioral paradigm that proposes the learner emit an overt and/or observable response and receive feedback in order to promote learning. For example, Skinner (1968) recommended learners be actively responding during learning activities and for teachers to provide appropriate contingencies to learners' responses. Specifically, he suggested generating answers before receiving feedback as to the correctness of the response resulted in better learning of the component skills than simply being shown the answer. An extension of this rule is that this activity should facilitate subsequent performance on related problem-solving tests (near and far transfer). More recently, other researchers have reasserted this learning paradigm (e.g., Gorman, Law and Lindegren, 1981). Many others have concluded that deliberate and effortful activity (Ericsson, Krampe and Tesch-Romer, 1993) during learning controlled by microcomputers definitively increases learning (e.g., Avner, Moore and Smith, 1980; Tudor and Bostow, 1991). The following is a summary of these reports.

Gorman, Law and Lindegren (1981) explored the utility of active learning in an introductory psychology course. Each author taught a group of 50 subjects "...three perspectives as representative of the dominant and prevailing approaches to understanding psychological phenomena". These included the biological, environmental and humanistic positions. Subjects were required to either defend one of the perspectives or serve as a member of the evaluation group. Two novels--Walden Two and The Eden Express--incorporating all three perspectives served as the materials to be presented and debated in critical discussion groups. After each discussion session, subjects were asked to complete a questionnaire "...designed to assess the subjects' perception of the usefulness of this position group technique" (Gorman, Law and Lindegren, 1981, p. 165). The responses were based on a Likert-type scale that ranged from 1 to 7, with seven representing the highest rating for a subject's perception of understanding the psychological perspectives. All groups rated that their understanding of a defense position due to group experience was favourable ($M = 5.30$, range = 4.40 to 5.68). Also, the subjects' understanding of all positions due to active group presentations and discussions was high ($M = 5.58$, range = 5.3 to 5.9). These authors concluded that small group participation was a useful technique to encourage critical thinking and increased general understanding of the course issues. No subsequent course examination scores were offered.

Hagman and Rose (1983) reviewed 13 learning experiments sponsored by the Army Research institute. These experiments examined the role of repetition with respect to training methods, task and ability issues. In one experiment, fuel and electrical repairers learned a 52-step procedure to test alternator output. The 60 repairers were divided into groups of 15. Each group performed the task either one, two, three or four times during training. Task repetition reduced performance time and errors on both immediate and delayed retention tests. Time and error scores generally varied inversely with the number of repetitions performed. It was also noticed that performance differences immediately after training were also present on the delayed test (p. 201). Another training experiment involved moving a sliding mechanism on a linear track until a physical stop was contacted. This was called a presentation learning trial. In contrast, test trials involved performing the same task but without the physical stop. Experimenters found that repetition was effective before and after task proficiency, and repetition of the presentation task promoted acquisition, however, repetition under test trials promoted long-term retention. One other experiment involved machine-gun assembly/disassembly and found that training to a mastery criterion was more effective than training to a proficiency criterion in terms of subsequent retention and error-free performance. However, the authors defined mastery as double the number of trials required to reach the proficiency criterion of one correct performance. This mastery definition was closer to the definition of overlearning or fluency learning than mastery. Retention was better when repetition was spaced rather than massed.

In terms of task issues, several evaluations of the effectiveness of basic training were conducted. The training generally involved reporting of enemy information, loading and firing the M203 grenade launcher, donning the gas mask and cardiopulmonary resuscitation. Researchers discovered that task steps that were not cued by the equipment or by the previous steps performed were more likely to be forgotten.

In terms of ability, one experiment compared performance on 13 basic training tasks with soldiers of varying abilities (as determined by the Armed Forces Qualification Test). Both baseline and delayed tests were used. It was found that higher ability trainees typically learned faster than do those of lower ability, and, if given equal training time, achieved higher levels of acquisition (p. 212).

The authors concluded that trainers need to consider the effects of training, task and ability variables when developing training programs, and suggested that further experiments be conducted to examine the potential interaction of ability level with computer-based instruction.

Robins and Mayer (1993) differentiated the above form of activity from active learning theory based upon cognitive science. The cognitive paradigm purports that learning occurs where "...the learner is mentally active during learning and the teacher's role is to assist the learner in constructing knowledge, such as relational schemas" (p. 530). Many studies have demonstrated that it is the qualitative cognitive activity that increases learning rather than the required behavioral activity (e.g., Bruner, 1961; Mayer, 1984; and Robins and Mayer, 1993)

Active learning theory suggests that the formation of relational schemas is central to learning when solving verbal analogy problems. Under the assumption that there are limited cognitive resources for knowledge acquisition, "...active learning theory predicts that having to generate solutions during training should *reduce* the cognitive capacity available for relational schema formation as it exhausts the working memory capacity and interferes with the building of schemas" (Robins and Mayer, 1993). This clearly contrasts with the Precision Teaching literature.

Ericsson, Krampe and Tesch-Romer (1993) conducted two comprehensive studies of musicians to support their hypothesized theoretical framework. They sought to explain the development of expert performance in a given domain. The authors presented a lengthy discussion to distinguish between deliberate practice and 'innate' talent (pp. 363-373). They noted that current literature indicated that ten years of learning, practice and development was needed to become an expert in a given domain (p. 366). The authors pointed out that there was an important distinction between effortful, deliberate practice and merely engaging in activity for a duration. Deliberate practice was defined as a lengthy process taking ten years and involving several considerations. First, it required "available time and energy of the individual, as well as access to teachers, training material, and training facilities". Second, "it was not inherently motivating" and required much effort to sustain (p. 368). Finally, this effortful activity was only optimized and sustained for a limited time each day before exhaustion occurred. Using this framework, several hypotheses were made by the authors. "First, the highest improvement of performance, and indirectly the highest attained performance, is associated with the largest amounts of deliberate practice" (p. 372). Another prediction was that "...deliberate practice would be rated very high on relevance for performance, high on effort, and comparatively low on inherent enjoyment" (p. 373). A third prediction was that adult elite performance, even among individuals with more than 10 years of practice, is related to their amount of deliberate practice (p. 373).

In Study 1, music professors at the Music Academy of West Berlin assisted in identifying 30 subjects for the study. Ten were identified as 'the best violinists' and 10 were selected as 'good violinists'. A further 10 subjects from the music education department (with lower admission requirements) were recruited and called 'music teachers' as this would likely be their profession rather than performing in a solo or orchestra career. Essentially, the music teachers served as a subgroup of violin performers to the two former groups. All three groups were matched for gender and age.

The violinist subjects were interviewed during three sessions. In Session 1, biographical information was recorded such as "...start of practice, sequence of music teachers, and participation in competitions" (p. 373). They were also asked to estimate the number of hours they had practiced alone in each year since they began practicing.

Further, subjects were asked to estimate the amount of time they spent on specific activities in the last week. Everyday activities were divided into 10 categories and musical activities were divided into 12. Using a scale of 0-10, they were asked to rate each activity upon its relevance to violin performance, the amount of effort it required and how enjoyable it was (p. 373). In Session 2, subjects were asked to recall all of the activities that they had engaged in during the previous day and then record the duration of each activity on a sheet which divided the day into 15-minute intervals (p. 374). In turn, this set of data was categorized using the taxonomy introduced in Session 1. Subjects were asked to continue to record their activities using diary sheet for the next seven days. They were supplied with addressed envelopes and asked to mail each day's data. For Session 3, subjects were allowed to ask any questions they had about encoding their recorded activities. Thereafter, some life-goal questions were used followed by debriefing time.

All three groups were similar in terms of musical background: they had about the same number of teachers, at least ten years of violin practice and they began lessons at about he same age. An analysis of variance revealed a significant difference in the number of open competitions won by each group. The frequencies of success differed greatly at M=2.9 for the 'best violinists' compared to M=0.6 for the 'good' violinists. The average success frequency for these two groups (M=1.9) was significantly greater than that of the 'music teachers' group (M=0.2).

One result from Session 1, showed that 'practice alone' was rated as the most relevant activity for improving performance (on a scale of 0-10), M=9.82 among 22 activities listed in the taxonomy. As comparisons, 'playing for fun with others' was rated moderately relevant (M=6.67) while mundane activities such as 'shopping' were the least relevant to improving performance (*M*=0.77). In terms of effort required to perform the activity, 'practice alone' was rated fourth highest (*M*=8.0), whereas 'playing for fun with others' and 'shopping' required little effort (*M*=3.93 and 2.80, respectively). When subjects were asked to rate the enjoyabililty of the activity, 'practice alone' was not significantly high (*M*=7.23) when compared to 'playing for fun with others' (*M*=8.60) which received the second highest enjoyment rating after 'leisure' (*M*=8.93). The subjects' estimated weekly practice durations were highly correlated with data recorded from the seven-day period.

The authors reported that there were two activities rated as highly relevant for violin performance. Each exceeded five hours per week. They were 'practice alone' and 'sleep'. Extrapolating from the diary sheet, 'practice alone' was significantly higher for the best and good violinists (*M*=26 hrs per week) than the music teachers' group (*M*=9.46 hrs per week). The 'best' and 'good' groups also slept significantly more (*M*=60 hrs per week) than their music teacher counterparts (*M*=54.6 hrs per week). As well, the two best groups napped more (*M*=2.8 hrs per week) than the others (*M*=0.9 hr per week). The authors suggested that sleep was a function of the need to recover from effortful practice. An analysis of variance also showed that the two best groups participated in significantly less leisure time (*M*=24.5 hrs per week) than the music teacher group (*M*=32.9 hrs per week). The authors concluded that the cumulative effect of greater deliberate practice time, concentration and involvement was related to improving violin performance, leaving less time for leisure. These data confirmed the authors' initial hypotheses. The authors stated that a detailed analysis of the 'practice alone' sessions would reveal qualitative differences between the three groups (p. 379).

In Study 2, twelve expert pianists from a Berlin music academy's advanced soloists classes were compared with twelve amateur pianists recruited through newspaper and campus advertisements. The two groups were balanced for gender and age (*M*=24.3 years). In Session 1, subjects were interviewed for biographical data and provided estimates of the average amount they had practiced alone every week since they had started practicing (p. 381). Next, a complex movement coordination task was administered. This task required subjects to play a series of nine keystrokes with one or both hands. Thereafter, subjects were shown how to manage a dairy record sheet and asked to maintain it for a seven-day period.

In Session 2, the subjects were debriefed regarding the dairy sheet and then asked to perform three successive performances of the Prelude No.1 in C-major by J.S. Bach. Two other tests were administered. One was the Digit-Symbol Substitution Test (DS); a subtest of the WAIS, used to measure perceptuo-motor speed. The other was a two-choice reaction time task (CRT) used to measure cognitive motor speed.

There were significant differences between the two groups (p. 383). All experts had 14 years of playing experience and amateurs ranged from 5-20 years. Experts started playing piano at the age of 5.8 years and received 19.1 years of formal instruction whereas amateurs started at 9.9 years of age and received 9.9 years of instruction. Only one amateur subject had participated in an open competition. The analysis of variance revealed a considerable difference in ‘practice alone’ time between the two groups. The experts spent 26.71 hrs per week practicing alone compared to the amateurs who spent 1.88 hrs per week. However, no significant differences were noticed for sleep and leisure time between the two groups. Also, results from the DS and CRT tasks showed no significant differences in cognitive motor and reaction abilities. The authors concluded that these results "...confirm that domain-specific mechanisms, rather than more general cognitive-motor abilities, are responsible for experts' superior performance" (p. 383). Three experts evaluated the tape- recordings of the musical performances by the subjects. There were seven assessment scales ranging from 0-10. The ratings were collapsed across scales and averaged for the three evaluators (p. 383). The expert group's recorded performances scored reliably higher (M=6.4, SE=.21) than the amateurs (M=4.7, SE=.42). The authors summarized that they found large differences in deliberate practice histories between the two groups (p. 386). It appeared that expert pianists started at an earlier age and continued to improve their performance through deliberate practice each year to their current high levels; whereas, amateurs "maintained their early levels until adulthood" (p. 386). Both studies supported the authors' theoretical framework that expert performance was the result of "...an extended process of skill acquisition mediated by large, but not excessive daily amounts of deliberate practice" (p. 387). This is contrary to the belief that 'talent' is something genetically inherited and that no amount of practice can replicate it.

The authors suggested that early signs of 'talent' are the product of early practice and it is probably more accurate to consider 'talent' as showing 'promise'. Furthermore, being told that one is talented or gifted "...most likely increases motivation, self-confidence and protects young performers against doubts about eventual success during the ups and downs of the extended preparation..." which may take up to 10 years (p. 399). The authors encouraged more inquires with elite performers to determine how motivation was actually promoted and sustained.

Alexander, Jetton and Kulikowich (1995) performed two experiments using the model of domain learning (MDL) to examine the interrelationship of subject-matter knowledge, interest and recall of learning human immunology/biology with the cross-domain reference domain of physics. The MDL considers that "...development in a particular field of study is characterized as a progression from an acclimated or naive stage of learning, to a more competent stage, and potentially, to one of proficiency or expertise" (p. 559). The first author stated that the "closer in knowledge, principles, and structure two domains are, the more likely individuals are to be at a similar stage of development for those domains" (p. 561). In Experiment 1, the authors wished to expand on prior research of domain learning by examining how domain knowledge, interest and recall related. Three questions guided this experiment (p. 561). First, what individual performance profiles emerge through a cluster analysis of subjects' interest in human immunology and their recall of passages drawn from that domain? Second, do these emergent performance profiles support the hypotheses detailed in the MDL for learners with different amounts of domain knowledge? Lastly, do individuals who seem to be at certain stages of domain learning in human immunology display similar performance patterns in the domain of physics? In Experiment 2, topic knowledge and individual interest indicators were added. Unlike the first experiment where mostly premedical and graduate educational psychology subjects served as subjects, a more heterogeneous group of undergraduate subjects participated.

The experimental procedure involved two 25-item pretests covering the topics of the stimulus material. The stimulus material consisted of four passages, two related to human immunology and two to physics. In each pairing of articles, there was one familiar and one technical passage. After reading each passage two measures were administered. One measure was an interest rating using a scale of least interesting (1) to most interesting (10). The other measure was a free recall exercise. Subjects were required to write down what they remembered from the passage with no time limit given. Several scorers (there is no mention of number) looked for the recall of idea units from each passage. Interrater reliability exceeded 0.93. Descriptive data analyses were performed, including the cluster analysis procedure, to explore the authors' first research question: What performance profiles emerged from recall and interest scores? Three clusters proved to be significantly different. From pretest scores, Clusters 1 and 2 demonstrated high knowledge in the domain of immunology (*M*=17.41, *M*=17.46, respectively). These two clusters also recalled more idea units (Cluster 1 *M*=50.82, 58.11 and Cluster 2 = 38.0, 36.0) on the two immunology passages than Cluster 3 (*M*=17.12 and 16.18). Interest ratings showed that subjects in Cluster 1 (*M*=7.94, 8.18), showed significantly higher interest than Cluster 3 (*M*=4.00, 5.35) but not Cluster 2 (*M*=6.15, 6.46). Using the MDL, the authors suggested that Cluster 3 data indicated that these subjects were domain naive and showed little interest in the subject matter. Therefore, it would be expected that they recalled less idea units affirming the authors' second research question that knowledgeable and interested learners outperformed naive and disinterested learners. This provided support for the MDL framework. When looking at cross-domain performance the authors predicted that subjects who were knowledgeable in one domain would also do well in learning a related domain (in this case physics). Again, significantly different recall scores from reading two physics passages are noticed when Cluster 1 (*M*=42.17, 40.00) is compared with Cluster 3 (*M*=23.76, 27.94). This answered the authors' third research question regarding cross-domain performance. A closer examination of the subjects in each group revealed group differences. Cluster 1 consisted of 13 premedical subjects and 2 graduate subjects in educational psychology. Cluster 3 consisted of 3 premedical subjects and 14 graduate subjects in educational psychology. The authors concluded that the use of such a homogeneous group of subjects may have resulted in "...a truncated range among the subjects with regard to their knowledge, interest, and recall in the domain of human immunology" (p. 566). In the next experiment a more variable subject group was employed along with two new measures to better assess the interplay of interest and recall. First, subjects were asked to rate their interest on each domain before reading the passages. Second, a topic knowledge test was administered after reading two domain-related passages. As in Experiment 1, all other procedures and data analyses remained the same. Seventy-eight undergraduate subjects in the Faculty of Education served as subjects. Using the cluster analysis procedure, four clusters indicated significant differences. The results were similar to Experiment 1, even with subjects who did not necessarily have career goals related to the domain topic; that is, they were not premedical subjects. Subjects who scored high on domain knowledge and interest were more likely to achieve higher recall, topic knowledge, and cross-domain scores. The reverse is also true, low knowledge and interest resulted in significantly lower scores across measures. Domain knowledge and interest systematically corresponded to recall and topic concept measures.

Perry, Huss, McAuliff and Galas (1996) instituted an active learning approach in a senior post-secondary psychology and law course in order to improve students' understanding and critical thinking skills. Over a six-year period these authors have continually developed and refined the course. Active learning assignments included an action project, a current event analysis, oral arguments and a mock trial. The action project required students to either attend an actual court case or to conduct three interviews with people involved in the legal system. The current event analysis required students to present a psychology and law article. The oral arguments consisted of students debating issues and the mock trial was based on an actual court case. The authors felt that course grades indicated that students learned the content. The spread of grades ranged from C+ to A with occasional failures. Feedback on the active learning was highly favourable (90%-92%). Most students complained about the heavy workload but also stated that the course was interesting and fostered learning. No pre and posttests were used but anecdotal observations from the instructors indicated that students increased their critical thinking skills. "At the beginning of the course students struggled to identify and describe one or two psycholegal dilemmas..." but towards the course end students included more dilemmas and "...more productive class discussion" (p. 79). As well, the quality of the oral arguments increased and the mock trial was better than the content of the action projects. The authors concluded with several suggestions. The most notable one was that proper planning and organization of such a course was imperative. This active learning approach provided structured activities but no emphasis was put on learning rate, accuracy or intensity. Simply put, activities were assigned to students instead of textbook reading and lectures.

Watson, Kessler, Kalla, Kam and Ueki (1996) explored the effects of active learning exercises with a group of underachieving college students. First, 56 students out of 130 in a psychology course were chosen for the experiment because they were scoring lower than C after the first four quizzes. Second, 29 of these students were assigned to the control condition and 27 to the treatment group. Finally, the active learning treatment consisted of four exercises. These included the "use of at least five principles of depth perception to sketch a picture showing the illusion of depth; test the two-point pressure threshold of two volunteers at two points in the hand and back; write a short story illustrating the use of our five senses in daily life; and carry out a 25 trial extrasensory perception test on one's ability to predict the order of five Rhine cards" (p. 132). Control students simply prepared on their own for quizzes. One week after the quiz and/or active learning exercises were completed students were asked to estimate the number of hours they had worked on each of the two chapters and rate their attitudes about each chapter. One month after each quiz date was administered unannounced quizzes were presented. Although students were informed that their performance on these particular quizzes would not effect their grade it was stated that their instructor needed to measure retention. The results indicated that active learning subjects reported they worked longer (3.3 and 2.9 hours) than control students (2.4 and 2.1 hours) and rated chapters as more interesting (3.3 and 3.8) than control students ratings (2.9 and 3.4). The difference between groups in retention was not significant. In fact, control subjects (8.2 and 9.5) outscored active learning subjects (7.8 and 9.0). The authors concluded that active learning led to greater preparation and positive student attitudes without major cost in retention (p. 133). They felt that the exercises helped the underachieving students to pace and improve their learning, which in turn increased student interest in the subject matter. Again, learning activities were assigned to students without any practice performance criteria. It is possible that the simple novelty of the activities increased the motivation of students to learn and participate.

A review of recent active learning research revealed that most studies defined active learning as incorporating a set of structured activities within a course or learning approach (Gorman, Law and Lindegren, 1981; Perry, Huff, McAuliff and Galas, 1996; Watson, Kessler, Kalla, Kam and Ueki, 1996). In contrast, active learning theory is defined as qualitatively increasing constructed knowledge such as the formation of relational schemas (Robins and Mayer, 1993). One comprehensive study demonstrated the desirable effects of sustained, effortful and deliberate active practice (Ericsson, Krampe and Tesch-Romer, 1993). Simply administering active learning assignments did not always result in superior learning in comparison to traditional study methods. In fact, one study showed that students learning on their own performed better on a subsequent quiz than students who had completed active learning exercises (Watson, Kessler, Kalla, Kam and Ueki, 1996). At the least, active learning must be combined with purpose and interest in order to increase the learning effort (Alexander, Jetton and Kulikowich, 1995). To date, contemporary active learning research has not measured or controlled for accuracy or learning rate to examine post-learning effects.

Computer-Based Instruction

The following is a review of the research in computer-delivered learning incorporating active learning. By considering the changes to computer programs since 1980's, one sees that they are now more user-friendly, capable of storing more functions, providing quick accurate feedback for the student and teacher and facilitate active learning. As well, there are simply more computers available for students and many have computers at home, which would aid in deliberate practice/learning.

The widespread use of computers in a variety of settings has made Computer-Based Instruction (CBI) a mode of delivery in many disciplines. When learning by computer, subjects must interact with the material as the programmer intended. Unlike printed material, software can be programmed so that bypassing sections of information is not possible. Also, subjects using CBI must be prohibited from gaining access to correct answers before actually composing their own responses. Dean (1977) argued that the external discipline required by subjects necessary to allow for learning to occur is the very ingredient missing from printed programmed materials. Some researchers have supported the claim that CBI is better in managing subjects' interactive responses than other competing media (Anderson, Kulhavy, and Andre, 1972).

A meta-analysis has been conducted to synthesize the results of hundreds of CBI experiments. Generally, these reviews concluded that CBI produced increased achievement at the elementary and secondary levels (Burns and Boseman, 1980; Edwards, Norton and Taylor, 1971; and Kulik, Bangert, and Williams, 1983). CBI also produced increased achievement at the college level when used as a supplement or substitute for traditional instruction (Kulik, Kulik, and Cohen, 1980).

Experiments investigating the effectiveness of CBI have not identified the variables responsible for increases in achievement. One reason is that the results from many CBI experiments frequently contain the combined effects of many independent variables. Clark (1985) reported that some experiments confound the effects of the medium of presentation with the instructional method. This occurred when one group of subjects read printed programmed instructional frames without blanks while another group worked through a computer presented program requiring overt interaction. In other words, these groups differed with regard to the medium of instruction and the type of responses made. This problem frequently appeared in experiments comparing printed programmed instruction to CBI.

Avner, Moore, and Smith (1980) controlled the medium of presentation by using computers to present instructional stimuli to all experimental subjects. Seven-hundred subjects who were enrolled in a college chemistry laboratory received CBI in one of two forms. One group used a set of instructional materials that required subjects to make overt responses. The authors did not provide a precise definition of these responses. Subjects in the other group could advance to the next frame by merely pressing a key. These experimenters measured observable laboratory performance as an index of achievement rather than written posttest responses . The results indicated that subjects who responded overtly made fewer errors during laboratory sessions. When subjects made laboratory decisions (these were not operationalized), 57% of the overt responding subjects performed without errors compared with 30% of the non-interactive subjects. Both the response contingency and post-response stimuli influenced these results. Only the responders received post-response stimuli following responses. Apart from subject responding, this factor alone could have influenced the experimental outcome.

Canelos, Murphy, Blomback and Heck (1980) compared three instructional methods for teaching music interval construction to 87 music majors. The instructional methods included a programmed text, mastery oriented computer-assisted program, and a conventional textbook. These instructional stimuli were intentionally described without sufficient detail. Based on a 35-item posttest, the computer approach produced the highest number of correct responses (*M*=22.97); this was followed by programmed instruction (*M*=19.97) and the textbook self-practice approach (*M*=18.58). However, these results contain the combined influence of the method and medium of presentation, thereby reducing the likelihood of correct interpretation.

Boettcher, Alderson, and Saccucci (1981) compared the effects of computer-based instruction with printed programmed instruction using identical instructional materials. The program taught the principles of psychopharmacological nursing to 83 undergraduate subjects. A pretest-posttest experimental design measured achievement with true-false and multiple choice questions. These subjects received course grades commensurate with their posttest achievement. While the results showed no group differences in posttest achievement, both groups made equally significant gains in the amount of material learned. Distinct procedural differences between the groups may have confounded the independent variable effects. For example, 'computer group' subjects were required to enter the correct response before viewing the next frame; 'printed programmed instruction' subjects had no similar requirement. Furthermore, post-response stimuli followed computer-entered responses immediately. Conversely, printed programmed instruction did not provide immediate reinforcement, as would have a computer. In the end, effects of instructional method and medium were confounded, eliminating the likelihood of correct interpretation.

Lundgren (1985) compared the effects of programmed-text instruction and computer-based instruction on achievement in learning English grammar. A 78-item pretest-posttest evaluated subjects' written achievement. During the study, one group read programmed frames from a printed text and then wrote their responses. A second group read identical materials and typed their responses on a computer. In contrast to previous research comparing these two presentation media, programmed instruction produced a higher mean number of correct responses (*M*=62.1) than did CBI (*M*=58.0). The magnitude of the difference, however, may not be educationally significant. It is important to note that the instructional methods differed in one important way; the printed program allowed subjects to review past frames whereas the computer prohibited review of past frames by strictly controlling the sequence of instructional stimuli. These differences may have affected the outcome. The combined influence of instructional method and medium were present in the results. In sum, any combination of variables could have influenced the experimental outcome of the aforementioned studies. These include: 1) the presence or absence or post-response stimuli; 2) the sequencing of frames controlled by the computer; 3) the response contingency; or 4) the computer representation of frames. Studies which systematically isolate the variables responsible for achievement differences need to be performed.

Other authors have commented on the state of computer-based instruction. For example, Wehrenberg (1985) discussed the increased popularity of the computer as a training tool. He distinguished two ways in which computers were currently being used. One category consisted of computer-assisted instruction (CAI) where actual training occurs and subjects acquire knowledge or skills as a supplement to the course. Another category was computer-managed instruction where computers are used to keep records, make assignments, administer tests, or compute grades and progress.

Chase (1985) discussed the need for behavioral science to develop advanced interactive computer systems. There were two main criticisms toward behaviorally based computer programs. One was that behavior analysts do not take advantage of the advances in the computer technology. The other criticism was that "...instructional programs created by behavior analysts concentrate on low level skills and ignore complex, conceptual behavior" (p. 65). He speculated that the reason for a lot of the reluctance to develop such software was that instructors were often not good computer programmers. Chase suggested that instructors use an authoring system that allowed them to create courseware without having to program the computer. He offered several examples. In response to the second criticism, Chase outlined a decision table for instructors to use when deciding upon learning objectives and the computer-delivery features required teaching those objectives. For instance, if an instructor wished to teach concepts or to have subjects define terms, then the authoring program should be developed such that definition tasks were required. Thus, the subjects may be required to define concepts or compare and contrast concepts without referring to notes. Similarly, he proposed that it was possible to use an authoring program to teach higher-order concepts. For example, if the learning objective were to have the subject state original examples of a psychological phenomenon, he/she would be required to perform exemplification tasks such as giving an original example of the concept. One example might be to write an original poem using iambic pentameter (p. 69). Chase also presented a checklist to evaluate what has been taught.

Ober, Trainor and Semb (1985) responded to Chase (1985) with two recommendations. One involved a need for the careful analysis of the behavior all those associated with the instructional setting, in order to maintain or improve the contingencies of reinforcement already in place. The second point noted by Ober, Trainor and Semb (1985) related to computer access. They pointed out that "...only one computer existed for every 100 subjects in the public schools..." and many institutions lacked the necessary hardware to support interactive software. Nevertheless, since the time this article was published, the state of computer accessibility has changed dramatically and every post-secondary student owns or has access to a computer.

Welsh and Null (1991) conducted an experiment with 24 college subjects enrolled in an advanced cognition course at the College of William and Mary, Richmond, Virginia. They wanted to determine the extent to which computer-based instruction could replace conventional teaching. Twelve subjects were assigned to a computer-based instruction group. Under this condition, these subjects were to read a computer-delivered replication of Schallert's (1976) work on "the role of context in prose comprehension and the experimental session of Carpenter and Just's (1975) sentence-picture verification" (Welsh and Null, 1991). The remaining twelve subjects were 'conventionally' taught. An instructor read directions and asked these subjects to "...conduct two experimental sessions, serving once as the subject answering questions and once as the experimenter recording the data" (Welsh and Null, 1991). At the end of the school semester, questions concerning the Schallert (1976) and Carpenter and Just's (1975) experiments appeared on the final examination. Differences in the mean scores were not significant between the two groups. In fact, the authors reported that the conventionally taught subjects (M = 52.8 and 45.8) outperformed the experimental condition subjects (M = 51.9 and 38.6).

There are several problems with the comparison performed in this study. Usually, conventional teaching is described as a didactic activity where an instructor lectures to a group of subjects and there is often no contingency for the subjects to participate other than passively. The 'conventionally' taught subjects in this study were actually required to make active responses by conducting experimental sessions. They probably received more feedback from peers whereas those in the 'experimental' computer-based instruction did not experience active responding or feedback. As well, there was no monitoring to ensure that subjects in the experimental condition actually worked through all of the learning components of the software used. This is borne out in the analysis as the authors noted that "...the group that finished first performed the worst". This is actually a good reminder that computer-based instruction requires active responding with feedback and well constructed contingencies in order for learning to occur.

Tudor and Bostow (1991) used a group experimental design with five conditions to isolate independent variables. They were: non-active reading (Group 1); non-active reading with feedback (Group 2); covert responding to frame blanks and feedback (Group 3); actively typing answers to blanks without correction (Group 4); and, typing answers to blanks with correction (Group 5). Fifteen subjects were randomly assigned to each experimental condition. After an initial pretest, each subject progressed through 315 frames of computer-delivered programmed instruction. These frames were designed to teach the topic of preparing automated instruction. Upon completion of the frames, each subject supplied written answers to a 47-item fill-in-the blank posttest and applied what they learned from the study content by producing two instructional frames for computer representation. The results showed that subjects who responded overtly (Groups 4 and 5) to program blanks answered more (14.3%) posttest questions correctly than those who read frames without blanks (Groups 1 and 2). However, these scores were not statistically significant. In the application test, subjects in Groups 3, 4 and 5 produced a significantly higher percentage of technically correct instructional frames than Groups 1 and 2. The authors concluded that active responding resulted in greater posttest gains than non-active response modes.

<u>Learner Stages and Cognitive Development</u>

The theoretical framework relating to mastery and fluency learning are reviewed in the following sections. Over the last 40 years, many authors have postulated learning stages in order to help educators better understand students and thereby deliver information in a manner to maximize learning and cognitive growth. Bloom (1956) ranked cognitive development from lower to higher-order thinking. Perry (1970) wrote about stages of learning and specifically the evolution of knowledge from the student's viewpoint. Recently, Grow (1991) defined four types of learner stages and a particular teaching style that best matches each type. He detailed the dependent, interested, involved and self-directed learner along with the 'best matching' teaching styles. All three theories show the interdependence of the learner/cognitive stages. For example, lower-order skills include remembering facts and concepts. These fundamental facts must be fully mastered in order for the student to progress to become a self-directed learner capable of understanding higher-order concepts and synthesizing information. It is not by coincidence that these three different authors have made similar observations of learner stages (see Table 1). In other words, sophistication in learning is progressive and no particular type of learning is more important than another; in fact, these stages are interdependent.

Theories of Learning

Behavior Analysis. Behavior analysts focus on observable events. Classical conditioning involves pairing an event (neutral stimulus) with an unconditioned stimulus to produce a desired behavior; thereafter, presentation of the newly conditioned stimulus elicits the conditioned response. This approach is not used in education. It demonstrates the effects of association in everyday life; but of course, this is not a part of teaching practice. Having said that, conditioning might inadvertently take place in the general school environment.

Operant conditioning is related to the consequences of actions made by the student and is the approach that continues to be used in many educational applications. One example includes making information sequential and logical. For instance, students must learn addition and subtraction before learning multiplication and finally division. Typically, students are reinforced for correct responses and learn until targeted goals/objectives are reached. In terms of designing educational technology, systematic

Table 1

A Comparison of Developmental Theories and Learner Stages

Dependent Learner

- Behavior analysis elements
- strict sequencing
- correct or incorrect answers
- factual
- mastery of fundamentals in order to understand higher-order concepts and facilitate creative behavior such as application and analysis
- the 'best matching' teacher or teaching tool should be the expert in the field who can explain facts and concepts, encourage knowledge and comprehension skills

Interested Learner

- both behavioral and cognitive elements
- software used to motivate students with interesting graphics and sounds
- interaction with screen is 'see screen and identify problem' or break down concepts and understand relationships between material
- use of goal setting and cognitive strategies (e.g, rehearsal)
- using factual material learned in different contexts, analyzing and understanding relationships
- the 'best matching' professor or teaching tool should motivate and demonstrate how to apply the factual learning (knowledge becomes a matter of educated opinion rather than right or wrong)

Involved and Self-Directed Learner

- constructivist design
- interaction with software is to gather information from various parts of the world (internet), link parts together synthesize to form a new whole and evaluate information when sifting through material discovered through software
- using knowledge base to analyze information, link parts to form new wholes and creative problem solving, also assessment of information and knowledge
- the best matching teacher or teaching tool should aid to seek out information relevant to what the learner is seeking (e.g., a consultant role)

sequencing, reinforcement, corrective feedback, fading of errors through differential reinforcement or extinction, response rate and learning objectives are all key elements.

Cognitive Theory. Cognitive theory is less focused on outcome measures. Cognitive scientists are concerned with learning autonomy and initiative of the learner (Simonson and Thompson, 1994, p. 36). Behavior is a product of how we structure ourselves and the external world. These theorists are interested in the structure and organization of knowledge, learning readiness, intuition (also known as 'educated guesses') and motivation toward learning. Some key cognitive strategies include rehearsal, elaboration, organization, comprehension monitoring and affective strategies. These elements should be incorporated into software design when this approach is used.

The behavioral and cognitive approaches do overlap in several key ways, although their respective terminology may differ. First, cognitive scientists consider predisposition as being important. "Instruction needs something to get it started, something to keep it going, and something to keep it from being random" (Simonson and Thompson, 1994, p. 37). They call these elements: activation, maintenance and direction. Behavior analysts have a similar learning paradigm but they call the elements: establishment of operation, reinforcement schedule and target behavior. Both theories consider pacing and reinforcement as important. That is, logical sequences should be presented and responses rewarded for maintenance. The key areas where they differ are the study of internal versus external variables. Cognitive scientists consider intuition, internal motivation, right brain-left brain learners and discovery learning. In contrast, behavior analysts maintain that they can only study what is observable and while not dismissing that such internal operations do exist they claim that it is problematic to study what is not observable.

Behavior analysts are more concerned with observable events, reinforcement histories, response rate and learning objectives.

Like the learner stages, these two theories are both valuable; each addresses a particular type of learning. Simonson and Thompson (1994) summed it up well by stating that while the behavioral approach may be the least sophisticated it is easiest to apply. Alternatively, while the cognitive approach may offer more potential possibilities it is also very difficult to apply in the classroom (p. 38).

Constructivists. This is a branch of cognitive science. Proponents using this approach make learning very student-centered. Students are encouraged to explore and learn/discover what they value within a given framework. The idea is to allow students to resolve problems creatively. A good example of this theory in application is the Hypercard software that allows students to browse through topics they choose/value at their own pace and in their manner.

Students may be performing at any particular learner stage given the material to be learned and their prerequisite experience. The three main theories of learning corresponded to the stages of learning and cognitive development (see Table 2). For example, the cognitive characteristics of self-directed learners are consistent with the constructivist theory while the behavioral approach more closely resembles the dependent learner.

Summary

The main focus of the mastery and fluency approaches has been the learning criteria. Specifically, mastery learning is an approach that concentrates on the accuracy of response; whereas, fluency learning incorporates both accuracy and response rate. In

Table 2

A Comparison of Three Learner Development Models

Bloom (1956) **Learner's Cognitive Development**	**Perry (1970)** **Four Stages of Cognitive Development**	**Grow (1991)** **Four Stages of Learner's Development**
1. Knowledge skills • Remembering facts and concepts 2. Comprehension skills • Understanding the meaning of remembered facts and reciting them	1. Either/Or thinking (dualism) • Single right answer • Knowledge is a set of truths • Professors are authorities and know the right answers • Teaching is a professor lecturing to students	1. Dependent learner • Student dependent on teacher for information • Require immediate corrective feedback • Best matching teaching style = professors who are authorities
3. Application skills • Using information in a new context • Solving a problem • Answering a question	2. Multiplicity of subjective knowledge • Knowledge no longer consists of right and wrong answers • Knowledge is a matter of educated opinion • All opinions are initially deemed valid	2. Interested learner • Inspired by teacher • Uses goal setting and learning strategies • Professors are motivators
4. Analysis skills • Breaking concepts down • Distinguishing relevant material • Showing relationships	3. Relativism/procedural knowledge • Knowledge is contextual/situation • It is relative and reflected by one's values, assumptions and perspectives • Professors are resources	3. Involved learner • Use group projects to learn • Use seminars to learn • Professors are facilitators/equal
5. Synthesis skills • Linking parts to form a new whole • Using creativity to problem-solve 6. Evaluation skills • Judging and assessing	4. Commitment in relativism, constructed knowledge • Students take their own stands on issues on the basis of their own analysis • Integrating knowledge from others with knowledge learned from self-reflection	4. Self-directed • Study groups • Projects such as internships and dissertations • Professors are consultants

terms of learning to accuracy, there are many reported benefits of the mastery learning approach (Levine, 1985; Kulik, Kulik and Bangert-Drowns, 1990). Additionally, more recent literature has added to the construct by incorporating response rate (speed) into the mastery learning equation. The benefits of including speed have been experimentally demonstrated (Binder, 1988; 1990; 1993; Binder and Bloom, 1989; McDade, Austin and Olander, 1985; McDade, Rubenstein and Olander, 1983; Olander, Collins, McArthur, Watts and McDade, 1985). However, only one comparison between the two approaches has been reported (see Kelly, 1996).

Certainly, active learning, whether to accuracy or rate (accuracy and speed) is important for expert-like performance. Ericsson, Krampe and Tesch-Romer (1993) conducted a comprehensive analysis and revealed the importance of deliberate practice.

These researchers discovered that what we normally labeled as 'expert performance' was actually the result of many years of effortful, intense and deliberate practice. The reality remains, however, that most students are only given a semester or two to master the knowledge domain for each course. Nonetheless, deliberate practice facilitates intense learning and mastery of facts and concepts. Aside from incorporating active learning assignments into the learning, how can deliberate and active learning be used in the academic setting? This was the focus of the forthcoming experiments. For instance, the inclusion of accuracy and rate learning criteria was used to demonstrate their effectiveness in enhancing recall, application and retention.

As well, computer-delivered practice can help by providing corrective feedback, maintaining performance records and controlling the sequencing of the information. Given the importance of mastering fundamentals before progressing to advanced study (see

Bloom, 1956; Grow,1991; Hirsch, 1988; and Perry, 1970), the learning must match the student's stage (ability and interest) and utilize active responding (Alexander, Jetton and Kulikowich, 1995).

Chapter 3

Method

Experiment 1

Subjects. Nine undergraduate students at the University of Victoria were the subjects for this study. Three were in their first year of study, two were completing their second and another was in third year; the remaining three were in their fourth year. Four subjects listed their major area of study as English and two stated political science. The remaining three subjects were separately enrolled in Fine Arts, Linguistics and Commerce. The gender mix was balanced with five females and four males. Their ages ranged from 18-38 (M=24.2).

Subjects were recruited by means of an advertisement posted at the University of Victoria's employment centre (Appendix 1). Prospective subjects called the researcher and were screened for suitability during the initial phone conversation. Three requirements were necessary: first, subjects had to be unfamiliar with psychology terminology; any students who had taken previous psychology courses were not eligible. Second, they had to be fluent readers and typists. Third, they had to be available for multiple sessions and return 30 days after the last session to conduct a follow-up session. To further insure that participants had no prior knowledge of the material to be learned a pretest screening process was used. At the beginning of the first session, subjects were asked to provide answers to a 6-item pretest (Appendix 2). When the pretest was completed the researcher scored the responses. Those who provided more than three correct responses were dropped from the study. Fortunately, all subjects met the criteria. That is, no subjects provided more than three correct responses. Of course, the initial telephone screening helped to avoid dropping of subjects after the pretest.

All subjects participated in three sessions. The first session lasted two hours and the remaining sessions each lasted approximately one hour. They were paid $10.00 per hour at the conclusion of each session. Subjects were informed that participation was completely voluntary and that they had the 'right to withdraw' at any time without indemnity. Confidentiality of records and identification was also explained. They were told that all of the data generated was stored on a computer diskette kept in a locked drawer. To further safeguard subjects' identity, each was assigned a unique numbered 'code name'.

Setting

Three training rooms at a downtown Victoria employment agency served as the experimental space. This space was used after business hours so no other persons were in attendance. The investigator controlled entry into this space; this ensured that distractions were kept to a minimum.

Apparatus and Materials

The rooms were equipped with IBM compatible computers, with keyboards and monitors. The Think Fast program was preloaded on the harddrive and a floppy disk was placed in the "A" drive of the computer to collect data. There were five workstations, allowing the researcher to run multiple subjects at one time.

Software

Parsons (1984; 1994) designed the fluency-building software program, Think Fast, to facilitate the learning of information. This software was constructed with operant learning principles, such as feedback, reinforcement and rate of response in mind. This software was chosen because it offered these features in an efficient and controlled manner. The program is capable of delivering information in many ways; however, only one mode (Type Keyword mode) was used for this study.

Type Keywords. In the *Type Keyword* mode each statement was displayed as a question with a keyword omitted (see Appendix 3). For example, "Fixed Ratio: A reinforcer is delivered for a ________ number of instances of a target behavior". The answer box at the bottom remained blank. The subject was instructed to type the answer component, in this case: f-i-x-e-d. The program immediately indicated the correctness of each keystroke. Even one incorrect keystroke resulted in a response being counted as incorrect. When four incorrect keystrokes were made in response to a particular answer, the subject was then prompted by the correct letter; however, this response was also counted as incorrect. The nature of this mode required subjects to type each letter of the answer component before progressing to the next frame. Again, subjects repeated this procedure until the last card was completed; this counted as one experimental trial. This mode was employed for all subjects during experimental conditions.

For this study, a special version was designed. In addition to the features listed above, this version recorded every keystroke made by the subject and time-stamped each entry to the nearest decisecond. These data, in turn, were deposited into a datafile for subsequent analyses. Some data examples included the speed (rate of response), accuracy (numbers correct and incorrect) and rate of fluency response (number correct divided into each trial completion time).

Study Content

Reading. In order to replicate the intention of Miller's teaching text, the subjects were given a copy of each chapter introduction to read (Miller, 1980, 71-113). For example, the three page introduction to the chapter teaching the concept of Reinforcement was provided for the subject to read prior to using the Think Fast software and before receiving specific learning instructions to progress through the study cards. Except for the control condition, the reading prior each Think Fast learning episode was repeated for each new concept and experimental condition

Think Fast. The study content consisted of 60 cards (Appendix 3). Ten study cards illustrated each one of the following six concepts: reinforcement, extinction, shaping, differential reinforcement, ratio schedules and interval schedules of reinforcement (Miller, 1980, 71-113). This material was entered into the Think Fast software.

Test Administration Sequence

At the beginning of Session 1, subjects completed a 6-item pretest and then a demonstration of the operation of the Think Fast software. Next, they read a chapter introduction before using the Think Fast software. Subjects repeated this procedure for a second concept introduction and Think Fast deck. The third condition involved reading only and excluded computer work. Upon conclusion of these three experimental conditions, the experimenter presented two posttests. The presentation order was: 1) Recall 1 and 2) Application 1. The sequence of Session 2's was similar except that two different chapters and decks of information were used. Subjects progressed through two experimental conditions and were administered Recall 2 and Application 2. After a 30-day delay, subjects returned for Session 3 and were presented with the retention tests. The presentation sequence was: Definitions, Recall 3, Application 3 and a subject survey. All of the posttests are described below.

Dependent Measures

Pretest. This 6-item test consisted of selected questions from the actual study cards (see Appendix 2). This test was used at the beginning of the first session to determine the extent of prior knowledge with the study material.

Recall 1. Another dependent variable was each subject's responses to a 30-item posttest (Appendix 4). Study content was proportionally represented; that is, 10 items each were based upon the concepts of reinforcement, extinction and shaping. Each question was randomly presented on a separate page, resulting in 30 pages. This was done to discourage returning to an earlier item once the subject had progressed to subsequent items. The investigator instructed subjects to keep progressing through each item and was present to ensure that subjects did not return to earlier items. In order to simulate the typical academic testing situation, subjects were presented with this posttest on paper. The responses required were identical to the corresponding missing keywords presented in the Think Fast study content and based on the chapter readings. After reading a question, the subjects wrote their answer in the corresponding answer space on the answer sheet. The time required to complete this test was recorded by the investigator. This test was used to measure recall.

Application 1. Another dependent measure administered in Session 1 consisted of 15 items (Appendix 5). The concepts of reinforcement, extinction and shaping were each represented by 5 items for a total of 15 examples. Subjects were asked to read each exemplar and attempt to identify the concept based on what they learned from the computer program and from the chapter readings. The time required to complete this test was recorded by the investigator. This test was used to measure application of the learned concepts to more complex questions (i.e., near transfer).

Recall 2. This test was used in Session 2. Ten items each were used to teach the concepts of differential reinforcement, ratio schedules and interval schedules of reinforcement using the Think Fast program (Appendix 6). Given that each subject was assigned to only two experimental conditions in this session (Think Fast decks were counterbalanced across subjects), a 20-item recall test was administered. These items were identical to the items that had been presented to the subjects through the Think Fast program and each item was presented on a separate page. Subjects were instructed to read each item and write their answer on the answer sheet. They were again reminded not to return to items after turning each page.

Application 2. Similar to the earlier application test, this test consisted of five exemplars illustrating each of the two concepts that the subject had been assigned to learn (Appendix 7). This ten-item test required subjects to read and identify each example. Subject responses were written on a corresponding answer sheet and once again subjects were instructed to proceed "one item at a time" and not return to items on that they had completed earlier. As with the earlier tests, the investigator recorded the time required to complete this test.

Retention Tests. After a period of at least 30 days, subjects were asked to return for a 60-minute session. For this session, subjects were presented with several tests, most of which were identical to the test materials given during the earlier sessions. The testing sequence was identical for all subjects. First, subjects were presented with the name of each concept that they had experienced and asked to write a definition (Appendix 8). In order to simulate a testing condition, subjects were informed that they had a maximum of 10 minutes to complete this test. Second, Recall 3 was presented. This test included all 50-recall items used in the Think Fast learning decks; the items were presented in random order on separate pages of paper (Appendix 9). Subjects were given a time limit of 20 minutes to complete this test. Third, the exemplars used in the earlier sessions were readministered (Appendix 10). Again, these exemplars were randomized and presented on separate pages of paper. A time limit of 20 minutes was allowed. Finally, subjects were asked to complete a survey requesting their ratings and comments regarding the learning they had experienced. They had the remainder of the session to complete this survey which was a minimum of 10 minutes, although no time limit was mentioned. For all tests, subjects were instructed to read and answer each question "one-at-a-time" and not to return to completed or passed items. As well, the time required to complete each test was recorded. These tests were used to assess learning retention. After this session, subjects were individually debriefed.

Data Analysis

Data on Posttests. Subjects wrote all responses to posttests using pen and paper. These posttest responses were scored either correct or incorrect and tabulated by the investigator. The measure for correctness was if subjects' responses corresponded to the answers prescribed by Miller (1980). The analysis of these data will be explained in the following section.

Think Fast Data Collection. The software and computer collected data on learning to accuracy, and learning to Accuracy and Speed. The experimental version of the software used was capable of recording each keystroke made by subjects as well as the speed of response from the time that each screen of information was presented to the time that the subject completed a response.

To measure the accuracy data, subjects were required to "think" of the correct response and then enter the response by typing or saying the answer and scoring it as either correct or incorrect. The computer tabulated all correct/incorrect keystrokes. To measure the speed data-- the time that each subject used to complete each trial through a sequence of study cards--was recorded by the computer and this total time was divided into the percentage correct/incorrect to produce a speed rate for that particular trial. Subjects had all of this data supplied on a "feedback" screen at the end of each trial.

Interest Survey. A six-question interest survey was used to check for relationships between subjects' reported interest and posttest scores. A simple Likert-type scale ranging from *least* (1) to *most* (5) was used. Appendix 11 lists these questions. A survey similar to this was successfully used to measure the relationship between domain interest and subsequent recall in Alexander, Jetton and Kulikowich (1995, p. 567).

Procedure and Research Design

After identifying suitable research participants through an initial phone screening, the experimenter arranged to meet each subject in one of the research rooms described earlier. Given that individuals learn in so many ways (e.g., rates of learning) a single-subject design was employed to enable within-subject analysis and replication. Using a table of random numbers, the nine subjects were randomly assigned to one of three countered-balanced learning sequences resulting in three subgroups. The main difference was that the experimental conditions varied in the number of trials per condition (see Table 3). Each experimental sequence will be described in detail in the following section.

Table 3

Experiment 1 Research Design and Sample Procedure

	A	B	C	Posttest 1	D	E	Posttest 2	Posttest 3
Subgroup 1								
1	20 trials	40	none		20	40		
2	20	40	none		20	40		
3	20	40	none		20	40		
Subgroup 2								
4	30	30	none		30	30		
5	30	30	none		30	30		
6	30	30	none		30	30		
Subgroup 3								
7	40	20	none		40	20		
8	40	20	none		40	20		
9	40	20	none		40	20		

Explanation of Conditions:

1. Numbers indicate the number of Think Fast trials per condition
2. Condition A – Learning to Accuracy Only
3. Condition B – Learning to Accuracy and Speed
4. Condition C – Reading Only
5. Condition D – Learning to Accuracy and Speed
6. Condition E – Learning to Accuracy Only
7. Posttest 1 – Recall and application tests for decks used in Conditions A, B and C.
8. Posttest 2 – Recall and application tests for decks used in Conditions D and E.
9. Posttest 3 – Write definitions, recall, application and interest survey presented after a 30-day delay.

The first subgroup included Subjects 1, 2 and 3. These subjects were instructed to read a three page introduction by Miller (1980) explaining a behavioral concept and then complete 20 Think Fast trials to Accuracy (see Appendix 12). The trials consisted of a deck of 10 cards containing information from the Miller reading that each subject had just completed. When the subjects finished they were presented with another three pages by Miller (1980) illustrating a different concept. Thereafter, these subjects completed 40 trials to Accuracy and Speed (see Appendix 12). Upon completion, they were given another concept explanation written by Miller (1980), however, no Think Fast learning was required. After reading about the third concept, the investigator administered Recall 1 tests. This concluded Session 1.

For Session 2, the same subjects progressed through 20 Think Fast trials to Accuracy and Speed and 40 trials to accuracy. Miller's (1980) chapter introductions preceded each Think Fast learning episode. Recall 2 and Application 2 tests were administered after the reading and Think Fast learning to conclude this session.

The second subgroup consisted of Subjects 4, 5 and 6. They completed equal numbers of trials for both Accuracy and Accuracy and Speed conditions. Specifically, in Session 1, each completed 30 Think Fast trials to Accuracy and then 30 trials to Accuracy and Speed. As with the other subgroups, one of the concept introductions was not followed by Think Fast learning in order to simulate reading only. For Session 2, the experimental conditions were presented in reverse order. The same subjects completed 30 Think Fast trials to Accuracy and Speed and then 30 trials to accuracy. All Think Fast sessions were preceded by Miller's concept introductions.

The last subgroup consisted of Subjects 7, 8 and 9. Each of these subjects read a concept introduction then completed 40 Think Fast trials to Accuracy before reading another concept introduction and completing 20 trials to Accuracy and Speed. Again, one reading was not followed with any Think Fast learning or contingencies other than completing the reading. For Session 2, these subjects completed 40 trials to Accuracy and Speed first and 20 trials to Accuracy second. As with the other subgroups, Session 2 did not incorporate a reading condition.

The study contents--chapter readings and Think Fast decks--were also counterbalanced across subjects (see Table 4). A thorough explanation including Subject 1's learning sequence as an illustration is presented in the following section.

Session 1. In Session 1, after introductions and an overview of the study, all subjects were shown how to operate the Think Fast program and asked to answer a subject information sheet. Next, subjects progressed through the experiment in the following manner: learning to Accuracy criterion (A), learning to Accuracy and Speed criteria (B) and a Reading (control) condition (C). The control condition was purposely introduced *after* the two experimental conditions in order to rule out the latency effect. (That is, if the control condition always preceded the experimental conditions then one could argue that the scores were a function of what the subject read most recently.) The three learning decks were counterbalanced across subjects (Table 4). For example, Subject 1 read Miller's three-page chapter introduction on shaping and was then instructed to learn using the Think Fast program. Specifically, she was instructed to read each frame slowly and carefully. Also, she was reminded to pay attention to the Accuracy score on the feedback screen at the end of each trial and maintain 100% accuracy as often as possible. The number of trials that each subject was asked to experience depended upon the experimental sequence assigned. In this case, Subject 1 was asked to complete 20 trials of learning to accuracy. Upon completion, the subject was asked to read the next chapter introduction outlining the concept of reinforcement.

Thereafter, the subject was instructed to use the Think Fast program learning the reinforcement deck by completing 40 trials as quickly and as accurately as possible. When the subject was finished, she was provided with the third chapter introduction on the topic of extinction. No subsequent learning with the Think Fast program was conducted in order to replicate the activity of simply reading before a test. This

Table 4

Counterbalanced *Think Fast* Deck Sequence for Experiment 1 Subjects Across All Experimental Conditions

	Session 1			**Session 2**	
Subject	**Reading**	**Accuracy**	**Accuracy/Speed**	**Accuracy/Speed**	**Accuracy**
1	Extinction	Shaping	Reinforcement	Ratio	Differential
2	Shaping	Reinforcement	Extinction	Interval	Ratio
3	Reinforcement	Extinction	Shaping	Differential	Interval
4	Extinction	Shaping	Reinforcement	Ratio	Differential
5	Shaping	Reinforcement	Extinction	Interval	Ratio
6	Reinforcement	Extinction	Shaping	Differential	Interval
7	Extinction	Shaping	Reinforcement	Ratio	Differential
8	Shaping	Reinforcement	Extinction	Interval	Ratio
9	Reinforcement	Extinction	Shaping	Differential	Interval

concluded the learning component of the session. Two posttests were then delivered. The first was a 30-item recall test. The second was a 15-item application test. This concluded the first session and a meeting for Session 2 was then arranged.

Session 2. In this session, the learning sequence and number of trials was reversed from Session 1. In other words, all subjects now started learning with Accuracy and Speed criteria before progressing to learning to accuracy. As well, those subjects who experienced 40 trials under the learning to Accuracy and Speed condition and 20 trials learning to Accuracy during Session 1 were now instructed to learn two new chapters and Think Fast decks under different conditions. Learning to Accuracy and Speed was now limited to 20 trials, learning to Accuracy required completion of 40 trials. Conversely, those subjects who learned to Accuracy in Session 1 (completing 40 trials and learned to Accuracy and Speed criteria in 20 trials) were now instructed to learn to Accuracy within 20 trials and then learn to Accuracy and Speed completing 40 trials. Subjects who completed the same number of trials (30) for both conditions in Session 1 also completed the same number of trials (30) under both conditions in Session 2. In the case of Subject 1, she was asked to read the chapter introduction on ratio schedules of reinforcement before learning to 100% accuracy and to achieve as fast a rate as possible. She was encouraged to improve on her correct rate from trial to trial. Next, the same subject was provided with the chapter introduction illustrating the concept of differential reinforcement. She was instructed to learn to 100% accuracy and reminded to read each card slowly and as carefully as possible for 40 trials. As with the earlier session, two posttests were administered. The first was a 20-item recall test and the second was a ten-item application test; both illustrated the concepts learned during this session.

Session 3. All subjects were asked to return 30 days later to write out definitions of each concept learned and complete recall and application questions. In order to replicate a testing situation, subjects were informed that both tests had to completed within 50 minutes, leaving 10 minutes for the completion of the subject survey. Subjects started by providing definitions for each of the concepts learned in the earlier sessions. Thereafter, subjects were all presented with identical 60-item recall tests containing all the concepts that they had previously learned. The application test contained the same 15-items that they had previously answered. The last part of the session included a subject feedback survey. The investigator recorded the time required to complete each test.

This particular design was used to examine the effects of varying exposure time in the experimental conditions. This allowed between-subjects comparisons in terms of posttest results and learning time. It also provided within-subject analysis and replication and eliminated time as a confounding variable. To control for the 'instructional set' confound, all subjects experienced identical learning sequences and instructions (Table 3); therefore, no subject had an instructional advantage over others.

The following is a description of Experiment 2. A quicker response mode—Saying Answer—was used instead of "Type Keyword". Potentially, a subject could respond faster in he say mode without the typing requirement. This would also make typing speed between subjects inconsequential. A between-subjects design was used with only one deck of 30 Think Fast cards instead of many smaller decks, in an attempt to generate more stable Think Fast performance than observed in Experiment1. As a result of having only one study deck, the posttests now consisted of a greater range of achievement between subjects

Experiment 2

Subjects. The subjects for this study were also six undergraduate students at the University of Victoria. Three subjects listed themselves as first year students, one was completing her second year and the remaining two were in third year studies. Two subjects listed their major area of study as Arts and Science with undeclared majors. The remaining four were each in different departments: Geography, Communications, Chemistry and Biology. The gender mix was four females and two males, with both males randomly assigned to the Accuracy and Speed condition. Their ages ranged from 19-24 (*M*=20.6).

Subjects were recruited through an advertisement posted at the University of Victoria's employment centre (Appendix 1). Interested students were asked to call the investigator. Students were screened over the phone by the investigator. As in Experiment 1, two requirements were necessary for participation. First, subjects had to be unfamiliar with psychology terminology; they must not have taken any psychology courses. Second, they had to be fluent readers.

All subjects participated in three sessions; the first session lasted two hours and the second session was approximately one hour. A follow-up session lasted approximately one hour. Subjects were paid $10.00 per hour at the conclusion of each session. Subjects were informed that participation was completely voluntary and that they had the 'right to withdraw' at any time without indemnity. Confidentiality of records and identification was explained. Specifically, they were told that all of the data generated was stored on a computer diskette kept in a locked drawer. To further safeguard subjects' identity, each was assigned an unique numbered "codename".

Setting

As in Experiment 1, training rooms at a local employment agency served as the experimental space. This space was used after business hours so no other persons were in attendance. The investigator controlled entry into this space; this ensured that distractions were kept to a minimum.

Apparatus and Materials

The rooms were equipped with IBM compatible computers with keyboards and monitors. The Think Fast program was preloaded on the harddrive and a floppy disk was placed in the "A" drive of the computer to collect data.

Software

Once again, the Think Fast software was used; however, only the Say mode was used for Experiment 2. In Experiment 1, the fastest correct rates did not exceed 30 per minute and only a few subjects were able to reach between 25-29 correctly typed responses per minute. Response speed was likely hindered by the requirement of typing and thus a ceiling effect was observed. The Say response mode was employed for Experiment 2 to allow subjects to reach faster response rates. The following is a description of this mode.

Say Mode. Using this mode, the question was displayed with a keyword missing and the answer component was not displayed without appropriate responding. For example, the question: "The operation of _______ reinforcement." was displayed while the answer box at the bottom of the screen remained blank (see Appendix 13). The subjects were instructed to respond by saying the answer "discontinuing" aloud. Next, the experimenter depressed the spacebar causing the missing keyword to appear in the bottom box. The investigator scored the subjects' responses by pressing "C" (correct) or "I" (incorrect) and repeated this procedure until the last card was completed. This was the process to complete one trial. This was the only response mode used for Experiment 2.

Study Content

Reading. In order to replicate the intention of Miller's teaching text, the subjects were given a copy of each chapter introduction to read (Miller, 1980, 71-113). For this experiment, the three chapter introductions explaining reinforcement, extinction and shaping were read consecutively before proceeding to the Think Fast computer learning.

Think Fast.

The computer study content consisted of 30 cards rather than the three decks of 10 cards used in Experiment 1 (Appendix 13). The cards covered the concepts of reinforcement, extinction, and shaping. The "differential reinforcement" and "schedules of reinforcement" cards were not used for this study.

Procedure and Research Design

It was evident from Experiment 1, that the group totals indicated an effect. That is, as a group, subjects answered more posttest and application items under the learning to Accuracy and Speed condition than any other condition. However, it was also evident that some subjects demonstrated the opposite effect while still other subjects scored comparably regardless of condition assigned. Given that individual variability across subjects was so great, a between-subject design was used to replicate the findings of Experiment 1. Subjects were randomly assigned to either an Accuracy condition or Accuracy and Speed condition. Aside from the experimental condition assigned, no other differences were included between subjects.

Baseline Measure. At the beginning of the Session 1, subjects were asked to read Miller's chapter 1 and then answer ten recall questions (Appendix 14). This test was used to check for the variability of achievement among the subjects with respect to reading and responding to questions. The purpose of this test was to detect differences in reading and answering questions between subjects.

Pretest. The same six-item pretest used in Experiment 1 was presented along with identical instructions (Appendix 2).

Session 1

After introductions and an overview of the study, all subjects were presented with the Baseline and six-item Pretest described earlier. Next, subjects were given Miller's chapter introductions on reinforcement, extinction and shaping. Unlike Experiment 1, there was no counterbalancing. The only difference between subjects was the experimental condition. Subjects were assigned to either an Accuracy or Accuracy and Speed condition and all subjects experienced the same 30 card Think Fast deck outlined earlier. Regardless of the experimental condition assigned, all subjects used the Say mode to respond to each study card. The experimenter operated the Think Fast program and students verbalized the answer. The experimenter also scored each response by pressing either the "C" (correct) or "I" (incorrect) key. Only responses that were identical to Miller's keywords were considered correct. Again, subjects in the Accuracy condition were instructed to learn the deck to a 100% accuracy rate as often as possible while progressing through each card slowly and carefully. Subjects in the Accuracy and Speed learning condition were instructed to maintain 100% accuracy and progress through each card as "quickly and as accurately as possible." Subjects were informed that they would have to complete 20 trials to conclude this session. This session typically lasted 2 hours. By the end of this session, all subjects completed 20 Think Fast trials.

Session 2

Subjects returned the next day and completed another 20 trials under the experimental condition assigned in Session 1. This resulted in 40 exposures to each card or 1,200 total exposures. After the completion of these trials, a 15-item application exercise was administered (Appendix 15). This session was typically an hour in duration. The recall exercise was not administered at this point; instead, the last five Think Fast trials were averaged to determine terminal accuracy rates.

Session 3

All subjects were asked to return 30 days later to complete a number of tests in a simulated classroom environment, with other subjects present. To replicate the typical testing situation, subjects were informed that tests would be administered with time limits for each test. Subjects met in a larger classroom setting with tables and chairs. First, they were asked to write out definitions of each concept learned using paper and pencil (Appendix 16). This task had not been previously presented. Second, a 30-item recall test was presented with items identical to those learned using the Think Fast software (Appendix 13). Application 2 consisted of the same 15 application items presented at the conclusion of Session 2 (Appendix 15). The last part of the session included a subject feedback survey with modifications from the one used in Experiment 1 (Appendix 18). The investigator recorded the time required to complete each test. All posttests are described in the following section.

Dependent Measures

Application 1. The only dependent measure administered in Session 2 consisted of 15 items (Appendix 15). The concepts of reinforcement, extinction and shaping were each represented by 5 items for a total of 15 examples. Subjects were asked to read each exemplar and attempt to identify the concept based on what they learned from the Think Fast computer program and from the chapter readings. The time required to complete this test was recorded by the investigator. This test was used to measure application of the learned concepts to more complex questions (i.e., near transfer).

Retention Tests

Write Definitions. First, subjects were presented with the name of each concept that they had experienced and asked to write a definition. In order to simulate a testing condition, subjects were informed that they had a maximum of 10 minutes to complete this test.

Recall Test. Another dependent variable was the subjects' responses to a 30-item posttest (Appendix 17). These items were identical to the 30 Think Fast cards covering reinforcement, extinction and shaping, except that here the items were presented on paper and subjects had to respond by writing the answer. Each question was presented on a separate page and in random order. This was done to discourage returning to an earlier item once the subject had progressed to subsequent items. To be sure of this, the researcher was present during testing. The pen and paper test was used to simulate another component of the typical academic testing situation. The responses required were identical to the corresponding missing keywords presented in the Think Fast study content and based on the chapter readings. After reading a question, the subjects wrote each answer in the corresponding answer space on the answer sheet. The time required to complete this test was recorded by the investigator. This test was used to measure recall and was administered in Session 3 only. Subjects were given a time limit of 20 minutes to complete this test.

Application 2. Similar to the earlier application test, this test consisted of the 15 Application Test 1 items that subjects had seen in Session 2 (Appendix 15). This 15-item test required subjects to read and identify each example. Each question was presented on a separate page and in random order. This was done to discourage returning to an earlier item once the subject had progressed to subsequent items. Subjects' responses were written on a corresponding answer sheet and once again subjects were instructed to proceed 'one item at a time' and not return to items that they had completed earlier. As with the earlier tests, the investigator recorded the time required to complete this test. A time limit of 20 minutes was allowed.

Interest Survey

Subjects were asked to complete a survey requesting their ratings and comments on interest and learning (Appendix 18). The same survey used in Experiment 1 was employed with a minor modification; subjects were only asked to rate the response rate they were assigned (i.e., Accuracy or Accuracy and Speed). A six-question interest survey was used to check for relationships between subjects' reported interest and posttest scores. A simple Likert-type scale ranging from *least* (1) to *most* (5) was used. Subjects' had the remainder of the session to complete this survey and no time limit was mentioned.

For all tests, subjects were instructed to read and answer each question "one-at-a-time" and not to return to completed or passed items. These instructions were omitted when the survey was presented. As well, the time required to complete each test was recorded. These tests were used to assess recall, application and retention. After this session, subjects were individually debriefed.

Chapter 4

Results

Experiment 1

The main dependent variables in both studies were subjects' written responses to recall, application tests and the same measures readministered as retention tests after a 30-day delay. Given that the research design allowed for replication across three subjects for each experimental sequence, three logical subgroups were formed (Tables 3 and 4). In other words, all subjects experienced the same experimental sequence, instructions and stimuli but the number of trials completed under each condition was dependent on the sequence assigned. Nonetheless, the total number of trials each subject completed was held constant. The forthcoming analyses examine the performance differences between the subjects and their part in subgroups, as well as group totals.

Think Fast Learning Data

Figures 1-9 represent the Think Fast learning rates for each subject across the experimental conditions. Subject 1 experienced the same experimental sequence as Subjects 2 and 3. Together they formed the first subgroup (see Table 3). For Session 1, Subject 1's specific instructions were to proceed as slowly and as accurately as possible for the first 20 trials. She started out slowly but toward the latter trials her performance improved to a high of 13 correct responses per minute. Her terminal rates for this phase were 9.19 correct per minute and 1.18 incorrect per minute. This rate was simply the mean average response rate based on the last five trials of each experimental phase. Next, the subject was instructed to respond quickly and accurately to another set of stimuli for 40 trials. Her performance did not increase rapidly but it appeared that she did make an

Figure 1. Correct and incorrect responses made per minute using the Think Fast program for Subject 1 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

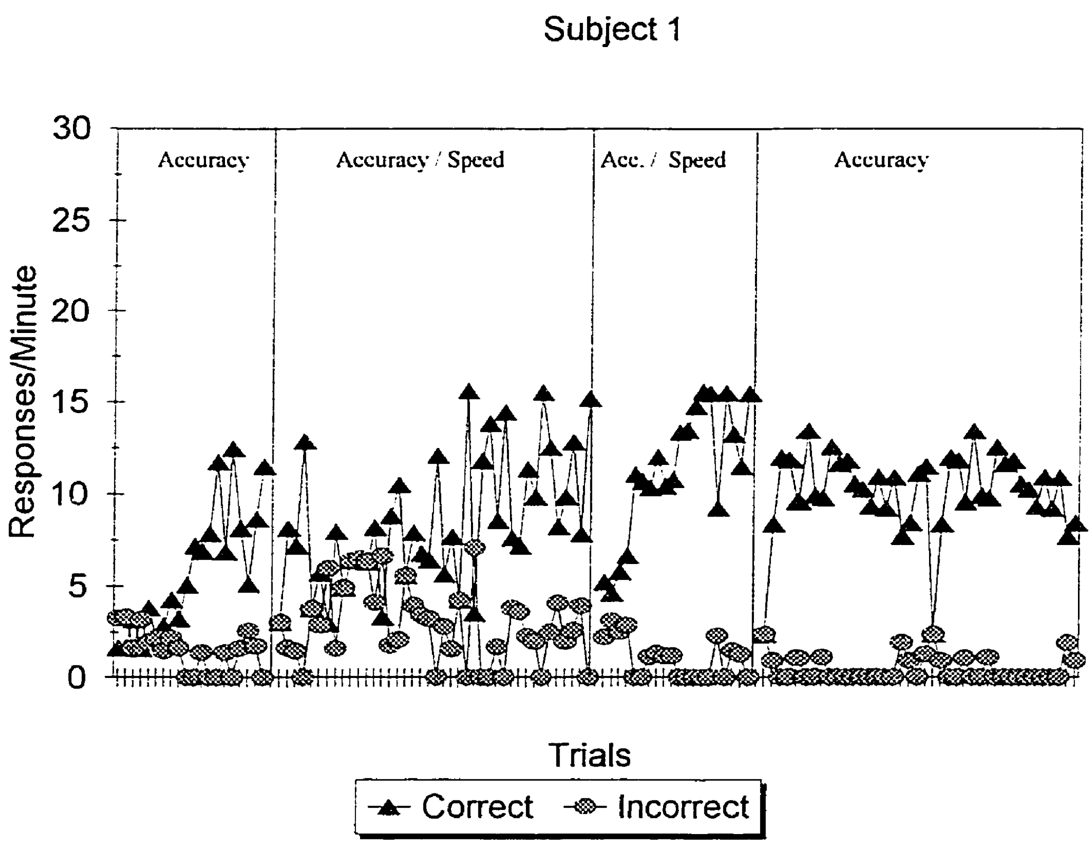
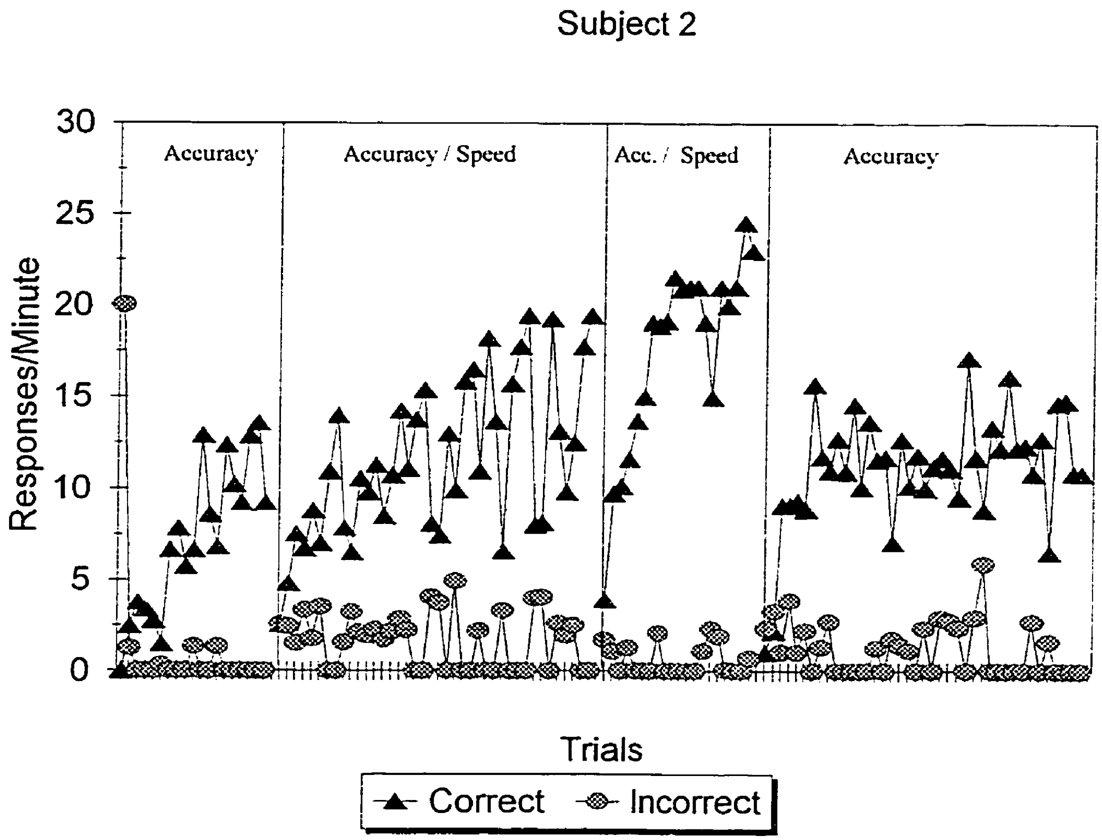

Subject 1
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Accuracy / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 2. Correct and incorrect responses made per minute using the Think Fast program for Subject 2 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.



Subject 2
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Accuracy / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 3. Correct and incorrect responses made per minute using the Think Fast program for Subject 3 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

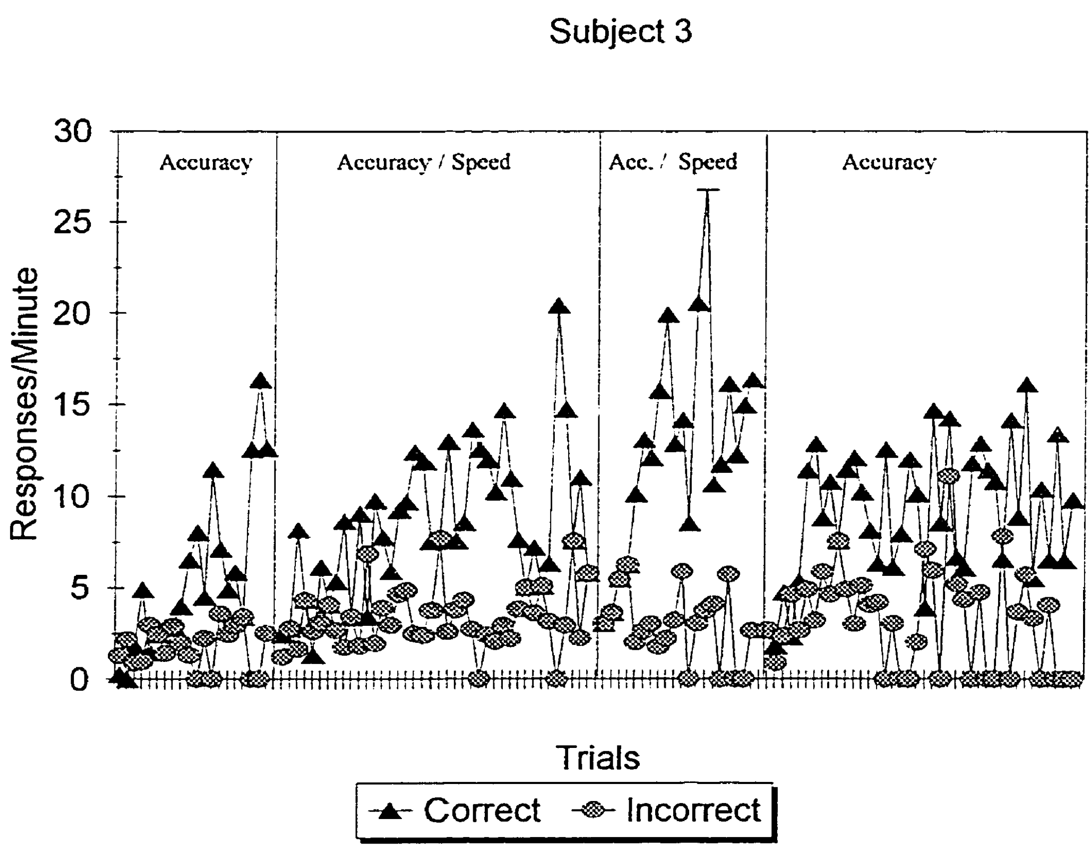

Subject 3
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Accuracy / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 4. Correct and incorrect responses made per minute using the Think Fast program for Subject 4 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

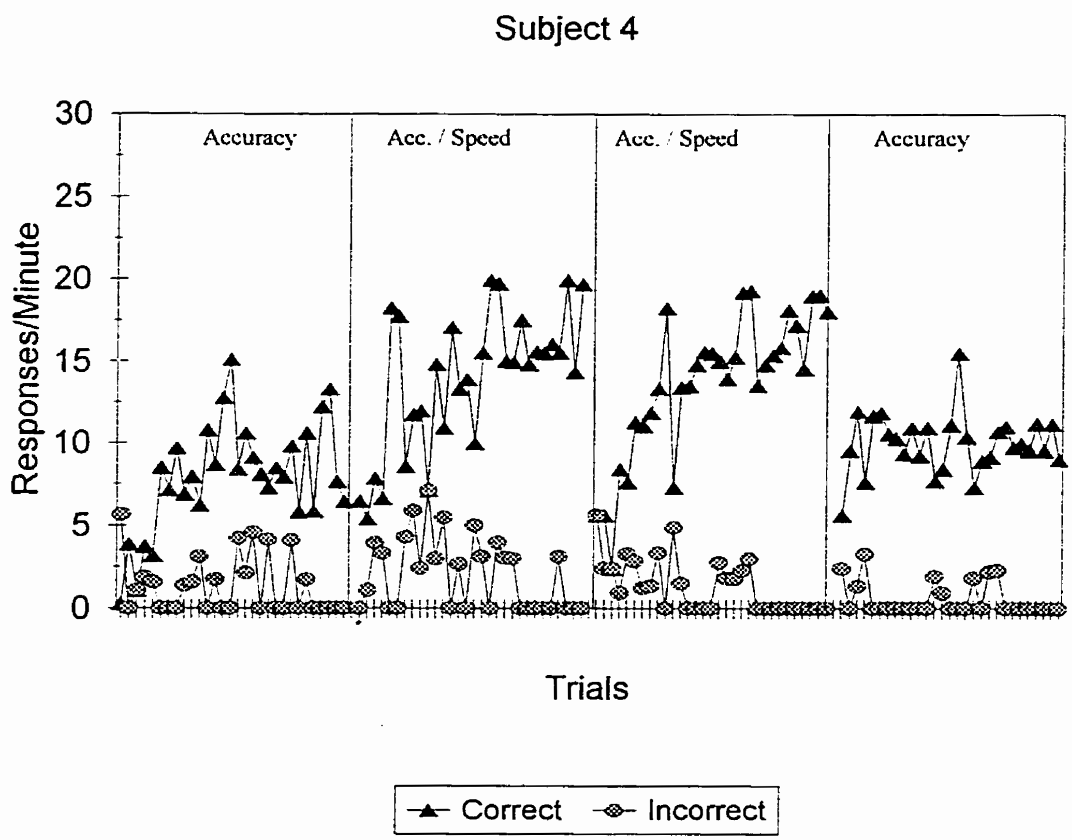

Subject 4
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Acc. / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 5. Correct and incorrect responses made per minute using the Think Fast program for Subject 5 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

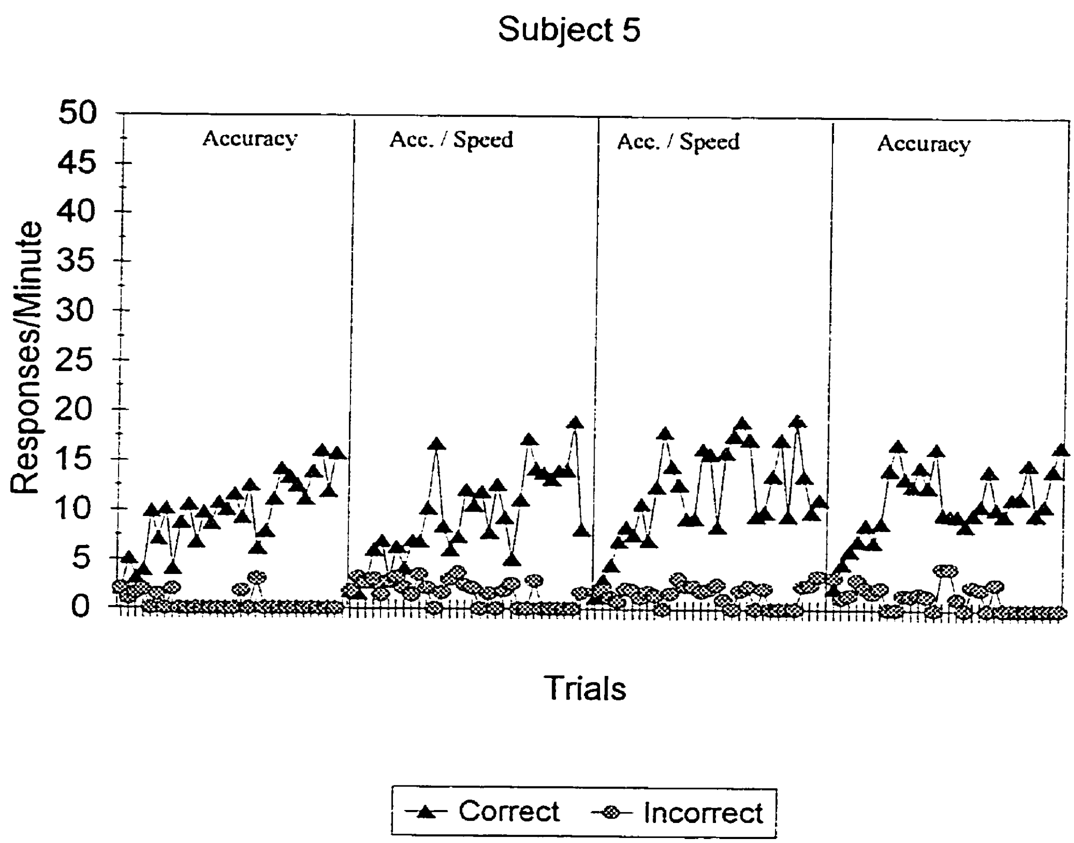

Subject 5
50
45
40
35
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Acc. / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 6. Correct and incorrect responses made per minute using the Think Fast program for Subject 6 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

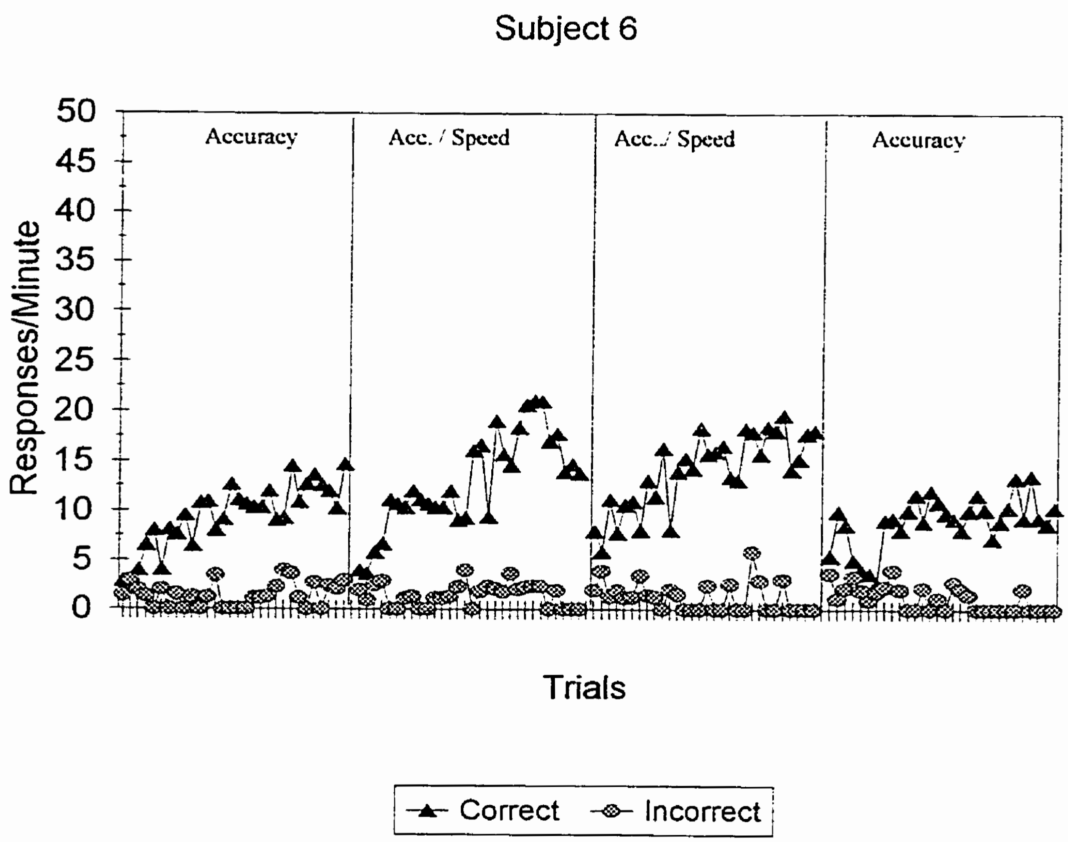

Subject 6
Accuracy
Acc. / Speed
Acc../ Speed
Accuracy
50
45
40
35
30
25
20
15
10
5
0
Responses/Minute
Trials
Correct
Incorrect

Figure 7. Correct and incorrect responses made per minute using the Think Fast program for Subject 7 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

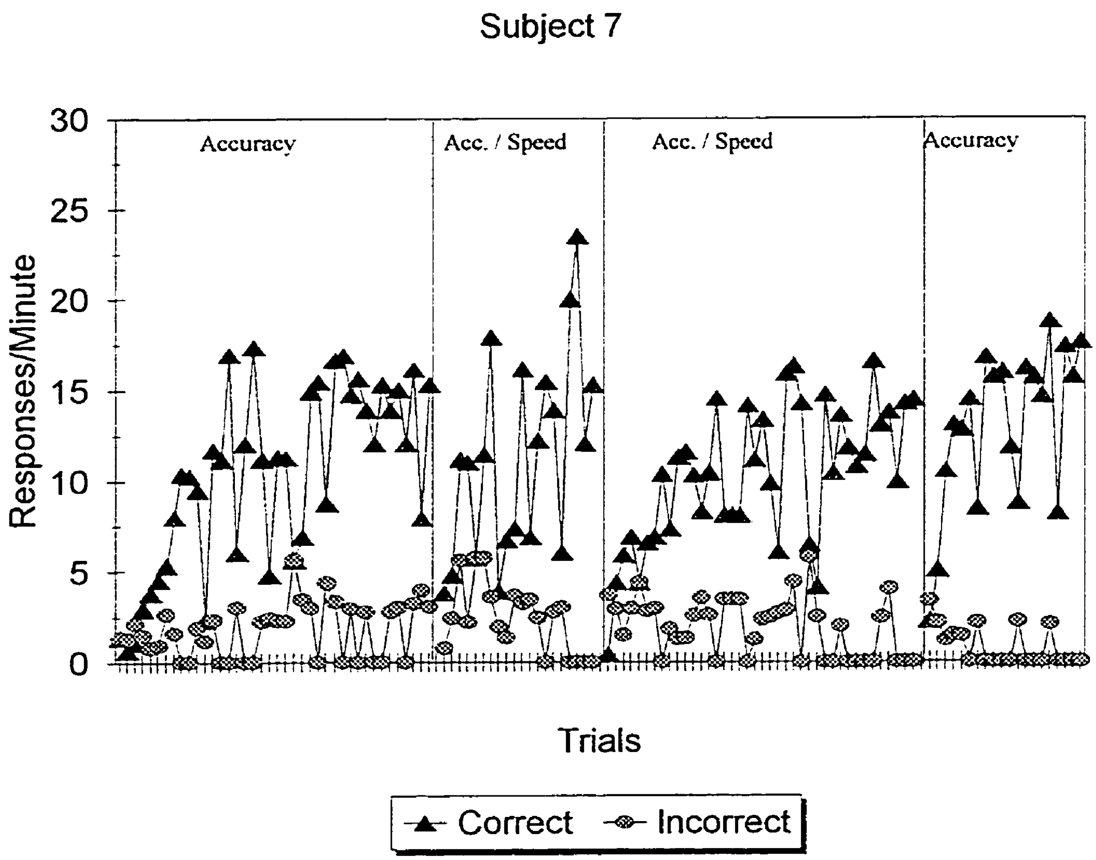

Subject 7
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Acc. / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 8. Correct and incorrect responses made per minute using the Think Fast program for Subject 8 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.

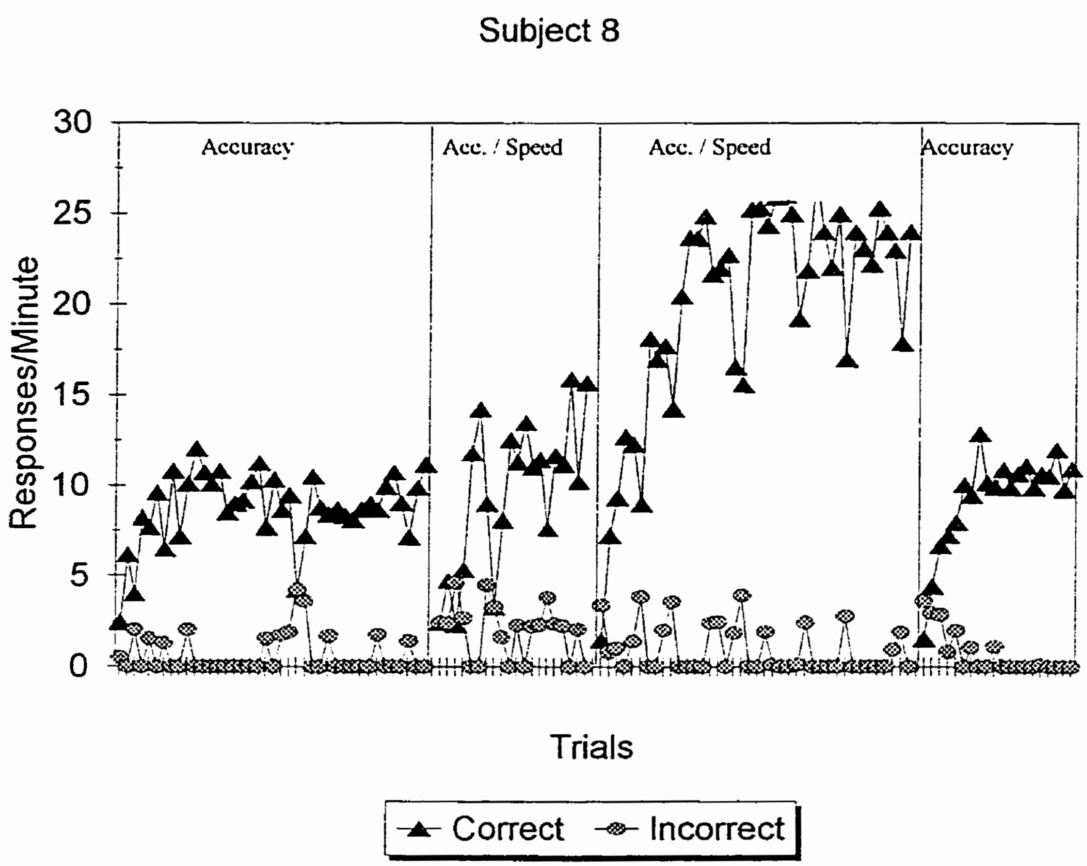
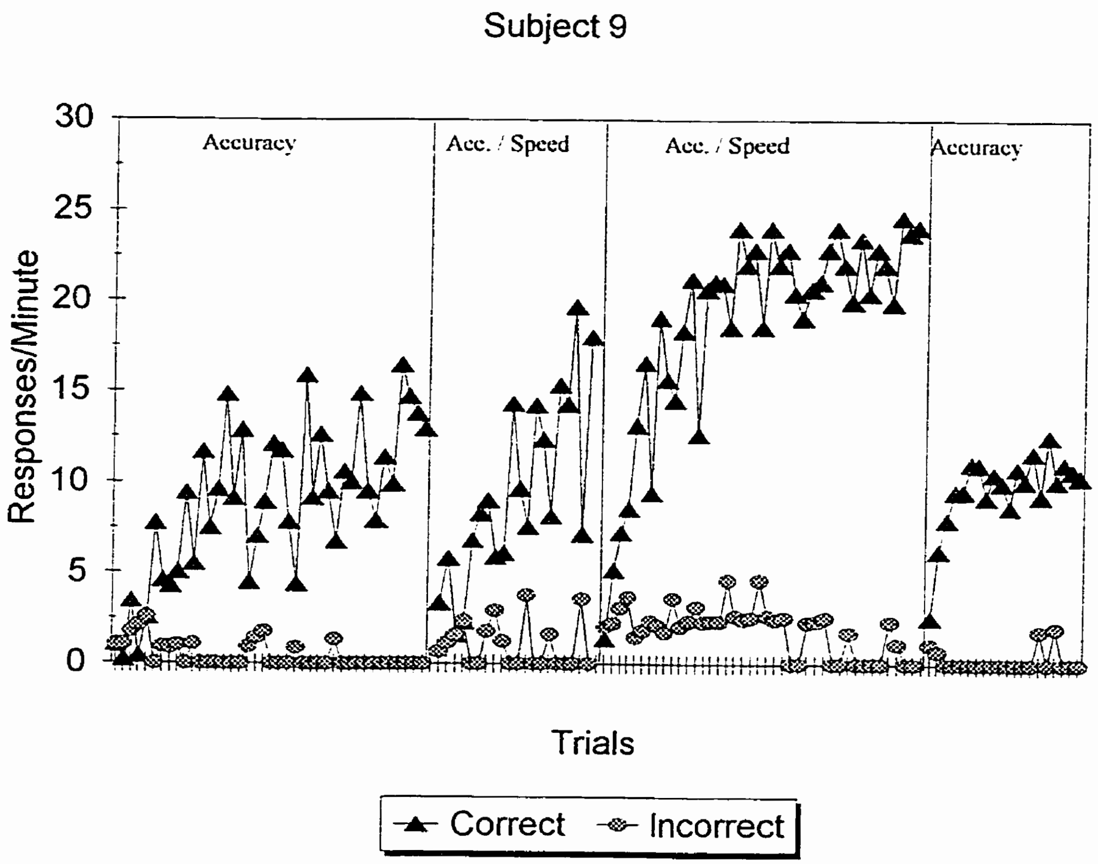

Subject 8
30
25
20
15
10
5
0
Responses/Minute
Accuracy
Acc. / Speed
Acc. / Speed
Accuracy
Trials
Correct
Incorrect

Figure 9. Correct and incorrect responses made per minute using the Think Fast program for Subject 9 in Experiment 1 for Accuracy only and Accuracy and Speed experimental conditions.


Subject 9
Accuracy
Acc. / Speed
Acc. / Speed
Accuracy
Responses/Minute
30
25
20
15
10
5
0
Trials
Correct
Incorrect

attempt to increase response rate. Her performance increased to a high of 16 correct responses per minute, however, her accuracy was not consistent. At mid-point (after 20 trials), she started to record lower incorrect rates with occasional 100% correct trials. Her terminal performance rates for these trials were 10.78 correct per minute with 2.51 incorrect per minute (Table 5).

For Session 2, this subject completed 20 trials concentrating on her Accuracy and Speed scores and it was evident from these data that she followed the instructions and progressed quickly and accurately. After the initial five trials, she produced many subsequent trials with over 15 correct responses per minute and zero incorrect responses. Her terminal rates for this phase were 13.00 correct per minute and 1.07 incorrect per minute. The instructions for the last condition were to complete 40 trials focusing on her Accuracy scores. As expected, her speed slowed and her terminal performance rate was 9.43 correct per minute and 0.57 incorrect per minute (Table 5).

Subject 2 experienced the same experimental sequence as Subjects 1 and 3. On her first trial, she scored 20 incorrect responses per minute (Figure 2). The keystroke records showed that she skipped through the cards using the 'enter' key to display the answers. However, doing this resulted in each response being counted as incorrect. After seven trials, this subject's performance increased to a constant rate of about 9 correct per minute with no errors for most trials. Her terminal performance rate for these 20 Accuracy trials was 11.04 correct per minute and zero errors. For the next 40 trials in the Accuracy and Speed condition, her response speed steadily increased until many trials had over 15 correct responses per minute. Her terminal performance rate was 14.52 correct per minute and 1.41 incorrect per minute (Table 5).

Table 5

Average and Terminal Think Fast Rates for Experiment 1 Subjects Across All Experimental Phases

Average	**Session 1**				**Session 2**			
Subject	Acc (Cor)	Acc (Incor)	Acc/Sp (Cor)	Acc/Sp (Incor)	Acc/Sp (Cor)	Acc/Sp (Incor)	Acc (Corr)	Acc (Incor)
1	5.8	1.9	8.5	2.7	9.5	1.8	10.6	0.6
2	6.9	1.3	11.5	1.7	14.2	0.6	10.2	1.8
3	5.7	1.7	8.3	3.3	10.2	3.3	8.7	3.2
4	9.5	1.2	13.8	2.0	11.8	1.2	9.5	0.9
5	9.6	0.5	9.6	1.6	10.8	1.2	10.2	1.6
6	9.5	1.4	12.8	1.4	11.5	1.5	9.9	1.4
7	10.2	1.9	11.2	2.2	9.5	1.8	9.3	1.5
8	8.7	0.6	9.6	1.9	16.7	1.3	8	1.4
9	8.8	0.4	9.5	1.0	15.6	2.5	8.7	0.1
Mean	**8.3**	**1.2**	**10.5**	**1.9**	**12.2**	**15.2**	**9.4**	**1.3**

Terminal	**Session 1**				**Session 2**			
Subject	Acc (Cor)	Acc (Incor)	Acc/Sp (Cor)	Acc/Sp (InCor)	Acc/Sp (Cor)	Acc/Sp (Incor)	Acc (Corr)	Acc (Incor)
1	9.19	1.18	10.78	2.51	13.00	1.01	9.43	0.57
2	11.04	0	14.52	1.41	21.91	0.54	11.55	0.32
3	10.16	1.76	11.91	3.70	14.27	1.67	9.33	0.81
4	9.07	0	17.09	0.62	17.55	0	9.41	0
5	13.76	0	13.73	0.32	12.72	1.65	13.27	0
6	12.64	2.02	15.44	0.39	16.98	0.61	10.27	0.43
7	13.29	2.65	15.36	0.60	13.12	1.29	15.53	0.40
8	9.57	0.28	12.94	1.32	22.85	0.56	10.78	0.01
9	13.57	0	14.90	0.71	22.90	0.69	10.96	0.40
Mean	**11.36**	**0.87**	**14.07**	**1.25**	**17.25**	**0.89**	**11.17**	**0.32**

Subject 2's performance increased dramatically in Session 2. Her response rates improved when instructed to complete 20 trials to her best accuracy and speed. Her terminal performance rate was 21.91 correct per minute and 0.54 incorrect per minute. Apart from the first trial, she responded to every trial at a rate between 9-22 correct responses per minute. Under the last 40 Accuracy trials, this subject's response rates slowed to terminal performance rate of 11.55 correct per minute and 0.32 incorrect per minute (Table 5).

Subject 3 also experienced the same experimental sequence as Subjects 1 and 2. Under all conditions, her rates were low and per or variable. From a total of 120 trials, she managed to complete only 21 error free trials (Figure 3). Her terminal performance rate was 10.16 correct per minute and 1.76 incorrect per minute for the first 20 trials learning to Accuracy. Learning to Accuracy and Speed over the next 40 trials resulted in terminal performance rate of 11.91 correct per minute and 3.70 incorrect per minute (Table 5).

For Session 2, she was instructed to complete 20 trials quickly and accurately. Her rates increased to a high of 28 correct per minute for one trial with variable performances for other trials. Her terminal performance rate was 14.27 correct per minute and 1.67 incorrect per minute. Next, she was instructed to complete another 40 trials concentrating on accuracy only. Her terminal rate for this phase was 9.33 correct per minute and 0.81 incorrect per minute (Table 5). Inspection of the data showed that there was no consistency in terms of accuracy or speed (Figure 3). At the conclusion of Session 2, she disclosed that she was not happy with the computer program in general and the fact that typographical errors were not allowed in particular.

Subject 4 was grouped with Subjects 5 and 6 for experimental sequence. These subjects formed the second subgroup (see Table 3). Their Think Fast learning episodes consisted of 30 trials for each experimental phase. Subject 4 was asked to complete the first 30 trials slowly and carefully, paying attention to Accuracy (Figure 4). His terminal performance rate for this phase was 9.07 correct per minute with no errors. Next, he was asked to complete 30 trials paying attention to his accuracy and speed rates. His performance increased to conclude with a terminal performance rate of 17.09 correct per minute and 0.62 incorrect per minute (Table 5).

For Session 2, his instructions were to respond quickly and accurately to the first 30 trials. His correct rates increased sharply to more than 15 correct per minute during these 30 trials. His terminal performance rate was 17.55 correct per minute with no errors. This subject's correct response rates decreased over the last 30 Accuracy trials and terminal performance rate was 9.41 correct per minute with no errors (Table 5). These data indicated that the subject followed the instructions and showed consistency in performance according to the assigned experimental condition.

Subject 5 progressed through the same experimental sequence as Subjects 4 and 6. Through all experimental phases her performances lacked consistency (Figure 5). She completed the first 30 Accuracy trials and her terminal performance rate was 13.76 correct per minute with zero errors (Table 5). Similarly, while her 30 Accuracy and Speed trials were much more variable, her terminal rate was virtually identical at 13.76 correct per minute and 0.32 incorrect per minute (Table 5). She managed several trials with over 15 correct per minute performances but her incorrect rate was variable. This variability may have been due to an increase in her number of typographic errors.

During Session 2, her rates correct and incorrect under both conditions were again similar. After 30 trials under the Accuracy and Speed condition, her terminal rates were 12.72 correct per minute with 1.65 incorrect per minute. Surprisingly, after 30 trials under the Accuracy condition, her terminal rates increased to 13.27 correct per minute with zero errors (Table 5). Accuracy was not consistent throughout both conditions. These data showed that terminal performance was similar under all experimental conditions and the subject did not follow the learning instructions outlined by the experimenter.

Subject 6 was the third member of this subgroup with trials equalized across conditions. Looking at Figure 6, it appeared he followed the instructions given. That is, he responded slowly and accurately, with few errors during the first 30 trials. His terminal performance rate was 12.64 correct per minute and 2.02 incorrect per minute. Under the Accuracy and Speed condition his terminal rate was 15.44 correct per minute with 0.39 incorrect per minute (Table 5).

For Session 2, he was instructed to respond with accuracy and speed to the first 30 trials. This subject's correct responses increased steadily from 5 correct per minute at trial 2 to 17 correct per minute towards the latter trials. His final performance rate for these 30 trials was 16.98 correct per minute and 0.61 incorrect per minute (Table 5). Under the Accuracy condition, his correct responses were low with many trials below 8 correct per minute. Terminal performance rate for these 30 trials was 10.27 correct per minute and 0.43 incorrect per minute (Table 5).

Subject 7, 8 and 9 were also grouped for experimental sequence and formed the third subgroup (see Table 3). For Session 1, they completed 40 trials under the Accuracy condition before doing 20 trials under the Accuracy and Speed condition. Subject 7's terminal rate was 13.29 correct per minute with 2.65 incorrect per minute for the 40 Accuracy trials (Table 6). Under the Accuracy and Speed condition, he recorded several trials with scores 15 correct per minute but there was also an equal numbers of trials below 10 correct per minute. Incorrect rates were also variable under both conditions. His terminal performance rate for these 20 Accuracy and Speed trials was 15.36 correct per minute and 0.60 incorrect per minute (Table 6).

For Session 2, the conditions were reversed and required subjects in this subgroup to complete 40 trials to their highest Accuracy and Speed rates before completing 20 trials to high Accuracy rates. Subject 7 recorded unusual performance rates; looking at his terminal performance rate, it appeared that he did not follow instructions. After 40 trials of trying to increase accuracy and speed, he recorded a terminal performance rate of 13.12 correct per minute and 1.29 incorrect per minute; whereas, after 20 Accuracy trials, his terminal performance rate was 15.53 correct per minute and 0.40 incorrect per minute (Table 5).

Subject 8 produced very definitive data for both sessions (Figure 8). During Session 1, her correct rates hovered around 10 per minute with terminal performance rate of 9.57 correct per minute and 0.28 incorrect per minute (Table 5). Under the Accuracy and Speed condition, her correct rates increased and she ended with a terminal performance rate of 12.94 correct per minute with 1.32 incorrect per minute (Table 5).

For Session 2, her correct rates under the Accuracy and Speed condition increased dramatically, resulting in terminal performance rates of 22.85 correct per minute with 0.56

Table 6

Pretest and Posttest Scores for Experiment 1 Subjects Across All Experimental Conditions

	Session 1							Session 2			
		Recall 1			Application 1			Recall 2		Application 2	
Subject	Pretest	Read	Acc	Acc/Sp	Read	Acc	Acc/Sp	Acc/Sp	Acc	Acc/Sp	Acc
1	0	4 (40)*	7 (70)	7 (70)	2 (40)	4 (80)	4 (80)	10 (100)	7 (70)	4 (80)	0
2	0	4 (40)	10 (100)	10 (100)	3 (60)	5 (100)	5 (100)	9 (90)	6 (60)	1 (20)	3 (60)
3	1	6 (60)	6 (60)	10 (100)	4 (80)	2 (40)	4 (80)	9 (90)	9 (90)	4 (80)	2 (40)
4	0	4 (40)	8 (80)	7 (70)	4 (80)	4 (80)	5 (100)	8 (80)	8 (80)	4 (80)	3 (60)
5	0	2 (20)	9 (90)	10 (100)	0	5 (100)	4 (80)	8 (80)	6 (60)	0	0
6	0	2 (20)	6 (60)	8 (80)	0	3 (60)	4 (80)	8 (80)	6 (60)	3 (60)	2 (40)
7	0	5 (50)	6 (60)	8 (80)	0	2 (40)	5 (100)	10 (100)	8 (80)	4 (80)	0
8	1	3 (30)	10 (100)	10 (100)	1 (20)	5 (100)	5 (100)	9 (90)	9 (90)	0	3 (60)
9	0	6 (60)	7 (70)	9 (90)	4 (80)	0	5 (100)	10 (100)	9 (090)	4 (80)	2 (40)
Totals	2	36 (40)	69 (76.66)	79 (87.77)	18 (40)	30 (66.66)	41 (91.11)	81 (90)	68 (75.55)	24 (53.33)	14 (31.11)

	Session 3 (Recall 3 and Application 3)										
		Recall 1 Items			Application 1 Items			Recall 2 Items		Application 2 Items	
Subject		Read	Acc	Acc/Sp	Read	Acc	Acc/Sp	Acc/Sp	Acc	Acc/Sp	Acc
1	0	4 (40)	3 (30)	6 (60)	2 (40)	3 (60)	3 (60)	5 (50)	5 (50)	2 (40)	0
2	0	5 (50)	10 (100)	9 (90)	5 (100)	5 (100)	5 (100)	9 (90)	4 (40)	3 (60)	0
3	0	9 (90)	3 (30)	7 (70)	1 (20)	1 (20)	5 (100)	7 (70)	5 (50)	0	0
4	0	4 (40)	7 (70)	7 (70)	3 (60)	5 (100)	5 (100)	7 (70)	7 (70)	2 (40)	3 (60)
5	0	0	6 (60)	5 (50)	0	3 (60)	0	6 (60)	5 (50)	0	1 (20)
6	0	2 (20)	4 (40)	3 (30)	2 (40)	4 (80)	4 (80)	6 (60)	6 (60)	2 (40)	1 (20)
7	0	4 (40)	3 (30)	7 (70)	5 (100)	0	5 (100)	6 (60)	6 (60)	2 (40)	1 (20)
8	0	1 (10)	9 (90)	9 (90)	2 (40)	5 (100)	5 (100)	8 (80)	3 (30)	4 (80)	0
9	0	5 (50)	2 (20)	10 (100)	4 (80)	0	5 (100)	4 (40)	7 (70)	0	0
Totals	0	34 (37.77)	46 (51.11)	63 (70)	24 (53.33)	26 (57.77)	37 (82.22)	58 (64.44)	48 (53.33)	13 (28.88)	5 (11.11)

* brackets indicate percentages

incorrect per minute. Under the Accuracy condition, her terminal performance rates were lower at 10.78 correct per minute with only 0.01 incorrect per minute (Table 5).

Subject 9 completed the same experimental sequence as Subjects 7 and 8 and also produced definitive data (Figure 9). His terminal performance rate after 40 Accuracy trials was 13.51 correct per minute with zero errors (Table 5). For the subsequent 20 Accuracy and Speed trials, his terminal rate was 14.90 correct per minute with 0.71 incorrect per minute.

During Session 2, his correct rates increased sharply to over 20 correct per minute during the 40 Accuracy and Speed trials. His terminal rate for this experimental phase was 22.90 correct per minute and 0.69 incorrect per minute. In contrast, after 20 Accuracy trials, his terminal performance rate was 10.96 correct per minute with 0.40 incorrect per minute.

It was apparent that subjects performed at very different response rates. In three cases (Subjects 3, 5 and 7) the instructions were not followed. For Session 1, the average Accuracy rates ranged from 5.8 to 10.2 correct per minute and the average Accuracy and Speed rates ranged from 8.3 to 13.8 correct per minute. For Session 2, the average Accuracy rates ranged from 8 to 10.6 correct per minute and the average Accuracy and Speed rates ranged from 9.5 to 14.2 correct per minute.

Greater differences were noticed upon close examination of terminal rates. For Session 1, the terminal Accuracy rates ranged from 9.07 to 13.76 correct per minute. The terminal Accuracy and Speed rates ranged from10.78 to 17.09 correct per minute. For Session 2, the terminal Accuracy rates ranged from 9.33 to 15.53 correct per minute and the terminal Accuracy and Speed rates ranged from 12.72 to 22.90 correct per minute.

As observed in Figure 1, Subject 1 appeared to follow the instructions although her performance was not consistent on many occasions throughout the first session. Her response rates were variable from trial to trial. However, during the second session, her performance became very consistent. Subject 2 appeared to follow the instructions given for each experimental phase for both sessions. Subject 3 had difficulty following the instructions. She concluded both experimental conditions in Session 1 with similar terminal rates. For Session 2, her response rate did increase under the Accuracy and Speed condition; however, her performance lacked consistency and included many errors. Interestingly, this subject reported that she was not pleased that the Think Fast program recorded all of her typographical errors as incorrect.

Subject 4's data demonstrated that she did follow the instructions and her performances were consistent with stable response rates and few errors, especially towards the end of each experimental phase (Figure 4). Subject 5's data were unexpected. Her terminal rates for both conditions for Session 1 were identical. During Session 2, she responded faster to the Accuracy items than the Accuracy and Speed items, she clearly did not following the instructions. Subject 6 followed the instructions for both sessions.

Looking at Figure 7, it appeared that Subject 7 followed the instructions for Session 1. His response rates increased when he was instructed to increase Accuracy and Speed. For Session 2, he made attempts to follow instructions for the Accuracy and Speed condition but his inconsistent performances included many errors; in fact, his terminal rates were higher for the Accuracy condition. Subjects 8 and 9 both followed the instructions for each experimental condition on both sessions.

In short, Subjects 1, 2, 4, 6, 8, and 9 followed the instructions for each phase of the experiment. Subjects 3 and 5 did not follow instructions for either session and Subject 7 followed instructions for Session 1 but not for Session 2. By chance, each subgroup contained one subject who did not follow the experimental instructions completely.

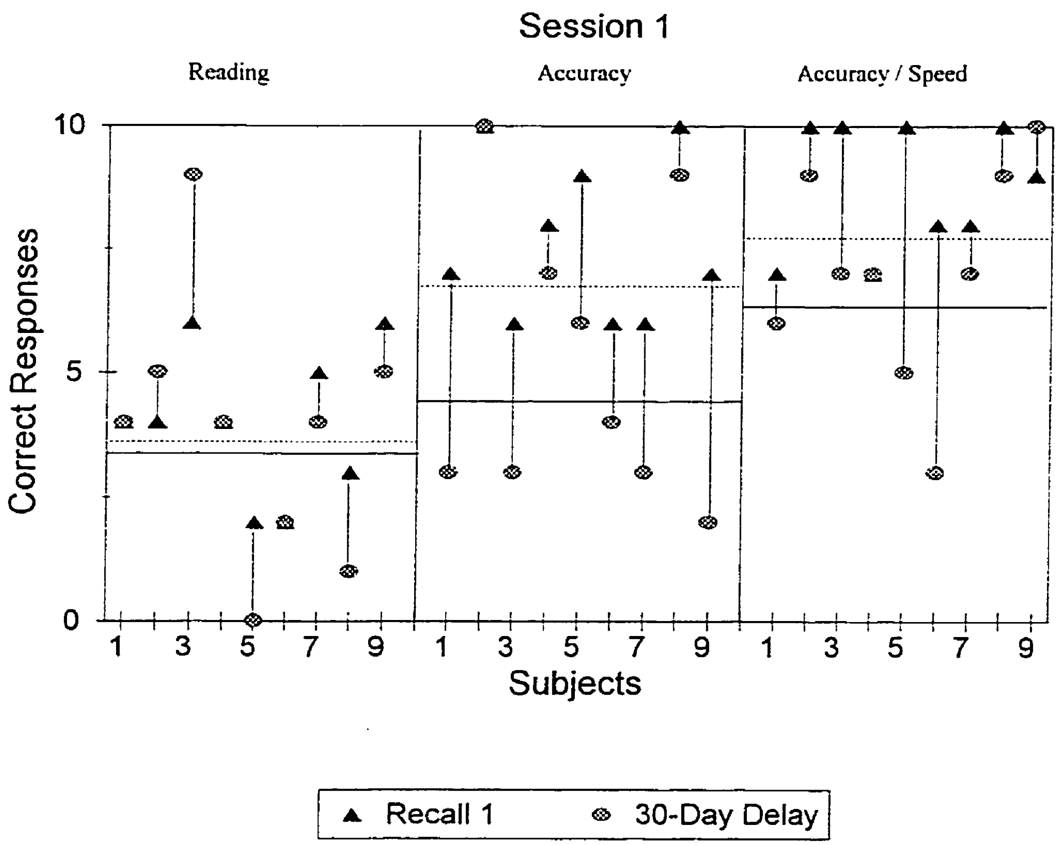
Session 1-Posttests

Recall 1. This test consisted of three sets of questions arranged in random order and presented on separate sheets of paper. All items were identical to the Think Fast decks that consisted of Miller's text (1980). Subjects prepared for this recall test by progressing through the experimental sequence assigned in one of three ways. Tables 3 and 4 summarize these sequences and Table 6 lists actual scores for all recall and application posttests.

The group's scores were also illustrated on Figures 10-13. The triangles represent subjects' actual number of correct responses for that particular posttest. The circles represented subjects' scores on Session 3 posttests, delivered 30 days after subjects' original responses. Two horizontal lines were graphed for each posttest. The broken horizontal lines represented the mean average for all subjects for that specific posttest while the unbroken horizontal line indicated the mean average for all subjects for the same items that were presented after the 30-day delay.

For Recall 1, the group collectively answered a total of 40% (36 items) of the questions correctly under the Reading condition and 76.6% (69 items) under the learning to Accuracy condition (Figure 10). Under the learning to Accuracy and Speed condition, the subjects answered 87.7% (79 items) of the questions correctly. The greatest difference was noticed between the learning to Accuracy and Speed condition (87.7%)

Figure 10. Recall 1 posttest scores and group means for subjects in Experiment 1 including the corresponding Session 3 data.



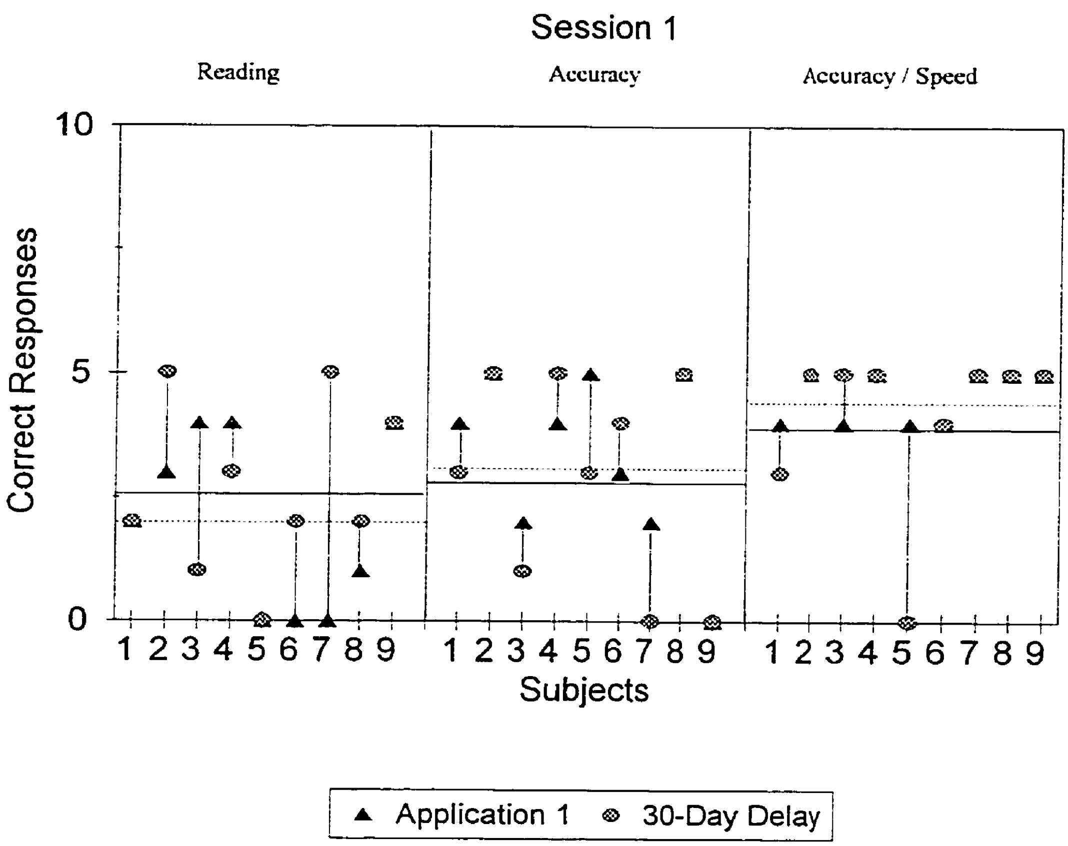
Session 1
Reading
Accuracy
Accuracy / Speed
10
5
0
Correct Responses
1
3
5
7
9
1
3
5
7
9
1
3
5
7
9
Subjects
Recall 1
30-Day Delay

and the Reading condition (40%), with a separation of 37.7% (34 items). The second largest gap was between the Accuracy (76.6%) and Reading (40%) conditions with 36.6% (32 items). There was a modest 11.1% (10 items) difference between the Accuracy and Speed (87.7%) and Accuracy (76.6%) conditions.

Looking at the subgroups revealed some interesting data. For example, Subgroup 1 trained for 20 trials under the Accuracy condition and 40 trials under the Accuracy and Speed condition; therefore, it was expected that given the greater number of trials, their posttest performance would be higher for Accuracy and Speed items. Indeed, this subgroup's mean score was 76.6% for Accuracy items and 90% for Accuracy and Speed items. In contrast, Subgroup 3 completed 40 Accuracy trials and only 20 Accuracy and Speed trials. Once again, it was expected that given the greater number of trials, posttest performance would be higher for Accuracy items than Accuracy and Speed items. This was not the case. This subgroup scored 76.6% correct for Accuracy items and 90% correct for Accuracy and Speed items even though these subjects experienced 20 fewer Think Fast trials. Both subgroups had a 26.6% (or 4 items) difference between the two conditions. Subgroup 2's trials were equated at 30 trials for both conditions. These subjects managed 76.6% correct for Accuracy recall items and 83.3% correct for Accuracy and Speed items. This created a difference of only 6.7% or 2 items.

Application 1. These data were listed on Table 6 and graphed on Figure 11. As a group, learning to Accuracy and Speed resulted in a superior score (91.1% or 41 items) than both Accuracy (66.6% or 30 items) and Reading (40% or 18 items). The greatest difference was 51.1% (23 items) between the Accuracy and Speed condition (91.1%) in comparison to Reading (40%). Interestingly, once again there was a large difference in

Figure 11. Application 1 posttest scores and group means for subjects in Experiment 1 including the corresponding Session 3 data.



Session 1
Reading
Accuracy
Accuracy / Speed
10
5
0
Correct Responses
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
Subjects
Application 1
30-Day Delay

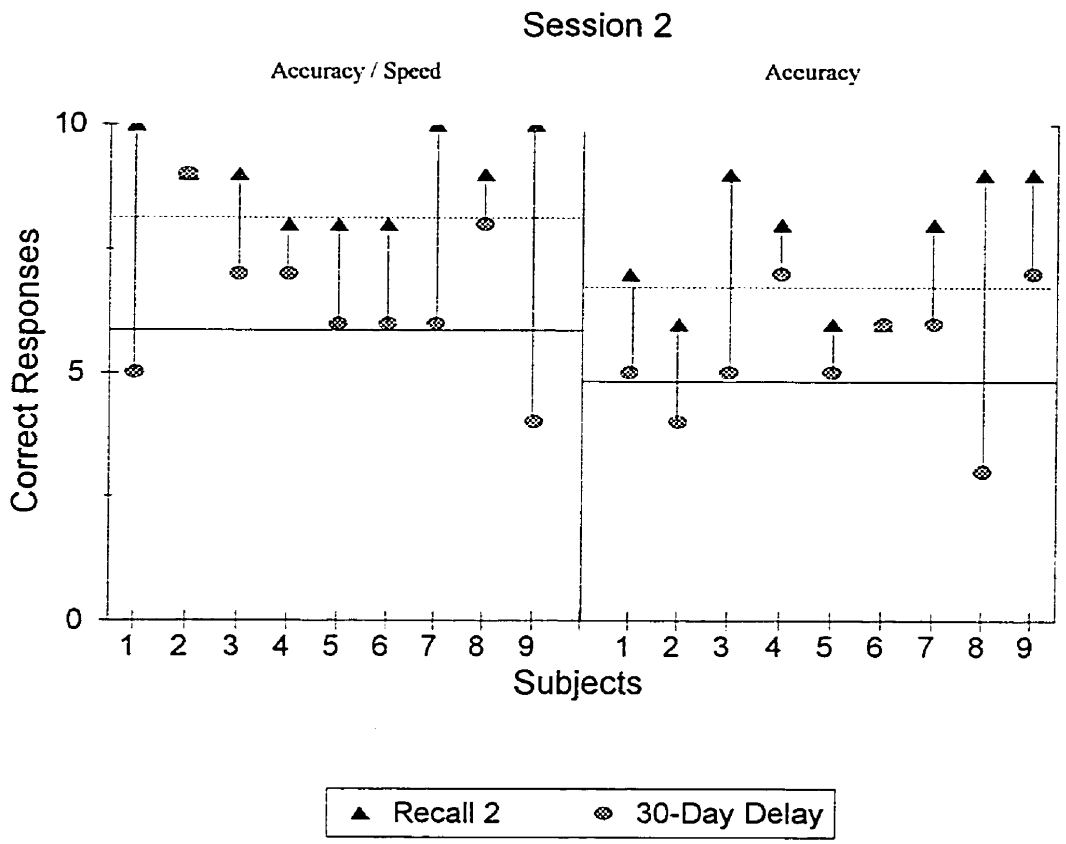
achievement between learning to Accuracy and learning to Accuracy and Speed, with the latter training resulting in a 24.5% (11 items) better score.

Most subjects did poorly in identifying exemplars for concepts that they had only read about. Scores ranged from 0%-80%, with an average of 40%. Scores increased for concepts learned under the Accuracy condition with a range of 0%-100% and an average of 66%. A noticeable increase was observed for all subgroups under the learning to Accuracy and Speed condition. Each subject recalled 80%-100% of the items, with an average of 95%. One subgroup's achievement was superior; Subjects 7, 8 and 9 identified all items correctly.

The subgroup data pattern was similar to recall data. Again, Subgroup 1 trained for 20 trials under the Accuracy condition and 40 trials under the Accuracy and Speed condition; therefore, it was expected that given the greater number of trials, their posttest performance would be higher for Accuracy and Speed application items. Subgroup 1's mean score was 73.3% for Accuracy items and 86.6% for Accuracy and Speed items. The difference of 13.3% represented only 2 items. Subgroup 2's trials were equalized at 30 trials for both conditions. These subjects managed 80% correct for Accuracy recall items and 86.6% correct for Accuracy and Speed items, a difference of 6.6% or 1 item.

In contrast, Subgroup 3 completed 40 Accuracy trials and only 20 Accuracy and Speed trials. Once again, it was expected that given the greater number of trials, posttest performance would be higher for Accuracy items than Accuracy and Speed items. This was not the case. This subgroup scored a mean of 46.6% correct for Accuracy items and 100% correct for Accuracy and Speed items even though these subjects experienced only 20 Accuracy and Speed trials. This was a large difference of 53.4% or 8 items.

Figure 12. Recall 2 scores and group means for subjects in Experiment 1 including the corresponding Session 3 data.


Session 2
Accuracy / Speed
Accuracy
Correct Responses
10
5
0
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9
Subjects
Recall 2
30-Day Delay

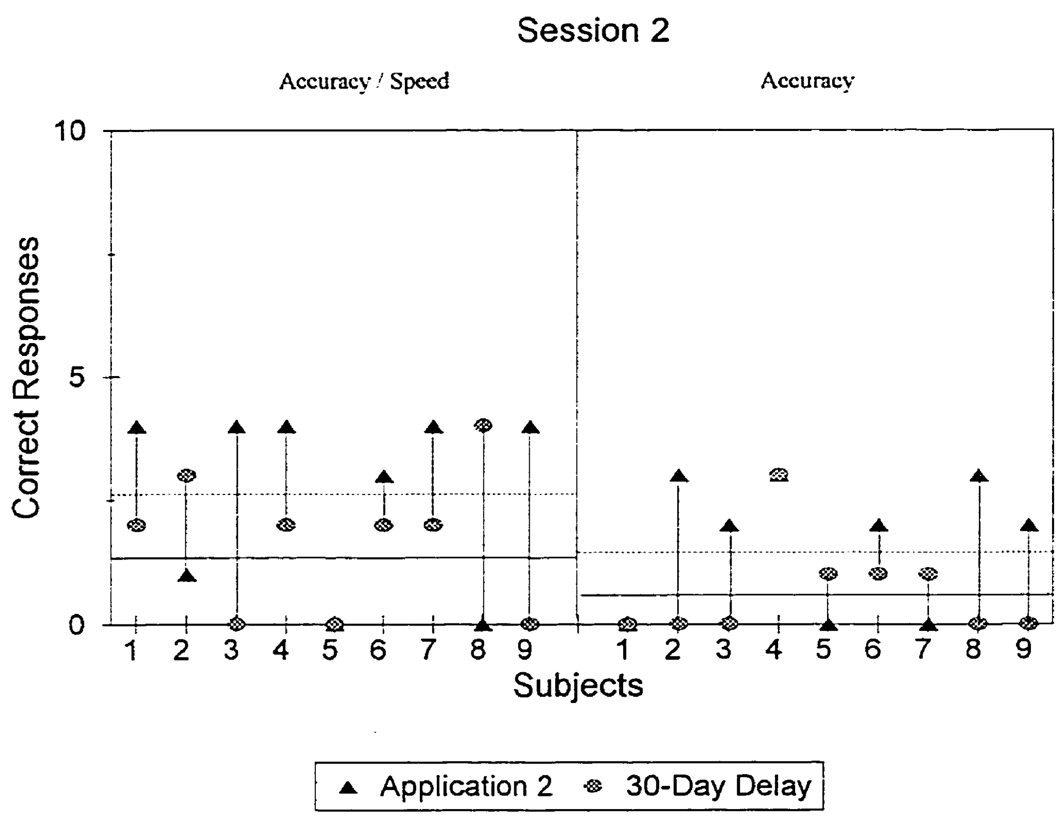
Session 2-Posttests

Recall 2. Given that the Reading condition was eliminated at this point of the study, there were no such data to analyze. The experimental conditions were reversed for all subjects. The Recall 2 scores were listed on Table 6 and graphed on Figure 12. Subgroup 1 completed 20 Accuracy and Speed trials and then 40 Accuracy trials. Subgroup 2 completed 30 Accuracy and Speed trials before completing 30 Accuracy trials. Subgroup 3 completed 40 Accuracy and Speed trials before completing 20 Accuracy trials.

The group totals indicated that the Accuracy and Speed condition 90% (81 items) resulted in moderately higher achievement scores than Accuracy 75.5% (68 items). Subgroup 1 correctly answered 93% (28 items) of the Accuracy and Speed questions and 73% (22 items) of the Accuracy questions. This was a difference of 20% (6 items). Subgroup 2 answered the fewest correctly in comparison to the other subgroups. They correctly answered 80% (24 items) of the Accuracy and Speed questions and only 66% (20 items) of the Accuracy questions. This was a difference of 14% (6 items). Subgroup 3 answered 96.6% (29 items) of the Accuracy and Speed questions correctly, representing only one error. These same subjects correctly answered 86.6% (26 items) of the Accuracy items translating into a difference of 10% or 3 items. Individual subject scores with these items were fairly consistent across subjects; that is to say, scores did not vary more than two responses per condition.

Application 2. Table 6 listed data for this posttest and Figure 13 illustrated these same data. The same pattern was noticed for the application test. The group totals showed that learning to Accuracy and Speed meant a higher score (53.3% or 8 items) than

Figure 13. Application 2 posttest scores and group means for subjects in Experiment 1 including the corresponding Session 3 data.


Session 2
Accuracy / Speed
Accuracy
10
5
0
Correct Responses
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9
Subjects
Application 2
30-Day Delay

learning to Accuracy (33.3% or 6 items). Interestingly, the subgroup scores were fairly close. Subgroups 1, 2 and 3 scored 60% (9 items), 46.6% (7 items), and 53.3% (8 items) respectively for the Accuracy and Speed condition. All subgroups scored under 33.3% (5 items) total for the Accuracy items. However, analysis of the individual subjects' scores showed much variability. For example, Subject 2 answered 60% (3 items) of the Accuracy questions correctly and only 20% (1 item) of the Accuracy and Speed questions correctly. Subject 8 also answered 60% (3 items) of the Accuracy questions correctly but none of the Accuracy and Speed questions. Subject 5 did not answer any Application 2 questions correctly for either condition. The remainder of the subjects scored higher for the Accuracy and Speed items (76.6%) than Accuracy (36.6%).

Session 3-Posttests

Definitions. The scores were surprisingly low across subjects. No individual subject excelled in this test. Table 7 listed these data. Each definition contained three main elements (for a maximum score of 15 elements for each subject). Only Subjects 1 and 8 managed to recall the main components of several definitions. Subject 1 recalled two elements of each concept learned under the Accuracy and Speed condition and one element of a concept learned under the Accuracy condition. Subject 8 also recalled two elements of each concept learned under the Accuracy and Speed condition as well as one element of an Accuracy concept from Session 1 and two elements of an Accuracy concept from Session 2. The remaining subjects recalled one element for most concepts. Subject 7 recalled the least. He wrote only one correct element of a concept learned under the Accuracy and Speed condition and failed to correctly define any other concepts.

Table 7

Write Definition Scores for Each Concept Learned by Experiment 1 Subjects

	Session 1			Session 2	
Subject	Read	Acc	Acc/Sp	Acc/Sp	Acc
1	0	1	2	2	0
2	0	1	1	1	1
3	1	0	1	0	1
4	0	1	2	1	1
5	0	1	1	0	1
6	1	1	1	1	0
7	0	0	0	1	0
8	1	1	2	2	2
9	0	0	2	0	0
Totals	**3**	**6**	**12**	**8**	**6**

A descriptive examination of the group's total scores showed that there were differences between conditions. For the concepts learned during Session 1, no subjects were able to define all of the concepts that they had simply read. Three subjects wrote one correct element for their Reading definition. Under the Accuracy condition, the group managed to correctly recall six elements. Under the Accuracy and Speed condition, the group recalled a total of twelve elements. This was clearly the superior score but still rather low. For Session 2 items, the group wrote eight correct elements for concepts learned under the Accuracy and Speed condition and six correct for the Accuracy condition.

Recall 3. The main difference for this test was that all recall items from Sessions 1 and 2 were packaged together and presented as one test after a 30-day delay. Table 6 listed these data and they were also graphed on Figures 10-13. A pattern similar to data obtained from the earlier sessions was noticed. For items learned from Session 1, the scores were low for concepts learned under the Reading condition (37.7% or 34 items). Retention was better for Accuracy items (52.2% or 47 items) and superior retention for Accuracy and Speed items (70.0% or 63 items). For all subgroups, items that were learned to Accuracy and Speed were more likely to be retained than Accuracy items. Subgroups 1, 2 and 3 recalled an average of 53.3%, 53.3% and 46.6% Accuracy items, respectively. In contrast, the same subgroups recalled an average of 73.3%, 63.3% and 86.6% Accuracy and Speed items, respectively.

For items learned previously in Session 2, these scores were marginal for concepts learned under the Accuracy condition (50%) and moderately high for the Accuracy and Speed condition (64.4%). Once again, more Accuracy and Speed items were retained than Accuracy items. Subgroups 1, 2 and 3 recalled an average of 46.6%, 50% and 53.5% Accuracy items, respectively. In contrast, the same subgroups recalled an average of 70%, 63.3% and 60% Accuracy and Speed items, respectively.

Overall, the group generally recalled less after a 30-day delay than they did at the conclusion of Sessions 1 and 2 (Table 8). For concepts learned by simply reading during Session 1, subjects recalled 3.4% fewer items. This represented three fewer items recalled, from 40% (36 items) to 36.6% (33 items) correct items when items were presented after a 30-day delay (Recall 3). A paired sample t-test indicated that the decrease from Recall 1 to Recall 3 was not statistically significant, $t(8)=6.32$, $p>.05$. For concepts learned under the Accuracy condition, subjects recalled 25.5% (23 items) fewer items correctly. This large decrease from 76.66% (69 items) at Recall 1 to 51.11% (46 items) at Recall 3 and was statistically significant, $t(8)=5.33$, $p=.011$.

The same subjects also recalled 12.2% (11 items) fewer Accuracy and Speed items. This was a decrease from 87.7% (70 items) at Recall 1 to 75.5% (69 items) at Recall 3. This difference was not statistically significant, $t(8)=2.05$, $p>.05$.

For Session 2 items, the decline in numbers of items recalled was equal. The group recalled 25.5% fewer items under both conditions (Accuracy and Accuracy and Speed). This difference of 23 items from Recall 2 to Recall 3 was statistically significant for both learning to Accuracy items, $t(8)=5.08$, $p=.001$, and the learning to Accuracy and Speed items, $t(8)=3.82$, $p=.005$.

Application 3. Once again, the pattern of higher retention for items learned under the Accuracy and Speed condition emerged when comparing scores from Session 1 to Session 3 (Table 6). With Session 1 concepts, the group scores were lowest under the

Table 8

Experiment 1-Changes in Posttest Scores for Sessions 1 and 2 in Comparison to Session 3 (30-Day Delay Scores)

	Session 1						Session 2			
	Recall 1			**Application 1**			**Recall 2**		**Application 2**	
Subject	Read	Acc	Acc/Sp	Read	Acc	Acc/Sp	Acc/Sp	Acc	Acc/Sp	Acc
1	0	-4	-1	0	-1	-1	-5	-2	-2	0
2	+1	0	-1	+2	0	0	0	-2	+2	-3
3	+3	-3	-3	-3	-1	+1	-2	-4	-4	-2
4	-1	-3	0	-1	-1	0	-1	-2	-2	-2
5	-2	-3	-5	0	-2	-4	-2	-1	0	0
6	0	-1	0	+2	+1	0	-2	-2	-1	-1
7	-1	-3	-1	-5	-2	0	-4	-2	-2	-1
8	-2	-1	-1	+1	0	0	-1	-6	+4	-3
9	-1	-5	+1	0	0	0	-6	-2	-4	-2
Change	-3	-23	-11	+6	-6	-4	-23	-23	-12	-10

Reading condition at 53.3% (24 items). Although this score was lower than the two other conditions, it represented a 13.3% (6 items) increase from Application 1 to Application 3. This improvement of 6 items recalled for Application 3 was not statistically significant, $t(8)=.894$, $p>.05$. It was, however, unusual that time away from items learned by simply reading resulted in increased scores.

As a group, the retention score for application items learned under the Accuracy condition was 53.3% (24 items). This was identical to the Reading score. In comparison to the same items presented in Application 1, this represented a 13.3% decrease or 6 fewer items recalled but was not statistically significant, $t(8)=2.00$, $p>.05$. As a group, the highest retention score for Application 3 was for items learned under the Accuracy and Speed condition (82.2% or 37 items). In comparison to identical items presented in Application 1 during Session 1, this represented a reduction of 8.9%, or 4 fewer items recalled. This was also not a statistically significant difference, $t(8)=.936$, $p>.05$.

Examination of the subgroups revealed that Subgroups 1 and 3 retained more Accuracy and Speed items than Accuracy items. In respective order, Subgroups 1, 2 and 3 recalled an average of 60%, 66.6% and 33.3% Accuracy items. In comparison, these same subgroups scored an average of 86.6%, 60% and 100% Accuracy and Speed items, respectively.

Unfortunately, when comparing recall under both conditions from Application 2 to Application 3, scores were low. Nonetheless, the collective score was higher for concepts learned under the Accuracy and Speed condition (28.8% or 13 items) than Accuracy (11% or 5 items). When examining retention there was a 24.4% decrease (or 11 fewer items) recalled for the Accuracy items for Application 3 scores compared to Application 2. This difference was not statistically significant, $t(8)=1.73$, $p>05$. There was a 20% decrease (or 9 fewer items) recalled for the Accuracy and Speed items from Application 3 compared to the same items in Application 2. This was also not statistically significant, $t(8)=1.13$, $p>.05$. Again, Subgroups 1, 2 and 3 respectively recalled more Accuracy and Speed items (M=33.3%, M=26.6% and M=40%) than Accuracy items (M=0%, M=33.3% and M=.06%).

Retention. These results were produced by subtracting subjects' Session 1 and 2 posttest scores from each corresponding score from Session 3 (Table 8). No substantial differences were noticed between Reading recall items from Session 1 to Session 3. The group total decreased to 36.6% (33 items) from 40% (36 items) correct items. This represented a drop of 3.3% (3 items). Accuracy scores compared from Session 1 decreased from 76.6% (69 items) to 51.1% (46 items) on Session 3. This represented a decrease of 25.5% (23 items). Accuracy and Speed items recalled from Session 1 decreased from 87.7% (79 items) to 75.5% (68 items) on Session 3. This represented a decrease of 12.7% (11 items).

An unexpected difference was noticed from the Application 1 (Reading) items between Session 1 to Session 3. The group total increased to 53.5% (24 items) from 40% (18 items). This was an increase of 13.3% (6 items). Application 1 (Accuracy) items decreased from 66.6% (30 items) to 53.5% (24 items) on Session 3. This was a decrease of 13.3% (6 items). Application 1 (Accuracy and Speed) items decreased from 91.1% (41 items) to 82.2% (37 items) on Session 3. This was a decrease of 8.9% (4 items).

Overall, for both Recall 1 and Application 1 items, more Accuracy and Speed items were recalled than Accuracy items. There were no statistically significant individual declines in performance for recall items learned under the Reading and Accuracy conditions. The non-compliant subjects recalled similar numbers of items in comparison to their subgroup counterparts. However, some interesting effects were noticed for Recall 1 items (Accuracy and Speed). Two of the non-compliant subjects experienced greater declines on Session 3 than their subgroups. Subjects 3 and 5 recalled 20% fewer items learned under this condition than their counterparts. Subject 7, however, did as well as the other subjects in his subgroup.

There were within-subjects differences from Session 1 to Session 3 for Application 1 (Reading) items. Subject 7 dropped from 40% to zero on Application 1 (Accuracy) items. Subject 5 dropped from 80% to zero for Application 1 (Accuracy and Speed) items on Session 3. Subject 9, who appeared to follow the Think Fast learning instructions, could not recall any Application 1 (Accuracy) items from either sessions. An examination of his responses showed that he had difficulty with the shaping concept even after 40 Accuracy trials. He had the shaping concept confused with reinforcement.

The group totals also revealed that the decreases in Accuracy and Accuracy and Speed items were similar for both the Recall and Application posttests from Session 2 to Session 3.

In sum, the group recalled less on the Recall 3 and Application 3 tests administered after 30-days than they did for posttests administered at the conclusion of Sessions 1 and 2. Strangely, for Application 1 (Reading) concepts learned during Session 1, subjects recalled 13.3% more items when the same posttest was presented after a 30-day absence. A general decrease in items recalled from Application 1 to Application 3 was expected; however, the degree of loss was interesting. Items under the Accuracy condition decreased by 13.3% (6 items). At the same time, the Accuracy and Speed items were more resistant to extinction, with an 8.9% (4 items) loss. A similar pattern was noticed for items compared from Application 2 to Application 3, although not to the same degree. None of the differences in retention scores for the application tests were statistically significant.

Single-Subject Analyses

Individual subject scores were presented on Figures 14-31. Each graph illustrated posttest data from either Sessions 1 or 2 along with the Session 3 scores (30-day absence) presented side by side. Subject 1's data from Recall 1 and Application 1 were displayed on Figure 14. There were no differences in achievement under the Reading condition. She recalled the same number of items on both sessions (40%). For Session 1, her scores were identical for Recall 1 (Accuracy and Accuracy and Speed both at 70%) and Application 1 (Accuracy and Accuracy and Speed both at 80%). The greatest decrease was noticed for Session 3. She went from 100% for Recall 2 (Accuracy and Speed) items to 50%. Under the Recall 2 (Accuracy) items, her performance decreased from 70% to 50%. A greater difference was observed for her Application 2 performance. She did not recall any Accuracy items for both sessions. For Accuracy and Speed items, her performance decreased from 80% to 40%. There was a 30% (3 items) decrease on Session 3 (Recall 1) (Accuracy) items when measured after the 30-day absence on Session 3.

Subject 1's Session 2 data were displayed on Figure 15. Under both Accuracy and Accuracy and Speed conditions, there were declines for Recall 2 items presented in Session 3. She went from 100% for Recall 2 (Accuracy and Speed) items to 50%. A

Figure 14. Subject 1's posttest performance on Session 1 compared to the same measures readministered on Session 3.

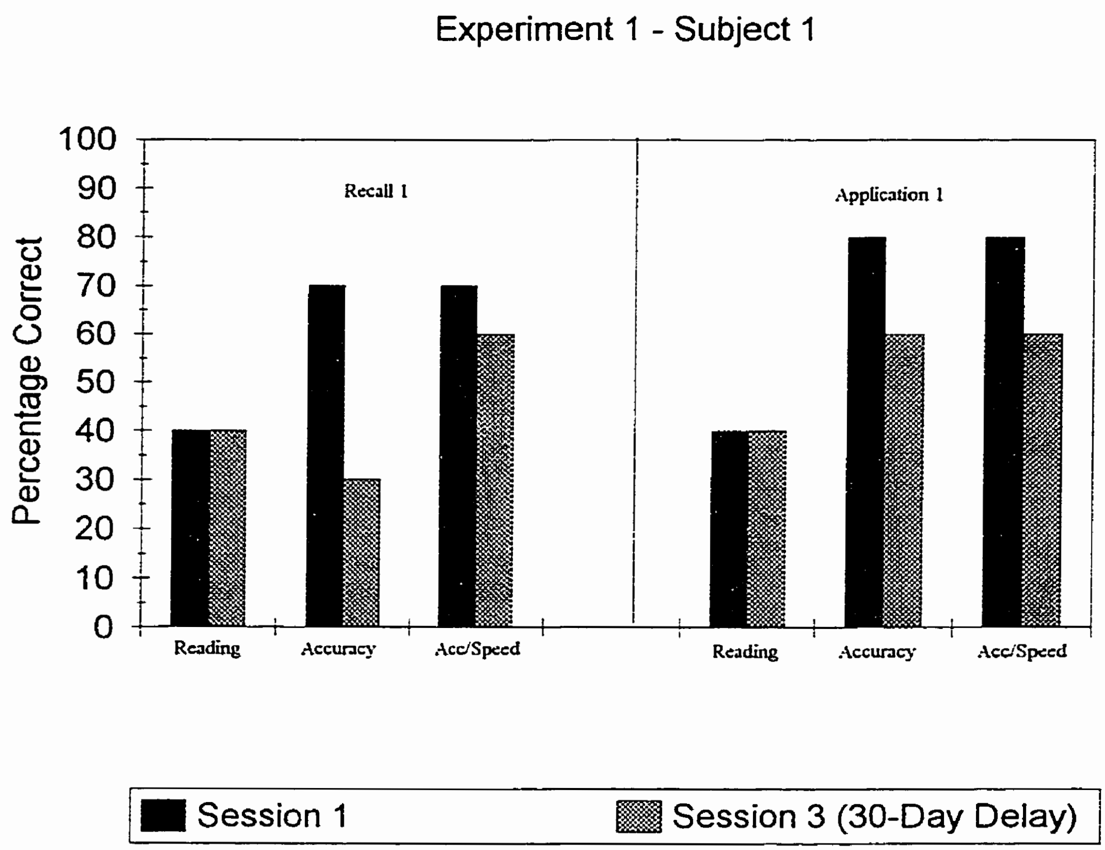

Experiment 1 - Subject 1
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 15. Subject 1's posttest performance on Session 2 compared to the same measures readministered on Session 3.

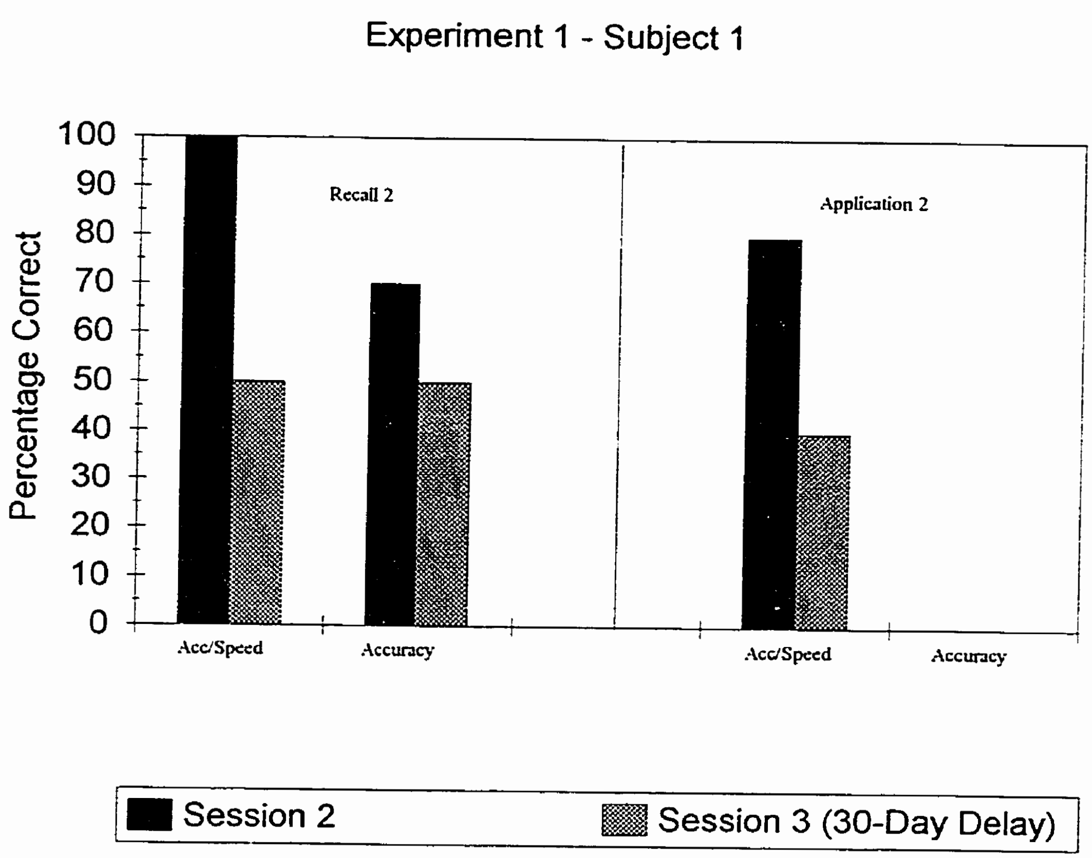

Experiment 1 - Subject 1
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 16. Subject 2's posttest performance on Session 1 compared to the same measures readministered on Session 3.

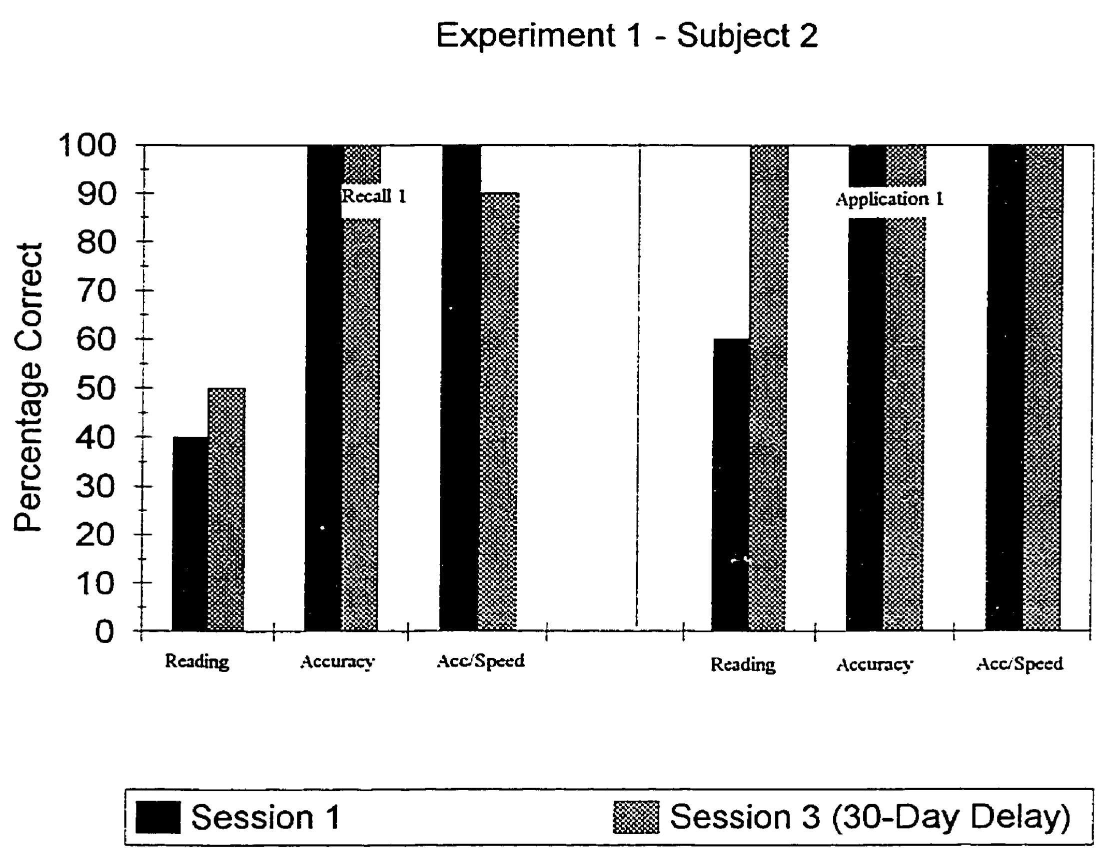

Experiment 1 - Subject 2
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 17. Subject 2's posttest performance on Session 2 compared to the same measures readministered on Session 3.

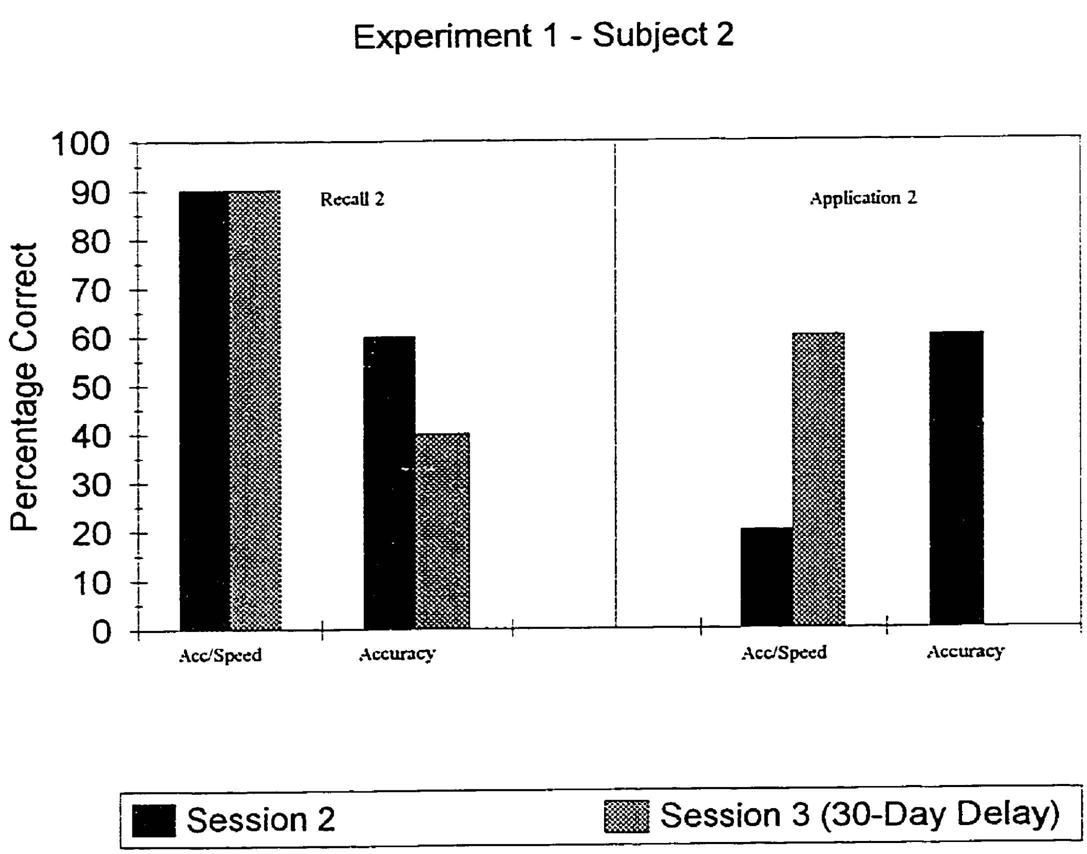

Experiment 1 - Subject 2
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 18. Subject 3's posttest performance on Session 1 compared to the same measures readministered on Session 3.

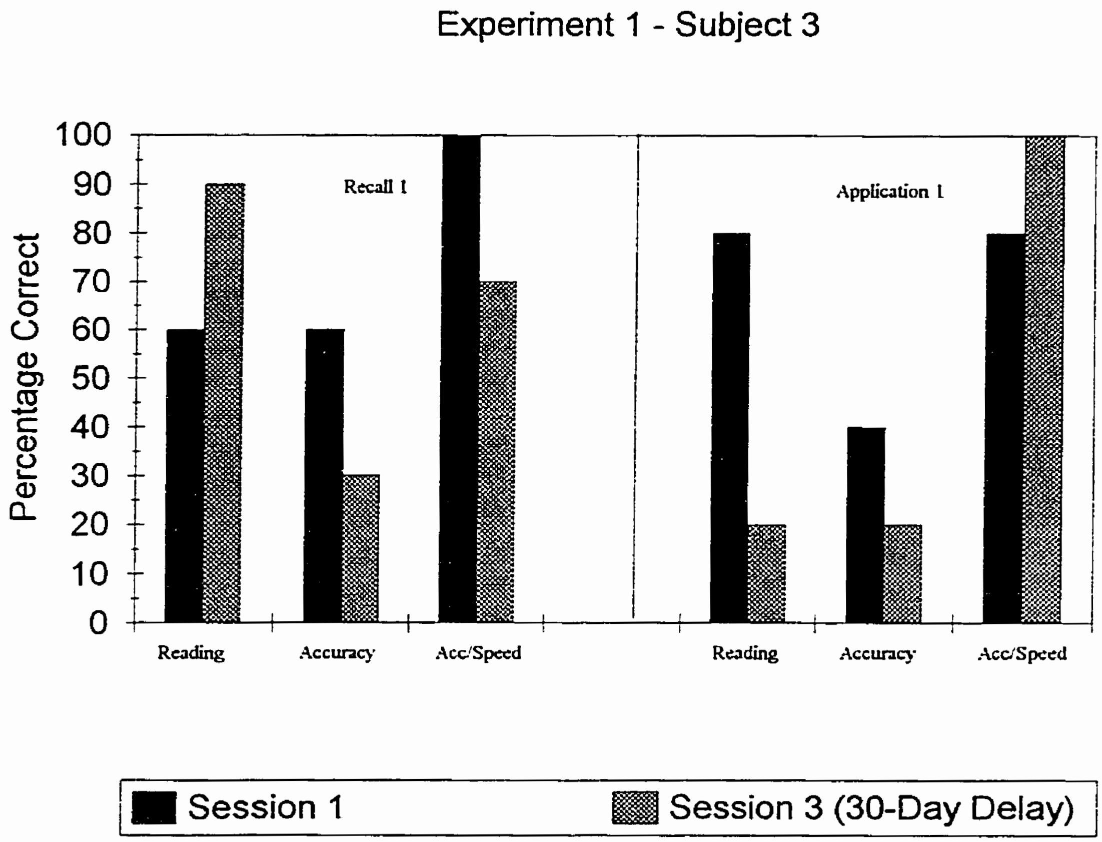

Experiment 1 - Subject 3
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 19. Subject 3's posttest performance on Session 2 compared to the same measures readministered on Session 3.

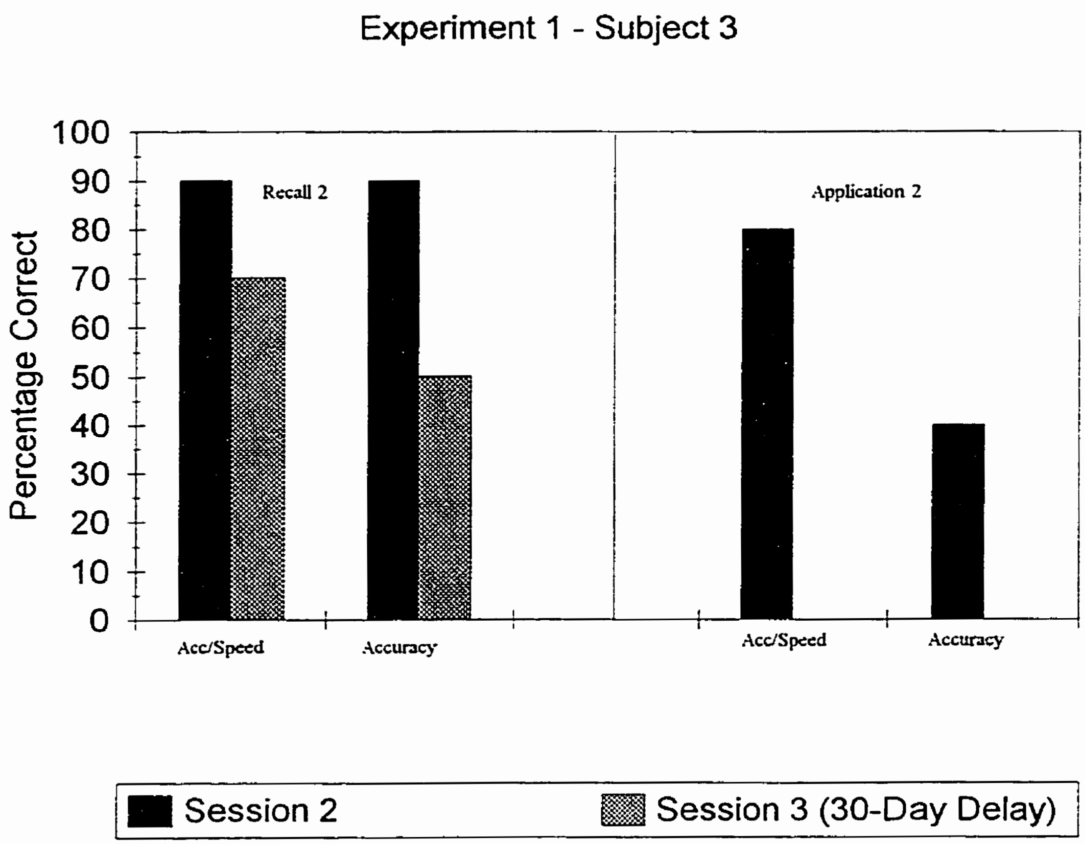

Experiment 1 - Subject 3
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 20. Subject 4's posttest performance on Session 1 compared to the same measures readministered on Session 3.

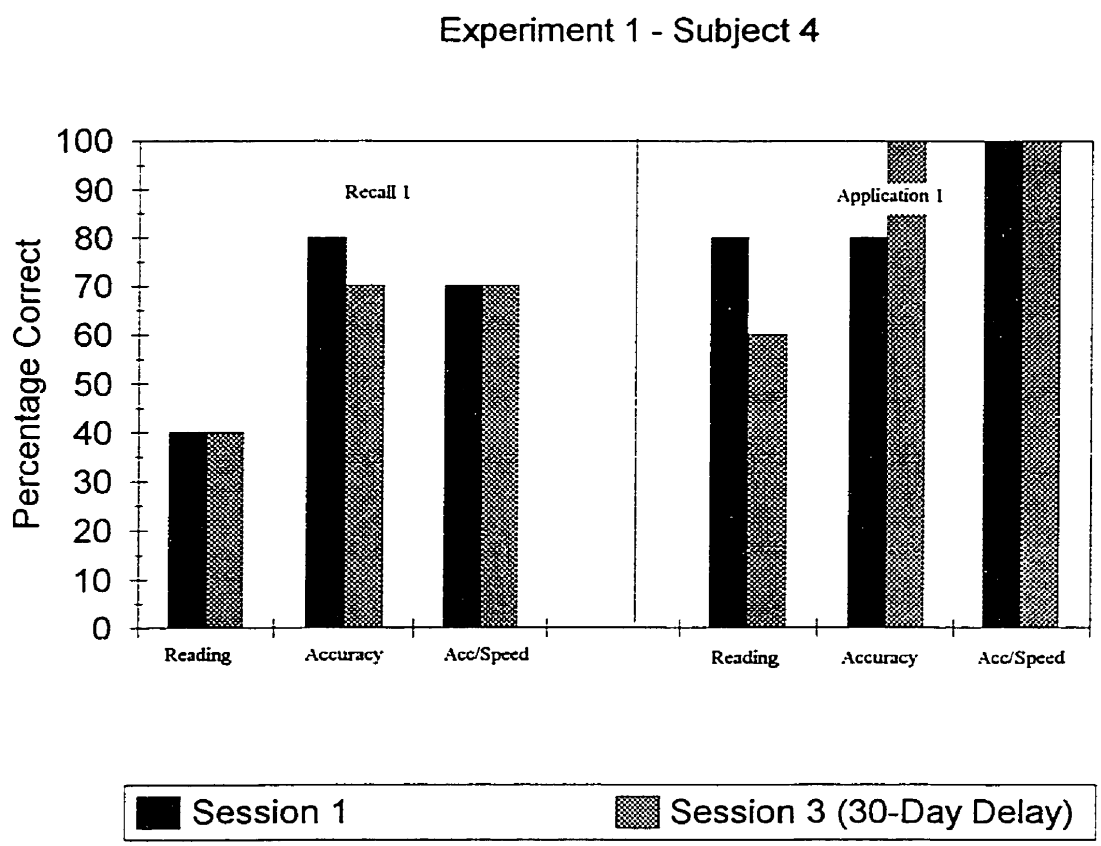

Experiment 1 - Subject 4
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 21. Subject 4's posttest performance on Session 2 compared to the same measures readministered on Session 3.

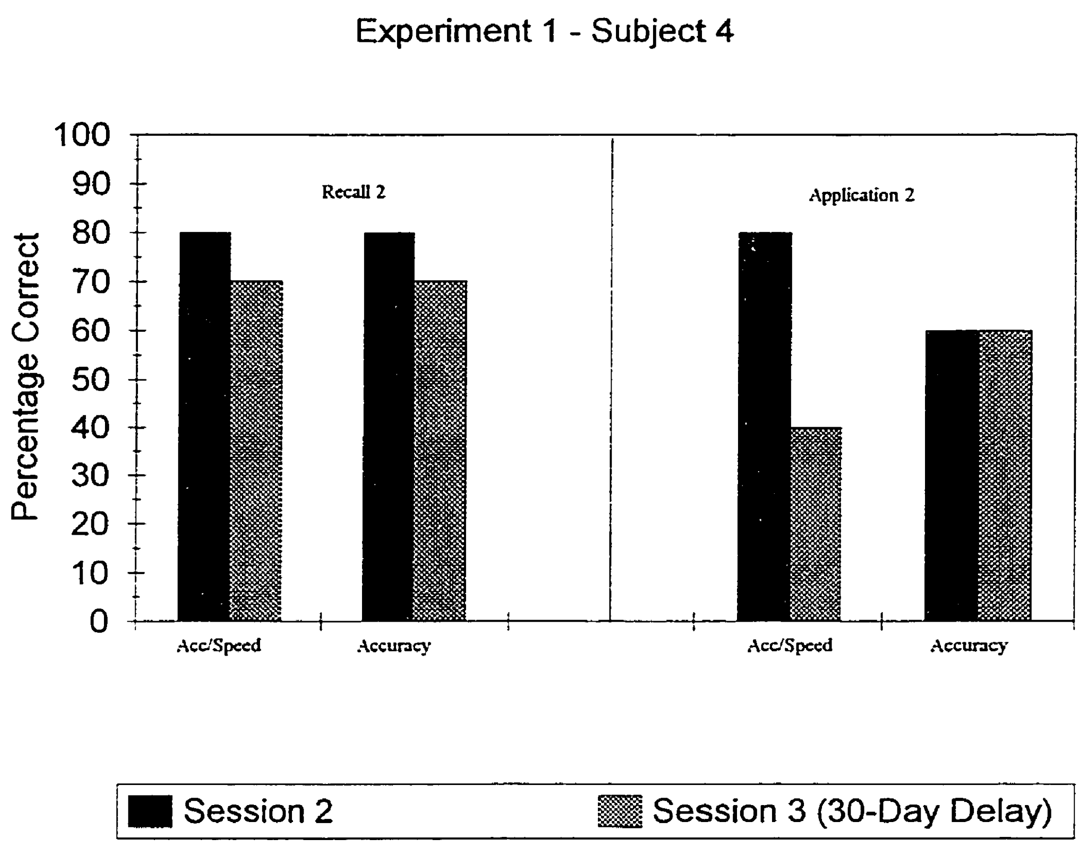
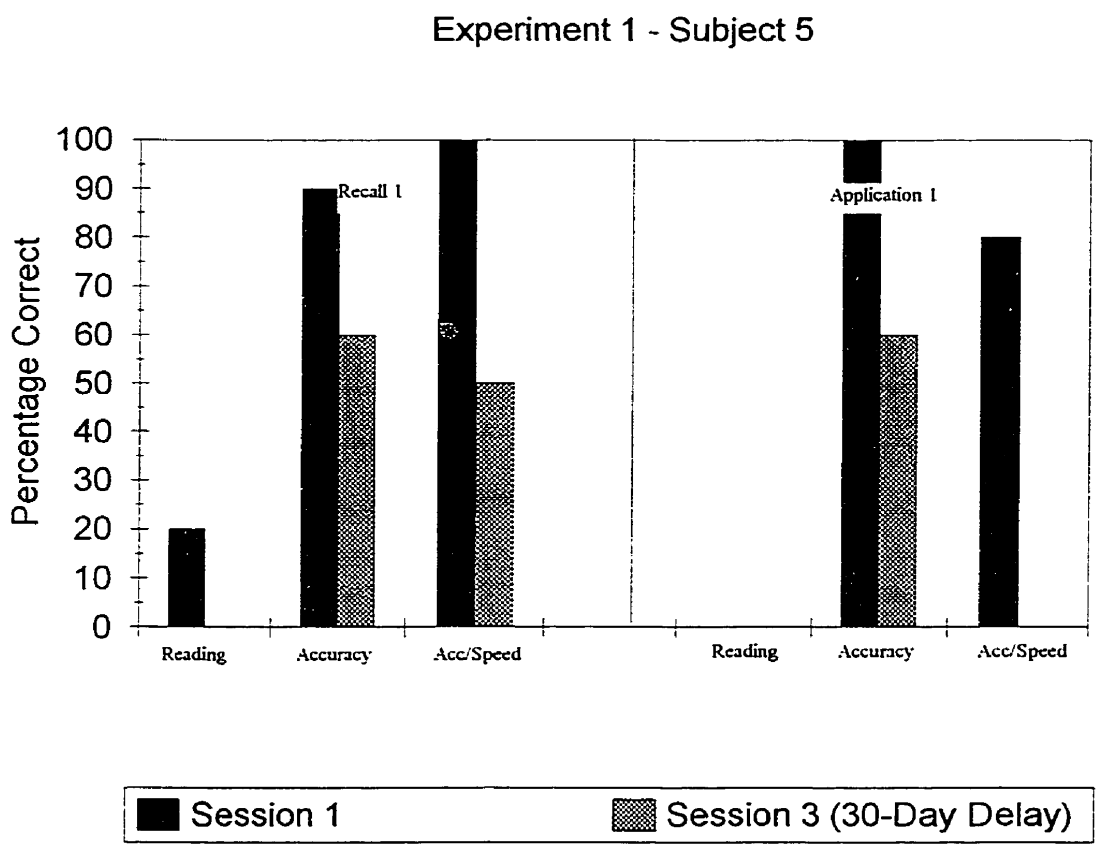

Experiment 1 - Subject 4
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 22. Subject 5's posttest performance on Session 1 compared to the same measures readministered on Session 3.



Experiment 1 - Subject 5
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 23. Subject 5's posttest performance on Session 2 compared to the same measures readministered on Session 3.

Experiment 1 - Subject 5

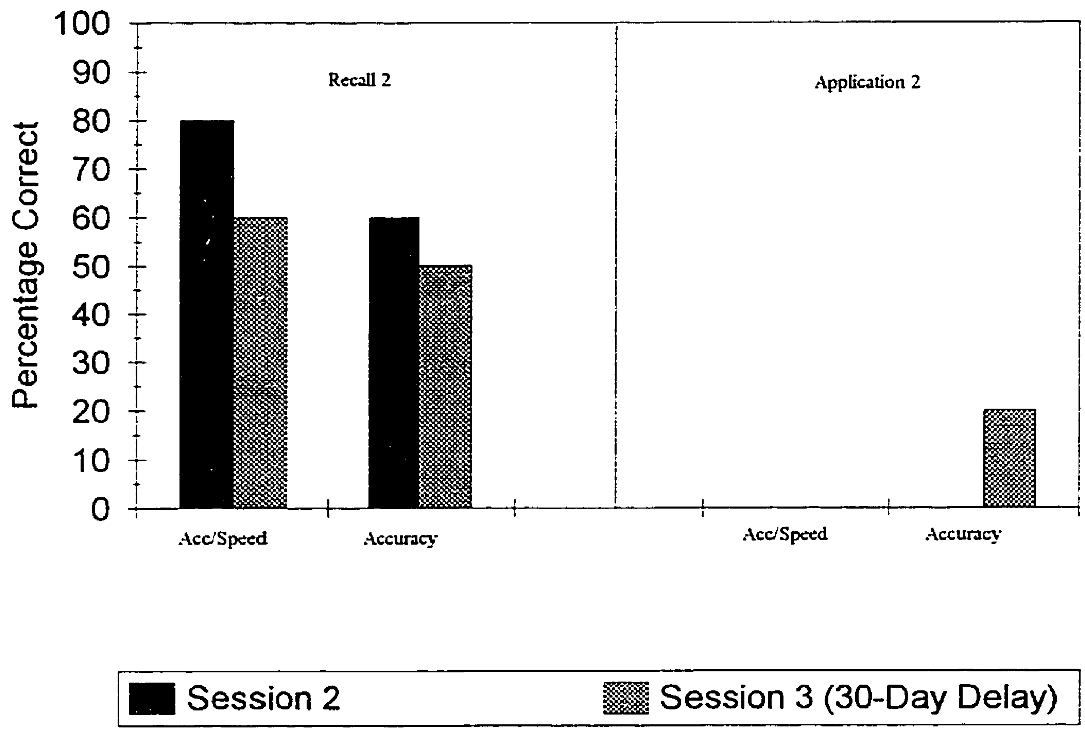
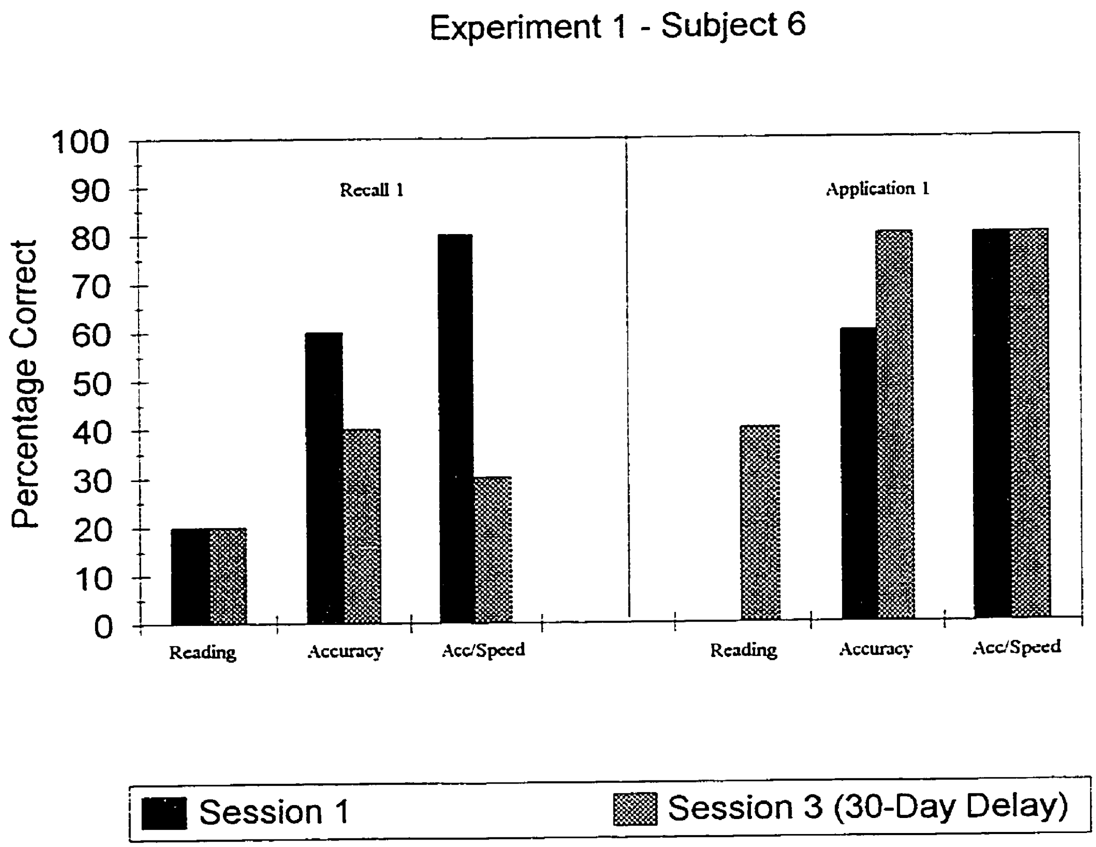


Figure 24. Subject 6's posttest performance on Session 1 compared to the same measures readministered on Session 3.



Experiment 1 - Subject 6
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 25. Subject 6's posttest performance on Session 2 compared to the same measures readministered on Session 3.

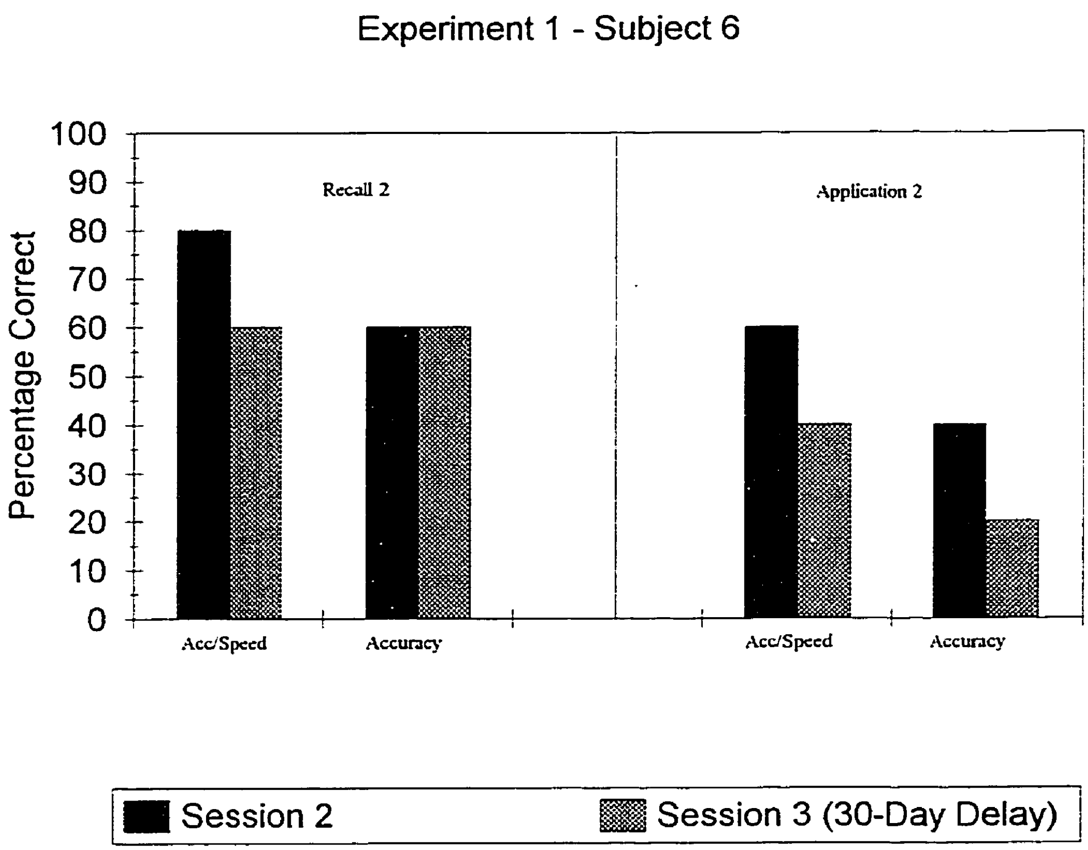

Experiment 1 - Subject 6
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 26. Subject 7's posttest performance on Session 1 compared to the same measures readministered on Session 3.

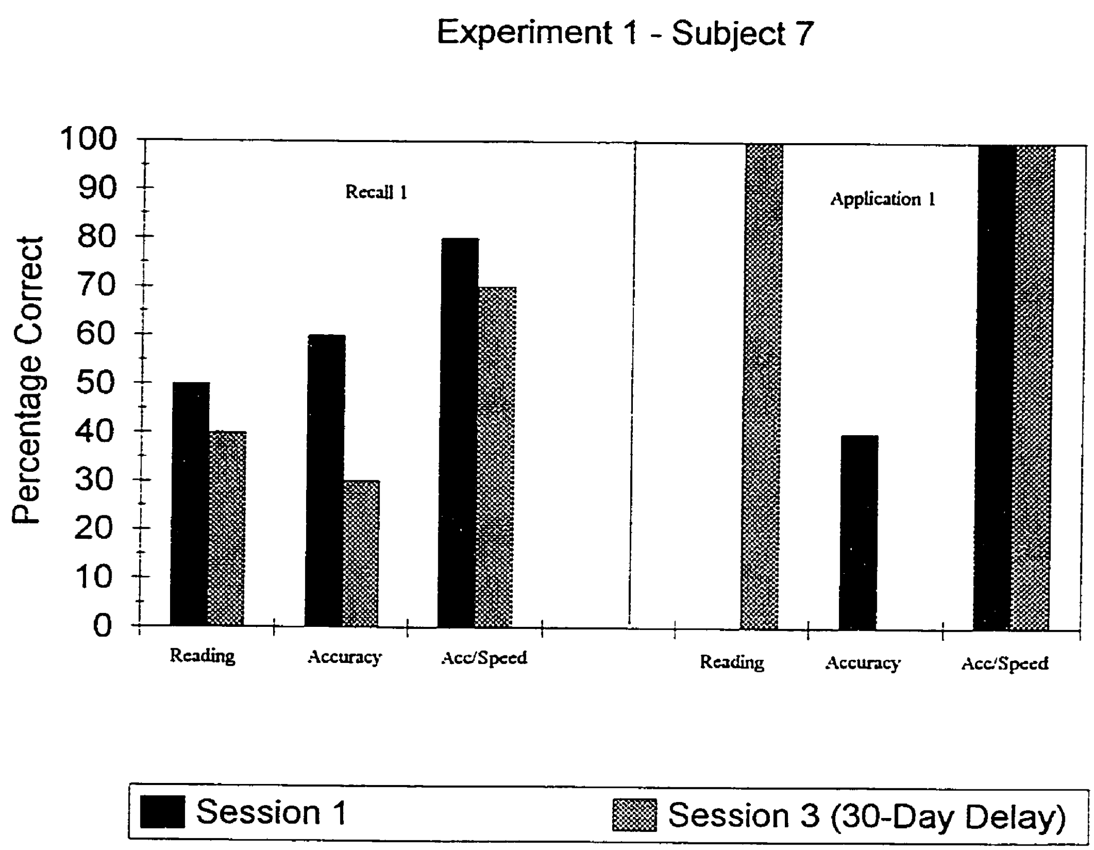

Experiment 1 - Subject 7
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 27. Subject 7's posttest performance on Session 2 compared to the same measures readministered on Session 3.

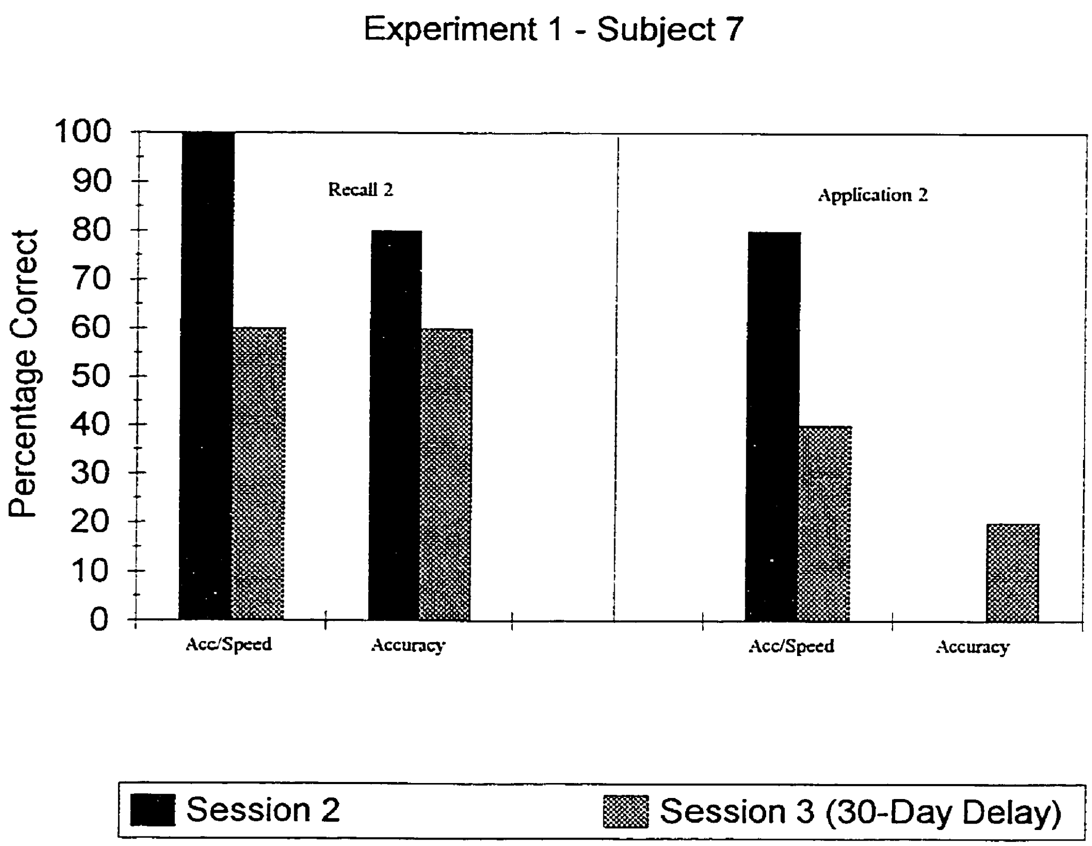

Experiment 1 - Subject 7
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 28. Subject 8's posttest performance on Session 1 compared to the same measures readministered on Session 3.

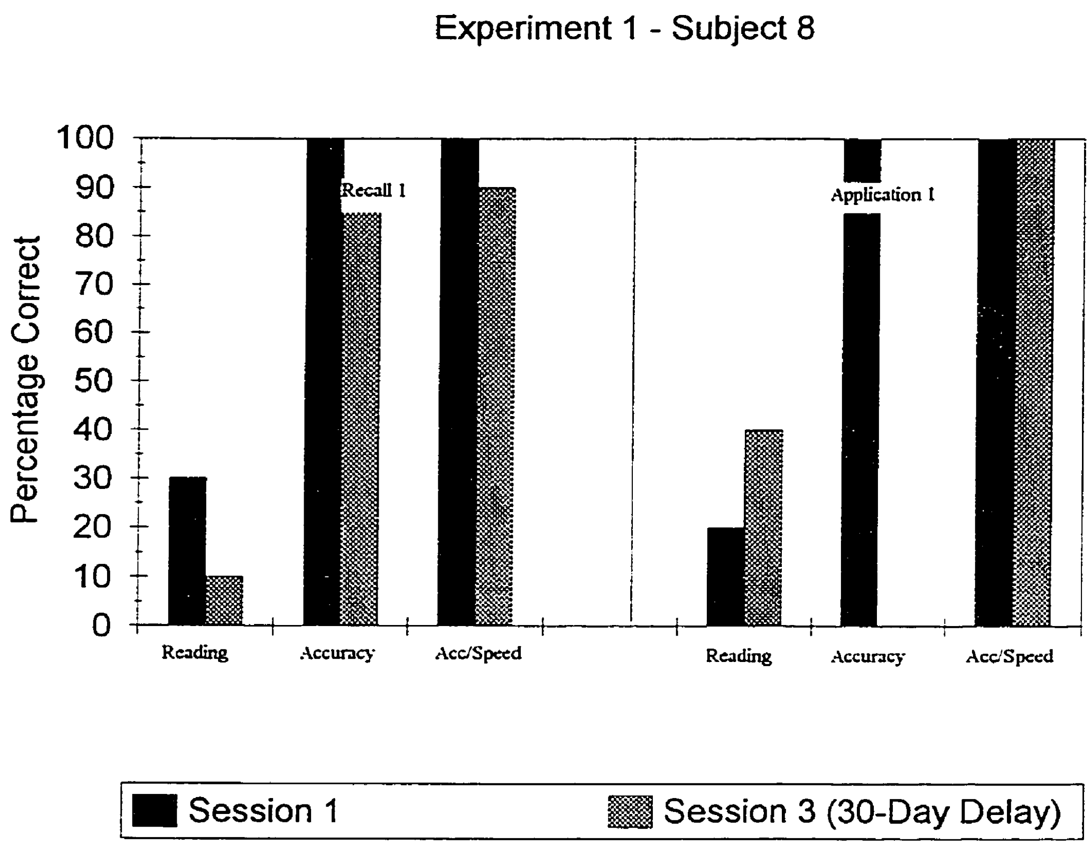

Experiment 1 - Subject 8
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 29. Subject 8's posttest performance on Session 2 compared to the same measures readministered on Session 3.

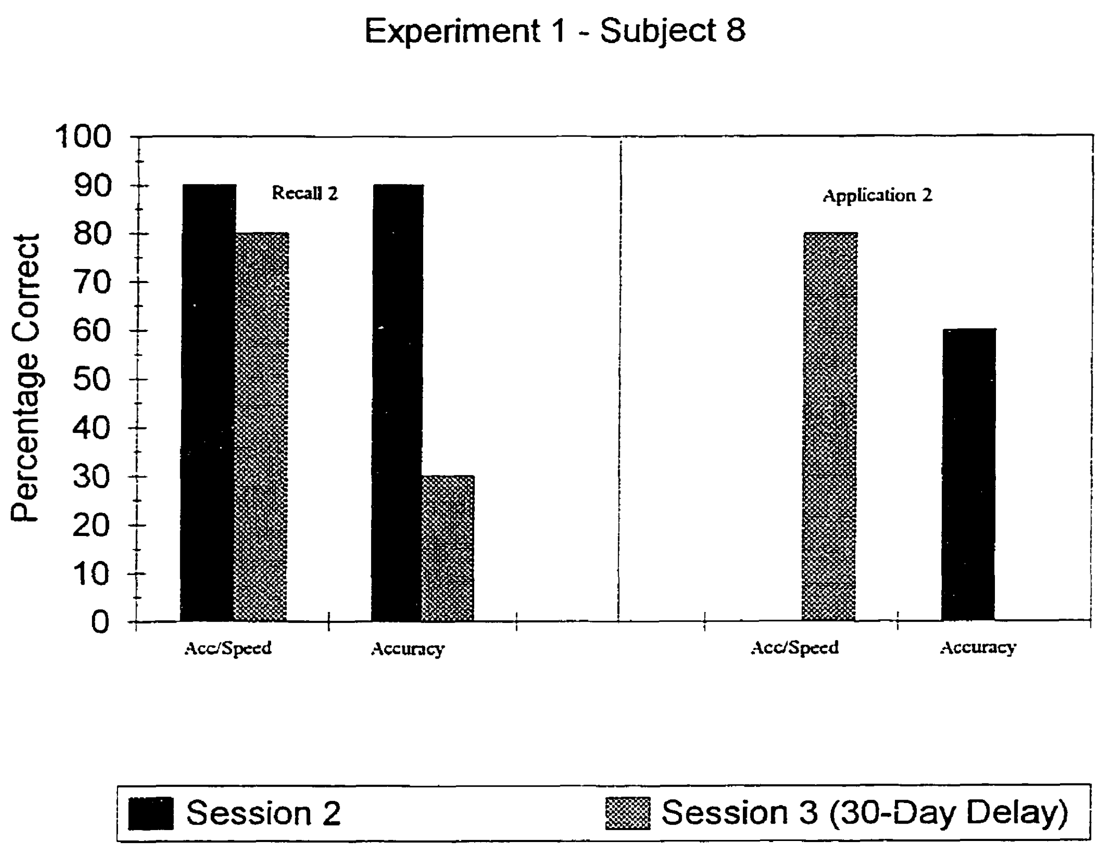

Experiment 1 - Subject 8
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

Figure 30. Subject 9's posttest performance on Session 1 compared to the same measures readministered on Session 3.

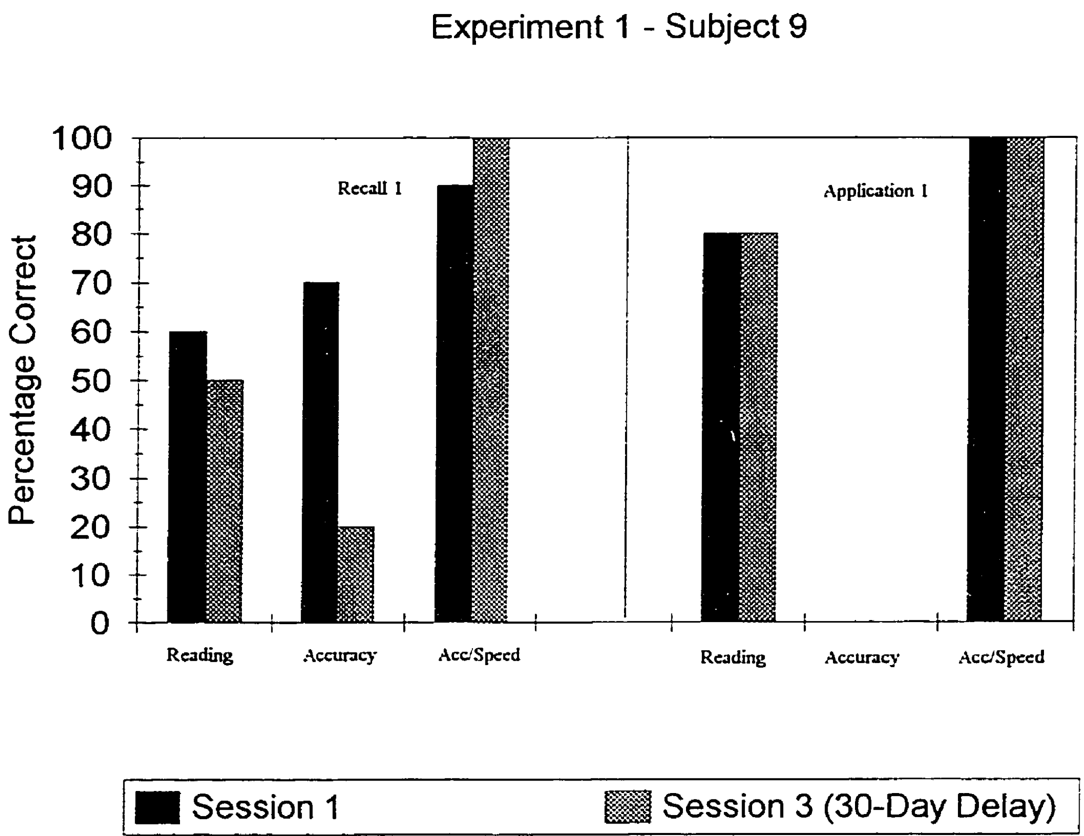
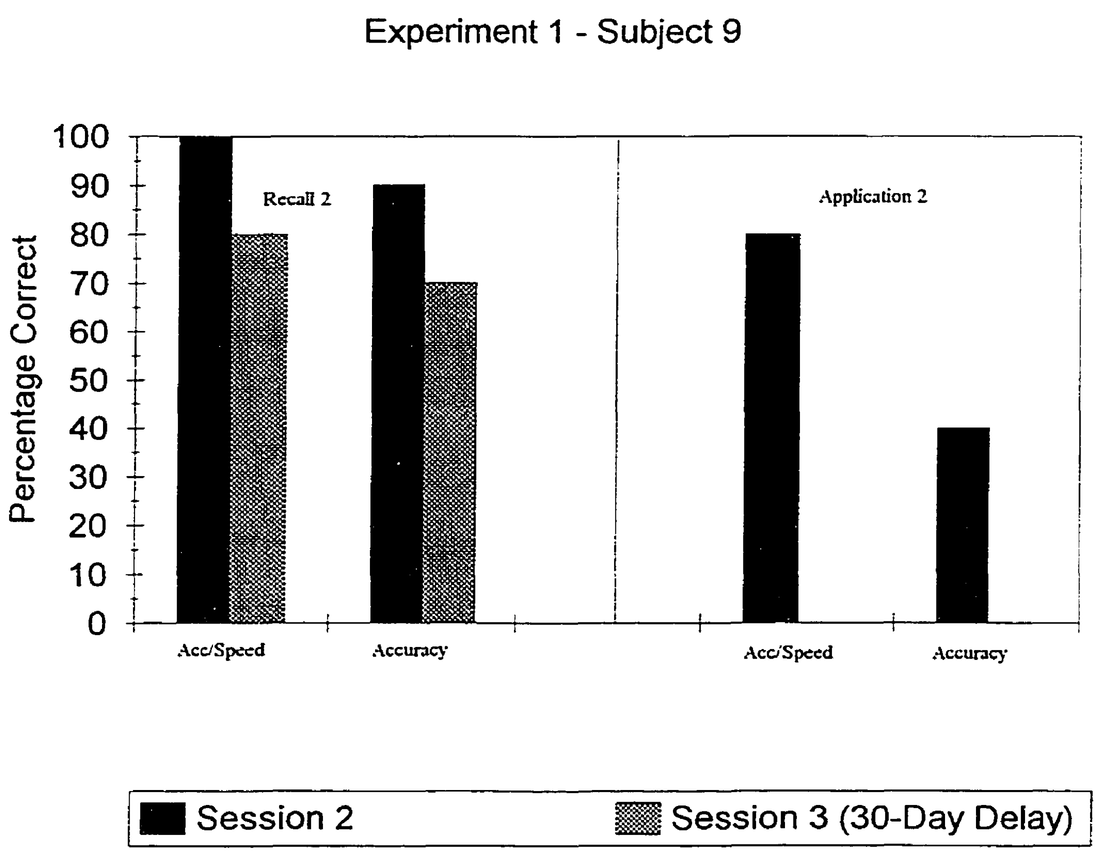

Experiment 1 - Subject 9
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 1
Application 1
Reading
Accuracy
Acc/Speed
Reading
Accuracy
Acc/Speed
Session 1
Session 3 (30-Day Delay)

Figure 31. Subject 9's posttest performance on Session 2 compared to the same measures readministered on Session 3.


Experiment 1 - Subject 9
Percentage Correct
100
90
80
70
60
50
40
30
20
10
0
Recall 2
Application 2
Acc/Speed
Accuracy
Acc/Speed
Accuracy
Session 2
Session 3 (30-Day Delay)

greater difference was observed for her Application 2 performance. She did not recall any Accuracy items for both sessions. For Accuracy and Speed items, her performance decreased from 80% to 40%.

Subject 2's data from Recall 1 and Application 1 were displayed on Figure 16. There was only a one-item difference in Recall 1 (Reading) scores. She recalled 50% of the Recall 1 items on Session 3 compared to 40% on Session 1. This trend continued as she recalled 100% of the Application 1 (Reading) items on Session 3 compared to 60% on Session 1. There were no differences in her recall for Application 1 (Accuracy) items for both sessions. She recalled the same number of items (100%). Her performance for Recall 1 (Accuracy and Speed) items was also high with only one fewer item recalled. The Application 1 (Accuracy and Speed) items were all recalled (100%).

For Session 2, her scores for Recall 2 (Accuracy and Speed) remained stable at 90% from Session 1 to Session 3 (Figure 17). Her Recall 2 (Accuracy) performance was lower at 60% for Session 1 and 40% for Session 3. Unexpectedly, her Application 2 (Accuracy and Speed) items increased from 30% on Session 1 to 60% for Session 3. In contrast, her Application 2 (Accuracy) recall decreased from 60% on Session 1 to zero on Session 3.

Subject 3's data from Recall 1 and Application 1 were displayed on Figure 18. Her Recall 1 (Reading) performance increased from Session 1 (60%) to Session 3 (90%). She recalled 60% of the Recall 1 (Accuracy) items on Session 1 compared to only 30% on Session 3 and her Recall 1 (Accuracy and Speed) performance decreased from 100% to 70% on Session 3. There was a large decline in her recall for Application 1 (Reading items from 80% on Session 1 to 20% on Session 3. A smaller decline was noticed for

Application 1 (Accuracy) items from 40% on Session 1 to 20% on Session 3. Her recall for Application 1 (Accuracy and Speed) items increased from 80% on Session 1 to 100% on Session 3. For Session 2, her scores for Recall 2 (Accuracy and Speed) dropped from 90% on Session 1 to 70 % on Session 3 but a greater decline was observed for Recall 2 (Accuracy) items as they dropped from 90% on Session 1 to 50% on Session 3 (Figure 19). Her Application 2 performance was disappointing. She started at 80% for Accuracy and Speed items and 40% for Accuracy items and dropped to zero recalled for both on Session 3.

Subject 4's data from Recall 1 and Application 1 were displayed on Figure 20. His Recall 1 (Reading) scores were identical for both Sessions 1 and 3 at 40%. His Recall 1 (Accuracy and Accuracy and Speed) scores were similar and ranged from 70% to 80% for Sessions 1 and 2. There was a two-item decrease on his Application 1 (Reading) scores from 80% on Session 1 to 60% on Session 3. His performance for Application 1 (Accuracy) items increased from 80% at Session 1 to 100% on Session 3. His Application 1 (Accuracy and Speed) stayed constant at 100% for both sessions. For Session 2, his scores for Recall 2 (Accuracy and Speed) and Recall 2 (Accuracy) were identical from Session 1 to Session 3 (Figure 21). Both showed a one-item decrease from 80% on Session 1 to 70% on Session 3. His Application 2 (Accuracy and Speed) performance dropped from 80% on Session 1 to 40% on Session 3. His Application 2 (Accuracy) performance remained stable at 60% for both sessions.

Subject 5's data from Recall 1 and Application 1 were displayed on Figure 22. This subject recalled two Recall 1 (Reading) items and zero Application 1 (Reading) items. Her Recall 1 (Accuracy) performance dropped from 90% on Session 1 to 60% on

Session 3. A larger drop was noticed for Recall 1 (Accuracy and Speed) items. She recalled 100% on Session 1 and only 50% for Session 3. For Application 1 (Accuracy) items she recalled 40% fewer items from 100% on Session 1 to 60% on Session 3. There was a more dramatic decline for her Application 1 (Accuracy and Speed) performance. She dropped from 80% on Session 1 to zero for Session 3. For Session 2, her scores for Recall 2 (Accuracy and Speed) decreased from 80% on Session 1 to 60% on Session 3 (Figure 23). Her Recall 2 (Accuracy) performance was lower at 60% for Session 1 and 50% for Session 3. Unexpectedly, her Application 2 (Accuracy and Speed) items were zero for both sessions but she did manage to recall one item for Application 2 (Accuracy) resulting in a 20% score for Session 3.

Subject 6's data from Recall 1 and Application 1 were displayed on Figure 24. His Recall 1 (Reading) scores were identical at 20% for Sessions 1 and 3. He recalled 60% of the Recall 1 (Accuracy) items on Session 1 compared to 40% on Session 3. He recalled 80% of the Recall 1 (Accuracy and Speed) items on Session 1 compared to 30% on Session 3. He did not recall any Application 1(Reading) items in Session 1 but managed to remember 40% (2 items) on Session 3. His performance on Application 1 (Accuracy) items actually increased from 60% on Session 1 to 80% on Session 3. There were no differences in his recall of Application 1 (Accuracy and Speed) items for both sessions (80%).

For Session 2, his scores for Recall 2 (Accuracy and Speed) decreased slightly from 80% on Session 1 to 60% on Session 3 (Figure 25). His Recall 2 (Accuracy) performance was 60% for both Sessions1 and 3. His Application 2 (Accuracy and Speed) performance decreased from 60% on Session 1 to 40% for Session 3. His Application 2 (Accuracy) performance also decreased from 40% on Session 1 to 20% on Session 3.

Subject 7's data from Recall 1 and Application 1 were displayed on Figure 26. His Recall 1 (Reading) scores dropped slightly from 50% on Session 1 to 40% for Sessions 3. He recalled 60% of the Recall 1 (Accuracy) items on Session 1 compared to 30% on Session 3. He recalled 80% of the Recall 1 (Accuracy and Speed) items on Session 1 and 70% on Session 3. He did not recall any Application 1(Reading) items during Session 1 but somehow managed to recall 100% on Session 3. His performance on Application 1 (Accuracy) items dropped from 40% on Session 1 to zero on Session 3. There were no differences in his recall for Application 1 (Accuracy and Speed) items for both sessions (100%).

For Session 2, his scores for Recall 2 (Accuracy and Speed) decreased from 100% on Session 1 to 60% on Session 3 (Figure 27). His Recall 2 (Accuracy) performance decreased from 80% for Session 1 to 60% for Session 3. His Application 2 (Accuracy and Speed) items decreased in half from 80% on Session 1 to 40% for Session 3. His Application 2 (Accuracy) performance was disappointing with zero for Session 1 and 20% for Session 3.

Subject 8's data from Recall 1 and Application 1 were displayed on Figure 28. Her Recall 1 (Reading) performances were low at 30% for Sessions 1 and only 10% for Session 3. In contrast, most of her other performances were high. She recalled 100% of the Recall 1 (Accuracy) items on Session 1 and 90% on Session 3. Similarly, she recalled 100% of the Recall 1 (Accuracy and Speed) items on Session 1 and 90% on Session 3. She only recalled 20%of the Application 1(Reading) items during Session 1 but improved to 40% on Session 3. Her performance on Application 1 (Accuracy) was unusual with 100% for Session 1 and zero for Session 3. There were no differences in her recall for Application 1 (Accuracy and Speed) items for both sessions (100%).

For Session 2, her scores for Recall 2 (Accuracy and Speed) decreased slightly from 90% on Session 1 to 80% on Session 3 (Figure 29). Her Recall 2 (Accuracy) performance was 90% for Sessions1 but decreased to 30% for Session 3. Her Application 2 (Accuracy and Speed) performance greatly increased from zero on Session 1 to 80% for Session 3. Her Application 2 (Accuracy) performance decreased from 60% on Session 1 to zero on Session 3.

Subject 9's data from Recall 1 and Application 1 were displayed on Figure 30. His Recall 1 (Reading) scores were similar at 60% for Sessions 1 and 50% for Session 3. He recalled 70% of the Recall 1 (Accuracy) items on Session 1 compared to only 20% on Session 3. He recalled 90% of the Recall 1 (Accuracy and Speed) items on Session 1 and improved to 100% on Session 3. He recalled 80% of the Application 1 (Reading) items for both Sessions. His performance on Application 1 (Accuracy) was a surprise. He registered zero for both sessions. There were no differences in his recall for Application 1 (Accuracy and Speed) items for both sessions (100%).

For Session 2, his scores for Recall 2 (Accuracy and Speed) decreased slightly from 100% on Session 1 to 80% on Session 3 (Figure 31). His Recall 2 (Accuracy) performance was 90% for Sessions1 and decreased to 70% for Session 3. His Application 2 (Accuracy and Speed) items decreased greatly from 80% on Session 1 to zero for Session 3. His Application 2 (Accuracy) performance also decreased from 40% on Session 1 to zero on Session 3.

Deck Scores Analyses

An analysis of the recall and application posttest scores relative to the content of the Think Fast learning decks was performed (see Tables 9-12). For Session 1, subjects progressed through the 'reinforcement', 'extinction' and 'shaping' Think Fast decks presented in a counterbalanced sequence (Table 4). In six of the eight comparisons, subjects recalled more items from the 'reinforcement' deck. For Session 1's recall items learned under the Accuracy condition, subjects scored higher for the 'reinforcement' deck (*M*=9.6) than the 'extinction' (*M*=6.33) and 'shaping' (*M*=7) decks. This was not the case for the Session 1's recall items learned under the Accuracy and Speed condition (Table 9). Subjects recalled more items from the 'extinction' deck (*M*=10) followed by the 'shaping' (*M*=9) and then 'reinforcement' (*M*=7.33) decks.

For Session 1's application items learned under the Accuracy condition, subjects scored higher for the 'reinforcement' deck (*M*=5) than the 'shaping' (*M*=3.33) or 'extinction' (*M*=1.66) decks (Table 9). This was also the case for the Session 1's application items learned under the Accuracy and Speed condition. Subjects recalled the most items from the 'reinforcement' (*M*=4.66) and 'extinction' (*M*=4.66) decks followed closely by the 'shaping' deck (*M*=4.33).

The learning content was changed for Session 2. Subjects now experienced two of the three new learning decks which consisted of either 'interval', 'ratio' or 'differential' schedules of reinforcement. The results for these decks were not as definitive as Session 1's learning decks. No particular deck contained items that were more likely to be recalled than others. For Session 2's recall items learned under the Accuracy and Speed condition, subjects scored highest for the ratio deck (*M*=9.33) followed by the differential

Table 9

Recall and Application Scores for Each *Think Fast* Deck for Experiment 1 Subjects on Session 1

	Session 1-Recall Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Reinforcement**	**Extinction**	**Shaping**	**Reinforcement**	**Extinction**	**Shaping**
1			7	7		
2	10				10	
3		6				10
4			8	7		
5	9				10	
6		6				8
7			6	8		
8	10				10	
9		7				9
Means	9.6	6.33	7	7.33	10	9

	Session 1-Application Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Reinforcement**	**Extinction**	**Shaping**	**Reinforcement**	**Extinction**	**Shaping**
1			4	4		
2	5				5	
3		2				4
4			4	5		
5	5				4	
6		3				4
7			2	5		
8	5				5	
9		0				5
Means	5	1.66	3.33	4.66	4.66	4.33

Table 10

Recall and Application Scores for Each *Think Fast* Deck for Experiment 1 Subjects on Session 2

	Session 2-Recall Posttest Scores					
	Accuracy/Speed			**Accuracy**		
Subject	**Interval**	**Ratio**	**Differential**	**Interval**	**Ratio**	**Differential**
1		10				7
2	9				6	
3			9	9		
4		8				8
5	8				6	
6			8	6		
7		10				8
8	9				9	
9			10	9		
Means	8.66	9.33	9	8	7	7.66

	Session 2-Application Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Interval**	**Ratio**	**Differential**	**Interval**	**Ratio**	**Differential**
1		4				0
2	1				3	
3			4	2		
4		4				3
5	0				0	
6			3	2		
7		4				0
8	0				3	
9			4	2		
Means	.33	4	3.66	2	2	1

Table 11

Recall and Application Scores for Each Think Fast Deck for Experiment 1 Subjects on Session 3 (Session 1 Items Readministered)

	Session 3 (30-day delay)-Session 1 Recall Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Reinforcement**	**Extinction**	**Shaping**	**Reinforcement**	**Extinction**	**Shaping**
1			3	6		
2	10				9	
3		3				7
4			5	7		
5	5				5	
6		5				8
7			3	7		
8	9				9	
9		2				10
Means	8	3.33	3.66	7.66	8.33	6.66

	Session 3 (30-day delay) Session 1-Application Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Reinforcement**	**Extinction**	**Shaping**	**Reinforcement**	**Extinction**	**Shaping**
1			3	3		
2	5				5	
3		1				3
4			3	5		
5	3					
6		0			0	5
7			0	5		
8	5					
9		0			5	5
Means	4.33	.33	2	4.33	3.33	4.33

Table 12

Comparison of Recall and Application Scores for Each *Think Fast* Deck for Experiment 1 Subjects on Session 3 (Session 2 Items Readministered)

	Session 3 (30-day delay) Session 2 Items-Recall Posttest Scores					
	Accuracy			**Accuracy/Speed**		
Subject	**Interval**	**Ratio**	**Differential**	**Interval**	**Ratio**	**Differential**
1		5				5
2	9				4	
3			7	5		
4		7				7
5	6				5	
6			6	6		
7		6				6
8	8				3	
9			4	7		
Means	7.66	6	5.66	6	4	6

	Session 3 (30-day delay) Session 2 Items-Application Posttest Scores					
	Accuracy/Speed			**Accuracy**		
Subject	**Interval**	**Ratio**	**Differential**	**Interval**	**Ratio**	**Differential**
1		2				0
2	3				0	
3			0	0		
4		2				3
5	0				1	
6			2	1		
7		2				1
8	4				0	
9			0	0		
Means	2.33	2	.66	.33	.33	1.33

(*M*=8.66) and interval (*M*=8.66) decks (Table 10). Recall 2 items learned under the Accuracy condition resulted in more items from the interval deck (*M*=8) followed by the differential (*M*=7.66) and then ratio (*M*=7) decks.

For Session 2's Application items learned under the Accuracy condition, subjects scored higher for the 'ratio' deck (*M*=4) than the 'differential' (*M*=3.66) and 'interval' (*M*=.33) decks (Table 10). For Session 2's application items learned under the Accuracy and Speed condition, subjects recalled an equally low number of items from the 'interval' (*M*=2) and 'ratio' (*M*=2) decks followed closely by the 'differential' deck (*M*=1).

Session 3 was a posttest presented after a 30-day delay with items from Sessions 1 and 2. For Session 1 items that were presented in Session 3, the recall items learned under the Accuracy condition resulted in higher scores for the 'reinforcement' deck (*M*=8) than the 'extinction' (*M*=3.33) or 'shaping' (*M*=3,66) decks (Table 11). It was different for Session 1's recall items learned under the Accuracy and Speed condition. Subjects recalled more items from the 'shaping' deck (*M*=8.33) followed by the 'extinction' (*M*=7.66) and then 'reinforcement' (*M*=6.66) decks.

For Session 1 application items presented in Session 3, the items learned under the Accuracy condition resulted in higher scores for the 'reinforcement' deck (*M*=4.33) than the 'shaping' (*M*=2) and 'extinction' (*M*=.33) decks (Table 11). This was also the case for the Session 3's application items learned under the Accuracy and Speed condition. Subjects recalled the most items from the 'reinforcement' (*M*=4.66) and 'shaping' (*M*=4.66) decks followed by the 'extinction' deck (*M*=3.33).

For Session 2 items that were presented in Session 3 as recall items learned under the Accuracy condition, subjects scored higher for the interval deck (*M*=7.66) than the ratio (*M*=6) or differential (*M*=5.66) decks (Table 12). For Session 2's recall items learned under the Accuracy and Speed condition, an equal number of items were recalled for the interval and differential decks (*M*=6) followed by the ratio deck (*M*=4).

For Session 2 application items presented in Session 3, the items learned under the Accuracy condition, were disappointingly low with the highest score for the interval deck (*M*=2.33) then the ratio (*M*=2) and differential (*M*=.66) decks (Table 12). Application items learned under the Accuracy and Speed condition were also low. Subjects recalled a few items from the differential deck (*M*=1.33) and only one item each for the interval and ratio decks (*M*=.33).

Interest Survey

The highest possible rating for this survey was 60 points (Table 13). As a group, the scores ranged from 28 to 52, with an average of 41.6. In the main, the higher the score, the more favourable the rating of interest in various components of the study; these included software, stimulus material and posttests. Subgroup 3 gave the most favourable reviews (*M*=43.3) with Subgroup 1 (*M*=41) and Subgroup 2 (*M*=40.6) close behind. Individually, the greatest difference was with two subjects in Subgroup 1. Subject 1 rated the study highly favourable (52); while Subject 3 rated it lowest (28). The last question asked subjects to provide some information about the effectiveness of the experiment and any suggestions for changes. The results were transcribed and included in Appendix 19. Subjects 1, 4, 6 and 8 enjoyed the Think Fast program and the experiment in general. Subjects 2, 5, 7, 9 offered suggestions for change and the responses seemed to be neutral. One suggested that a writing component be added to the experiment, as that was her preferred method for learning. Also, a second reading of the 2-3 page concept

Table 13

Subject Profiles and Interest Survey Results for Experiment 1

Subject	Age	Year of Study	English Level	Typing Speed	Study Major	Gender	Interest Survey
1	18	1	1	25	Writing	F	52
2	21	3	3	60	Linguistics	F	43
3	26	4	1	35	Political Sc.	F	28
4	20	1	1	25	Undeclared	F	40
5	28	3	2	50	English	F	34
6	20	2	1	35	English	M	48
7	27	4	4	30	English	M	38
8	20	1	1	35	Commerce	F	46
9	38	4	1	35	Political Sc.	M	46
Mean	**24.2**	**2.6**	**1.6**	**36.1**			**41.6**

introductions after the Think Fast learning was suggested. Subject 3 was clearly frustrated by the Think Fast program and was not interested in the material that she read.

Typing Speed

As a group, the scores ranged from 25 to 60 words per minute, with an average of 36.6 (see Table 13). These scores were subjective and subjects were asked to estimate if they did not know their exact typing speed. Subgroup 1, on average, were the fastest typists (*M*=40) with Subgroup 2 (*M*=36.6) and Subgroup 3 (*M*=33.3) close behind. Individually, the greatest difference existed between four subjects in two subgroups. Subjects 1 and 4 reported the slowest typing speed (25 words per minute) with Subjects 2 (60) and 5 (50) indicating the highest speeds. On average, typing speeds were not significantly different between subjects.

Durations

Think Fast. For all subjects, time spent using the Think Fast program was recorded to the closest minute (Table 14). The group score showed that total time spent learning with the Think Fast program ranged from 79 to 122 minutes with an average of 102.2. Subgroup 1 and 2 spent about the same time using the Think Fast program, with averages of 104 and 103.3 minutes, respectively. Subgroup 3, however, required almost 5 minutes less training with Think Fast (*M*=99.3 minutes).

Reading Time. These data were presented in Table 15. The differences in amount of time required to read each concept introduction between conditions were minimal. The Reading condition (*M*=6.55 minutes), Accuracy condition (*M*=6.22 minutes) and the Accuracy and Speed condition (*M*=5.77 minutes) were all very similar. Looking at the subgroups, the only noticeable difference was that the third subgroup--consisting of

Table 14

Time Required by Experiment 1 Subjects to Complete Each Experimental Condition and Posttest

Subject	Intro	Reading	TF Time	Total Test	Total Time
1	10 (minutes)	35	122	81	248
2	6	34	79	65	184
3	6	42	111	89	248
4	10	30	110	79	229
5	7	41	94	92	234
6	8	37	106	76	227
7	10	24	96	70	200
8	12	34	82	79	207
9	10	24	120	82	236
Mean	8.77	33.4	102.22	79.22	223.66

Subject	Recall 1	Application 1	Recall 2	Application 2	Recall 3	Application 3	Survey
1	14	11	10	4	18	14	10
2	10	8	10	6	16	10	5
3	18	11	11	6	17	16	10
4	14	10	10	8	18	14	5
5	13	9	12	8	20	20	10
6	12	8	8	5	15	14	6
7	9	10	8	6	18	13	6
8	10	13	10	5	18	16	7
9	12	9	10	8	19	14	10
Mean	12.4	9.8	9.8	6.2	17.6	14.5	7.6

Table 15

Time Required for Experiment 1 Subjects to Read Each Concept Introduction Prior to *Think Fast* Learning

	Session 1			**Session 2**		
Subject	Reading	Accuracy	Accuracy/Speed	Accuracy/Speed	Accuracy	Totals
1	5 (minutes)	8	6	10	6	35
2	8	7	6	7	6	34
3	8	10	5	9	10	42
4	7	5	5	8	8	30
5	8	10	8	10	5	41
6	6	8	8	6	8	37
7	4	7	7	40	5	24
8	8	7	7	7	6	34
9	5	4	4	5	6	24
Mean	6.55	6.22	5.77	7.33	6.55	33.44

Subjects 7, 8 and 9--read the concept introductions faster (*M*=5.4) than the first (*M*=7 minutes) and second (*M*=7.2 minutes) subgroups. This was also the case during Session 2. Reading concepts in preparation for the Accuracy Think Fast training decks required an average of 6.55 minutes and an average of 7.33 minutes for the Accuracy and Speed reading. The third subgroup read faster (*M*=5.5) than the first (*M*=8) and second (*M*=7.5) subgroups.

As a group, the total reading time for Sessions 1 and 2, ranged from 24 to 42 minutes with an average of 33.4 minutes (see Table 15). Overall, there were no substantial group differences in the time needed to read the materials. This demonstrated the effectiveness of counterbalancing the reading material.

Test Completion Time-Recall 1. Table 14 listed the time required to complete this posttest. The subjects' durations ranged from 9 to 18 minutes with an average of 12.4 minutes. There was a small difference in completion times between subgroups. Subjects 1, 2 and 3 needed an average of 14 minutes and Subjects 4, 5 and 6 needed an average of 13 minutes. Subjects 7, 8 and 9 finished this test the fastest, requiring only an average of 10.3 minutes.

Test Completion Time-Application 1. Table 14 listed the time required to complete this posttest. The subjects' durations ranged from 8-13 minutes with an average of 9.86 minutes. The average time between subgroups was very close. Subjects 1, 2 and 3 needed an average of 10 minutes to complete the test while Subjects 4, 5 and 6 needed an average of 9 minutes. Subjects 7, 8 and 9 averaged 10.6 minutes.

Test Completion Time-Recall 2. Table 14 listed the time required to complete this posttest. The subjects'durations ranged from 8 to 12 minutes with an average of 9.8

minutes. The duration time was very similar between subgroups. Subjects 1, 2 and 3 needed an average of 10.3 minutes while Subjects 4, 5 and needed an average of 10 minutes. Subjects 7, 8 and 9 finished this test the fastest, at 9.3 minutes on average.

Test Completion Time-Application 2. Table 14 listed the time required to complete this posttest. The subjects' durations ranged from 4 to 8 minutes with an average of 6.2 minutes. The duration time was very similar between subgroups. Subjects 1, 2 and 3 needed an average of 5.3 minutes to complete the test while Subjects 4, 5 and 6 needed an average of 7 minutes. Subjects 7, 8 and 9 averaged 6.3 minutes.

Test Completion Time-Recall 3. Table 14 listed the time required to complete this posttest. The subjects' durations ranged from 15 to 20 minutes with an average of 17.6 minutes. There was a small difference in completion times between subgroups. Subjects 1, 2 and 3 needed an average of 17 minutes to complete the test while Subjects 4, 5 and 6 needed an average of 17.6 minutes. Subjects 7, 8 and 9 averaged 18.3 minutes.

Test Completion Time-Application 3. Table 14 lists the time required to complete this posttest. The subjects' durations ranged from 13 to 20 minutes with an average of 14.5 minutes. There was a small difference in completion times between subgroups. Subjects 1, 2 and 3 needed an average of 13.3 minutes to complete this test while Subjects 4, 5 and 6 needed an average of 16 minutes. Subjects 7, 8 and 9 finished this test the fastest, at 14.3 minutes.

Test Completion Time-Survey. Table 14 listed the time required to complete this posttest. The subjects' durations ranged from 5 to 10 minutes with an average of 7.6 minutes to complete the survey. The average time between subgroups was very close.

Subjects 1, 2 and 3 needed an average of 8.3 minutes to complete this test while Subjects 4, 5 and 6 needed an average of 7 minutes. Subjects 7, 8 and 9 averaged 7.6 minutes.

Total Test Completion Time. Table 14 listed the time required to complete this posttest. The total time required to complete all of the posttests listed above ranged from 65 to 92 minutes with an average of 79.2 minutes. Subjects 1, 2 and 3 needed a mean average of 78.3 minutes and Subjects 4, 5 and 6 needed a mean average of 82.3 minutes to complete the test while Subjects 7, 8 and 9 averaged 77 minutes.

Experiment 2

Subjects 1, 2 and 3 were randomly assigned to the Accuracy condition while Subjects 4, 5 and 6 were randomly assigned to the Accuracy and Speed condition (Tables 16 and 17). A substantial difference between two subjects was revealed upon analysis of the baseline data but no differences were found between subjects from the 6-item pretest. As in Experiment 1, the major dependent variable in this study was subjects' written responses to recall and application tests before and after a 30-day delay. The between-subject design allowed for comparisons from three subjects between two experimental conditions. In other words, all subjects experienced the same experimental sequence, instructions, stimuli and number of trials with the exception of the Think Fast learning instructions.

Think Fast Learning Rates

The first three subjects described below were all given instructions to proceed through the Think Fast program as slowly and accurately as possible (Table 18). These three subjects formed Subgroup 1 for this experiment. Subject 1's learning performance was presented in Figure 32. Her rates increased steadily, surpassing 10 correct per minute

Table 16

<u>Research Design for Experiment 2 and Sample Procedure</u>

	Session 1	**Session 2**	**Session 3**
Subgroup 1	**A**		
1	20 trials	20 trials & Posttest 1	Posttest 2
2	20	20	
3	20	20	
Subgroup 2	**B**		
4	20	20	
5	20	20	
6	20	20	

Explanation of Conditions:

1. Numbers indicate the number of <u>Think Fast</u> trials per condition
2. Condition A – learning to Accuracy Only
3. Condition B – learning to Accuracy and Speed
4. Posttest 1 – Recall is assessed by examining the last <u>Think Fast</u> trial and a paper and pencil application test is administered
5. Posttest 2 – Write definitions, Recall, application tests and Interest Survey are administered after a 30-day delay with no practice.

Table 17

Think Fast Deck Content for Experiment 2

Subject	**Session 1**	**Session 2**
Accuracy		
1	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction
2	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction
3	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction
Acc/Spd		
4	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction
5	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction
6	Reinforcement, Shaping and Extinction	Reinforcement, Shaping and Extinction

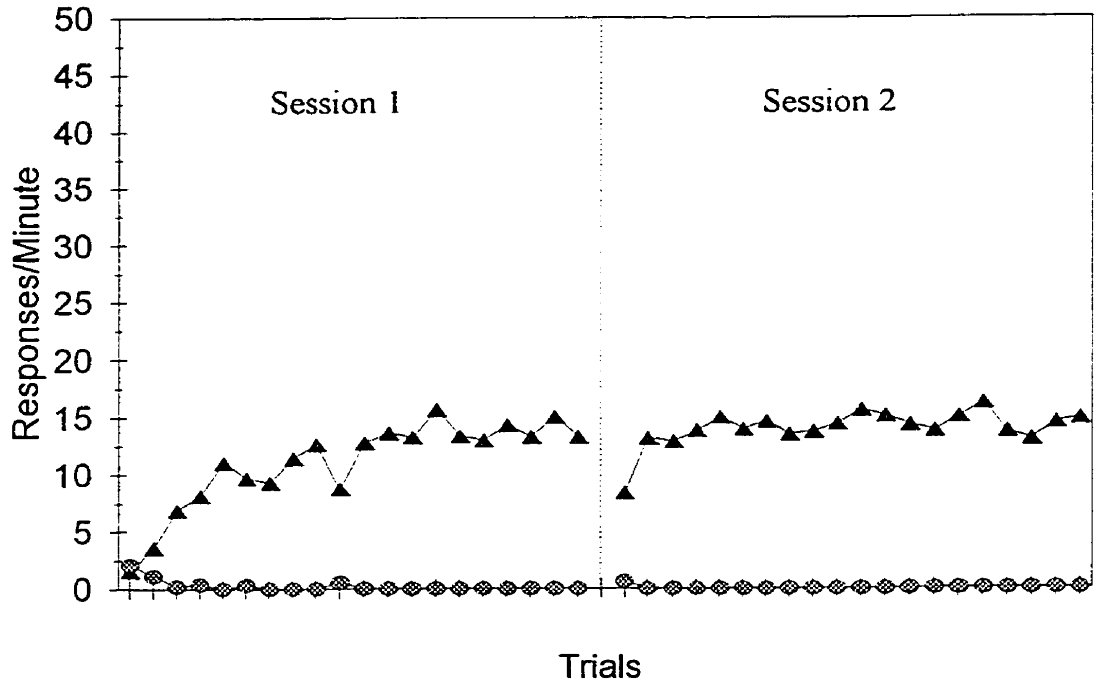
Table 18

Average and Terminal *Think Fast* Rates for Experiment 2 Subjects

	Terminal Rates		**Average Rates**	
Subject	Correct	Incorrect	Correct	Incorrect
1	12.51	0.13	14.47	0.13
2	9.73	0.08	14.58	0.08
3	8.10	0.49	12.18	0.49
Mean	**10.11**	**0.23**	**13.74**	**0.23**
4	12.00	0.720	18.39	0.72
5	10.45	0.52	13.59	0.52
6	19.26	1.43	33.9	1.43
Mean	**13.90**	**0.89**	**21.96**	**0.89**

Figure 32. Correct and incorrect responses made per minute using the Think Fast program for Subject 1 in Experiment 2 under an Accuracy only condition.

Subject 1 - Accuracy



on the fifth trial. The next five trials were of variable performance, before stabilizing with performances of between 12-15 correct per minute for the remainder of the trials with only a few errors. Subject 1's terminal performance rate was 14.47 correct per minute and 0 incorrect.

Subject 2 also surpassed 10 correct per minute on the fifth trial, but her performance over the following 20 trials varied between 6 to 15 correct per minute (see Figure 33). This was followed with five trials at 10 correct per minute, with some trials at about 6 correct per minute before a rapid increase for the last five trials. Aside from some errors at the start of Session 1, she was accurate for the remaining trials. Her terminal performance rate was 14.58 correct per minute and 0 incorrect.

Subject 3's data were presented in Figure 34. During Session 1, her rates were low, with all trials under 10 correct per minute with many errors throughout the session. There was a drop in performance at the beginning of Session 2, but her rates improved to over 10 correct per minute by the third trial. She averaged between 8-12 correct per minute for the remaining trials with few errors. Her terminal performance rate was 12.18 correct per minute and 0 incorrect.

The following three subjects were instructed to proceed as quickly and as accurately as possible. These subjects formed Subgroup 2 for Experiment 2. Subject 4's data were presented in Figure 35. For Session 1, her performance increased steadily to 10 correct per minute by the twelfth trial. Then, her performance increased slowly, with two of her last three trials scoring over15 correct per minute. Throughout Session 1, she responded incorrectly on many occasions but errors decreased toward the end of Session 2. Her terminal performance rates were 18.39 correct per minute and 0 incorrect.

Figure 33. Correct and incorrect responses made per minute using the Think Fast program for Subject 2 in Experiment 2 under an Accuracy only condition.

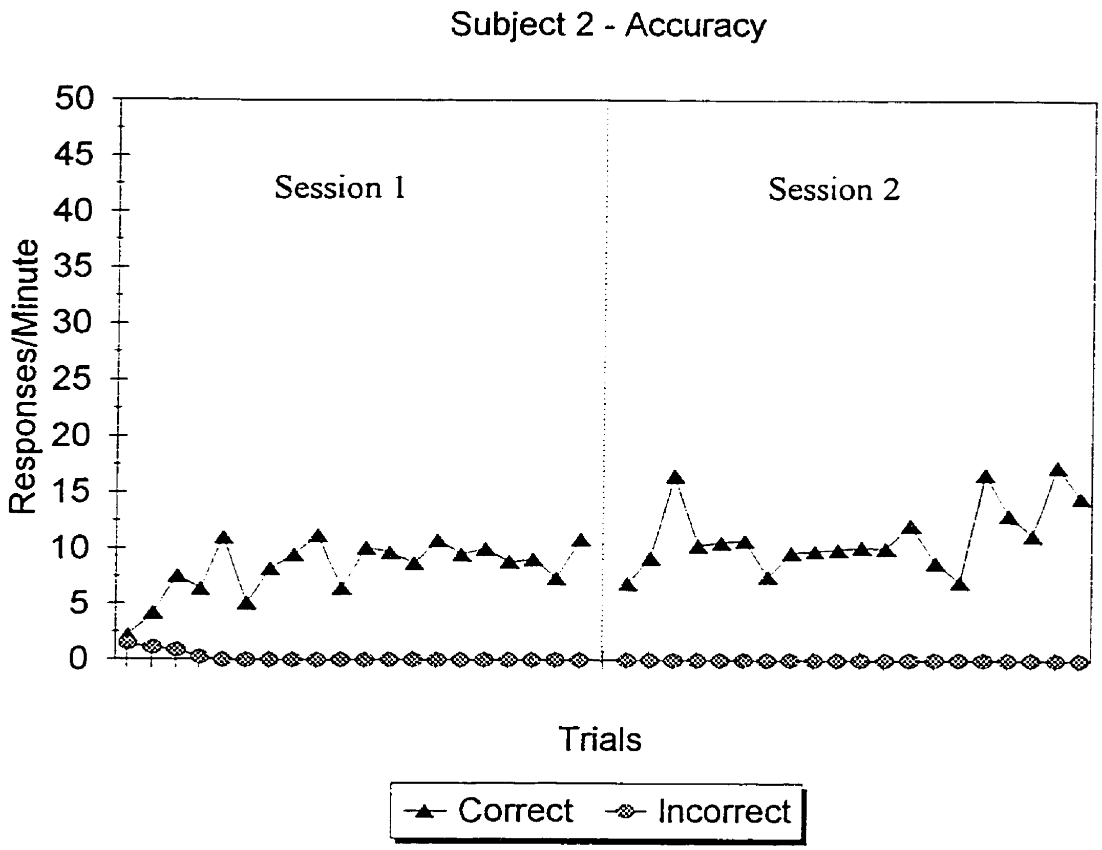

Subject 2 - Accuracy
50
45
40
35
30
25
20
15
10
5
0
Responses/Minute
Session 1
Session 2
Trials
Correct
Incorrect

Figure 34. Correct and incorrect responses made per minute using the Think Fast program for Subject 3 in Experiment 2 under an Accuracy only condition.

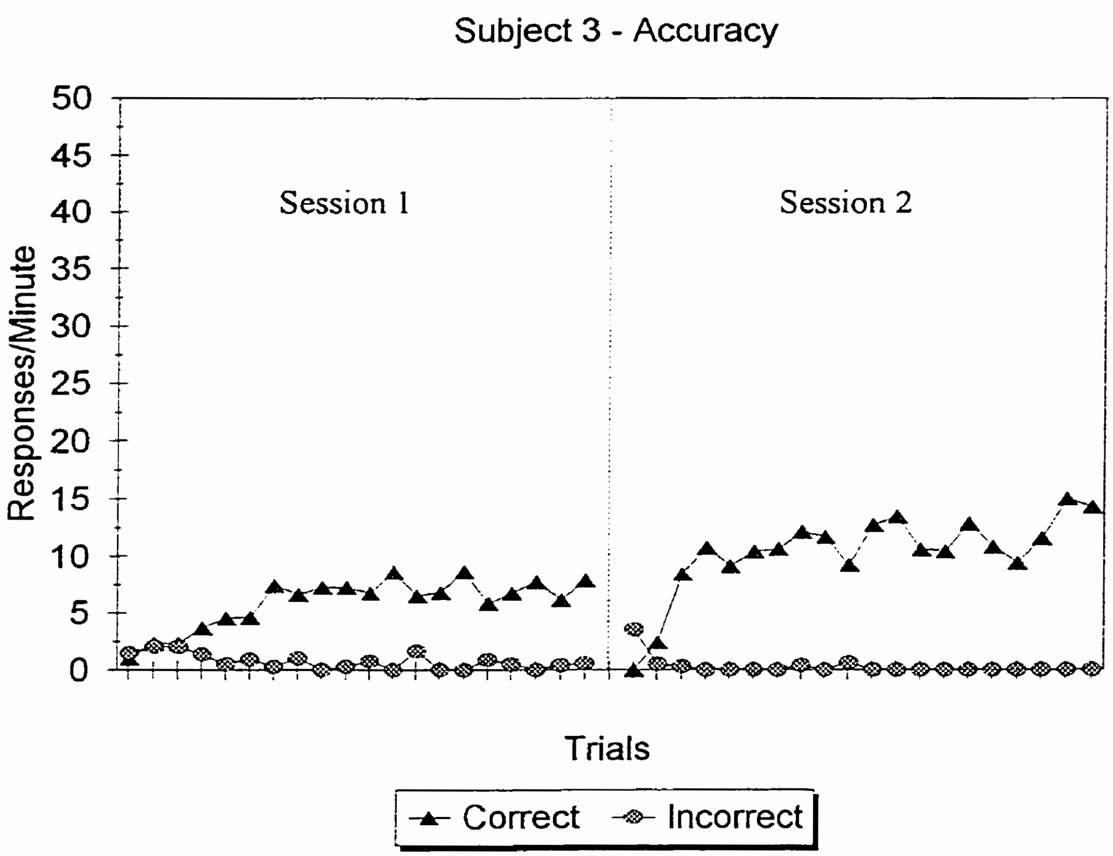

Subject 3 - Accuracy
50
45
40
35
30
25
20
15
10
5
0
Responses/Minute
Session 1
Session 2
Trials
Correct
Incorrect

Figure 35. Correct and incorrect responses made per minute using the Think Fast program for Subject 4 in Experiment 2 under an Accuracy and Speed condition.

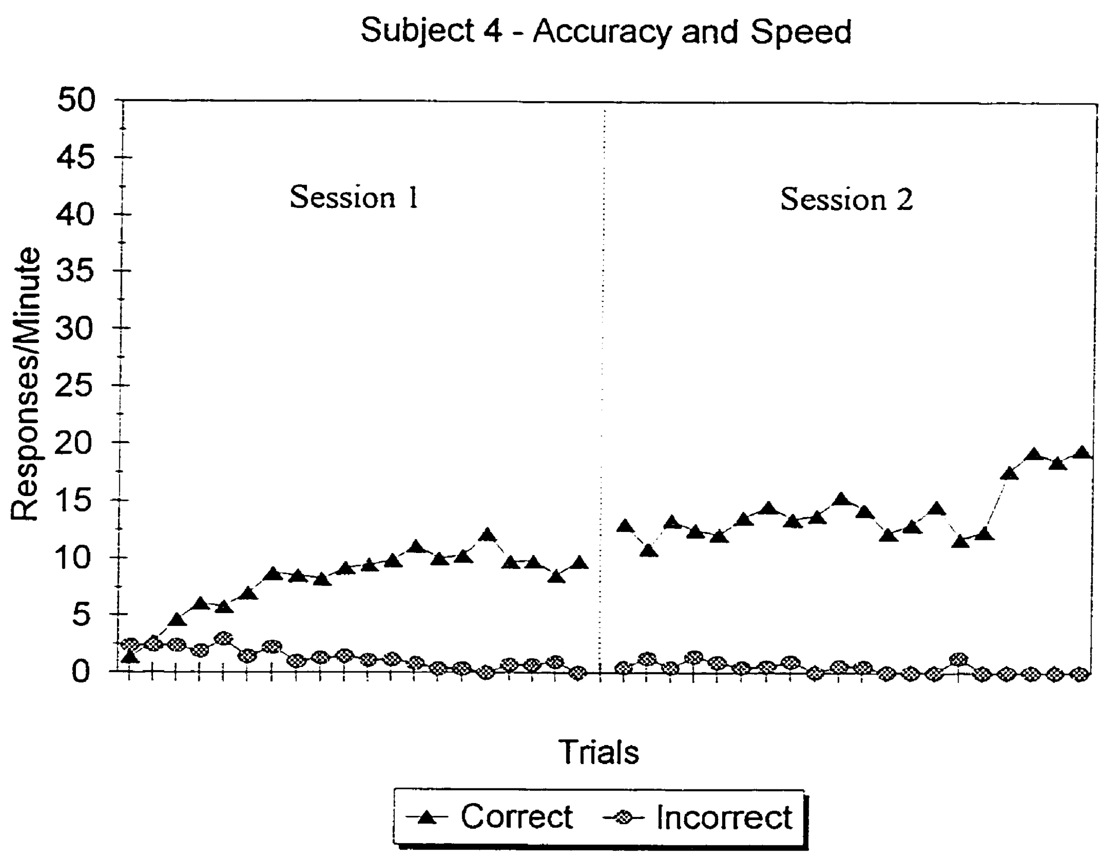
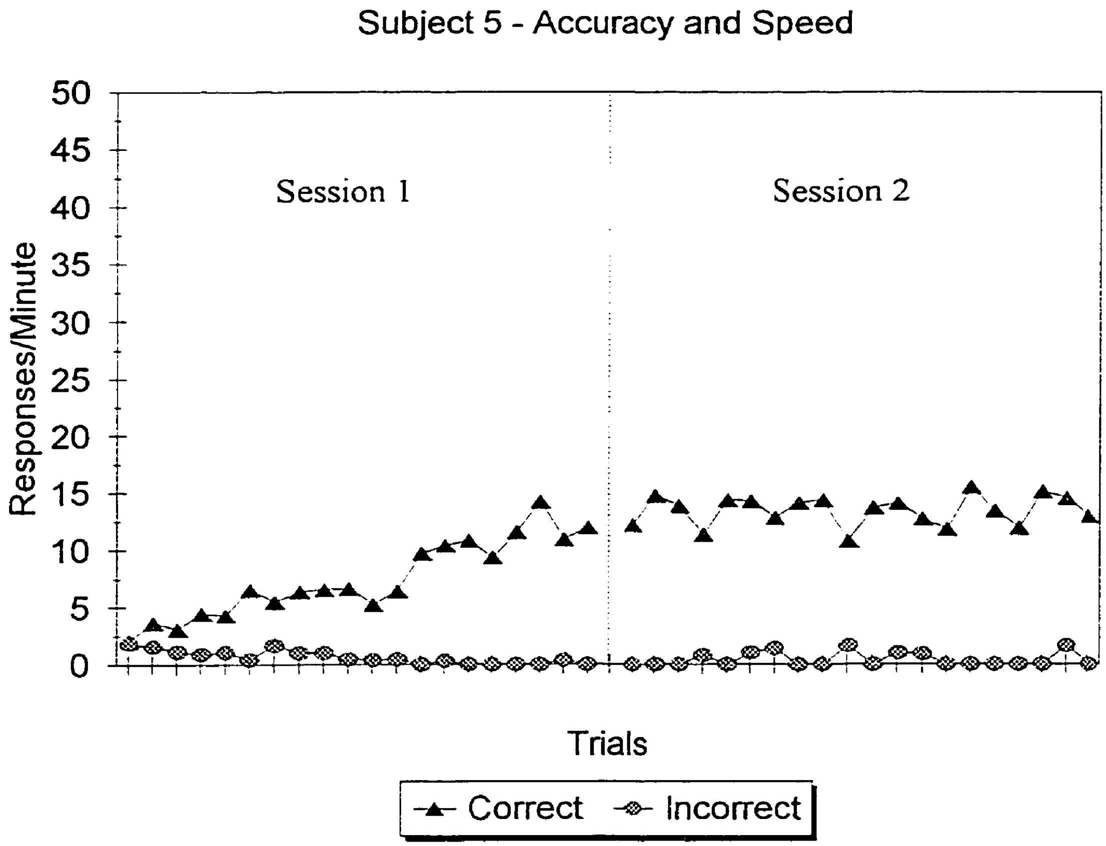

Subject 4 - Accuracy and Speed
50
45
40
35
30
25
20
15
10
5
0
Responses/Minute
Session 1
Session 2
Trials
Correct
Incorrect

Figure 36. Correct and incorrect responses made per minute using the Think Fast program for Subject 5 in Experiment 2 under an Accuracy and Speed condition.



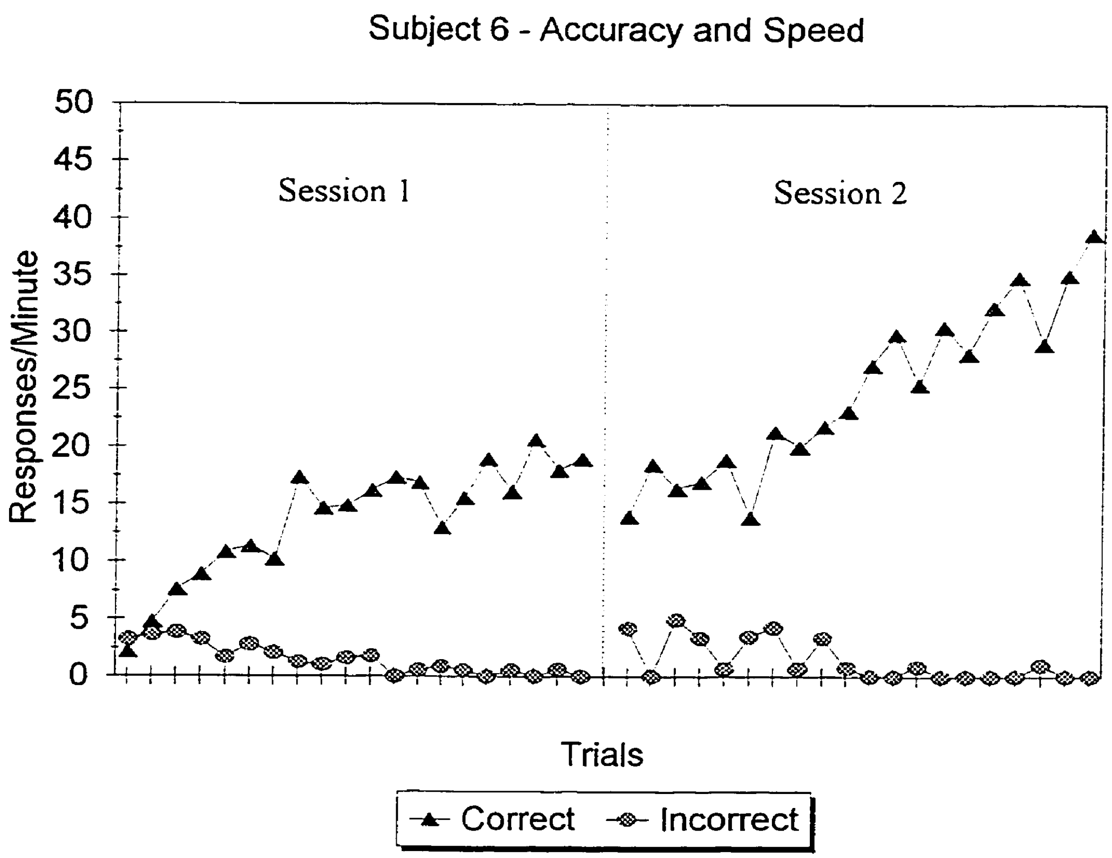
Subject 5 - Accuracy and Speed
Session 1
Session 2
Responses/Minute
0
5
10
15
20
25
30
35
40
45
50
Trials
Correct
Incorrect

Subject 5's performance resembled Subject 4, except this subject did not record a sharp increase over the last five trials (Figure 36). His performance increased slowly reaching 10 correct per minute by the thirteenth trial and increasing steadily to 13 correct per minute before stabilizing around this rate for the remaining 22 trials. Incorrect rates were sporadic and only stabilized towards the end of Session 2. His terminal performance rates were13.56 correct per minute and 0.33 incorrect per minute.

Subject 6's performance was by far superior to the other five subjects (Figure 37). He surpassed the 10 correct per minute by the fifth trial and continued to improve on each trial with a large leap to 18 correct per minute by the eighth trial. He continued to improve until the end of Session 1. At the start of Session 2, he needed six trials to *war-up*. After that, his performance rose dramatically, reaching almost 30 correct per minute by the middle of Session 2. He scored over 35 correct per minute on several of the final trials. His incorrect rates were variable (and high at times reaching 5 incorrect per minute) but became very stable for the latter half of Session 2. His terminal performance rate was 33.9 correct per minute and 0.19 incorrect per minute.

Given that each subject was assigned to one experimental condition, only one set of instructions was provided. There were no performances to compare within subjects and no way to verify whether or not subjects followed the instructions. Subgroup 1's terminal performance rates were 14.47, 14.58 and 12.18 correct per minute, respectively. Subgroup 2's terminal rates were 18.39, 13.59 and 33.9 correct per minute, respectively. Incorrect rates were extremely low with only Subjects 5 and 6 recording .33 and .10 incorrect per minute, respectively. In comparison, two subjects in Subgroup 1 responded faster to the last five trials than the slowest subject in Subgroup 2. Subject 6

Figure 37. Correct and incorrect responses made per minute using the Think Fast program for Subject 6 in Experiment 2 under an Accuracy and Speed condition.



Subject 6 - Accuracy and Speed
Session 1
Session 2
Responses/Minute
50
45
40
35
30
25
20
15
10
5
0
Trials
Correct
Incorrect

outperformed all other subjects by a large margin. Interestingly, aside from Subject 6's performance, the remaining performances were similar to the rates obtained from Experiment 1 for each corresponding condition.

Baseline

Subjects assigned to learn using the Accuracy condition (73.3%) outscored those assigned to the Accuracy and Speed (50%) condition by 23% or an average of 2.3 correct responses (Table 19). A total of 7 correct responses separated the two groups. Substantial differences between subjects were observed between Subject 1 (90%) and Subject 6 (20%). This difference accounted for the total difference between the two groups as Subjects 3 and 5 each answered 60% correctly, while Subjects 2 and 4 answered 70% correctly.

Pretest

No significant differences were found with this test (Table 19). It was clear that all subjects did not have prior knowledge of the study material.

Session 1

No posttests were administered because the Think Fast learning trials had not been completed at this point.

Session 2

Recall 1. Unlike in Experiment 1, the recall test was not administered at the conclusion of the Think Fast learning in Session 2. Recall 1 consisted of recording the Accuracy score of the last Think Fast trial. Table 19 listed the accuracy rates for all subjects in Experiment 2.

Table 19

Pretest and Posttest Scores for Experiment 2 Subjects

Subject	Baseline	Pretest	Recall 1	Application 1	Recall 2	Application 2	Definition Scores
1	9 (90)*	2	30 (100)	15 (100)	30 (100)	15 (100)	8
2	7 (70)	0	30 (100)	10 (66.66)	29 (96.66)	10 (66.66)	2
3	6 (60)	1	30 (100)	10 (66.66)	25 (83.33)	9 (60)	0
Mean	**7.33 (73.33)**	**1**	**30 (100)**	**11.66 (77.73)**	**28 (93.33)**	**11.33 (75.55)**	**3.33**
4	7 (70)	0	30 (100)	11 (73.33)	27 (90)	10 (66.66)	5
5	6 (60)	1	30 (100)	8 (53.33)	28 (93.33)	11 (73.33)	2
6	2 (20)	1	30 (100)	8 (53.33)	30 (100)	12 (80)	3
Mean	**5 (50)**	**0.66**	**30 (100)**	**9 (60)**	**28.33 (93.33)**	**11 (73.33)**	**3.33**

*brackets indicate percentages

Application 1. Some unexpected results were obtained. As a group, the learning to Accuracy condition scored more (M=73%) correct responses than the Accuracy and Speed subjects (M=60%) (see Table 19). This represented a small difference of 13% or an average of 1.6 correct items. A total of 5 correct responses separated the two groups. These scores contradict the application test results observed in Experiment 1.

Session 3

Definitions. There were no significant differences between the two groups. Each group scored a total of 10 points out of a possible 30 for a 33.3% correct average. Five of the six subjects did poorly. They scored between zero and five points. Only Subject 1 wrote most of the key elements in her definitions. She had been assigned to an Accuracy group and was also the subject who scored well on the baseline measure; perhaps this indicated better learning abilities than the other subjects. The raw scores were listed in Table 19.

Recall 2. These scores indicated no significant differences between the two groups (Table 19). Subjects assigned to the Accuracy condition included Subjects 1, 2 and 3. They scored 100%, 96.6% and 83.3% respectively. The group average was 93.3%. Subjects assigned to the Accuracy and Speed condition included Subjects 4, 5 and 6. They scored 90%, 93.3% and 100% respectively. This group's average score was 94.4%. These findings were not consistent with Experiment 1's data. In comparison to their Recall 1 scores, no significant differences were noticed for both subgroups, $t(2) = 1.30$, $p > .05$ (Subgroup 1) and $t(2) = -1.89$, $p > .05$ (Subgroup 2).

Application 2. The same pattern was noticed for the application test. The raw scores were presented in Table 19. The group totals showed that learning to Accuracy

(75.55%) resulted in a slightly higher score than learning to Accuracy and Speed (73.33%). Subjects assigned to the Accuracy condition included Subjects 1, 2 and 3. They scored 96.6%, 63.3% and 56.6% respectively. Subjects assigned to the Accuracy and Speed condition included Subjects 4, 5 and 6. They scored 90%, 63.3% and 70%, respectively. In comparison to their Application 1 scores, no significant differences were noticed for both subgroups, $t(2) = 1.00$, $p > .05$ (Subgroup 1) and $t(2) = -1.30$, $p > .05$ (Subgroup 2).

Interest Survey

The ratings for this survey are listed in Table 20. The highest possible rating for this survey was 35 points. As a group, the scores ranged from 20 to 27, with an average of 24.5 points. In the main, the higher the score, the more favourable the rating of interest in various components of the study (including the software, stimulus material and posttests). Subjects 1, 2 and 3 rated the experiment 27, 27 and 20 respectively. Subjects 4, 5 and 6 gave ratings of 27, 22 and 24 respectively. The Accuracy subgroup's average rating was 24.6 while the Accuracy and Speed subgroup rated their interest as an average of 24.3 points. One survey question in particular, asked subjects to rate the experimental condition assigned. Subjects assigned to the Accuracy group provided ratings of four, three and two out of a possible five. Subjects assigned to the Accuracy and Speed condition provided ratings of four, three and three. It was obvious that ratings were not significantly different between subjects, $t(2) = .128$, $p > .05$.

The last survey question asked subjects to provide some information about the effectiveness of the experiment and any suggestions for changes. The results were transcribed in Appendix 20. Subjects 1, 4 and 6 wrote positive statements about the

Table 20

Experiment 2 Subject Profiles

Subject	**Age**	**Year of Study**	**English Level**	**Major**	**Gender**	**Survey**
1	20	3	1	Biology	F	27
2	21	2	1	Chemistry	F	27
3	23	1	1	Arts	F	20
Mean	**21.33**	**2**	**1**			**24.66**
4	24	3	1	Geography	F	27
5	19	1	1	Arts	M	22
6	20	2	1	Comm	M	24
Mean	**21**	**2**	**1**			**24.33**

experiment. Subjects 2 and 5 focused on suggestions for improvement. Subject 2 suggested that a picture be associated with each concept and Subject 5 wanted a more detailed reading for each concept. Subject 3 was clearly uninterested in the whole experiment as she stated that she "...found the whole thing repetitive" and her rating was the lowest at 20.

Durations

Pretest. There was only a one-minute difference separating the time needed to review this test (3 to 4 minutes). Subjects 1 and 6 needed three minutes and the rest used four minutes (see Table 21).

Baseline. These durations ranged from 2-7 minutes (Table 21). Subject 1 took four minutes while Subject 2 needed six minutes. Subject 3 required the most time at 7 minutes. Subject 4 used 4 minutes and Subject 5 spent 3 minutes on this task. Subject 6 needed only two minutes to review the baseline.

Introduction. Only two minutes separated subjects in terms of time required to demonstrate the Think Fast software and describe the experiment (Table 21). Subject 1 was provided with an introduction lasting four minutes and Subject 6 only needed 3 minutes of coaching. The experimenter spent five minutes on each of the remaining four subjects.

Reading. Time used to read the three chapter introductions ranged from 13-21 minutes with a mean of 17.3 minutes for Subgroup 1 and 18.6 minutes for Subgroup 2 (Table 21). The fastest reader was Subject 1 while Subjects 3 and 5 both were slowest at 21 minutes. Subjects 2, 4 and 6 required 18, 19 and 16 minutes respectively.

Table 21

Time required by Experiment 2 Subjects to Complete Each Experimental Condition and Posttest

Subject	Pretest	Baseline	Introduction	Reading	Posttest Time	Think Fast	Total Time
1	3 (minutes)	4	4	13	47	120	196
2	4	6	5	18	49	125	207
3	4	7	5	21	40	134	211
Mean	**3.66**	**5.66**	**4.6**	**17.33**	**45.33**	**126.33**	**204.66**
4	4	4	5	19	45	119	196
5	4	3	5	21	41	112	186
6	3	2	3	16	33	92	149
Mean	**3.66**	**3.33**	**4.3**	**18.66**	**39.66**	**107.66**	**177**

Test-Taking Time. These durations ranged from 33 to 49 minutes (Table 21). Subgroup 1 needed a mean of 45.3 minutes while Subgroup 2 used a mean of 39.6 minutes to complete all the written posttests.

Think Fast Time. The time required to complete 40 Think Fast trials ranged from 92 to 134 minutes (Table 21). As expected, the learning to Accuracy (Subgroup 1) needed more time to complete the trials (*M*=126.3 minutes) than the Accuracy and Speed Subgroup 2 with an average of 107.6 minutes. Subject 3 needed the most time (134 minutes) whereas Subject 6 was fastest (92 minutes).

Total Time. The time required to complete all posttests was listed on Table 21. The total time needed for all three sessions was greater for Subgroup 1 (*M*=204.6 minutes) than Subgroup 2 (*M*=177 minutes). This was expected, as the first subgroup was not instructed to proceed at a fast pace.

Chapter 5

Discussion

The purpose of both experiments was to determine the effectiveness of learning to accuracy (mastery) and learning to accuracy and speed (fluency) instructions. Three questions guided the investigation. First, which approach was most effective in post-learning achievement as measured by recall, application and retention tests? This was accomplished in Experiment 1 by using a counterbalanced within-subject design, whereas, Experiment 2 was designed to replicate the findings of Experiment 1 and allow for between-subject analyses. Second, to what extent did learning without either an accuracy or accuracy and speed requirement (i.e., reading) increase subsequent performance on posttests such as recall, application and retention? Thus, the effects of simply reading the stimulus material were included in the first experiment and served as a control condition. Finally, what was the relationship, if any, between subjects' interest in the experiment with their Think Fast performance and posttest scores? The following discussion summarizes the findings of Experiments 1 and 2 in order to answer these questions and build upon the current literature in the mastery and fluency areas.

Experiment 1

Think Fast Learning Rates. In order to answer the first research question it was necessary to determine whether or not subjects followed instructions for each experimental condition. That is, did they proceed slowly and accurately when instructed to do so under the Accuracy condition? Similarly, did subjects increase their response rates while maintaining accuracy under the Accuracy and Speed condition? In other words, the purpose of this examination was to verify that the Think Fast learning instructions were followed in order to make speculations concerning subjects' posttest achievement relevant to their learning.

Based upon a descriptive analysis of these data, it appeared that Subjects 1, 2, 4, 6, 8, and 9 followed the researcher's instructions whereas Subjects 3, 5 and 7 did not. The latter subjects responded at high rates when instructed to proceed slowly and accurately. In particular, Subjects 3 and 5 had performances that were extremely variable and accuracy rates that were never consistent. Upon closer inspection, it appeared Subject 7 followed instructions for Session 1 but not for Session 2.

Session 1 Posttests

Recall 1. A descriptive examination of these scores showed that the Reading condition did not help students recall much of the information. In fact, reading about the concepts only resulted in an average of 40% of the facts being recalled. However, when subjects were asked to use the Think Fast software and focus on Accuracy (answering each item correctly), their recall scores improved to an average of 76.6%. Moreover, when subjects performed under the Accuracy and Speed condition their scores further increased to an average of 87.7%. Two of the three non-compliant subjects recalled fewer Accuracy and Accuracy and Speed items than their subgroup counterparts for this posttest. Subjects 3 and 7 answered fewer items correctly but Subject 5 performed well for this posttest, she correctly answered more Accuracy and Accuracy and Speed items than other subjects in her subgroup.

Application 1. Subjects correctly identified more exemplars for items they had learned under the Accuracy and Speed condition than the other two conditions. Of the non-compliant subjects, Subject 3 identified fewer Accuracy and Accuracy and Speed items than her subgroup counterparts. Subject 5 identified as many exemplars as the best performer in her subgroup. Subject 7 identified more Accuracy and Accuracy and Speed items than one subject in his subgroup and fewer than another. Once again, the group totals showed that demanding both accuracy and speed resulted in better application performances. This conclusion was based on a descriptive examination without a statistical protocol, as such a statistical comparison was not feasible.

Session 2 Posttests

Recall 2. Even though another set of stimulus material was used, the posttest findings from Session 1 were replicated in Session 2. Examination of the group scores revealed that demanding Accuracy and Speed resulted in an average of 90%, while, Accuracy resulted in a lower mean of 75.5%. For both experimental conditions, Subjects 3, 5 and 7 all produced mid-range performances (better than one subject and worse than another) in comparison to their subgroup counterparts. The Reading condition was eliminated for this Session.

Application 2. The same recall difference was observed for this application exercise; however, many subjects had difficulty and produced lower scores. Demanding Accuracy and Speed resulted in an average of 53.3% correct while Accuracy resulted in an average of 33.3%. Subject 3 registered her best performance by outscoring the two other subjects in her subgroup. Subject 5 could not identify any exemplars and Subject 7's performance was mid-range given his respective subgroup.

Session 3 Posttests

Definitions. This posttest demonstrated that even after reading about a given concept and training with Think Fast by typing keywords to relevant facts, subjects were not able to define, in their own words, each concept. Most definitions that the subjects provided would not be considered 'correct' in a normal academic testing situation. Subjects 3, 5 and 7 provided the poorest definitions with respect to their subgroups. The group totals showed that subjects wrote better definitions for concepts learned under the Accuracy and Speed condition than the Accuracy or Reading conditions (see Table 7).

Recall 3 and Application 3. When all of the recall items from the two previous sessions were combined and presented after a 30-day delay, the pattern of achievement was replicated. Concepts learned under the Accuracy and Speed condition were more likely to be recalled. This was also the case for application items from the two previous sessions. Concepts that required learning to Accuracy and Speed resulted in more exemplars identified. In other words, the concepts learned under the Accuracy and Speed condition were most resistant to being forgotten. Two of the non-compliant Subjects (3 and 5) registered a greater drop in overall retention scores than other subjects. This was the case for Session 1 items they learned under the Accuracy and Speed condition but not for items learned under the Reading or Accuracy conditions. This effect was not noticed for Session 2 items that were readministered in Session 3. Subject 7 followed the Think Fast instructions for Session 1 and his retention rates reflected this fact. His retention scores were identical to his subgroup peers.

Interest Survey. It was noteworthy that Subjects 3, 5 and 7 rated the experiment least favorably in terms of interest in comparison to the entire group (see Table 8). Although the quantitative rating differences may not have been statistically significant, there was a relationship between subjects' interest, their Think Fast performances and subsequent posttest scores. As discussed earlier, these three subjects generally recalled fewer posttests items than their subgroup counterparts. When asked for suggestions to improve the experiment, Subject 3 in Experiment 1 was clearly frustrated by the Think Fast program. In particular, she was upset that she could not remember many facts after repeated trials and had difficulty matching facts to their corresponding concepts. Subjects 5 and 7 both felt note-taking or writing the answer was a better method for learning than using the computer. The remaining subjects either stated that they enjoyed the experiment or made a suggestion for improvement.

All of the non-compliant subjects were senior students. Subject 3 was in her fourth year, Subject 5 in her third year and Subject 7 in his fourth year. These subjects were also older than all but one of the other subjects. (Subject 9 was older and he was in his fourth year of study).

These subject ratings and posttest results supported Grow's (1991) theory. He postulated that there was a range of learner stages and, therefore, learner-teacher matches and mismatches. Looking at the Interest Survey ratings supplied by Experiment 1 subjects, it became evident that there was a mismatch between learner stages and the computer-delivered teaching style for the non-compliant subjects. The non-compliant subjects rated the experiment least favourably. These subjects did not follow the researcher's instructions for each experimental phase and their posttest scores tended, for the most part, to be lower than their subgroup counterparts. This was the case with respect to retention scores obtained in Session 3. There, the teaching technology was authoritarian in style and the fundamental material required repetitious responses and recall of answers. Using Grow's (1991) theory one may conclude that the noncompliant subjects may have been advanced learners who were 'put off' by the software's repetitious nature and the learning instructions. Perhaps, they would have preferred to learn more complex concepts with greater flexibility in their response mode and their posttest demonstration of knowledge acquisition.

Typing. Typing speed did not appear to be a factor as seven of the nine subjects were comparable typists. Subjects 2 and 5 indicated that they typed at superior rates. Examination of Figures 1-3 showed that subjects appeared to reach a 'ceiling' rate in terms of typing their response to each item.

Durations

The time required to complete each phase of the experiment did not appear to be significantly different between subjects when examined statistically and descriptively. As was expected, subjects used more time to complete Think Fast trials when instructed to proceed slowly under the Accuracy condition. The time required to read each concept introduction and complete the posttests were not significantly different. The only conclusion made from the examination of these data was that the Accuracy and Speed approach required less time.

Experiment 1 Summary

For all posttests, the group recalled more facts for concepts that were learned to both accuracy and speed. This was also the case for identifying exemplars. A within-subject analysis of Accuracy and Accuracy and Speed posttest scores further supported the effectiveness of the latter method. For Session 1, the posttest scores revealed that Accuracy outscored Accuracy and Speed on only two posttest comparisons. On six comparisons, the scores were identical and on ten comparisons the scores were higher for Accuracy and Speed questions. For Session 2, the posttest scores revealed that Accuracy outscored Accuracy and Speed on only two comparisons. On four comparisons, the scores were identical and on twelve comparisons the scores were higher for Accuracy and Speed. For the retention scores from Session 3, the posttest scores revealed that Accuracy outscored Accuracy and Speed on only four comparisons. On eight comparisons, the scores were identical and on twenty-four comparisons the scores were highest for Accuracy and Speed.

Experiment 2

Think Fast Learning Rates. In Experiment 1, many subjects appeared to hit a ceiling rate with respect to typing answers and several subjects were frustrated by the Type Mode's strict spelling. Therefore, the Say Mode was employed during Experiment 2. The difficulty of using a between-subject design with only one experimental condition was the impossibility to determine whether or not subjects followed the researcher's instructions. There were no performances from which to compare subjects and therefore no way to verify whether or not subjects followed the researcher's instructions. Subjects 1, 2 and 3 scored comparably in terms of average and terminal rates, but their rates were also close to Subjects 4 and 5. The only performance deviation occurred with Subject 6. He responded at such a rapid and accurate rate that his terminal performance rate doubled most of the other subjects at 33.9 correct per minute. Therefore, it was difficult to definitively report that Subjects 1-5 followed the Think Fast learning instructions. Subject 6 was the only definitive case whereby optimum performance was expected and likely achieved.

Also, aside from Subject 6, the other performances were similar to Think Fast Type Mode rates observed from Experiment 1 subjects after the same number of trials.

Performances were not significantly faster as predicted would happen with the switch to the Think Fast Say Mode.

Baseline and Pretest

The baseline measure revealed that Subject 1 was proficient at reading and immediately recalling what she had read (90%) while Subject 6 was least effective (20%). The other subjects' baseline scores were very similar. No differences were noticed between subjects on the 6-item pretest.

Session 2 Posttest

At the conclusion of this session, there were no differences between subjects responding to the Think Fast items correctly. Records from the last Think Fast trial demonstrate that all subjects scored 100%. Unexpectedly, Subgroup 1 (Accuracy) correctly identified a few more exemplars than Subgroup 2 (Accuracy and Speed) for the Application exercise.

Session 3 Posttests

Definitions. Aside from the exceptional performance of one subject, no substantial differences were noticed between subjects. Subject 1 provided eight of the nine components required to define the three concepts that she had been learning. The other five subjects were not able to write complete definitions. Even though Subject 6's Think Fast rates were incredibly high, he was also not able to write complete definitions.

Recall 2. The Think Fast items that subjects had been learning were presented on paper after a 30-day delay and the results showed that there were no substantial differences in recall. Most subjects were able to recall the majority of responses correctly. This result was not consistent with Experiment 1's data where the Accuracy and Speed condition resulted in better posttest scores than both the Accuracy and Reading conditions.

Application 2. The same surprising results were found with these items. The subgroup scores differed by only one item. Again, this result was not consistent with the application posttest results obtained from Experiment 1.

Interest Survey

These ratings were similar between subjects. Subject 3 reported the lowest interest rating and her comments were brief and terse. She thought the experiment was too repetitive. Her Think Fast learning rates and posttest performances indicated that she was disinterested in the experiment and her posttest scores were the lowest in comparison to her subgroup counterparts. In this experiment, there were no significant differences between the ages and year of study between subjects. The remaining subjects' ratings and comments were mostly positive.

Durations

As with Experiment 1's data, subjects assigned to the Accuracy condition needed more time to complete the same number of trials. The time required to complete the pretest, concept introduction reading, and posttests was not significantly different between subjects.

Experiment 2 Summary

Several variables in Experiment 2 were changed from those in Experiment 1. First, the Think Fast response mode was changed from typing to saying the response. Second, the experimenter (instead of the software) scored each Think Fast response as it was made. Third, the learning task was changed from five Think Fast decks of 10 cards to one deck of 30 cards. Fourth, each subject was randomly assigned to either the Accuracy or Accuracy and Speed condition. Contrary to Experiment 1, no significant posttest differences were obtained between five of the six subjects. Furthermore, the switch to the Say mode did not improve response rates except for one subject.

Educational Implications

Embedded within the discussion above are educational speculations that resulted from this study. The following is a summary of the main educational implications.

The Think Fast software was efficient in providing untiring practice and feedback for subjects and was effective with respect to improving learning but to varying degrees dependent on subjects' interest, ability and adherence to learning instructions. Any instructor, proctor or fellow student in a 'real-life' academic setting could not provide this form of tutoring. Software such as Think Fast can be used to facilitate practice and mastery of the course material.

The learning instructions affected subsequent posttest performance but only under certain circumstances. Experiment 1 involved several learning materials, alternating subject response modes and varying numbers of trials to each learning unit. Experiment 2 was the opposite with only one learning unit and response mode. In short, Experiment 1 was a complex learning situation; whereas, Experiment 2 was simple and straightforward. When the experimenter demanded subjects continually improve accuracy and speed responses, this resulted in greater posttest achievement than learning to accuracy or simply reading the material. However, this only occurred under the complex learning situation and not under the simple learning situation. In the latter case, the learning instructions (Accuracy and Speed or Accuracy) did not matter.

Whether or not the mastery or fluency approach is used in a particular learning situation is dependent on the complexity of the task. Fluency is required in complex situations requiring the maximum retention. The accuracy component of Mastery learning is as effective as the accuracy and speed component of the Fluency paradigm when learning a clearly defined and simple task. Under these circumstances, the only advantage to requiring learning speed improvement appeared to be efficiency in shortening the learning time.

Examination of the Interest Surveys showed that subjects' interest in the learning task affected both the actual learning and posttest results. Interested subjects followed the learning instructions and recalled more posttest items, even after a 30-day absence. If at all possible, the learning situation must stimulate the interest of the students. In the post-secondary academic setting, this can only be done by experimentation each semester and solicitation of student feedback until the learning task can reliably stimulate interest for the greatest number of students.

Subject ability must also match the learning task. In the post-secondary setting, the instructor must consider the 'make-up' of his/her audience and, therefore, the best matching teacher style. Failure to do so may result in frustrated students who do not follow the guidance of the instructor or instruction and unrealized learning potential. Of course, students interested in the learning task may do well regardless of the instructional method. In this case, the subject matter becomes the primary focus and the learning method, even if incongruent, is tolerated (Hagman and Rose, 1983).

Conclusions

This research specifically targeted learning in introductory-type courses at the post-secondary level; therefore, speculations about student learning was limited. In consideration of the three main educational theories outlined in the literature review, these experiments relied primarily on the behavior-analysis framework with some overlap from cognitive theory. Behavior analysts prescribe that learners need to master component skills (e.g., Think Fast facts) before proceeding to more complex tasks (e.g., application tasks). For these experiments, factual information from an introductory psychology text was broken into smaller units and was logically sequenced from simple to progressively more complex. Subjects received immediate corrective feedback for each response and their response rates were shown at the conclusion of each trial.

Principles of cognitive theory used for these experiments included contextual organization, rehearsal and comprehension monitoring. Putting the learning into context was accomplished by providing a 2-3 page introduction for each concept. Rehearsal and comprehension monitoring was accomplished by repetition of trials and feedback from the Think Fast program. These two theoretical approaches shared similar principles which best suited the learning required for these experiments, namely, learning factual material with correct/incorrect answers.

There were two subject variables that appeared to affect posttest achievement. First, subject ability/learner stage with respect to the nature of the Think Fast software may have been mismatched for some. Most subjects were first and second year students (except Subjects 3, 5, 7 and 9 in Experiment 1 and Subjects 1 and 4 in Experiment 2).

This was an important observation because several researchers have reported the importance of matching learner stage with the appropriate teaching style.

For example, using Bloom's (1956) framework as a yardstick, the nature of the Think Fast learning involved lower-order cognitive ability. Perry (1970) called this kind of knowledge *dualism*. That is, subjects learned facts that were either right or wrong. There were no subjective or relative knowledge skills required. Grow (1991) called this stage *dependent* learning and considered an *expert* as the best teacher match. For these experiments, Think Fast was used as the expert teaching tool, delivering facts and providing immediate corrective feedback. It appeared that there was a teaching technology-learner stage (ability) match for 9 of the 15 subjects and a mismatch for the remaining subjects. Subjects 3, 5 and 7 in Experiment 1, were considered mismatched. However, Subject 9 in Experiment 1 and Subjects 1 and 4 in Experiment 2 who were also considered mismatched (senior students) rated the experiment favourably and attained high posttest scores.

The educational implication is that software applications designed to enhance student learning must consider the user's cognitive ability and learner stage. For example, a software application such as Think Fast designed for repetition and practice may not be suitable for advanced students studying familiar material. The teaching technology must match the student's stage of learning, cognitive development and the learning objective.

Second, subjects' interest in the experiment also appeared to influence performance. Subjects who rated the experiment favourably were more likely to follow the Think Fast learning instructions regardless of the learner stage-teaching technology mismatch. For example, Subject 9 in Experiment 1--who was a senior student and reported a favourable rating of the experiment--followed the learning instructions and performed higher on most posttests measures than other senior subjects. This demonstrated that although subject ability may have been mismatched with the Think Fast software, subjects' favourable interest in the experiment compensated for the incongruency. Therefore, another conclusion was that student interest could affect the learning outcome by counteracting the effects of a learner-teacher mismatch (or in this case, educational software).

The constructivist framework was not used. The learning required for these experiments was not dependent on student-direction. This was not possible given the nature of a controlled experiment and would not be appropriate to answer the research questions. In short, it was necessary to demand a certain response for each experimental condition and introduce learning in a sequential, controlled manner in order to minimize confounding variables.

The Think Fast program worked flawlessly. Information was entered into the software by the researcher and subjects learned how to operate the program in a matter of minutes. The program provided all of the sequencing, corrective feedback and monitoring. Each keystroke was recorded by the software and deposited into a computer-generated datafile. The datafile was easily imported into a spreadsheet program for subsequent analysis. This software was a very effective medium for conducting educational research.

For these experiments, active responding by typing the responses was superior to Reading on both immediate and delayed recall. This evidence supported the active learning paradigm literature. Requiring subjects to 'think' of the answer first and then overtly respond by typing the answer resulted in greater posttest achievement than simply reading with no requirement to 'think' beforehand.

In Experiment 1, multiple learning tasks and various learning methods were used. Training to both accuracy and speed optimized recall, application and retention. Specifically, six of the nine subjects followed the instructions to continually improve speed while maintaining accuracy and this was effective in producing intense practice/learning. In Experiment 2, there was only one task and learning method. It appeared that it did not matter which approach was used (Accuracy or Accuracy and Speed). The only benefit from demanding speed in addition to accuracy was that the learning time was shortened. Perhaps, this is the best approach for learning fundamental material given the relative brevity of one or two semesters per course. Unfortunately, reading about the concept and then experiencing the Think Fast learning was not sufficient in terms of preparing students to define concepts regardless of the training method. In other words, performing the Think Fast training, recalling facts and identifying examples did not prepare subjects for the more complex task of defining concepts in their own words.

For both experiments, interest seemed to play an important role during the learning of concepts, and the recall, application and retention of facts. Subjects who rated the experiment favourably on the Interest Survey appeared to follow the Think Fast learning instructions and performed better on posttests than subjects who did not. This supported the discovery by Alexander, Jetton and Kulikowich (1995) that subjects' interest in a given knowledge domain enhances post-learning recall.

For subsequent experiments, the Type Mode should be used since it appeared the Say Mode made most subjects uncomfortable. The Type Mode did not require a scorer to be present and therefore eliminated this variable in Experiment 1. The Type Mode also recorded every keystroke automatically without depending on the accuracy of the experimenter. Aside from one subject's performance, subjects using the Say Mode in Experiment 2 did not significantly increase their Think Fast response rates relative to the Type Mode rates from subjects in Experiment 1.

Subjects' pre-training ability levels played a role in their subsequent learning. This was discovered by studying the posttest scores obtained in Experiment 1, even under the same experimental conditions (i.e., same subgroup). When a baseline measure was used in Experiment 2, the highest scoring subject also scored highest on all subsequent posttest measures. She displayed an aptitude to read and recall facts. This remained consistent upon examination of her retention scores. Hagman and Rose (1983) found that higher-ability trainees typically learned faster than those of lower-ability. As well, if training time was equated, higher-ability subjects achieved higher levels of acquisition (p. 212). This may explain why some subjects in both experiments consistently attained higher accuracy and speed rates than their subgroup counterparts.

Furthermore, Subgroup 3 in Experiment 1 provided definitive ability-related evidence. These subjects outperformed other subgroups on most measures, even under experimental phases where they were limited to fewer Think Fast trials. One explanation for their performances was that two fourth-year students were randomly assigned to Subgroup 3 and both were older subjects relative to the group. (The other subject was a younger, first-year student). It is reasonable to assume that fourth-year students have acquired greater learning ability than first and second-year students. They were probably beyond the first cognitive/learner stage as Bloom (1956), Perry (1970) and Grow (1991) defined. The learner stage-teaching technology mismatch only adversely affected one of the senior subjects. This was where 'subject interest' played a role in learning and posttest scores.

Specifically, Subject 7 (a fourth-year student) rated the experiment at 38, which was lower than the mean rating of 41.6 and he was also the lowest performer in Subgroup 3. Subjects 8 (first-year) and 9 (fourth-year) both rated the experiment favourably at 46 and performed well on all of the posttests. Perhaps, the effects of the learner-teacher mismatch were not as apparent when subjects were interested in the learning situation. This explains why some students who are considered 'advanced' can do well in situations that are considered incongruent with their learning stage.

It was evident that posttest achievement was a function of many subject dimensions including the learning, the task, and subjects' ability and interest. Learning with Think Fast and specifying learning instructions along with frequent testing was an effective way for most subjects to learn the behavior analysis concepts. For these experiments, using the Think Fast program to deliver facts and provide immediate corrective feedback proved to be effective. Again, subjects who rated the experiment favourably tended to follow the learning instructions, enjoyed the Think Fast learning and displayed superior posttest achievement.

The findings from Experiment 1 replicated results from other reported research. Binder (1990; 1993; 1998); Binder and Bloom (1989); Haughton (1980); and Lindsley (1972) found that learning to a fluency criterion improved short and long-term retention.

Kelly (1996) conducted a series of single-subject experiments and demonstrated that mastery learning with a fluency criterion helped children with learning disabilities maintain what they had learned. Learning component skills to fluency also increased performance of related, more complex skills (White, 1984). Johnston and Layng (1992; 1994) reported that the benefits of achieving fluency included the likelihood of varying but significant improvements in retention, endurance, application, performance and stability of performance.

In summary, Experiments 1 and 2 sufficiently answered the three research questions posed in the introduction. First, the two learning instructions—learning to Accuracy and learning to Accuracy and Speed—were systematically compared. Requiring activity during the learning and demanding both accurate and fast responses improved learning and decreased retention loss for subjects who reported interest in the experiments. Experiment 1 also demonstrated how conditions could be arranged to observe the effects of different learning instructions. Then, Experiment 2 showed that it was difficult to demonstrate the different effects of these learning criteria by simply providing each group with one task to perform. The simplicity of such an experiment made it difficult for differential effects to be noticed: having only one task made it easy for subjects to recall and deduce answers on posttests. The hardest part of conducting both experiments was ensuring that all subjects followed the Think Fast learning instructions for each particular experimental condition. Perhaps, future experiments could be conducted with software capable of controlling students' response rates and therefore their exposure time to reading and learning each fact.

Second, simply reading about each concept was not enough to produce adequate posttest scores. Clarifying the learning task by breaking down concepts and presenting the facts using a computer program with a required response was superior to simply reading about each concept.

Finally, there was a relationship (although not statistically significant) between subjects' interest ratings, their ability and their learning and posttest scores. Recall, application and retention achievement was enhanced for subjects who reported interest in the learning. Conversely, subjects who rated the experiment less favourably did not comply with the Think Fast learning instructions and performed poorly on the subsequent posttests. Ability and interest were related. Students who supposedly had higher ability (senior students) did not perform to a high level unless they were interested in the experiment. One may speculate that perhaps the teaching technology and learning instructions were incongruent with these subjects' learner stage and that this was responsible for these subjects' disinterest and the low posttest performance.

Limitations of the Study

There were some inherent weaknesses in the research design of Experiment 1. These included the fact that concepts were progressively harder and therefore more difficult on Session 2 than Session 1. It was possible that items not learned well in Session 1 may have hindered learning in Session 2. In fact, the Think Fast deck analysis performed showed that subjects were more likely to recall items from the reinforcement deck than extinction and shaping decks (Tables 9-10). Nevertheless, all subjects would have experienced this problem. This was not the case for decks used in Session 2 (Tables 11-12). Subjects did not consistently recall any one of the interval, ratio or differential schedule of reinforcement decks more than others. Of course, given that subjects experienced the same counterbalanced Think Fast decks, they were equally confounded. Subjects' ability to read and recall facts was not assessed in Experiment 1. Thus, random assignment was used to minimize the effects of varying abilities between these subjects. However, this sample was small with only nine subjects leaving open the possibility that some subgroups may have been biased with more lower or higher ability subjects than other subgroups.

In Experiment 2, subjects assigned to the Accuracy condition may have been affected more by internal variables than subjects assigned to the Accuracy and Speed condition. As the subject feedback indicated, going through the same 30 cards for 40 trials with instructions to progress slowly and accurately may have caused boredom and students naturally wanted to demonstrate progression, especially in this setting (i.e., laboratory with experimenter present). Therefore, a weakness of this research design was that some subjects may not have complied with the instructions to proceed slowly. Examining Think Fast data supported this conclusion. It appeared Accuracy subjects found it difficult to keep their response rates slow, as these subjects' rates were comparable to two of the three subjects assigned to the Accuracy and Speed condition.

As well, given the presence of the experimenter and his scoring, it may have been difficult for subjects to respond slowly for all trials. They may have wanted to show the researcher that they were 'intelligent' subjects, even though they were instructed to proceed slowly and accurately.

Furthermore, being assigned to only one experimental condition and having only one deck of Think Fast cards to complete each trial may have benefited posttest recall for all subjects. In comparison to Experiment 1, there was much less information to learn in Experiment 2. It was possible that the simplicity of Experiment 2 made it easier for subjects to remember all of the information regardless of the condition assigned. For contrast, in Experiment 1, there were five concepts, four Think Fast sessions and three experimental conditions. In Experiment 2, it was very simple for all subjects to recall the majority of facts simply because there were fewer to remember. In other words, it is reasonable to conclude that unlike Experiment 1, having only one learning deck and one experimental condition made it easier for all subjects to remember and deduce posttest answers and thus reach a performance ceiling.

The chosen subject population also limited generalization. All subjects were post-secondary students and this limited the external validity of these findings. Furthermore, Experiment 1 did not include any kind of pretest measure to determine the extent of learning rate differences between subjects. Therefore, conclusions based on the results must be interpreted with caution and the realization that the subjects were both limited in numbers and, in the case of Experiment 1, unassessed subject variables.

With respect to Experiment 1, the group totals indicated a significant posttest achievement between conditions; however, examined individually, three subjects did not demonstrate this difference. Some speculations were made that perhaps subjects' interest and ability may have affected their posttest performance. Unfortunately, it may also be the case that the results were spurious and that within any given group of nine subjects a range of achievement can be observed. More research is needed to control for these and other internal and external variables.

Not all aspects of the mastery and fluency learning approaches were considered. These experiments were limited to the analysis of the requirement of rate-building to either accuracy or accuracy and speed. Some components of the mastery approach that were not examined included remedial testing and flexibility in learning time.

In terms of the fluency approach, components such as self-charting and fluency sprints/timings were not incorporated. Therefore, speculations from these experiments were not about the effectiveness of the fluency and mastery learning approaches per se but rather one component of each, namely, the particular performance indicator (i.e., accuracy and rate). Therefore, this study focused on one dimension of these learning approaches and provided only a 'peek' into the vast world of mastery and fluency learning.

Future Research Directions

Further empirical research in the area of rate-building is worthy of exploration. This can be accomplished systematically, for example, by altering the experimental sequence of Experiment 1 and then changing one variable at a time until all possible factors affecting response rate and achievement are investigated. For example, these present experiments were limited to post-secondary students. A natural extension would be to recruit different populations, greater numbers and use different stimulus material. In all cases of subsequent research, it is strongly recommended that prelearning assessments be used to measure subjects' baseline learner profiles (e.g., ability and interest). It would be interesting to apply the fluency paradigm with subjects counterbalanced and grouped for various learner abilities and interest ratings. This would allow for an examination of subjects' variables in relation to learning and achievement.

Several subjects in each experiment did not achieve stable and optimum Think Fast response rates that would be considered fluent. Given that subjects vary in terms of trials required to reach fluent rates, perhaps future studies could require subjects to learn until stability of performance has been reached. Moreover, the learning instructions could be more specific than simply requiring accurate or accurate and fast responses. For example, subjects could be instructed to learn material to a rate of 50 correct responses per minute. It may also be possible to perform a baseline activity to determine learning rate and then identify *fast* and *slow* learners. Subjects could be 'yoked' to control for the number of trials and learning experienced by each.

If resources were unlimited and subsequent experiments could control for subject variables, learning trials and rates, perhaps a longitudinal study could be conducted to explore the differential effects of groups of students as they progress from introductory to more complex courses and an examination of long-term retention.

At the least, future studies must include a long-term follow-up (three months to one-year). Such a retention measure has direct educational implications as fundamental information learned during the first year of study is often required the next year usually after an extended period of time without learning or practice (e.g., summer break).

In summary, these experiments not only added to the active learning and Precision Teaching literature but also improved the understanding of the effects of rate (i.e., responses per minute). Still, more research is required to control for subject variability and the longer-term effects of learning rates.

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Appendix I

Subject Recruitment Advertisement

Paid Research Participants

Purpose:

This study is designed to examine the different ways a computer can be used to teach post-secondary students. A computer program has been developed to facilitate learning; however, understanding the effectiveness of the ways in which materials are presented is not known.

Therefore, I have put together a few units/chapters of information which will serve as the learning materials for each participant.

Your contribution:

You must be a fluent reader as you will be required to read a lot of information in a relatively short period of time. You must not have taken any psychology or biology courses as this is the substance of the learning units. I will demonstrate how to use the program and have each participant learn using different instructions.

Reward:

For you contribution in providing me with data, and in effect, helping me to complete my dissertation, I will pay you $10.00 per hour. The first session should take about 2 hours and there will probably be two other session after that which should not take longer than 1.5 hours each. Your availability for all sessions is crucial, otherwise, this data will be incomplete. I am flexible in arranging session times.

Please contact me-Bill- at (phone number) for more information.

Thank You.

Appendix 2

Pretest and Sample Answer Sheet

Instructions: Read each example, one-at-a-time, and write your answer in the appropriate "blank" space on the answer sheet. When you have completed one item, go to the next one and do not return to any passed items. Answer in the order that is presented and immediately state when you have finished. Thanks.

1. The term reinforcement is used to refer to the procedure of arranging for an _______ to follow a behavior, knowing that the event will increase the rate of the behavior.

2. A behavior that is _______ to the target behavior in a shaping program is called an approximation.

3. Extinction is defined as stopping the delivery of a _______ that has followed a behavior in the past and causing a decrease in the subsequent rate of the behavior.

4. Extinction applies only to stopping ________ that occur after a behavior is emitted."

5. Reinforcement: an event is added to the environment contingent upon a behavior and there is an increase in the subsequent _______ of that behavior. "

6. "_______ is used to mold a new behavior.

Pretest-Answer Sheet

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

Appendix 3

Experiment 1-*Think Fast* Content for Sessions 1 and 2

1. A reinforcer is any event that ~follows~ a behavior and that increases the probability of that behavior to occur again.

2. A reinforcer is any event that follows a behavior and that ~increases~ the probability of the behavior to occur again.

3. The term reinforcement is used to refer to the procedure of arranging for an ~event~ to follow a behavior, knowing that the event will increase the rate of the behavior.

4. The term reinforcement is used to refer to the procedure of arranging for an event to ~follow~ a behavior, knowing that the event will increase the rate of the behavior.

5. The term reinforcement is used to refer to the procedure of arranging for an event to follow a behavior, knowing that the event will ~increase~ the rate of the behavior.

6. ~Reinforcement~: an event is added to the environment contingent upon a behavior and there is an increase in the subsequent rate of that behavior.

7. Reinforcement: an event is ~added~ to the environment contingent upon a behavior and there is an increase in the subsequent rate of that behavior.

8. Reinforcement: an event is added to the environment ~contingent~ upon a behavior and there is an increase in the subsequent rate of that behavior.

9. Reinforcement: an event is added to the environment contingent upon a behavior and there is an ~increase~ in the subsequent rate of that behavior.

10. Reinforcement: an event is added to the environment contingent upon a behavior and there is an increase in the subsequent ~rate~ of that behavior.

11. ~Shaping~ is used to mold a new behavior.

12. Shaping is used to mold a ~new~ behavior.

13. The behavior that is the goal of a shaping program is called the ~target~.

14. A behavior that is ~similar~ to the target behavior in a shaping program is called an approximation.

15. A behavior that is similar to the target behavior in a shaping program is called an ~approximation~.

16. In shaping, once ~reinforcement~ has increased the rate of the first approximation, reinforcement is then applied to a second, closer approximation to the target.

17. In shaping, once reinforcement has ~increased~ the rate of the first approximation, reinforcement is then applied to a second, closer approximation to the target.

18. In shaping, once reinforcement has increased the rate of the ~first~ approximation, reinforcement is then applied to a second, closer approximation to the target.

19. Shaping: reinforcing ~successive~ approximations of a desired goal behavior until the target is reached.

20. ~Shaping~: reinforcing successive approximations of a desired goal behavior until the target is reached.

21. The operation of ~discontinuing~ reinforcement is called extinction.

22. ~Extinction~: the operation of discontinuing reinforcement.

23. Extinction is defined as ~stopping~ the delivery of a reinforcer that has followed a behavior in the past and causing a decrease in the subsequent rate of the behavior."

24. Extinction is defined as stopping the delivery of a reinforcer that has followed a behavior in the past and causing a ~decrease~ in the subsequent rate of the behavior.

25. Extinction is defined as stopping the delivery of a reinforcer that has followed a behavior in the past and causing a decrease in the subsequent ~rate~ of the behavior.

26. Extinction applies only to stopping events that occur ~after~ a behavior is emitted.

27. The term ~extinction~ involves stopping an event that conforms to the definition of a reinforcer.

28. The term extinction involves stopping an event that conforms to the definition of a ~reinforcer~.

29. The act of applying extinction to a behavior is called ~extinguishing~ the behavior.

30. Extinction applies only to stopping ~events~that occur after a behavior is emitted.

Experiment 1-Session 2

31. If you think that an interval schedule is involved, ask: “If the person makes no responses will a time arrive when only ~one~ response will produce the reinforcer?

32. Typically, people on a fixed interval schedule of reinforcement pause just after reinforcement and then their rate of responding ~increases~ as the time for reinforcement approaches.

33. Theoretically, a person on a fixed interval schedule of reinforcement could wait for the passage of the fixed interval without making any responses and then be reinforced for making ~one~ response.

34. A fixed interval schedule is one in which the person is reinforced for the first response made after a ~fixed~ period of time passes.

35. The pattern of responding produced by a fixed interval is a ~pause~ after reinforcement and the gradually increasing response rate.

36. A fixed interval schedule is one in which the person must ~wait~ for a ~fixed~ period of time to pass and make a response after that time.

37. A variable interval schedule is one in which the person must ~wait~ for a ~varying~ time to pass and make a response after that time.

38. Theoretically, a person reinforced on a variable interval schedule could wait for the passage of time without responding and then be reinforced for making ~one~ response(s) after that time.

39. A variable interval schedule of reinforcement is one in which the person is reinforced for the first response after ~varying~ periods of time.

40. In which type of schedule is the rapidity of the reinforcement time-controlled? ~interval~

41. In which type of schedule is the rapidity of the reinforcement response-controlled? ~ratio~

42. If a reinforcer is delivered after every seventh response on the average, you should assume that it is delivered after ~variable~ numbers of responses averaging 7. Thus the schedule would be called ~variable ratio~.

43. If a person is reinforced after differing numbers of responses, he or she is on a ~variable~ ratio schedule of reinforcement.

44. If you think that a schedule is a ratio schedule, ask: If the person makes the responses very rapidly, will the next reinforcer arrive ~sooner~?

45. The variable-ratio schedule produces a ~higher~ rate of responding than the other schedules.

46. If a person receives a reinforcer on the average of every six responses, the schedule of reinforcement involved is called ~variable ratio~.

47. Mr. Davis helped his daughter with her math homework by checking her work after every seven problems. If having her homework checked is a reinforcer, what schedule is doing homework on? ~fixed ratio~

48. If a person can speed up the delivery of a reinforcer by working harder, he/she is on what type of schedule? ~ratio~

49. If a person receives a reinforcer after every six responses exactly, then he or she is on what schedule? ~fixed ratio~

50. If a behavior produces a reinforcer every second time that it occurs, the behavior is said to be reinforced on a ~fixed ratio~ schedule.

51. One characteristic of differential reinforcement is that two or more physically ~different~ behaviors are involved.

52. The different behaviors occurring in an example of differential reinforcement must occur in one ~situation~.

53. A second characteristic of differential reinforcement is that one of those behaviors is ~reinforced~.

54. The third characteristic of differential reinforcement is that one or more other behaviors are ~extinguished~.

55. Performing the same behavior (that is, using the same muscles) in two different places ~is not~ considered to be two behaviors.

56. Using the same muscles at different speeds ~is~ considered to be two behaviors.

57. The three characteristics of differential reinforcement are: two or more physically ~different~ behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished.

58. The three chracteristics of differential reinforcement are: two or more physically different behaviors (occurring in one situation) are involved; one behavior is ~reinforced~; other behaviors are extinguished.

59. The three characteristics of differential reinforcement are two or more physically different behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished~.

60. To determine whether an example (of differential reinforcement) contains two or more different behaviors you must analyze whether the individual makes different physical movements of his/her ~muscles~.

Appendix 4

Experiment 1-Recall 1 and Answer Sheet

1. The operation of __________ reinforcement is called extinction.

2. __________: the operation of discontinuing reinforcement.

3. Extinction is defined as __________ the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent rate of the behaviour.

4. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a __________ in the subsequent rate of the behaviour.

5. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent __________ of the behaviour.

6. Extinction applies only to stopping __________ that occur after a behaviour is emitted.

7. Extinction applies only to stopping events that occur __________ a behaviour is emitted.

8. The term extinction involves stopping an event that conforms to the definition of a __________.

9. The term __________ involves stopping an event that conforms to the definition of a __________.

10. The act of applying extinction to a behaviour is called __________ the behaviour.

11. __________ is used to mold a new behaviour.

12. Shaping is used to mold a __________ behaviour.

13. The behaviour that is the goal of a shaping program is called the __________ behaviour.

14. A behaviour that is __________ to the target behaviour in a shaping program is called an approximation.

15. A behaviour that is similar to the target behaviour in a shaping program is called an __________.

16. In shaping, once __________ has increased the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

17. In shaping, once reinforcement has __________ the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

18. In shaping, once reinforcement has increased the rate of the __________ approximation, reinforcement is then applied to a second closer approximation to the target.

19. __________: reinforcing successive approximations of a desired goal behaviour until the target is reached.

20. Shaping: reinforcing __________ approximations of a desired goal behaviour until the target is reached.

21. A __________ is any event that follows a behavior and that increases the probability of that behaviour to occur again.

22. A reinforcer is any event that follows a behavior and that __________ the probability of that behaviour to occur again.

23. The term reinforcement is used to refer to the procedure of arranging for an __________ to follow a behaviour, knowing that the event will increase the rate of the behaviour.

24. The term reinforcement is used to refer to the procedure of arranging for an event to __________ a behaviour, knowing that the event will increase the rate of the behaviour.

25. The term reinforcement is used to refer to the procedure of arranging for an event to follow a behaviour, knowing that the event will __________ the rate of the behaviour.

26. __________: an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

27. Reinforcement: an event is __________ to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

28. Reinforcement: an event is added to the environment __________ upon a behaviour and there is an increase in the subsequent rate of that behaviour.

29. Reinforcement: an event is added to the environment contingent upon a behaviour and there is an __________ in the subsequent rate of that behaviour.

30. Reinforcement: an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent __________ of that behaviour.

Recall 1-Answer Sheet

1. ________________________________

2. ________________________________

3. ________________________________

4. ________________________________

5. ________________________________

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10. ________________________________

11. ________________________________

12. ________________________________

13. ________________________________

14. ________________________________

15. ________________________________

16. ________________________________

17. ________________________________

18. ________________________________

19. ________________________________

20 ________________________________

21. ________________________________

22. ________________________________

23. ______________________________

24. ______________________________

25. ______________________________

26. ______________________________

27. ______________________________

28. ______________________________

29. ______________________________

30. ______________________________

Appendix 5

Experiment 1-Application 1 and Answer Sheet

Instructions: Read an example and write your answer in the appropriate "blank" space on the answer sheet. When you have completed one item, go to the next one and do not return to any passed items. Answer in the order that is presented and immediately state when you have finished.

1. Marie helped Fran to not get angry over a minor annoyance. She taught him to count to 10 if an annoying event occurred. She continued to praise him during future annoyances until he was doing it all the time. Next she would praise him only when he counted to 20, which he soon mastered. In this way she finally got him to count to 100, at which time he was no longer angry. What is counting to 100 called?

2. At first Dave swam the 100 in about 75 seconds. His coach praised him only when he swam it under 75 seconds. Then his coach praised him only when he swam it in under 70 seconds. Using this same approach, the coach eventually got Dave swimming the 100 in under 50 seconds. What procedure did his coach use?

3. John praised and hugged his infant daughter when she tried to say "dada". At first he praised her only when she said something that started with "da"; later only when she said both the "da" and a following "da".
What procedure is this an example of?

4. Carla sometimes smiled at men that she passed on campus. One day she smiled at a guy who then came right up and asked her for a date. Carla now smiles at many of the guys who she passes on campus and frequently gets asked out for dates.
What procedure is this an example of?

5. Professor Jones disrupted faculty meetings with his insane ideas. His colleagues used to argue vehemently with him. However, the chairman finally convinced them to simply ignore Jones. Soon, Jones wasn't disrupting meetings anymore.
What procedure is this an example of?

6. Ward liked Bev a lot so he went out of his way to find things about her to compliment. At first, Bev liked this and smiled and thanked him. However, after she got engaged to Tom she felt embarrassed by Ward's compliments. As a result she invariably ended up ignoring them. Ward doesn't compliment her anymore.
What procedure is this an example of?

7. Joe's TV went on the blink during the NFL playoffs, so he tapped it with the palm of his hand. Immediately, the picture cleared up. Now, whenever, the picture goes bad, he taps the set. What procedure is this an example of?

8. Gail felt that her 6-year-old son was not expressive enough. So she decided to give him a special treat every time that he spontaneously hugged her. She found that he gradually became more expressive. What procedure is this an example of?

9. Mary wanted to teach John how to do really good, fast dancing. She decided to start by teaching him some very slow steps. Slow dancing would be called a(n) ______.

10. A baby may say "dad" to may males other than his father. His parents, by reserving their attention for those occasions when the child says "dada" to his father, will eventually teach the child not to say "dada" to any other males.
What procedure is this an example of?

11. Clarence is a skilled carpenter. One day he was reminiscing about how he had learned to hammer in a 16-penny nail with one thump. At first his father had praised him only when he hit the nail with each tiny tap-taking many taps to drive the nail in. His father had then praised him only when he drove it in with several rough raps. Finally, his father had praised him only when he drove it in with one thunderous thump. What procedure was his father using?

12. Pat teased Carol incessantly about her weight. At first, Carol took it all seriously. Then later she stopped taking it so seriously and just laughed it off and soon Pat stopped the teasing. What procedure is this an example of?

13. Tom liked compliments a lot. So anytime that he got one he beamed and profusely thanked the person for the compliment. Tom noticed that this increased the number of compliments he got from each person that he had thanked.
What procedure is this an example of?

14. At first Mary tried to be nice to Fred. But she did not like the kind of attention that he gave her, so she finally just totally ignored his attention and he stopped paying attention to her. What procedure is this an example of?

15. Jim spontaneously trimmed the front hedge around his home one day. His parents were delighted and took him out for a steak dinner to reward his work around the house. His helping continued. What procedure is this an example of?

Application 1-Answer Sheet

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

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10. ______________________________

11. ______________________________

12. ______________________________

13. ______________________________

14. ______________________________

15. ______________________________

Appendix 6

Experiment 1-Recall 2 and Answer Sheet

1. If you think that an interval schedule is involved, ask: If the person makes no responses will a time arrive when only ~one~ response will produce the reinforcer?

2. Typically, people on a fixed interval schedule of reinforcement pause just after reinforcement and then their rate of responding ~increases~ as the time for reinforcement approaches.

3. Theoretically, a person on a fixed interval schedule of reinforcement could wait for the passage of the fixed interval without making any responses and then be reinforced for making ~one~ response.

4. A fixed interval schedule is one in which the person is reinforced for the first response made after a ~fixed~ period of time passes.

5. The pattern of responding produced by a fixed interval is a ~pause~ after reinforcement and the gradually increasing response rate.

6. A fixed interval schedule is one in which the person must ~wait~ for a ~fixed~ period of time to pass and make a response after that time.

7. A variable interval schedule is one in which the person must ~wait~ for a ~varying~ time to pass and make a response after that time.

8. Theoretically, a person reinforced on a variable interval schedule could wait for the passage of time without responding and then be reinforced for making ~one~ response(s) after that time.

9. A variable interval schedule of reinforcement is one in which the person is reinforced for the first response after ~varying~ periods of time.

10. In which type of schedule is the rapidity of the reinforcement time-controlled? ~interval~

11. In which type of schedule is the rapidity of the reinforcement response-controlled? ~ratio~

12. If a reinforcer is delivered after every seventh response on the average, you should assume that it is delivered after ~variable~ numbers of responses averaging 7. Thus the schedule would be called ~variable ratio~.

13. If a person is reinforced after differing numbers of responses, he or she is on a ~variable~ ratio schedule of reinforcement.

14. If you think that a schedule is a ratio schedule, ask: If the person makes the responses very rapidly, will the next reinforcer arrive ~sooner~?

15. The variable-ratio schedule produces a ~higher~ rate of responding than the other schedules.

16. If a person receives a reinforcer on the average of every six responses, the schedule of reinforcement involved is called ~variable ratio~.

17. Mr. Davis helped his daughter with her math homework by checking her work after every seven problems. If having her homework checked is a reinforcer, what schedule is doing homework on? ~fixed ratio~

18. If a person can speed up the delivery of a reinforcer by working harder, he/she is on what type of schedule? ~ratio~

19. If a person receives a reinforcer after every six responses exactly, then he or she is on what schedule? ~fixed ratio~

20. If a behavior produces a reinforcer every second time that it occurs, the behavior is said to be reinforced on a ~fixed ratio~ schedule.

21. One characteristic of differential reinforcement is that two or more physically ~different~ behaviors are involved.

22. The different behaviors occurring in an example of differential reinforcement must occur in one ~situation~.

23. A second characteristic of differential reinforcement is that one of those behaviors is ~reinforced~.

24. The third characteristic of differential reinforcement is that one or more other behaviors are ~extinguished~.

25. Performing the same behavior (that is, using the same muscles) in two different places ~is not~ considered to be two behaviors.

26. Using the same muscles at different speeds ~is~ considered to be two behaviors.

27. The three characteristics of differential reinforcement are: two or more physically ~different~ behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished.

28. The three chracteristics of differential reinforcement are: two or more physically different behaviors (occurring in one situation) are involved; one behavior is ~reinforced~; other behaviors are extinguished.

29. The three characteristics of differential reinforcement are two or more physically different behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished~.

30. To determine whether an example (of differential reinforcement) contains two or more different behaviors you must analyze whether the individual makes different physical movements of his/her ~muscles~.

Recall 2-Answer Sheet

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
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29. ______________________________

30. ______________________________

Appendix 7

Experiment 1-Application 2 and Answer Sheet

1. At first, John's teacher praised him lavishly whenever he wrote a short poem. He wrote several poems one stanza long. Later, she praised him whenever he wrote a poem two stanzas long and paid no attention to his shorter poems. By this method, the teacher eventually got him writing 20 stanza poems.

What behavioral procedure did the teacher use to teach John to write 20 stanza poems?

____

2. In Dr. Smith's course, each subject used to take a daily quiz that had six questions on it. Any subject who got all six questions correct advanced one step toward an A. What schedule is having to make six correct responses for one step toward an A an example of _______________?

3. Rich had talked Fran into washing the windows of their house, but Fran needed encouragement. At first Rich made it a point to come by after every window Fran completed. Soon, however, Rich just didn't have the time, so he came by after Fran had completed 3, 1, 8 and 4 windows. Fran seemed to finish the windows faster then. What schedule was Fran on for her last 16 windows?

4. Nancy was difficult to engage in a conversation and, in particular, she was difficult to get started talking about herself. Frank found out that if you asked her enough questions about herself she would eventually open up. Sometimes it took only a couple of questions, but other times it took many more. What schedule of reinforcement is Frank's questioning on if "opening up" is the reinforcer _______________?

5. John was fascinated by comets. He watched patiently to catch sight of Alpha 13, which was visible at 4 A.M. on August 24 every two years. What schedule of reinforcement was his watching for Alpha 13 on _______________?

6. Nancy was always thrilled when she saw a deer. She used to sit by the hour on her favorite hill waiting to see one. What schedule of reinforcement is her deer-looking behavior on _______________?

7. Stan wanted everyone around him to be happy and cheerful. Anytime that Susan said something cheerful he was happy and smiled. Anytime that she said something down, he was unhappy and glum. Susan began saying cheerful things more often. What behavioral procedure did Stan unconsciously apply to Susan's behavior _______________?

8. Darlene's clock radio always woke her at exactly 5:45. As she dressed she would occasionally listen to see if the 7:00 news had come on yet. What schedule of reinforcement is her listening behavior on _______________?

9. Believe it or not, Gloria is a peeper. She can see into Dave's room from her own room. She starts watching his room at 11:30 each night. Dave comes into his room and starts undressing at exactly 11:40 every night. What schedule of reinforcement is Gloria's peeping behavior on _______________?

10. John had been trying to teach his son to bring his plate into the kitchen and put it in the sink immediately after dinner. During the first month, John gave his son an ice-cream dessert each time he brought his plate into the kitchen. In the second month, John started giving his son an ice-cream dessert when he brought his plate to the kitchen for several meals in a row, averaging four. What schedule of reinforcement is the son on during the second month?

11. Alice was a radar scanner in Alaska. She was supposed to scan the radar screen continually for an 8-hour period looking for unidentified (and possible hostile) planes. Alice spotted an average of two unidentified planes per night. Usually they were American planes that were off course. What schedule of reinforcement is Alice's scanning on _______________?

12. David was the new psychiatrist for Mrs. Brooke. She became annoyed at David's habit of discussing his own problems but never trying to find out what help Mrs. Brooke needed. So Mrs. Brooke started ignoring all discussions about his problems and paid attention only when her own problems came up. He soon talked about her problems. What procedure was Mrs. Brooke using?

13. Grace wanted desperately to learn how to dance, but she had little sense of rhythm. Her roommate volunteered to help by dancing in rhythm to the radio. Grace would dance at the same time and by watching whether she was moving at the same time as her roommate, determine whether she was in rhythm or not. She was happy when her movements coincided and unhappy when they did not. Gradually her movements were in time with her roommates. What schedule of reinforcement was built into this situation encouraging Grace to move in rhythm _______________?

14. Johnny found that if he nagged his mother long enough, she would eventually give him a cookie. Sometimes she wouldn't give it to him until he had asked for it 20 times, but other times she should give him one the first time that he asked. Suppose that his mother stopped giving him cookies. Would his nagging stop faster with the schedule described in the example or with a schedule in which he was given a cookie every time that he asked for it (name the schedule)? _______________

15. Ron and Betty were watching a movie containing a few scene showing classical dancing. Since they were interested in learning some new steps, these scenes were the only ones that were of interest to them. Suppose that the scenes were 2 minutes long and

the first one occurred after 15 minutes had elapsed, the second after another 5 minutes, the third after another 25 minutes and the last after another 15 minutes. Since the time between scenes varies from 5 to 25 minutes, this example illustrates a(n) _______________ schedule.

Application 2-Answer Sheet

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

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13. ______________________________

14. ______________________________

15. ______________________________

Appendix 8

Experiment 1-Write Definitions

Instructions: Read each word, one-at-a-time, and write the definition in the appropriate "blank" space. When you have completed one item, go to the next one and do not return to any passed items. Answer in the order that is presented and immediately state when you have finished. Thanks.

1. Reinforcement:

2. Shaping:

3. Extinction:

4. Differential reinforcement:

5. Variable interval:

Appendix 9

Experiment 1-Recall 3 and Answer Sheet

1. A reinforcer is any event that ~follows~ a behavior and that increases the probability of that behavior to occur again.

2. A reinforcer is any event that follows a behavior and that ~increases~ the probability of the behavior to occur again.

3. The term reinforcement is used to refer to the procedure of arranging for an ~event~ to follow a behavior, knowing that the event will increase the rate of the behavior.

4. The term reinforcement is used to refer to the procedure of arranging for an event to ~follow~ a behavior, knowing that the event will increase the rate of the behavior.

5. The term reinforcement is used to refer to the procedure of arranging for an event to follow a behavior, knowing that the event will ~increase~ the rate of the behavior.

6. ~Reinforcement~: an event is added to the environment contingent upon a behavior and there is an increase in the subsequent rate of that behavior.

7. Reinforcement: an event is ~added~ to the environment contingent upon a behavior and there is an increase in the subsequent rate of that behavior.

8. Reinforcement: an event is added to the environment ~contingent~ upon a behavior and there is an increase in the subsequent rate of that behavior.

9. Reinforcement: an event is added to the environment contingent upon a behavior and there is an ~increase~ in the subsequent rate of that behavior.

10. Reinforcement: an event is added to the environment contingent upon a behavior and there is an increase in the subsequent ~rate~ of that behavior.

11. ~Shaping~ is used to mold a new behavior.

12. Shaping is used to mold a ~new~ behavior.

13. The behavior that is the goal of a shaping program is called the ~target~.

14. A behavior that is ~similar~ to the target behavior in a shaping program is called an approximation.

15. A behavior that is similar to the target behavior in a shaping program is called an ~approximation~.

16. In shaping, once ~reinforcement~ has increased the rate of the first approximation, reinforcement is then applied to a second, closer approximation to the target.

17. In shaping, once reinforcement has ~increased~ the rate of the first approximation, reinforcement is then applied to a second, closer approximation to the target.

18. In shaping, once reinforcement has increased the rate of the ~first~ approximation, reinforcement is then applied to a second, closer approximation to the target.

19. Shaping: reinforcing ~successive~ approximations of a desired goal behavior until the target is reached.

20. ~Shaping~: reinforcing successive approximations of a desired goal behavior until the target is reached.

21. The operation of ~discontinuing~ reinforcement is called extinction.

22. ~Extinction~: the operation of discontinuing reinforcement.

23. Extinction is defined as ~stopping~ the delivery of a reinforcer that has followed a behavior in the past and causing a decrease in the subsequent rate of the behavior."

24. Extinction is defined as stopping the delivery of a reinforcer that has followed a behavior in the past and causing a ~decrease~ in the subsequent rate of the behavior.

25. Extinction is defined as stopping the delivery of a reinforcer that has followed a behavior in the past and causing a decrease in the subsequent ~rate~ of the behavior.

26. Extinction applies only to stopping events that occur ~after~ a behavior is emitted.

27. The term ~extinction~ involves stopping an event that conforms to the definition of a reinforcer.

28. The term extinction involves stopping an event that conforms to the definition of a ~reinforcer~.

29. The act of applying extinction to a behavior is called ~extinguishing~ the behavior.

30. Extinction applies only to stopping ~events~that occur after a behavior is emitted."

Experiment 1-Session 2

31. If you think that an interval schedule is involved, ask: If the person makes no responses will a time arrive when only ~one~ response will produce the reinforcer?

32. Typically, people on a fixed interval schedule of reinforcement pause just after reinforcement and then their rate of responding ~increases~ as the time for reinforcement approaches.

33. Theoretically, a person on a fixed interval schedule of reinforcement could wait for the passage of the fixed interval without making any responses and then be reinforced for making ~one~ response.

34. A fixed interval schedule is one in which the person is reinforced for the first response made after a ~fixed~ period of time passes.

35. The pattern of responding produced by a fixed interval is a ~pause~ after reinforcement and the gradually increasing response rate.

36. A fixed interval schedule is one in which the person must ~wait~ for a ~fixed~ period of time to pass and make a response after that time.

37. A variable interval schedule is one in which the person must ~wait~ for a ~varying~ time to pass and make a response after that time.

38. Theoretically, a person reinforced on a variable interval schedule could wait for the passage of time without responding and then be reinforced for making ~one~ response(s) after that time.

39. A variable interval schedule of reinforcement is one in which the person is reinforced for the first response after ~varying~ periods of time.

40. In which type of schedule is the rapidity of the reinforcement time-controlled? ~interval~

41. In which type of schedule is the rapidity of the reinforcement response-controlled? ~ratio~

42. If a reinforcer is delivered after every seventh response on the average, you should assume that it is delivered after ~variable~ numbers of responses averaging 7. Thus the schedule would be called ~variable ratio~.

43. If a person is reinforced after differing numbers of responses, he or she is on a ~variable~ ratio schedule of reinforcement.

44. If you think that a schedule is a ratio schedule, ask: If the person makes the responses very rapidly, will the next reinforcer arrive ~sooner~?

45. The variable-ratio schedule produces a ~higher~ rate of responding than the other schedules.

46. If a person receives a reinforcer on the average of every six responses, the schedule of reinforcement involved is called ~variable ratio~.

47. Mr. Davis helped his daughter with her math homework by checking her work after every seven problems. If having her homework checked is a reinforcer, what schedule is doing homework on? ~fixed ratio~

48. If a person can speed up the delivery of a reinforcer by working harder, he/she is on what type of schedule? ~ratio~

49. If a person receives a reinforcer after every six responses exactly, then he or she is on what schedule? ~fixed ratio~

50. If a behavior produces a reinforcer every second time that it occurs, the behavior is said to be reinforced on a ~fixed ratio~ schedule.

51. One characteristic of differential reinforcement is that two or more physically ~different~ behaviors are involved.

52. The different behaviors occurring in an example of differential reinforcement must occur in one ~situation~.

53. A second characteristic of differential reinforcement is that one of those behaviors is ~reinforced~.

54. The third characteristic of differential reinforcement is that one or more other behaviors are ~extinguished~.

55. Performing the same behavior (that is, using the same muscles) in two different places ~is not~ considered to be two behaviors.

56. Using the same muscles at different speeds ~is~ considered to be two behaviors.

57. The three characteristics of differential reinforcement are: two or more physically ~different~ behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished.

58. The three chracteristics of differential reinforcement are: two or more physically different behaviors (occurring in one situation) are involved; one behavior is ~reinforced~; other behaviors are extinguished.

59. The three characteristics of differential reinforcement are two or more physically different behaviors (occurring in one situation) are involved; one behavior is reinforced; other behaviors are extinguished~.

60. To determine whether an example (of differential reinforcement) contains two or more different behaviors you must analyze whether the individual makes different physical movements of his/her ~muscles~.

Recall 3-Answer Sheet

1. ______________________________
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53. ____

54. ____

55. ____

56. ____

57. ____

58. ____

59. ____

60. ____

Appendix 10

Experiment 1-Application 3 and Answer Sheet

1. Marie helped Fran to not get angry over a minor annoyance. She taught him to count to 10 if an annoying event occurred. She continued to praise him during future annoyances until he was doing it all the time. Next she would praise him only when he counted to 20, which he soon mastered. In this way she finally got him to count to 100, at which time he was no longer angry. What is counting to 100 called?

2. At first Dave swam the 100 in about 75 seconds. His coach praised him only when he swam it under 75 seconds. Then his coach praised him only when he swam it in under 70 seconds. Using this same approach, the coach eventually got Dave swimming the 100 in under 50 seconds. What procedure did his coach use?

5. John praised and hugged his infant daughter when she tried to say "dada". At first he praised her only when she said something that started with "da"; later only when she said both the "da" and a following "da".
What procedure is this an example of?

4. Carla sometimes smiled at men that she passed on campus. One day she smiled at a guy who then came right up and asked her for a date. Carla now smiles at many of the guys who she passes on campus and frequently gets asked out for dates.
What procedure is this an example of?

5. Professor Jones disrupted faculty meetings with his insane ideas. His colleagues used to argue vehemently with him. However, the chairman finally convinced them to simply ignore Jones. Soon, Jones wasn't disrupting meetings anymore.
What procedure is this an example of?

6. Ward liked Bev a lot so he went out of his way to find things about her to compliment. At first, Bev liked this and smiled and thanked him. However, after she got engaged to Tom she felt embarrassed by Ward's compliments. As a result she invariably ended up ignoring them. Ward doesn't compliment her anymore.
What procedure is this an example of?

7. Joe's TV went on the blink during the NFL playoffs, so he tapped it with the palm of his hand. Immediately, the picture cleared up. Now, whenever, the picture goes bad, he taps the set. What procedure is this an example of?

8. Gail felt that her 6-year-old son was not expressive enough. So she decided to give him a special treat every time that he spontaneously hugged her. She found that he gradually became more expressive. What procedure is this an example of?

9. Mary wanted to teach John how to do really good, fast dancing. She decided to start by teaching him some very slow steps. Slow dancing would be called a(n) ______.

10. A baby may say "dad" to may males other than his father. His parents, by reserving their attention for those occasions when the child says "dada" to his father, will eventually teach the child not to say "dada" to any other males.
What procedure is this an example of?

11. Clarence is a skilled carpenter. One day he was reminiscing about how he had learned to hammer in a 16-penny nail with one thump. At first his father had praised him only when he hit the nail with each tiny tap-taking many taps to drive the nail in. His father had then praised him only when he drove it in with several rough raps. Finally, his father had praised him only when he drove it in with one thunderous thump. What procedure was his father using?

12. Pat teased Carol incessantly about her weight. At first, Carol took it all seriously. Then later she stopped taking it so seriously and just laughed it off and soon Pat stopped the teasing. What procedure is this an example of?

13. Tom liked compliments a lot. So anytime that he got one he beamed and profusely thanked the person for the compliment. Tom noticed that this increased the number of compliments he got from each person that he had thanked.
What procedure is this an example of?

14. At first Mary tried to be nice to Fred. But she did not like the kind of attention that he gave her, so she finally just totally ignored his attention and he stopped paying attention to her. What procedure is this an example of?

15. Jim spontaneously trimmed the front hedge around his home one day. His parents were delighted and took him out for a steak dinner to reward his work around the house. His helping continued. What procedure is this an example of?

16. At first, John's teacher praised him lavishly whenever he wrote a short poem. He wrote several poems one stanza long. Later, she praised him whenever he wrote a poem two stanzas long and paid no attention to his shorter poems. By this method, the teacher eventually got him writing 20 stanza poems.

What behavioral procedure did the teacher use to teach John to write 20 stanza poems?

____

17. In Dr. Smith's course, each subject used to take a daily quiz that had six questions on it. Any subject who got all six questions correct advanced one step toward an A. What schedule is having to make six correct responses for one step toward an A an example of ________________?

18. Rich had talked Fran into washing the windows of their house, but Fran needed encouragement. At first Rich made it a point to come by after every window Fran completed. Soon, however, Rich just didn't have the time, so he came by after Fran had

completed 3, 1, 8 and 4 windows. Fran seemed to finish the windows faster then. What schedule was Fran on for her last 16 windows?

19. Nancy was difficult to engage in a conversation and, in particular, she was difficult to get started talking about herself. Frank found out that if you asked her enough questions about herself she would eventually open up. Sometimes it took only a couple of questions, but other times it took many more. What schedule of reinforcement is Frank's questioning on if "opening up" is the reinforcer _______________?

20. John was fascinated by comets. He watched patiently to catch sight of Alpha 13, which was visible at 4 A.M. on August 24 every two years. What schedule of reinforcement was his watching for Alpha 13 on _______________?

21. Nancy was always thrilled when she saw a deer. She used to sit by the hour on her favorite hill waiting to see one. What schedule of reinforcement is her deer-looking behavior on _______________?

22. Stan wanted everyone around him to be happy and cheerful. Anytime that Susan said something cheerful he was happy and smiled. Anytime that she said something down, he was unhappy and glum. Susan began saying cheerful things more often. What behavioral procedure did Stan unconsciously apply to Susan's behavior _______________?

23. Darlene's clock radio always woke her at exactly 5:45. As she dressed she would occasionally listen to see if the 7:00 news had come on yet. What schedule of reinforcement is her listening behavior on _______________?

24. Believe it or not, Gloria is a peeper. She can see into Dave's room from her own room. She starts watching his room at 11:30 each night. Dave comes into his room and starts undressing at exactly 11:40 every night. What schedule of reinforcement is Gloria's peeping behavior on _______________?

25. John had been trying to teach his son to bring his plate into the kitchen and put it in the sink immediately after dinner. During the first month, John gave his son an ice-cream dessert each time he brought his plate into the kitchen. In the second month, John started giving his son an ice-cream dessert when he brought his plate to the kitchen for several meals in a row, averaging four. What schedule of reinforcement is the son on during the second month?

26. Alice was a radar scanner in Alaska. She was supposed to scan the radar screen continually for an 8-hour period looking for unidentified (and possible hostile) planes. Alice spotted an average of two unidentified planes per night. Usually they were American planes that were off course. What schedule of reinforcement is Alice's scanning on _______________?

27. David was the new psychiatrist for Mrs. Brooke. She became annoyed at David's habit of discussing his own problems but never trying to find out what help Mrs. Brooke needed. So Mrs. Brooke started ignoring all discussions about his problems and paid attention only when her own problems came up. He soon talked about her problems. What procedure was Mrs. Brooke using?

28. Grace wanted desperately to learn how to dance, but she had little sense of rhythm. Her roommate volunteered to help by dancing in rhythm to the radio. Grace would dance at the same time and by watching whether she was moving at the same time as her roommate, determine whether she was in rhythm or not. She was happy when her movements coincided and unhappy when they did not. Gradually her movements were in time with her roommates. What schedule of reinforcement was built into this situation encouraging Grace to move in rhythm ______________?

29. Johnny found that if he nagged his mother long enough, she would eventually give him a cookie. Sometimes she wouldn't give it to him until he had asked for it 20 times, but other times she should give him one the first time that he asked. Suppose that his mother stopped giving him cookies. Would his nagging stop faster with the schedule described in the example or with a schedule in which he was given a cookie every time that he asked for it (name the schedule)? ______________

30. Ron and Betty were watching a movie containing a few scene showing classical dancing. Since they were interested in learning some new steps, these scenes were the only ones that were of interest to them. Suppose that the scenes were 2 minutes long and the first one occurred after 15 minutes had elapsed, the second after another 5 minutes, the third after another 25 minutes and the last after another 15 minutes. Since the time between scenes varies from 5 to 25 minutes, this example illustrates a(n) ________________ schedule.

Experiment 1-Application 3-Answer Sheet

1. ______________________________
2. ______________________________
3. ______________________________
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29. ______________________________________

30. ______________________________________

Appendix 11

Experiment 1-Research Participant Survey

THANKS FOR YOUR HELP!

Circle the number that best corresponds to your ratings.

1. Which method did you prefer learning with, if any?

a) Reading only

Least		Somewhat		Most
1	2	3	4	5

b) Reading sentences and learning to an accuracy rate (going slow)

Least		Somewhat		Most
1	2	3	4	5

c) Reading and learning to an accuracy and speed rate (going fast)

Least		Somewhat		Most
1	2	3	4	5

2. Were you interested in the material (i.e., reading and the decks of computer cards) that you were asked to learn?

a) Ratio schedules

Least		Somewhat		Most
1	2	3	4	5

b) Interval Schedules

Least		Somewhat		Most
1	2	3	4	5

c) Shaping

Least		Somewhat		Most
1	2	3	4	5

d) Differential Reinforcement

Least		Somewhat		Most
1	2	3	4	5

e) Reinforcement

Least		Somewhat		Most
1	2	3	4	5

f) Extinction

Least Somewhat Most
1 2 3 4 5

3. In reference to the decks that you were interested/not interested, please state why?
a) Ratio

b) Interval

c) Shaping

d) Differential

e) Reinforcement

f) Extinction

4. Which exercise did you enjoy, if any? Any particular reason why?

a) Fill-in-the blanks
Least Somewhat Most
1 2 3 4 5
Reason:

b) Identifying Examples
Least Somewhat Most
1 2 3 4 5
Reason:

5. Did you enjoy using the computer to learn?
Disagree Somewhat Most
1 2 3 4 5

6. Is there anything that you would suggest could be changed/added to help you learn this material better? (use back page if needed)

Appendix 12

Experimental Condition Instructions

Reading

Subjects read 2-3 pages of a chapter introduction by Miller (1980) and informed the investigator when they finished. Regardless of experimental condition, each concept was introduced by this type of reading. This served as the control condition to determine the effects of reading and subsequent learning as compared to the other conditions.

Accuracy

Subjects were instructed to use the "Type Keyword" mode and they experienced the blanked out information screens that made up each Think Fast learning deck. Under this condition, subjects were asked to read each card slowly and carefully. Specifically, they worked to reach and maintain an accuracy of 100% correct for each trial but were instructed progress slowly and accurately. Subjects received accuracy feedback from the Think Fast program at the conclusion of each trial. They were told to concentrate on achieving 100% accuracy for each trial. This condition represented the learning to Accuracy only condition.

Accuracy and Speed

Subjects were instructed to use the "Type Keyword" mode and they experienced the blanked out information screens that made up each Think Fast learning deck. Under this condition, subjects were asked to read each card as quickly as possible. Specifically, they worked to reach and maintain an accuracy of 100% correct for each trial but were also instructed to increase their response rate with each passing trial. Subjects received accuracy and response rate feedback at the conclusion of each trial from the Think Fast program. They were told to concentrate on achieving 100% accuracy for each trial and improve their response rate for each subsequent trial. This condition represented the learning to Accuracy and Speed condition.

Appendix 13

Experiment 2-*Think Fast* Content and Answer Sheet

1. The operation of __________ reinforcement is called extinction.
2. __________: the operation of discontinuing reinforcement.
3. Extinction is defined as __________ the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent rate of the behaviour.
4. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a __________ in the subsequent rate of the behaviour.
5. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent __________ of the behaviour.
6. Extinction applies only to stopping __________ that occur after a behaviour is emitted.
7. Extinction applies only to stopping events that occur __________ a behaviour is emitted.
8. The term extinction involves stopping an event that conforms to the definition of a __________.
9. The term __________ involves stopping an event that conforms to the definition of a __________.
10. The act of applying extinction to a behaviour is called __________ the behaviour.
11. __________ is used to mold a new behaviour.
12. Shaping is used to mold a __________ behaviour.
13. The behaviour that is the goal of a shaping program is called the __________ behaviour.
14. A behaviour that is __________ to the target behaviour in a shaping program is called an approximation.

15. A behaviour that is similar to the target behaviour in a shaping program is called an __________.

16. In shaping, once __________ has increased the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

17. In shaping, once reinforcement has __________ the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

18. In shaping, once reinforcement has increased the rate of the __________ approximation, reinforcement is then applied to a second closer approximation to the target.

19. __________: reinforcing successive approximations of a desired goal behaviour until the target is reached.

20. Shaping: reinforcing __________ approximations of a desired goal behaviour until the target is reached.

21. A __________ is any event that follows a behavior and that increases the probability of that behaviour to occur again.

22. A reinforcer is any event that follows a behavior and that __________ the probability of that behaviour to occur again.

23. The term reinforcement is used to refer to the procedure of arranging for an __________ to follow a behaviour, knowing that the event will increase the rate of the behaviour.

24. The term reinforcement is used to refer to the procedure of arranging for an event to __________ a behaviour, knowing that the event will increase the rate of the behaviour.

25. The term reinforcement is used to refer to the procedure of arranging for an event to follow a behaviour, knowing that the event will __________ the rate of the behaviour.

26. __________: an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

27. Reinforcement: an event is __________ to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

28. Reinforcement: an event is added to the environment __________ upon a behaviour and there is an increase in the subsequent rate of that behaviour.

29. Reinforcement: an event is added to the environment contingent upon a behaviour and there is an __________ in the subsequent rate of that behaviour.

30. an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent __________ of that behaviour.

Recall 1-Answer Sheet

1. ____________________
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Appendix 14

Experiment 2-Baseline Measure and Answer Sheet

Instructions: Read an example and write your answer in the appropriate "blank" space on the answer sheet. When you have completed one item, go to the next one and do not return to any passed items. Answer in the order that is presented and immediately state when you have finished.

1. Behavior modification has been found to be more effective in the area of psychiatry than traditional __________ therapy.

2. Behavior modification is a very young discipline that did not begin large-scale publication of its results until __________.

3. Behavioral analysis is a behavioral science that develops and experimentally analyzes practical procedures for producing changes in socially significant __________.

4. The first characteristic of behavior analysis is that it focuses on ________.

5. The second characteristics of behavior analysis is that it studies __________ influences on people's behavior.

6. The third characteristic of behavior analysis is that it uses single-subject designs to _________ with different environmental arrangements.

7. Who is considered to be the founder of behavior analysis? ____________

8. The term behavior modification can be replaced by what term? ___________

9. Behavior modification has come under _________ from a number of sources, because it seems to point to any method for modifying behavior.

10. The term behavior modification can easily be __________.

Baseline Measure-Answer Sheet

Session: ______

Codename: ______

Date: ______

1. ____________________

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3. ____________________

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Appendix 15

Experiment 2-Application 1 and 2 and Answer Sheet

Instructions: Read an example and write your answer in the appropriate "blank" space on the answer sheet. When you have completed one item, go to the next one and do not return to any passed items. Answer in the order that is presented and immediately state when you have finished.

1. Marie helped Fran to not get angry over a minor annoyance. She taught him to count to 10 if an annoying event occurred. She continued to praise him during future annoyances until he was doing it all the time. Next she would praise him only when he counted to 20, which he soon mastered. In this way she finally got him to count to 100, at which time he was no longer angry. What is counting to 100 called?

2. At first Dave swam the 100 in about 75 seconds. His coach praised him only when he swam it under 75 seconds. Then his coach praised him only when he swam it in under 70 seconds. Using this same approach, the coach eventually got Dave swimming the 100 in under 50 seconds. What procedure did his coach use?

3. John praised and hugged his infant daughter when she tried to say "dada". At first he praised her only when she said something that started with "da"; later only when she said both the "da" and a following "da".
What procedure is this an example of?

4. Carla sometimes smiled at men that she passed on campus. One day she smiled at a guy who then came right up and asked her for a date. Carla now smiles at many of the guys who she passes on campus and frequently gets asked out for dates.
What procedure is this an example of?

5. Professor Jones disrupted faculty meetings with his insane ideas. His colleagues used to argue vehemently with him. However, the chairman finally convinced them to simply ignore Jones. Soon, Jones wasn't disrupting meetings anymore.
What procedure is this an example of?

6. Ward liked Bev a lot so he went out of his way to find things about her to compliment. At first, Bev liked this and smiled and thanked him. However, after she got engaged to Tom she felt embarrassed by Ward's compliments. As a result she invariably ended up ignoring them. Ward doesn't compliment her anymore.
What procedure is this an example of?

7. Joe's TV went on the blink during the NFL playoffs, so he tapped it with the palm of his hand. Immediately, the picture cleared up. Now, whenever, the picture goes bad, he taps the set. What procedure is this an example of?

8. Gail felt that her 6-year-old son was not expressive enough. So she decided to give him a special treat every time that he spontaneously hugged her. She found that he gradually became more expressive. What procedure is this an example of?

9. Mary wanted to teach John how to do really good, fast dancing. She decided to start by teaching him some very slow steps. Slow dancing would be called a(n) ______.

. A baby may say "dad" to may males other than his father. His parents, by reserving their attention for those occasions when the child says "dada" to his father, will eventually teach the child not to say "dada" to any other males.
What procedure is this an example of?

11. Clarence is a skilled carpenter. One day he was reminiscing about how he had learned to hammer in a 16-penny nail with one thump. At first his father had praised him only when he hit the nail with each tiny tap-taking many taps to drive the nail in. His father had then praised him only when he drove it in with several rough raps. Finally, his father had praised him only when he drove it in with one thunderous thump. What procedure was his father using?

12. Pat teased Carol incessantly about her weight. At first, Carol took it all seriously. Then later she stopped taking it so seriously and just laughed it off and soon Pat stopped the teasing. What procedure is this an example of?

13. Tom liked compliments a lot. So anytime that he got one he beamed and profusely thanked the person for the compliment. Tom noticed that this increased the number of compliments he got from each person that he had thanked.
What procedure is this an example of?

14. At first Mary tried to be nice to Fred. But she did not like the kind of attention that he gave her, so she finally just totally ignored his attention and he stopped paying attention to her. What procedure is this an example of?

15. Jim spontaneously trimmed the front hedge around his home one day. His parents were delighted and took him out for a steak dinner to reward his work around the house. His helping continued. What procedure is this an example of?

Application 1 and 2-Answer Sheet

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Appendix 16

Experiment 2-Write Definitions

In your own words, please write a definition for each of the following concepts listed below. Once you have completed an item, go on to the next one and do not return to any previous items. Use the back of the page if you need more space.

1. Shaping

2. Reinforcement

3. Extinction

Appendix 17

Experiment 2-Recall 2

1. The operation of __________ reinforcement is called extinction.

2. __________: the operation of discontinuing reinforcement.

3. Extinction is defined as __________ the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent rate of the behaviour.

4. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a __________ in the subsequent rate of the behaviour.

5. Extinction is defined as stopping the delivery of a reinforcer that has followed a behaviour in the past and causing a decrease in the subsequent __________ of the behaviour.

6. Extinction applies only to stopping __________ that occur after a behaviour is emitted.

7. Extinction applies only to stopping events that occur __________ a behaviour is emitted.

8. The term extinction involves stopping an event that conforms to the definition of a __________.

9. The term __________ involves stopping an event that conforms to the definition of a __________.

10. The act of applying extinction to a behaviour is called __________ the behaviour.

11. __________ is used to mold a new behaviour.

12. Shaping is used to mold a __________ behaviour.

13. The behaviour that is the goal of a shaping program is called the __________ behaviour.

14. A behaviour that is __________ to the target behaviour in a shaping program is called an approximation.

15. A behaviour that is similar to the target behaviour in a shaping program is called an __________.

16. In shaping, once __________ has increased the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

17. In shaping, once reinforcement has __________ the rate of the first approximation, reinforcement is then applied to a second closer approximation to the target.

18. In shaping, once reinforcement has increased the rate of the __________ approximation, reinforcement is then applied to a second closer approximation to the target.

19. __________: reinforcing successive approximations of a desired goal behaviour until the target is reached.

20. Shaping: reinforcing __________ approximations of a desired goal behaviour until the target is reached.

21. A __________ is any event that follows a behavior and that increases the probability of that behaviour to occur again.

22. A reinforcer is any event that follows a behavior and that __________ the probability of that behaviour to occur again.

23. The term reinforcement is used to refer to the procedure of arranging for an __________ to follow a behaviour, knowing that the event will increase the rate of the behaviour.

24. The term reinforcement is used to refer to the procedure of arranging for an event to __________ a behaviour, knowing that the event will increase the rate of the behaviour.

25. The term reinforcement is used to refer to the procedure of arranging for an event to follow a behaviour, knowing that the event will __________ the rate of the behaviour.

26. __________: an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

27. Reinforcement: an event is __________ to the environment contingent upon a behaviour and there is an increase in the subsequent rate of that behaviour.

28. Reinforcement: an event is added to the environment __________ upon a behaviour and there is an increase in the subsequent rate of that behaviour.

29. Reinforcement: an event is added to the environment contingent upon a behaviour and there is an __________ in the subsequent rate of that behaviour.

30. an event is added to the environment contingent upon a behaviour and there is an increase in the subsequent _________ of that behaviour.

Recall 1 and 2-Answer Sheet

1. ______________________________

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Appendix 18

Experiment 2-Research Participant Survey

THANKS FOR YOUR HELP!

Circle the number that best corresponds to your ratings.

1. Rate the method of learning you were assigned? Each person was asked to perform in a particular way, please rate the method. Ask if you are unclear about this question.

a) Reading sentences and learning to an accuracy rate (going slow)

Least		Somewhat		Most
1	2	3	4	5

or

b) Reading and learning to an accuracy and speed rate (going fast)

Least		Somewhat		Most
1	2	3	4	5

2. Were you interested in the material (i.e., reading and the decks of computer cards) that you were asked to learn?

a) Shaping

Least		Somewhat		Most
1	2	3	4	5

b) Reinforcement

Least		Somewhat		Most
1	2	3	4	5

c) Extinction

Least		Somewhat		Most
1	2	3	4	5

3. In reference to the decks that you were interested/not interested, please state why?

a) Shaping

____

____

b) Reinforcement

____

____

c) Extinction

4. Which exercise did you enjoy, if any? Any particular reason why?

a) Fill-in-the blanks

Least		Somewhat		Most
1	2	3	4	5

Reason:

b) Identifying Examples

Least		Somewhat		Most
1	2	3	4	5

Reason:

5. Did you enjoy using the computer to learn?

Disagree		Somewhat		Most
1	2	3	4	5

6. Is there anything that you would suggest could be changed/added to help you learn this material better? (use back page if needed)

Appendix 19

Experiment 1-Interest Survey Results

Subject 1
I really liked the computer and the feeling of being 'reinforced' by the sound whenever I got something right. I know it sounds silly, but a screen-color change on right answers would further the excitement in getting something right!

Subject 2
A lot of the examples sound like the same thing. So it was hard to differentiate.

Subject 3
I find I learn much better when I have to write down the material. I became very frustrated with my difficulty in remembering the information. I don't feel like I was able to remember very much at all. I am usually quite happy with my ability to comprehend and write tests. The academic nature of the information wasn't very exciting for me and I found I became lazy and bored by the topic. I was surprised to find that I stopped trying hard to remember when I didn't experience success easily. I was terribly frustrated that I couldn't remember even after so many exposures to the same sentence. I certainly could distinguish the difference between examples but couldn't remember the name.

Subject 4
The computer program was good. I really got caught up in it. It was difficult at times remembering whether I was supposed to go slow or fast, because I always wanted to get through it quickly. Maybe the computer could remind me to slow or speed up.

Subject 5
For better recall-use notes or note taking and/or a refresher period prior to the last appointment.

Subject 6
I really liked the computer program but I felt that going slow through the sentences was boring.

Subject 7
I found writing the answers better than using the computer to help me remember them.

Subject 8
By learning on the computer you are just memorizing the words that fill in the appropriate blanks. I didn't find that I learned the concepts as well, however, this was also the most enjoyable way to fill in the information.

Subject 9
A second reading of the written material after computer session to put the rote learning back in context. Most of the time I focused on accomplishing the specific task, I'm not sure I learned things long-term.

Appendix 20

Experiment 2-Interest Survey Results

Subject 1
Filling in the blanks (repeats) is good for memorization of the key words but it is not enough for actual comprehension and retention of theory.

Subject 2
Along with cue cards of distinct words, have examples for them as well as part of the learning. This would help the learner to quickly associate a 'picture'/'example' to the distinct words, making it perhaps faster to learn and remember.

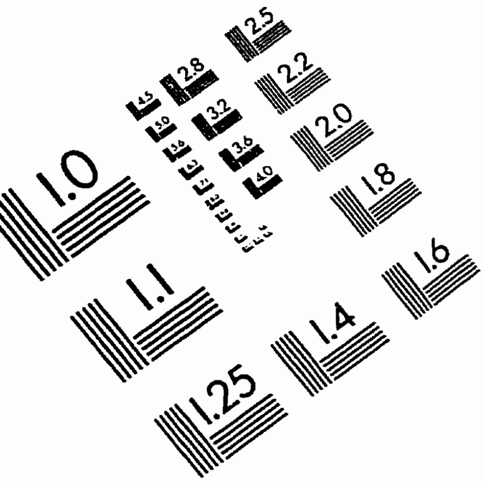
Subject 3
I found the whole thing too repetitive.

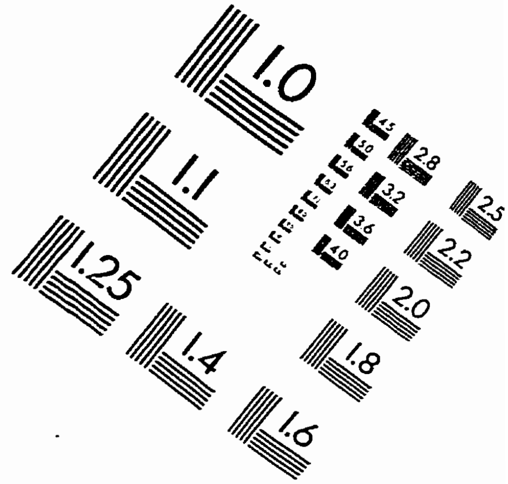
Subject 4
Think Fast was a good program and I think I would like the opportunity to use it as part of a survey course. However for me, nothing can beat an obscure, funny professor standing up there trying to impart his/her take on the text.

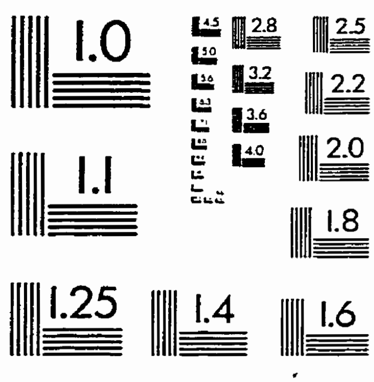
Subject 5
Possibly a more critical or detailed introduction to the ideas of shaping, reinforcement and extinction. This would ground to testing in a more broad context.

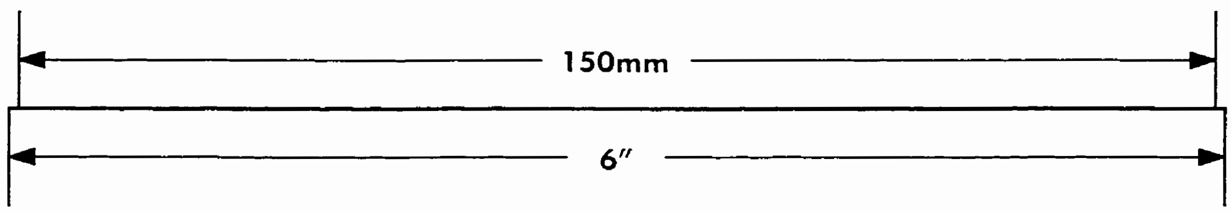
Subject 6
I am amazed that I still remember so much of it. A lot to absorb, but it stuck. Information overload was an understatement.

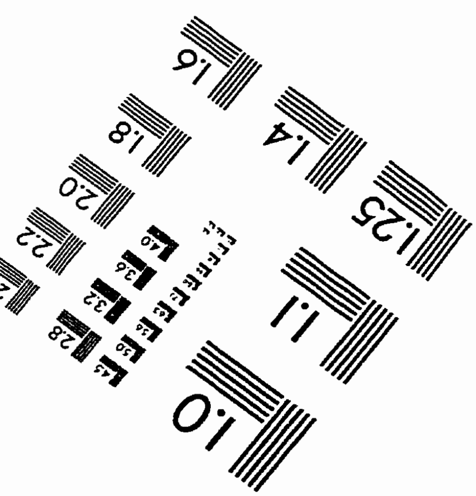
IMAGE EVALUATION TEST TARGET (QA-3)

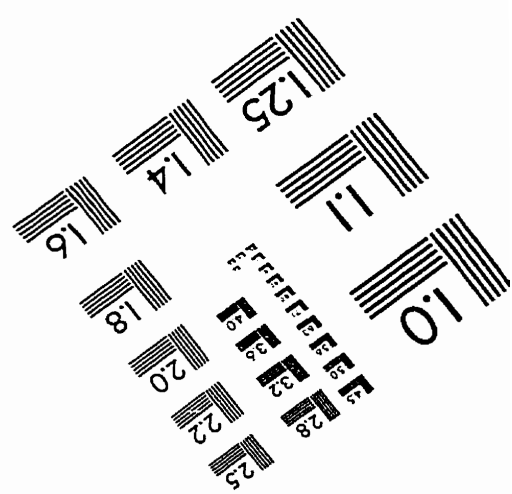












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