6-1988

Feedback and Learning Style in Concept Teaching Computer Assisted Instruction

William Bruce Allen

University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by William Bruce Allen entitled "Feedback and Learning Style in Concept Teaching Computer Assisted Instruction." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Richard A. Saudargas, Major Professor

We have read this dissertation and recommend its acceptance:

Donald Dickenson, Michael Johnson, Albert Wiberely

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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FEEDBACK AND LEARNING STYLE IN CONCEPT TEACHING COMPUTER ASSISTED INSTRUCTION

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

William Bruce Allen

June 1988

ACKNOWLEDGEMENTS

A number of scholars provided very valuable assistance to me in the process of the dissertation research. I am especially indebted to Professors Richard Saudargas, Donald Dickinson, Michael Johnson, and Albert Wiberely, who served as my dissertation chairman and committee respectively. This dissertation would not have been possible without the guidance and support of these men.

I am thankful for the assistance and cooperation of Dr. Arthur Butler and the rest of the staff of the Psychology Department at Carson Newman Community College. Dr. John Ray (at the University of Tennessee) and Dr. Karen Adams (at Carson Newman Community College) were also helpful in allowing me to use the computer lab facilities at the two institutions.

I am extremely grateful for the patience and cooperation of my wife, Dawn Pekarchick, and my daughter, Chenoa Dawn Allen.

ABSTRACT

The purpose of this study was to investigate the role of informative feedback in CAI and to examine possible interactions between learning style and type of feedback. An additional focus of the study was a subject matter error analysis that provided the basis for two of the six types of feedback studied. These two types of feedback were hypothesized to be more effective than the four types of feedback that were developed without consideration for common errors in the subject matter.

The study involved a two factor (feedback and learning style) repeated measures design. The participants were 106 undergraduate students who completed the Inventory of Learning Processes (ILP), took a pretest, ran a concept teaching CAI lesson, and finished both an immediate posttest and a long term (two to four weeks) retention test.

The results indicated that the two types of feedback that were based on the subject matter error analysis (corrective [misconception] feedback and process feedback) were more effective than the types of feedback that were not related to the error analysis. Regarding learning style, the two groups (the deep, elaborative group and the shallow, reiterative group) did not differ on measures of immediate performance but were significantly different on the long-term retention test. The deep, elaborative learners retained more knowledge. This is consistent with theories on learning styles (Craik

knowledge. This is consistent with theories on learning styles (Craik & Tulving, 1975; Schmeck, 1983).

The results of interactions between feedback and learning style were significant. The interaction comparisons suggested that shallow, reiterative learners benefited more consistently from feedback that was based on identified reasons for errors (both learning style groups benefited from this feeback, but the shallow, reiterative group benefited more consistently). The interaction comparisons also showed that the deep, elaborative learners benefited from a form of feedback that simply repeated and applied the concept difinitions (as well as from corrective [misconception] feedback and process feedback), while the shallow, reiterative learners performed significantly lower with this type of feedback. Compared to the deep, elaborative learners, the shallow, reiterative learners benefited more from the feedback designed to fit identified subject matter errors.

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CHAPTER 1

INTRODUCTION

Computer assisted instruction (CAI) may have a strength in the ability to use feedback promptly and effectively, based on a student's performance (Gilman, 1967; Roberts & Park, 1984; Roblyer, 1985; Roper 1977). CAI evaluation systems (Blease, 1986; Kleiman, Humphrey, & Buskirk; 1981; Marshall & Cannings, 1984; McPherson-Turner, 1979; Walker & Hess, 1984) usually assert that feedback is an important component of CAI, although few of these sources specify how, or under what circumstances, the different types of feedback should be used. Some experts (Cartwright, 1976; Cramer, 1984; Meadowcraft, 1976) have reported that feedback is often used inappropriately in CAI software. The research on feedback in CAI is not consistent and has not related types of feedback to student variables (different students may benefit from different types of feedback). In addition, most of the CAI feedback research has failed to specify the processes used to develop the types of feedback studied, and the characteristics of the subject matter that might relate to type of feedback. The purpose of this study was to examine the role of informative feedback in concept teaching CAI, and to investigate possible interactions between type of feedback and student variables (student learning styles). Another unique aspect of this study was the systematic analysis of the subject

matter, conducted so that types of feedback could be developed to match the characteristics of the subject matter.

CHAPTER 2

LITERATURE REVIEW

A number of different bodies of literature are relevant to the study of informative feedback in CAI and to interactions between feedback and student learning styles. There is much theory and research on feedback in instruction, although most of the feedback research involved programmed instruction, rather than CAI. Another relevant body of literature covers the instructional design process, especially procedures for analyzing a subject matter. This is important because instructional feedback may be most effective when it is based on an analysis of the subject matter. A final source of literature is the growing number of articles and books on student learning styles and relationships between learning styles and instruction.

Informative Feedback

Types of Feedback

In instructional settings, feedback is the information that follows a learner's response. This information can take a variety of forms and may serve different purposes, depending on whether it follows correct responses or incorrect responses.

Skinner (1958) emphasized the importance of feedback following correct responses. In teaching machine programs there are supposed to be few incorrect responses and many correct responses. The confirmation (in the form of feedback) of a correct answer was theorized to be reinforcing.

While Skinner focused on feedback as reinforcement for correct responses, others (Amsel, 1960; Anderson & Faust, 1973; Anderson, Kulhavy, & Andre, 1972; Bloom, 1976; Cramer, 1984; Gagne, 1977; Kulhavy, 1977; Pickthorne, 1983) have emphasized the value of errors and the importance of feedback following incorrect answers. Making errors, learning that they are incorrect, and receiving more information about the correct answer may help the learner refine his or her understanding of the material being taught.

Buss and associates (Buss, Braden, Orgel, & Buss, 1956; Buss & Buss, 1956) conducted research suggesting that, for concept learning, it is more important to provide feedback after incorrect responses than it is to provide feedback after correct responses. A group that received feedback only after incorrect responses and a group that received feedback after both correct and incorrect responses performed at about the same level, while both of these groups learned faster than a group that received feedback only after correct responses. The investigators concluded that feedback after incorrect responses (informative feedback) can be more powerful than feedback after correct responses (reinforcing feedback) in concept learning tasks.

There are many different ways in which feedback (after incorrect

responses) can provide information. Roberts and Park (1984) examined the research and then categorized informative feedback based on a continuum of complexity. The more complex types of feedback are assumed to be the most effective. The simplest type of informative feedback provides information about the accuracy of a response by indicating that the response is either correct or incorrect. This type of feedback can be called knowledge of results (KR). Another type of feedback, knowledge of correct response (KCR), conveys more information than KR because KCR informs learners of the correct answer.

The most complex types of feedback provide additional information to help learners. More informative feedback is hypothesized to be more effective. Roberts and Park (1984) noted that there are many ways in which feedback can provide additional information. Examples include descriptions of the correct answer, explanations of specific parts of the correct answer, and information about the incorrectly chosen answer. The first two examples can be called corrective feedback because they give explanations about the correct answer. When corrective feedback addresses the students incorrectly chosen answer it can be called response sensitive feedback (the feedback statement depends on the students chosen response).

Another type of corrective feedback, process feedback, deserves special mention. Process feedback takes a different approach by presenting the correct problem solving procedures and by showing learners where they went wrong in the problem solving process.

Anderson and Faust (1973) included process feedback in the category that focuses on the correct answer (corrective feedback). However, because an analysis of problem solving processes may provide much more information than explanations of the correct answer, process feedback and corrective feedback will be considered as separate types of informative feedback.

These various types of feedback have been the focus of much research. This research has been conducted with a number of instructional formats, including classroom settings, programmed instruction, and CAI.

Research on Feedback in Classroom Settings

A large number of studies have examined the use of feedback in classroom settings with live teachers. Travers, VanWagenen, Haygood, & McCormick (1964) conducted a study that involved KR and KCR in a simulated classroom setting. The learning task involved paired associations (German-English word pairs). The students were asked to choose between two possible answers. Even though the KCR provided redundant information (in the KR group the correct answer was implied when the chosen answer was said to be wrong, because there were only two choices per question), it resulted in significantly higher scores on the criterion test. The researchers concluded that "a relationship seems to exist between information content of the feedback condition and extent of learning" (p. 170-171).

Lysakowski and Walberg (1982) published the results of a

meta-analysis of 54 studies conducted in classroom settings and found "large and consistent effects" of informative feedback. The results applied to fact learning and concept learning. The value of informative feedback in classroom settings seems to be well documented.

Research on Feedback in Programmed Instruction

As with the research involving classroom instruction, the research with programmed instruction has included many studies dealing with the effectiveness of different types of feedback, especially KR and KCR. This research is less consistent than the work involving classroom settings and live teachers.

Some of these studies have found that feedback did not improve posttest scores. Two studies (Krumboltz & Weisman, 1962; Rosenstock, Moore, & Smith, 1965), both involving concept learning, found that various schedules of continuous, fixed ratio, and variable ratio feedback (KR) were no better than no feedback (based on posttest scores). Other studies have also failed to find advantages for informative feedback (Bivens, 1964; Wentling, 1973). Merrill (1970) examined the following types of feedback: none, KR, KR plus single or multiple repetitions of the question, and process feedback (a step-by-step explanation of how to reach the correct answer) plus repetition of the question. The groups did not differ on the posttest, although the process feedback groups did complete the programs significantly faster than the other groups.

One study actually suggested that no feedback may, at times, be more beneficial than feedback. Lublin's (1965) study involved various feedback schedules (no feedback, continuous KCR, variable ratio 50% KCR, and fixed ratio 50% KCR) in Holland and Skinner's (1961) The Analysis of Behavior (a programmed text that teaches concepts). The effect of feedback on posttest performance was significant, with the no feedback group scoring highest and the continuous KCR group scoring lowest. This seems to contradict the idea that informative feedback should facilitate learning.

A number of the programmed instruction feedback studies (Anderson, Kulhavy, & Andre, 1971; Holland & Porter, 1961; Karraker,1967, Meyer, 1960; Moore & Smith, 1964; Suppes & Ginsberg, 1962) are more consistent with the theories of informative and corrective feedback, which state that feedback facilitates learning and more informative types of feedback are more effective. Meyer (1960) studied feedback using programmed texts that taught common prefixes to eighth grade students. One group received delayed feedback (KCR), a second group received KCR, and a third group received KCR and repeated incorrectly answered questions. The KCR groups did not differ significantly but both KCR groups performed above the delayed feedback group (based on pretest to posttest gain scores). In addition, the delayed feedback group made more errors and failed to answer more questions within the programmed lesson.

Moore and Smith's (1964) study also lends support to the use of feedback in programmed instruction. These researchers compared KCR

and KR in Holland and Skinner's (1961) programmed text. KCR resulted in higher posttest scores (but only for students who completed multiple choice lessons, and not for students who completed constructed response lessons).

The work of Anderson, Kulhavy, and Andre (1971) attempted to account for the contradictory findings of the programmed instruction feedback studies. Most of the studies that found no benefit for informative feedback involved over-prompted programs and/or programs in which it was possible to look ahead and copy the answer from the feedback statement. There were probably few errors and little need for informative feedback. This could account for the fact that informative feedback was not effective in some of the programmed instruction research.

This theory was tested in a series of studies (Anderson, Kulhavy, & Andre, 1971, 1972). The 1971 report included two experiments involving undergraduate students and a programmed test on the diagnosis of myocardial infarction from electrocardiograms. In the first experiment the criterion test showed significant differences. The KCR group, time out (15 seconds) plus KCR group, and KCR plus repetition of questions group scored higher than the no feedback group. In a second experiment, a "peek" KCR condition was studied. The KCR was on the same page as the question in the peek condition. This approximates some programmed tests in which students have easy access to feedback statements. The KCR group scored significantly higher than the peek group and the no feedback group, even though the

peek group made significantly fewer errors within the lesson. Similar results were found in a study using CAI lessons that taught population genetics concepts (Anderson, Kulhavy, & Andre, 1972).

Considering the results of this work, it seems that KR and KCR (the most frequently studied types of feedback in the programmed instruction research) can be beneficial in programmed instruction if errors occur and if the feedback is not available prematurely. This seems to apply to programmed instruction lessons that teach facts, procedures, or concepts.

Research on Feedback in CAI

A relatively small number of published studies have examined the use of feedback in CAI. Some of these research studies involved concept learning, while others involved paired associate learning or mathematical procedural learning. Only about half of these studies supported the idea that more informative types of feedback are more effective than less informative types of feedback.

Three studies, all involving concept learning, found KCR to be valuable in CAI (Anderson, Kulhavy, & Andre, 1972; Gilman, 1969; Roper, 1977). Roper (1977) used an adjunctive program (the initial instruction was not done on the computer) that tested students on statistical concepts and procedures. One group received KCR, one group received KR, and one group received no feedback. On a posttest, the KCR group performed significantly higher than the other two groups.

A study by Anderson, Kulhavy, and Andre (1972), mentioned earlier, also involved concept teaching CAI and KCR. A group that received KCR following errors performed at a significantly higher level (on a posttest) than did a group that was exposed to KCR before responding (the "peek" condition).

One study failed to show any significant benefit for KCR in CAI. Steinberg (1980) used CAI to teach procedural problem solving to young children (first graders). The students received either practice, KCR, or process feedback. These three conditions did not result in significant differences on performance within the lesson. The researchers concluded that the feedback conditions used were not effective with first grade children.

In general, it seems that KCR can be valuable in CAI, at least with older students who are learning concepts. The CAI research on corrective feedback is not as consistent.

Three studies have lent support to the idea that corrective feedback is effective in CAI. Roberts and Park (1984) examined corrective feedback, KR, and no feedback in an adjunctive CAI lesson (the concepts were not initially taught by computer). When compared to the other two groups, the corrective feedback group required fewer questions to reach criterion and scored higher on a posttest. Long term retention was not measured.

Tait, Hartley, and Anderson (1973) used CAI to teach 2 and 3 digit by 1 digit multiplication to young children. Three feedback conditions were examined: no feedback, "passive" feedback (corrective

feedback explaining the correct answer), "active" feedback (process feedback that led students through the correct steps in the procedure), and active feedback with repetition of incorrectly answered questions. The authors concluded that feedback, in general, is better then no feedback, but they did not find significant differences between corrective (passive) feedback and process (active) feedback. With young children learning procedural math skills, corrective feedback may be valuable and may be as effective as process feedback.

Another study examined three types of corrective feedback (Keats, 1968). In this study, sixth grade students studied CAI lessons involving procedural math skills. One group received a brief verbal definition as feedback, a second group received a numerical example as feedback, and a third group received a complex form of corrective feedback that included detailed instructions, a review question, and either a definition or a numerical example, as determined by the experimenter's intuition. During the program the verbal definition group performed significantly better than the numerical example group. However, there were no significant differences on the posttest. In addition, the study did not include groups receiving no feedback or less informative types of feedback (KR or KCR). Therefore, the only conclusion that can be drawn from this study is that, during procedural mathematical learning, corrective feedback in the form of verbal definitions may be better than corrective feedback in the form of numerical definitions. Retention may be uneffected by type of

feedback. Nothing can be said about corrective feedback in relation to other types of feedback.

A different type of corrective feedback was studied by Siegel and Misselt (1983). The corrective feedback compared the correct answer and the student's incorrecty chosen answer, and can be called response-senstive corrective feedback. One group received response-sensitive corrective feedback, another group received response-sensitive corrective feedback along with discrimination training (additional questions on the correct answer and the incorrectly chosen answer), and a third group received KCR. The study involved CAI lessons that taught paired associations (Japanese-English word pairs) to undergraduate students. The group receiving response-sensitive corrective feedback with discrimination training confused the stimuli significantly less often than did the other two groups (the other two groups were not significantly different). However, the results of this study, which involved paired associate learning, cannot automatically be generalized to concept learning CAI.

The studies by Keats, 1968; Roberts and Park (1984), Siegel and Misselt (1983), and Tait, Hartley, and Anderson (1973) all support the idea that corrective feedback may be effective in some CAI programs. However, a number of studies have failed to support the value of corrective feedback (Gilman, 1969; Lasoff, 1981; Schoen, 1972). Merrill (1987) reported an experiment that involved junior level chemistry students who studied concept teaching CAI lessons. One group received KCR and a second group received corrective feedback.

There were no significant differences between these two groups. However, this study had a few notable weaknesses. First, the corrective feedback group received feedback only after the second incorrect response to a question, while the KCR group apparently received feedback after every incorrect response to a question. Additionally, neither group made many errors in the CAI lesson, and thus the feedback was not received very often. Finally, the posttest was very short (10 items) and may not have been very sensitive to differences between groups of students.

Another study (Schoen, 1972) offered inconsistent evidence on the value of corrective feedback. Schoen's (1972) study used CAI lessons that presented mathematical concepts to undergraduate students. When errors occured, one group received an explanation of the correct answer (corrective feedback) and the other group received KCR plus an explanation of why the chosen answer was wrong (response sensitive corrective feedback). The participants took two immediate posttests covering different sets of concepts. The two groups did not differ on the posttest covering the first set of concepts. The response sensitive corrective feedback group scored significantly higher on the posttest covering the second set of concepts. The authors concluded that response sensitive corrective feedback was not clearly superior. It is important to note that the researchers failed to describe the two sets of concepts. It is possible that differences in the sets of concepts might explain the different effects of the feedback.

A study by Gilman (1969) also failed to support the effectiveness

of corrective feedback. This study involved concept teaching CAI, undergraduate students, and a large main frame computer. Types of feedback studied included no feedback, KR, KCR, corrective feedback, and KR, plus KCR, plus corrective feedback. On number of responses to criterion and number of times through the program (to criterion), the corrective feedback group performed better than the no feedback and KR groups, but did not perform better than the KCR group. On time to reach criterion, the corrective feedback group was significantly lower than all the other groups. On the posttest, the no feedback, KR, and KCR groups scored significantly higher than the group that received KR, plus KCR, plus corrective feedback, and slightly (but not significantly) higher than the corrective feedback only group. The author concluded that KCR seemed to be the most effective type of feedback.

A fourth study questioning the value of corrective feedback was conducted by Lasoff (1981). Undergraduates studied CAI lessons on programming procedures and received either no feedback, KR, or corrective ("enriched") feedback. On a 20 item posttest, the KR group performed significantly higher than both the corrective feedback and no feedback groups. However, the number of students involved was small (9 to 12 students per group) and there was no pretest. These facts indicate that the equivalence of the groups (before treatment) may be in question.

To summarize the CAI research on corrective feedback, it seems that corrective feedback may be effective in CAI, but is not

necessarily the best type of feedback in some circumstances. Lasoff (1981) suggested that, in some cases, brief feedback statements may be the most valuable (Lasoff's study involved procedural skill learning). Merrill (1987) noted that corrective feedback may be beneficial when the subject matter is more complex and when feedback is received often. However, no firm conclusions can be drawn at this time.

The final type of feedback that has been researched in CAI is process feedback (a description of the procedures for reaching the correct answer). Lau (1979) compared KR, corrective feedback, and process feedback in CAI lessons teaching concepts. The process feedback group performed significantly higher on a posttest than did the other two groups. The researcher suggested that the results should be verified with studies that also measure long term retention (Lau's study did not include a delayed retention test).

Three other research studies have investigated process feedback in CAI. The study by Tait, Hartley, and Anderson (1973) is described above. Young children studied simple multiplication procedures in CAI lessons. Process feedback was more effective than no feedback, but was not significantly better than corrective feedback. Young children learning procedural math skills may benefit as much from an explanation of the correct answer as from a description of the correct procedures.

Another CAI study involved procedural skill learning and process feedback. Gilman (1967) used ninth and tenth grade students and a large main frame computer (which responded slowly by today's

standards). KCR was compared to process feedback, with no significant differences found between these groups. The researcher tentatively concluded that less elaborate types of feedback may be as effective as more elaborate, informative types of feedback.

One other study (Steinberg, 1980), mentioned above, investigated process feedback in CAI that was used to teach procedural problem solving to first grade children. The students received either practice, KCR, or process feedback. The three groups did not differ significantly in their performance within the lesson. Steinberg concluded that neither of the feedback groups (process feedback and KCR) were especially effective with first grade children.

The results of the research on process feedback in CAI are not conclusive. Three studies failed to show the effectiveness of process feedback (Gilman, 1967; Steinberg, 1980; Tait, Hartley, & Anderson; 1972). All three of these studies involved procedural skill learning. Only one study examined process feedback in concept teaching CAI (Lau, 1979). This study found that process feedback significantly improved immediate retention (no delayed retention test was used). More research is needed to determine if process feedback is effective in concept teaching CAI.

Summary of the research on feedback in CAI. Overall, the research on feedback in CAI has been inconsistent. The single exception to this seems to be the conclusion that, in CAI, KCR is often more effective than no feedback. Corrective feedback can be

effective, but may not always be better than less informative types of feedback. In some cases (perhaps in procedural skill learning) a brief form of feedback may be more effective than corrective feedback. Lessons on more complex material may benefit from corrective feedback, especially if the error rate is high. However, in CAI research, corrective feedback has not consistently been found to be better than less informative types of feedback (this may be due to improper fit between the types of feedback used and the subject matter studied).

Process feedback may not be better than less informative types of feedback for young children learning procedural math skills. However, one study (Lau, 1979) involving older students and concept learning found that process feedback was beneficial on an immediate posttest (long term retention was not measured).

Further research is needed to investigate various types of feedback in different types of CAI learning tasks. The research reported so far has been variable and inconsistent. Therefore, it is important to carefully investigate and describe variables that may interact with type of feedback. The most effective type of feedback for one learning task may not be the most effective type of feedback for other learning tasks. Similarly, the most effective type of feedback for one student may not be the most effective type of feedback for other learners.

Subject Matter Error Analysis

The contradictory results of the CAI feedback research may be due to the wide variety of learning tasks studied. Many of the CAI feedback research reports do not describe the subject matter very well. Additionally, many of these studies do not describe how the types of feedback were chosen. Different types of informative feedback may be effective for different types of subject matter, especially if the types of feedback are carefully developed. An analysis of a particular subject matter may give clues about the best type of feedback, especially if frequent errors, and reasons for errors, can be clearly identified.

Students make errors for various reasons. One reason that comes to mind quickly, perhaps because of overuse, is lack of knowledge about the subject matter. However, errors can also occur because of incorrect input (mis-reading the problem), incorrect output (a mistake in responding, even though the correct answer was intended), and, most importantly, faulty processing.

Processing errors may occur because of an incomplete or faulty understanding of the material, and may involve simplification of the material, omission of material, or use of inappropriate rules or strategies (Bachor, 1979). It may be possible to examine performance and errors and then to determine the reason for the errors, including possible underlying misconceptions or processing errors (Bachor, 1979;

Cramer, 1984; Larkin & Rainard, 1984; Pickthorne, 1983). If the errors are due to misconceptions or faulty problem solving procedures, and if these "error factors" (Pickthorne, 1983) can be identified through error analysis, then instruction (including the effective use of feedback) may be improved when these error factors are taken into consideration.

Bachor (1979) has described two types of error analysis procedures, intra-student error analysis and inter-student error analysis. Intra-student error analysis involves the study of one student's performance in order to diagnose and correct his or her misconceptions. This approach is the one used by a tutor working individually with a learner. This approach has also been used in the field of artificial intelligence, where efforts have focused on developing computer programs that can simulate experts' problem solving processes and learners' (novices') faulty problem solving processes. These efforts have focused on many different subject matter areas, including arithmetic word problems (Kintsh & Greeno, 1985), algebraic word problems (Paige & Simon, 1966), algebraic equation solving (Lantz, Bregar & Farley, 1983), geometric problems (Greeno, 1980; Greeno, 1978), physics problems (Larkin, McDermott, Simon & Simon, 1980; Simon & Simon, 1978), conversion problems (Larkin & Rainard, 1984), "spy problems" (Hayes, 1966), computer programming (Soloway, Rubin, Woolf, Bonar, & Johnson, 1983) and statistics and probability problems (Cohen, 1982; Kehneman & Tversky, 1982). However, a tremendous amount of time and effort will be needed before

any of these systems will have the sophistication necessary to identify and correct a learner's misconceptions during the instructional process.

Bachor's (1979) second type of error analysis, inter-student error analysis, focuses on errors common to a particular subject matter. This approach may be helpful for developing effective CAI software and for identifying the most effective types of informative feedback. Inter-student error analysis involves an analysis of the subject matter and an examination of the performance of a group of students who are studying the subject matter. Typical errors, misconceptions, and faulty procedures can then be identified. Pickthorne (1983) has noted that "at a particular stage or level in the learning of a subject (e.g., 'elementary' physics) it has been found that learners are vulnerable to highly similar EFs [error factors] and tend to make very similar errors." (p. 285). If inter-student error factors (common reasons for errors in a particular subject matter) can be identified then they can be addressed when errors occur. An inter-student error analysis could be conducted before CAI programs are written so that the information gained can (hopefully) be used to develop the most effective type(s) of feedback.

An inter-student (subject matter) error analysis could involve a number of different methods, including an analysis of the subject matter, an examination of the demands of the task, and a review of the performance of learners working on the subject matter. Additionally, important information can be generated through an investigation of

expert and novice problem solving procedures typically used with the subject matter.

The analysis of the subject matter involves a taxonomical study of the structure of the material to be taught (Tennyson & Park, 1980). For concept teaching, this means that the relationships among the concepts are established.

After the initial version of the learning task (the manner in which the subject matter is taught) has been developed, it should also be analyzed. This is done to determine the specific demands involved in the task (Ribich & Schmeck, 1979). Each learning task requires a learner to do certain things. The objectives and the initial questions clue the learner about the task demands. Bloom's taxonomy (Bloom, 1976, Bloom, 1956) offers a useful way for classifying the demands of the task (based on level of understanding required) and provides information that may be helpful in a subject matter error analysis.

Further information about the subject matter is gained through a review of the performance of learners working on various tasks that teach the subject matter. Expert instructors (who observe learners) may have ideas about the difficulties learners have with the subject matter. Completed tests on the subject matter can be analyzed in search of common mistakes and patterns of errors. More important than performance on existing tests is performance on specialized test questions developed during the error analysis (Bachor, 1979). These specialized questions can be designed to tap suspected misconceptions

or processing errors. Students' performance on the specialized tests can be examined for further information about the subject matter.

The specialized tasks can also be used to investigate the problem solving procedures typically used to approach the subject matter. Experts and novices may be asked to talk as they work on a number of learning tasks. This method generates think-aloud protocols which can provide information about the problem solving procedures used (Larkin & Rainard, 1984; Pask, 1976a, 1976b). Comparison of the learners' procedures and the experts' procedures may provide valuable information about why learners make errors.

A combination of these subject matter analysis (inter-student error analysis) procedures may provide insight into the reasons for students' errors. It may then be possible to identify types of feedback that will be effective for the subject matter that has been analyzed. If more of the research on feedback in CAI involved subject matter error analysis procedures, then the results might more consistently support the effectiveness of corrective feedback and process feedback (these more informative types of feedback may not be effective unless they are carefully matched to the subject matter). The subject matter error analysis is a way of describing the subject matter and of attempting to match the feedback to the subject matter. As more CAI feedback research uses the subject matter error analysis it may become possible to analyze the accumulated knowledge in order to identify generalizable relationships between specific types of feedback and specific subject matter variables.

Learning Style

Learning Style Definitions

Just as the most effective type of feedback may vary across different types of learning tasks, the best type of feedback may vary for students with different learning styles. Schmeck (1983) defined learning style as "a predisposition on the part of some students to adopt a particular learning strategy regardless of the specific demands of the learning task" (p. 233). Learning strategy is then defined as "a pattern of information-processing activities used to prepare for an anticipated test of memory" (p. 234). A learning style is a hypothetical construct that describes a tendency to prefer certain approaches (learning strategies) to learning.

Tallmadge and Shearer (1969) stated that a learning style is "an attribute of an individual which interacts with instructional circumstances in such a way as to produce differential learning achievement as a function of these circumstances" (p. 222). Different types of instruction may be best for different learning styles. Additionally, learning styles are assumed to be relatively stable, although they may vary slightly in different contexts (with different learning tasks and/or learning goals).

Research on Learning Styles

Recently, much work (theory and research) has focused on individual differences in preferences for certain cognitive learning practices. Craik and his associates (Craik & Lockhart, 1972; Craik & Tulving, 1975) have discussed a theory of memory which considers the "depth of processing" during learning. "'Depth' implies a greater degree of semantic or cognitive analysis" (Craik & Lockhart, 1972, p. 675). Simply repeating a phone number over and over is processing at a shallow level. An example of processing at a deeper level is the creation of links comparing and contrasting ideas.

Craik and Tulving (1975) reported ten experiments on depth of processing. Students answered different types of questions about stimulus words. The different types of questions required different levels of processing of the stimulus words. Students who answered questions about typescript were assumed to be processing words at a shallow level. Questions about rhyme were used to lead to an intermediate level of processing. A deeper level of processing was required of students who answered questions about word categories. This was an incidental learning task because the students were unaware that they would later be tested for recall. In a number of different experiments the researchers found performance to be consistently related to level of processing (students who processed words deeply remembered the words better). As the authors concluded:

> It is clear that what determines the level of recall or recognition of a word event is not intention to learn, the amount of effort involved, the difficulty of the orienting task, the amount of time spent making judgements about the items, or even the amount of rehearsal the items receive...rather it is the qualitative nature of the task, the kind of operations carried out on the items, that determines retention, (Craik & Tulving, 1975).

The authors noted that "spread" of encoding was an important aspect of depth of processing. A variety of elaborations and connections make the information more meaningful to the learner. These meaningful elbaorations and connections may make the material easier to remember over long periods of time. Craik and Lockhart concluded that the ability to remember material "is a positive function of the depth to which the stimulus has been analyzed" (Craik & Lockhart, 1972, p. 675).

The idea that deep processing leads to better long term memory seems consistent with current theories of memory. Miller (1956) noted that learners can increase the amount learned by organizing information into "chunks." Deep processing involves the connecting of pieces of information into larger units, or chunks. Loftus and Loftus (1976) described these types of deep processing activities as elaborative rehearsal, which leads to better long term memory than maintenance rehearsal (shallow, or rote processing). In a similar manner, Neisser (1976) and Simon (1981) have both noted that memory involves relations, or associations, rather than separted bits of information. Deep processing seems to involve the creation of

associations and thus may lead to better memory than shallow, riterative, rote processing.

Marton and Saljo (1976a, 1976b) conducted research which suggests that depth of processing may be a learning style which is somewhat consistent, but is also influenced by task demands. In one study (Marton & Saljo, 1976a), students were given text to read with the general goal of learning from the text (this is an intentional learning task, in comparison to the incidental learning task used by Craik and Lockhart, 1972, and Craik and Tulving, 1975). After posttests, the researchers asked students about the processes used to learn from the text. The students tended to prefer certain learning strategies, which fell into two general categories: deep-level processing and surface-level processing. Some students tended to focus on learning factual content (the sign), which is shallow-level processing. Other students tried to learn the meaning of the text (that which is signified), which is deep-level processing. Marton and Saljo's (1976a, 1976b) conception of level of processing corresponds with the same concept as used by Craik and associates (Craik & Lockhart, 1972, Craik & Tulving, 1975). In the Marton and Saljo study (1976a), level of processing was clearly related to level of performance on general, conceptual questions about the text. Deep-level processing resulted in better performance.

In another study (Marton & Saljo, 1976b), the same authors found that surface-level processing could be induced by factual questions within the text. However, deep-level processing could not be induced

in all of the students. When given comprehension questions within the text, some of the students were led to use deep-level processing. Other students used only surface-level processing. For these students, surface-level processing was a more consistent learning style.

The work by Marton and Saljo (1976a, 1976b) and Craik and associates (Craik & Lockhart, 1972; Craik & Tulving, 1975) suggests that many learners tend to use either deep- or surface-level processing strategies. In some students, however, these tendencies (learning styles) can be influenced by task demands. Surface-level processing seems to be induced more easily than deep-level processing.

Pask (1976a, 1976b) reached very similar conclusions using a different approach to research on learning. Pask examined learning style with intentional learning tasks and a "conversational" technique. Students studied with the general goal of understanding. The conversational technique involved a dialogue in which the students verbalized while they learned. During the "conversation," students explained and answered questions about the subject matter and about their learning activities. This required learners to make their learning strategies explicit.

Pask found that learners fell into three different learning style groups: comprehension learners, operation learners, and versatile learners. Comprehension learners use holist learning strategies that focus on a number of goals and topics and conceptually relate concepts. This is very similar to the concept of deep-processing.

Operation learners use serialist learning strategies dealing with one goal or topic at a time, and build models that only describe facts (without making comparisons or inferences). Thus these learners may acquire only factual information. Versatile learners use both holist and serialist learning strategies, as required by perceived task demands. These learners may be the most effective, as both holist and serialist strategies are seen as prerequisites for full understanding.

Pask (1976b) conducted further research in which comprehension learners (deep processors) and operation learners (surface processors) were given either matched or mismatched instruction. Matched instruction was aligned with the identified learning style, while mismatched instruction taught to the opposite learning style. The results showed that "matched instruction favours learning and mismatched instruction completely disrupts it..." (Pask, 1976b, p. 138). This research did not involve versatile learners, who may be able to use any of the learning strategies, based on task demands.

Entwistle and his colleagues (Entwistle, 1981; Entwistle, Hanley & Hounsell, 1979) approached the study of learning style independently of Pask and Craik, yet came up with very similar conclusions about types of learning styles and consistency of learning styles. Entwistle and associates collected and analyzed questionaire data on approaches to learning. Factor analysis of the data suggested the existence of three major orientations to learning: meaning, reproduction, and achievement. The meaning orientation focuses on the ideas to be learned and ways for making new information personally

meaningful. The meaning orientation is similar to the idea of a deep approach to learning (Craik & Lockhart, 1972; Marton & Saljo, 1976a, 1976b) and the conception of the comprehension learning style (Pask, 1976a, 1976b). The reproduction orientation is like the surface approach (Marton & Saljo, 1976a, 1976b) and the operation learning style (Pask, 1976a, 1976b), because the focus is on syllabus-bound rote learning. The achievement oriented learner is guided by the desire to compete and to succeed. There is some indication that those using the achievement orientation may use both surface and deep approaches (Entwistle, 1981, p. 102). Thus the achievement orientation may be similar to the concept of the versatile learner (Pask, 1976a, 1976b) who uses different strategies in order to meet the demands of a particular task.

Schmeck (1983) has commented on the similarities in the results of the work of the various researchers in the area of learning style. He concluded that one of the most important factors in learning styles is depth of processing. Deep processing may be related to better retention of material, because deep processing strategies involve associative and elaborative rehearsal. Additionally, some learners may be more consistent than others in choosing certain types of learning strategies. To the extent that learning styles are consistent, instruction may be most valuable if it is matched to the learning style.

The Inventory of Learning Processes. Schmeck and associates have put much work into the development and validation of the Inventory of Learning Processes (ILP), a self report measure of learning styles (Schmeck, 1983; Schmeck, Ribick & Ramanaiah, 1977). Items were developed by experts, administered to students, and factor analyzed. The end result was a 62 item test (a 72 item research edition is also available) that appeared to measure four factors: Deep Processing, Elaborative Processing, Fact Retention, and Methodical Study.

The Deep Processing factor contains items assessing "the extent to which students critically evaluate, conceptually organize, and compare and contrast" (Schmeck, 1983, p. 245). This factor covers organizational procedures used in information processing. The Elaborative Processing factor includes items dealing with use of imagery, personal examples and terminology, and other linkages to personal experience. Like the Deep Processing factor, the Elaborative Processing factor has to do with information processing, but covers elaborative encoding procedures (as compared to organizational procedures). There is some evidence to suggest that the Deep Processing factor and the Elaborative Processing factor are somewhat similar. The correlation between these factors seems moderately high (Schmeck, 1983, cited an intercorrelation of .45). However, there is also some evidence of differential validity (this evidence is described below). Due to the similarity of the Deep Processing and Elaborative Processing factors, for the purposes of the current study Schmeck has recommended a scoring procedure involving the summation of

the Deep Processing and Elaborative Processing scores (R. R. Schmeck, personal communication, March 15, 1988). High scores indicate the use of a deep, elaborative learning style, while low scores represent a shallow, reiterative learning style. In this scoring system, the Fact Retention and Methodical Study scores are ignored.

The Fact Retention factor items center on a learner's focus on specific details. The Methodical Study factor items have to do with systematic techniques, especially drill and practice.

A fair amount of research has addressed the reliability and validity of the ILP. In fact, there seems to be more research on this instrument than there is on any of the other learning styles measures. Schmeck, Ribich, and Ramanaiah (1977) found the factors of the ILP to have adequate internal consistency (based on a sample of 434 students), although these statistics were a little low for the Elaborative Processing factor (.67) and the Fact Retention factor (.58). These researchers also reported that the factors have acceptable test-retest reliability statistics, which ranged from .79 to .88 (for a sample of 95 students).

Research pertaining to construct validity was reported by Schmeck and Ribich (1978). Relatively large numbers of undergraduate students were given a variety of tests, including the ILP. The Deep Processing factor was positively correlated with a critical thinking test and a self-report measure of curiosity, and was negatively correlated with two anxiety scales. The Elaborative Processing factor was positively correlated with two measures of mental imagery (especially a visual

imagery subscale), while the Deep Processing factor was negatively related to one of these imagery measures. These results support the idea that the Deep Processing and Elaborative Processing factors are somewhat different.

In the Schmeck and Ribich (1978) study, the Methodical Study factor was negatively related to the critical thinking test, and was positively related to a measure of conforming (versus independent) achievement striving. The Fact Retention factor was not significantly related to any of the other tests given. The Schmeck and Ribich (1978) study provides evidence for the construct validity of the ILP.

In another study, Schmeck and Grove (1979) found that the Deep Processing, Elaborative Processing, and Fact Retention factors were significantly correlated with college achievement, as measured by grade point average (GPA) and scores on the American College Testing (ACT) Program Assessment. There was also a significant (although small) negative correlation between ACT scores and the Methodical Study factor. This suggests that students who focus heavily on systematic drill and practice may have low ACT scores. High ACT scores are associated with other methods of learning facts, and with deep and elaborative processing.

The Deep Processing factor has been found to be related to measures of reading vocabulary and reading comprehension (Schmeck, 1980), suggesting that those who process deeply seem to understand more of what they read. The Deep Processing factor was not related to reading rate, which was interpreted as evidence of differential

validity. None of the other factors of the ILP were related to the reading measures.

These studies on the validity of the ILP could be explained by an alternate hypothesis: the correlations between the ILP factors and other measures may be due to general intelligence, rather than to different learning styles. Schmeck described an unpublished doctoral dissertation (Schmeck, 1983, p. 259) that dealt with this issue. Relationships between the ILP and performance remained after the effects of intelligence were statistically removed. Additionally, the strongest relationship found between the ILP and intelligence test scores was r=.39. These two results provide evidence suggesting that differences in intelligence may not fully explain the relationships found between the ILP and performance.

Thus, after initial research, the ILP has been found to be a relatively reliable and valid instrument for assessing the learning styles of undergraduates. When compared to two other self-report learning style tests, the ILP was found to correlate best with numerous performance measures (Ribich and Schmeck, 1979).

Learning Style: Summary

The work on learning styles suggests that learners often tend to prefer certain cognitive learning strategies. At the same time, students show a little variability in their use of learning strategies. More specifically, some students show more variability and may be able to adapt their use of learning strategies to task

demands. Research has rather consistently shown that depth of processing (making connections and focusing on meaning) and use of elaborative processing (using imagery and personal associations) are important dimentions along which learners vary. Deep and elaborative processors generally achieve at a higher level and have better long term retention. Learners who use shallow, reiterative learning strategies dwell on rote learning and may not learn or remember as effectively as deep, elaborative learners. The ILP seems to be a relatively reliable and valid tool for assessing these learning styles.

Research has indicated that students may learn best when instruction is matched to their learning style. The idea that students with different learning styles may benefit from different types of informative feedback has not been investigated.

Hypotheses

The current study was designed to investigate the role of informative feedback in concept teaching CAI, and to investigate possible interactions between types of feedback and student learning style. Additionally, this study involved a systematic subject matter analysis conducted to develop types of feedback that match the characteristics of the subject matter. These types of feedback were compared to more commonly used types of feedback.

Specifically, the following hypotheses were generated:

1. Informative feedback based on a subject matter error analysis is more effective than other types of feedback.

2. Students who report using deep, elaborative learning strategies learn and retain more than students who report using shallow, reiterative learning strategies.

3. Students who use deep, elaborative learning strategies perform at a higher level when given more informative types of feedback, while students who use shallow, reiterative learning strategies perform at a higher level when given less informative types of feedback that repeat the material to be learned.

The methods and procedures used to test these hypotheses are described in the next chapter.

CHAPTER 3

METHOD

The study involved a two factor, repeated measures design. One factor was feedback (six types were examined) and the other factor was learning style (two types were examined). Participants took a pre test, a posttest, and a two to four week retention test. Lesson time was considered as a covariate (as described below) because the individuals and feedback types were expected to differ widely in the time spent on the CAI lesson.

The participants, the equipment, and the materials used in the study are described below. This chapter also includes descriptions of the procedures used to develop the subject matter test, the CAI lesson, and the feedback types. The data collection procedures are specified at the end of the chapter.

Participants

The study involved 106 undergraduate students enrolled in general psychology courses at either a large university (82 participants) or a smaller private college (24 participants). The sample was roughly 65% female and 35% male. The mean age was 23 years (the age range was 18

to 41, although the range narrowed to 18 to 32 when the oldest participant was not counted).

The students earned extra credit for participating (participation was not required). Before beginning the study, all of the students reported that they had not previously been instructed in the subject matter taught by the CAI lessons.

Fourteen students (not included in the 106 described above) began but did not complete the study. Eight students indicated that, before completing the retention test, they had recieved additional instruction in the subject matter. Four students did not complete the retention test (the high rate of return for the retention test is believed to be due to the fact that extra credit was not assigned until the retention test was completed and returned). One student failed to return the ILP protocol, and one student did not return the short answer portion of the pretest. None of these students were included in the data analysis.

Equipment

Apple IIe computers were used to run the CAI lessons. Both of the schools involved had educational computing labs equipped with 10 computers.

Materials

The Development of the Lesson and Test

The subject matter to be taught was selected after interviews with instructors of undergraduate psychology courses (subject matter experts) and after an examination of errors on tests from a general psychology course. A set of difficult associated concepts (positive reinforcement, negative reinforcement, positive punishment, negative punishment, response cost, time out, and extinction) was identified for the research study. These concepts were chosen mainly because they cause notable confusion for learners. The concept definitions (presented in Figure 1) were derived from a textbook (McConnell, 1983) and from interviews with the subject matter experts.

Taxonomical analysis. The set of seven concept definitions was subjected to a taxonomical analysis (Tennyson & Park, 1980) in order to determine the relationships among the concepts. Four of the concepts (positive reinforcement, negative reinforcement, positive punishment, and negative punishment) are coordinate concepts, covering examples of behavior change resulting from the presentation or removal of stimuli. These concepts are at the same conceptual level, while the remaining concepts are subordinate. Two of the remaining concepts (time out and response cost) are subordinate to negative punishment, as they specify two distinct types of negative punishment. The final concept, extinction, is subordinate to positive reinforcement

POSITIVE REINFORCEMENT: A behavior occurs, followed by the presentation of a stimulus, resulting in an increase in the rate or strength of the behavior.

NEGATIVE REINFORCEMENT: A behavior occurs, followed by the removal of a stimulus, resulting in an increase in the rate or strength of the behavior.

POSITIVE PUNISHMENT: A behavior occurs, followed by the presentation of a stimulus, resulting in a decrease in the rate or strength of the behavior.

NEGATIVE PUNISHMENT: A behavior occurs, followed by the removal or unavailability of a stimulus, resulting in a decrease in the rate or strength of the behavior.

TIME OUT: A behavior occurs, followed by a period in which stimuli is unavailable, resulting in a decrease in the rate or strength of the behavior.

RESPONSE COST: A behavior occurs, followed by the removal of a stimulus, resulting in a decrease in the rate or strength of the behavior.

EXTINCTION: A formerly reinforced behavior occurs and is not followed by reinforcing stimuli (the stimuli is absent), resulting in a decrease in the rate or strength of the behavior.

Figure 1. Concept Definitions Used in the Test and CAI Lesson.

(extinction occurs when positive reinforcement is no longer available) and to negative punishment (extinction involves the absence or unavailability of stimuli, resulting in a decrease in the rate or strength of the behavior).

Expert interviews. Further information about the concepts was obtained from interviews with subject matter experts. Negative reinforcement was described as one of the hardest of the concepts taught in the general psychology courses. The experts gave three major reasons for the difficulty with negative reinforcement and associated concepts. One reason was misunderstanding about the meaning of the words "positive" and "negative." Many students seem to think that these terms referred to the pleasantness (positive) or aversiveness (negative) of the stimuli involved.

A second reason given by the experts was the similarity of the terms positive reinforcement, negative reinforcement, positive punishment, and negative punishment, which are different combinations of the same four words. There are also some confusing similarities in the meanings of the concepts. This similarity may confuse and overwhelm some students.

One of the experts mentioned a third reason for student's difficulty with the subject matter. The learners may fail to devote attention and effort to mastering the concepts, and thus have incomplete knowledge of the subject matter.

Review of general psychology exams. While the expert interviews provided valuable information about the subject matter and the reasons for errors, the general psychology course exam questions were less helpful. Exams from a number of different years were reviewed. The exams contained few questions on the seven identified concepts. Although the error rates were high, the questions were not diagnostically helpful.

Development of the pool of questions. Following the expert interviews and the exam review, examples and a large bank of questions were developed. Many of these questions were created to address the possible reasons for frequent errors, especially the idea that the terms "positive" and "negative" are used incorrectly (the example in Appendix B is one of these types of questions). The definitions and questions were reviewed by subject matter experts to insure that the definitions and questions were accurate (five experts were involved, although most experts reviewed subsets of the group of questions and examples). The definitions were revised once and were then approved by three out of three experts. Questions were accepted for the study only after having been answered correctly by at least three experts. Some questions were discarded while other questions were revised and reviewed again by subject matter experts.

The expert review served not only to validate the materials (as described above) but was also used to estimate question difficulty (Tennyson and Boutwell, 1974). After answering each question, the

experts completed a five point Likert rating scale which had the following labels: too easy (1), easy (2), moderately difficult (3), difficult (4), and too difficult (5). The expert ratings were then averaged for each question.

A second difficulty rating was obtained when the questions were field tested (in pencil and paper format) on small groups of undergraduate and graduate students (Tennyson & Boutwell, 1974). The difficulty rating was the percentage of students correctly answering each question.

These two difficulty ratings (one by experts and one by students) were used to eliminate very hard questions (rated 5 by the experts and answered correctly by less than 10% of the students) and easy questions (rated 1 or 2 by the experts and answered correctly by over 66% of the students). The remaining questions were used in either the lesson or the test.

Think aloud protocols from experts. The final purpose of the expert review (in addition to validating the materials and estimating the difficulty level of the questions) was to determine the problem solving procedures used by experts. As they worked on the questions the experts described the problem solving procedures they were using. The expert's procedures were recorded in a format similar to think-aloud protocols (Larkin & Rainard, 1984). The protocols were analyzed qualitatively for patterns. Quatitative data was also collected, in the form of the frequency of the patterns in the five

expert's think aloud protocols (which contained a total of 28 questions). The results provided information about effective problem solving processes.

All five of the expert reviewers usually attacked the questions in much the same way. After reading a question, the experts usually stated clearly the behavior that was the focus of the question. Next, the change in the rate or strength of the behavior (an increase or decrease in the rate of the behavior) was identified. Finally, the experts noted the change in stimuli following the behavior (stimuli were presented, removed, or unavailable). This problem solving sequence occured in 61 % of the 28 questions reviewed in the experts' think aloud protocols.

On the easiest questions, and occasionally on harder concepts, the experts sometimes reversed the order of the last two steps. In these cases the experts identified the change in the stimuli before focusing on the change in the rate or strength of the behavior (this occured in 29% of the questions reviewed in the experts' think aloud protocols; the remaining 10% could not be easily classified).

By using the steps above the experts were able to correctly answer the questions. However, it was apparent that the frequent use of "positive" and "negative" sometimes confused the experts, although usually only momentarily. Further evidence of the difficulty of the subject matter comes from the observation that, when working on the hardest questions, the experts sometimes made written notes as they followed the problem solving procedures.

Think aloud protocols from novices. Think-aloud protocols (Larkin & Rainard, 1984) were also collected from three naive students as they ran the CAI lesson (the lessons are described below in detail). These protocols wera analyzed in the same manner used to analyze the experts' protocols (the protocols were examined for patterns, and then the frequency of these patterns was calculated). There were many similarities in the ways the three students (novices) attacked the lesson. All three students complained about the fact that the words "positive," "negative," "reinforcement," and "punishment" were used frequently in the concept names. At times these learners forgot which concept was involved in a question on which they were working ("Is this supposed to be positive or negative reinforcement?").

In the think aloud protocols, all three learners sometimes used "positive" and "negative" to refer to pleasantness or averseness of the stimuli involved. Two of the three learners had a notable difficulty in using "positive" and "negative" correctly, with one of these learners always using these terms incorrectly. An example of this confusion of terms is when one learner, analyzing an example to determine the concept involved, stated "...negative reinforcement...a negative something removed..." In this instance, the learner mentioned both the correct and the incorrect meaning of the term "negative." On occasion, one learner used "negative" to refer to a

decrease in the behavior rate, and used "positive" to refer to an increase in the behavior rate.

The learners who contributed think aloud protocols used problem solving procedures that differed somewhat from the procedures used by the experts (as described previously). The novice learners often began, like the experts, by noting the behavior in question. The learners sometimes (but not always) used the second and third steps of the experts, although in variable order (the novices clearly followed one of the two expert problem solving sequences in 10% of the 128 questions reviewed by the novices). While the experts usually focused on the change in the behavior before attending to the change in the stimuli, the learners did not consistently attend to one before the other. At times the learners ignored the change in the stimuli, looking instead for the averseness of the stimuli (as discussed earlier). Thus, the learners rarely used the problem solving sequences used by the experts.

One other error the learners made during the think aloud protocols was to analyze the question from a common sense point of view. This error was fairly rare and occurred on some of the questions that the expert reviewers called "counterintuitive." For instance, one question (on positive reinforcement) involved a student who yelled answers in class. Each time this happened the insturctor screamed at the student. In the question, the instructor's screaming increased the rate at which the student yelled answers, although it might be expected (from a common sense point of view) that the

professor's screaming would decrease the student's yelling. The think aloud protocols show that on such counterintuitive examples the learners often classified the examples as if they conformed more to expectations. In the example above, the learners seemed to expect the instructor's yelling to decrease the rate of the behavior, and so classified the example as though that is what happened. In the words of one learner, "...but that's not gonna increase it, it [referring to the increase in the behaior] can't be right...." This learner then incorrectly chose positive punishment instead of the correct answer, positive reinforcement.

A description of the CAI lesson. After the questions were developed, refined, and analyzed, the test and first version of the lesson were assembled. The test and CAI lesson were reviewed by subject matter experts who made critical comments. The lesson was revised and reviewed again by subject matter experts. After the second review, the lesson was deemed acceptable (based on the experts' comments).

The lesson sequence is described in Figure 2. The lesson began with introductory frames, which included a title frame, a goal and motivational frame, and an objectives frame (see Appendix A for specific wording). A series of instructional and testing frames followed the introductory frames. First, a definition and example were presented for each of the four coordinate concepts (positive reinforcement, negative reinforcement, positive punishment, and

1. Introductory frames (see Appendix A);
2. Instruction:
   Definition and example of positive reinforcement;
   Definition and example of negative reinforcement;
   Definition and example of positive punishment;
   Definition and example of negative punishment;
3. Testing:
   Identify definition for positive reinforcement;
   Identify definition for negative reinforcement;
   Identify definition for positive punishment;
   Identify definition for negative punishment;
   Identify new example of positive reinforcement;
   Identify new example of negative reinforcement;
   Identify new example of positive punishment;
   Identify new example of negative punishment;
4. Instruction:
   Definition and example of response cost;
   Definition and example of time out;
5. Testing:
   Identify definition for response cost;
   Identify definition for time out;
   Identify new example of response cost;
   Identify new example of time out;
6. Instrtuction:
   Definition and example of extinction;
7. Testing;
   Identify definition of extinction;
   Identify new example of extinction;
8. Testing:
   Fourteen examples (two for each concept, presented in a mixed order [the exaples do not follow a systmatic order by concept, but are presented in the same order for each student]) to identify (chose the correct concept name);
9. Testing:
   Seven examples, each involing two concepts to identify (each concept is included in two examples, and the order of presentation is mixed);
10. Closing frame which tells the student that the lesson is over and instructs the student to report to the lab monitor to take the posttest.

FIGURE 2: A Description of the Components of the CAI Lesson.

negative punishment). Then the learner was asked to choose the correct definition when given the concept name (once for each concept). Next the learner had to recognize a new example (from a set of examples) when given the concept name (once for each concept).

Definitions and examples were then presented (one at a time) for the two subordinate concepts related to negative reinforcement (response cost and time out). As with the first four concepts, the instructional definitions and examples were followed by questions on the concept definitions. Next came questions requiring the identification of new concept examples.

Instruction (definition and example) for the final concept (extinction, a concept subordinate to positive reinforcement and negative punishment) was then presented. As with the other instruction-test sequences described above, the instruction was followed by a question requiring the learner to choose the correct definition of extinction. Then the learner was asked to recognize a new example of extinction.

The initial instruction-testing sequence was followed by 14 questions (two per concept) in which examples were presented singly for identification (learners were given concept names to choose from). The learner was next given seven complex examples which involved two concepts per example (the learner was required to identify both concepts involved, one at a time). A brief closing frame ended the program.

After the lesson was created, the task demands of the lesson were

specified. The objectives and types of questions determined the task demands. The lesson required knowledge of categories, comprehension, and application (Bloom, 1956). Knowledge of categories was needed to recognize and recall the concept definitions. Although the questions on the definitions involved wording similar to the wording in the instructional frames (which teach the definitions), the concepts were so difficult that comprehension was very helpful for performance. Application of knowledge is required on questions in which learners had to identify and give examples of the concepts. Considering these task demands, learners needed to gain a good understanding of the concepts in order to perform well on the lesson. Rote learning of concept definitions should not have been enough for mastery.

Summary of the subject matter error analysis. The subject matter error analysis included a review of the subject matter, a taxonomical analysis of the subject matter, expert interviews, the creation and testing of specialized questions, expert and novice think-aloud protocols, and an analysis of the task demands of the lesson. These procedures provided information about the subject matter and learning task and suggested a number of different reasons for the difficulty of the subject matter. The subject matter includes a set of four coordinate concepts and three subordinate concepts. All of the concepts are similar in meaning. Four of the concepts have very similar names. The learning task requires knowledge, comprehension, and application learning (Bloom, 1956).

The subject matter error analysis suggested that one possible reason for errors is incorrect use of the terms "positive" and "negative" to refer to the aversiveness of the stimuli, or, much less frequently, to refer to the change (increase or decrease) in the behavior. Another possible reason for errors is the similarity of the names of four of the seven concepts (positive reinforcement, negative reinforcement, positive punishment, and negative punishment). The expert interviews and think aloud protocols suggested a third reason for errors: experts and novices may use somewhat different steps in problem solving. A fourth reason for errors, suggested by one expert (but encountered nowhere else), is lack of full attention to the learning task. If students are well motivated to learn then lack of full attention may not be a common reason for errors. One final reason for errors involved the occasional tendency to interpret counterintuitive examples as though they fit common sense expectations. However, this error was rare.

Types of feedback developed from the subject matter error analysis. Based on this subject matter error analysis it may be possible to predict the most effective types of feedback. If the task involved rote learning (knowledge) then KR or KCR might be best. However, the task requires more in-depth learning (comprehension and application). Therefore, it seems likely that a more informative type of feedback may be better than KR or KCR. Additionally, the task is complex, errors are frequent (as demonstrated in the pilot study,

described later), and learners tend to have certain problems with the task. This suggests that well designed explanatory feedback may be hypothesized to be more effective than other types of feedback.

The subject matter error analysis led to the creation of two types of explanatory feedback which address the most likely reasons for errors. A form of corrective feedback was created to explain the meaning of the terms "positive" and "negative," which were found to be frequently misunderstood. This form of feedback also explains the words "reinforcement" and "punishment." More specifically, when a learner makes an error involving one of the coordinate concepts, the terms in the name of the concept are explained (i.e. an error on a question about negative reinforcement results in an explanation of the terms "negative" and "reinforcement"). When a learner makes an error on one of the subordinate concepts response-sensitive corrective feedback (feedback that explains the correct answer in relation to the incorrect answer) is given to help learners discriminate among confusing concepts. This first type of feedback, specially designed in light of suspected misconceptions (misunderstanding of the terms "positive" and "negative," and confusion of terms with similar names and meanings), will be called corrective (misconception) feedback. This form of feedback is hypothesized to be the most effective type of feedback for the learning task.

A second type of feedback was developed to address another of the suspected reasons for errors: students use ineffective problem solving processes. Experts and novices seem to approach the learning task in

different ways. Novices sometimes use problem solving steps that differ from those used by experts. Given these observations about the subject matter, it seems that process feedback may be effective for this learning task.

A form of process feedback was developed to describe the correct problem solving process used most frequently by the experts. The process feedback also points out to the learner where he or she went wrong in the problem solving process for a particular question. This form of feedback is hypothesized to be more effective than KR and KCR. Because there are few steps in the problem solving process, and because experts sometimes used the steps in different orders, it may be that the use of ineffective problem solving processes is a less important reason for errors than is confusion about the concept terms and meanings (described above). If this is true then corrective (misconception) feedback may be more effective than process feedback.

In addition to corrective (misconception) feedback and process feedback, the current study also involved other types of feedback that are routinely used in CAI. These types of feedback were: no feedback, KR, KCR, and corrective feedback. This form of corrective feedback repeats the definitions and applies information given during initial instruction. This type of corrective feedback was designed without consideration of the information gained from the subject matter error analysis.

The types of feedback examined in the study are summarized and defined in Figure 3 (see Appendix B for an example of each of the

NO FEEDBACK: The learner received no feedback message.

KNOWLEDGE OF RESULTS (KR): The learner was told only that his or her answer was incorrect.

KNOWLEDGE OF CORRECT RESPONSE (KCR): The learner received a statement specifiying the correct answer.

CORRECTIVE FEEDBACK: The learner was presented with the concept definition (as in the initial instruction), and, if the question involved an example, the learner was told how the defintion fit the example.

PROCESS FEEDBACK: The learner received an explanation of problem solving steps to use, and was told where he or she went wrong in the problem solving process. This type of feedback was based on the subject matter error analysis.

CORRECTIVE (MISCONCEPTION) FEEDBACK: If the question involved a concept with the terms "positive" or "negative," the learner received an explanation of all of the parts of the term involved (i.e., the learner recieved explanations of "postive" or "negative" and "reinforcement" or "punishment"). If the question involved a concept without the term "positive" or "negative," the learner received a comparison of the correct answer and the incorrectly chosen answer. This type of feedback was based on the subject matter error analysis.

Figure 3. Descriptions of the Feedback Types Studied. Appendix B includes examples of each type of feedback.

feedback types). The six types of feedback apply to incorrect answers (correct answers are follwed by the word "correct"). The experts reviewed all of the types of feedback and helped refine the feedback statements.

The test. The test used to measure performance was in pencil and paper format and included a total of 42 questions (Appendix C contains the test). The test began by asking for examples of each concept (these questions required the application of knowledge). Then the test asked the learner to recall (in his or her own words) the definitions of the concepts. The questions which asked for definitions and examples constituted the short answer portion of the test. Next, single examples were presented and the learner identified the concept involved in each example (three times for each concept, in a multiple choice format). Finally, concept names were given along with various definitions for recognition (also multiple choice).

Scoring of the multiple choice section of the test was routine. The short answer test was scored for accuracy by two scorers. The scorers agreed 91% of the time. Disagreements were discussed by the scorers until a consensus was reached.

The test, which was used as pretest, posttest, and retention test, was administered twice to 32 students in order to investigate reliability. The test-retest interval was two to four weeks. The test-retest reliability was .91. This suggests that the test is reliable.

Pilot study. After the types of feedback were developed, the CAI lesson versions and the paper and pencil test were pilot tested by 24 undergraduate students. All of the feedback versions were pilot tested by at least three students. The lesson versions took the students about one hour to complete (45 to 70 minutes) as did the test (50 to 75 minutes).

The lesson versions were found to be moderately difficult for this group of subjects (they correctly answered 12% to 81% of the questions correctly, with the average being 51% correct). The students received the feedback from 8 to 37 times within the lesson. On the average, they received the feedback 20.47 times within the lesson (indicating that errors were frequent and that the treatment was received often). The students' scores on the test ranged from 17% to 93% of the answers correct, with the average being 53%, indicating that the test was also moderately difficult. Additionally, all seven concepts seemed difficult, especially negative reinforcement and negative punishment. In general, the students found it easier to recognize and recall definitions and examples and harder to apply the concepts to their own examples.

The pilot study resulted in some important changes. The initial instructions were clarified. A small number of typographical errors were corrected. The format of the program was altered (the objectives were reworded, key words were highlighted, spacing was changed, and "please wait" messages were inserted before long pauses). In one

version of the lesson a "bug" was discovered which caused the computer to stop and report a system error (this was corrected).

The Inventory of Learning Processes

The Inventory of Learning Processes (ILP) is described in Chapter 4. The ILP is a 62 item self report measure which asks questions about learning strategies (Appendix D contains a copy of the ILP). The test can be scored in a number of ways. Based on the recommendations of the author of the ILP (R. R. Schmeck, personal communication, March 15, 1988) the scoring used in this study divides learners into two basic learing styles (some learners fall into neither learning style group and are not classified on learning style). The Deep Processing and Elaborative Processing scores are summed. High scores (in the top third of the entire group of participants) indicate a deep, elaborative learning style. Low scores (in the bottom third of the group) represent a shallow, reiterative learning style.

The ILP was scored with scoring templates. Each ILP answer sheet was scored twice, to insure the accuracy of the scores.

Procedures

Participants were solicited from general psychology courses during the first half of each academic term (before the general

psychology courses covered the subject matter taught in this study). Participants who completed the study received extra credit.

Each student began the study by completing a pretest packet. This included signing an informed consent sheet (included in Appendix E) and a GPA release form, filling out the Inventory of Learning Processes, and completing the pretest. The participants were instructed to complete the pretest packet the day before they were scheduled to run the computer lessons. They were further instructed to do the pretest packet on campus and without assistance. All of the participants agreed that they had followed these procedures.

The students came to the computer lab the day after completing the pretest packet. Lab monitors were in the lab to confirm that students had not previously studied the subject matter, to check the pretest packet, and to assist with the CAI lesson. The students were randomly assigned to the feedback groups (the two schools were equally represented in each of the feedback groups). Students running the lesson were seated so they could not see the computer screens of other participants. Lab monitors started the computers and answered questions about the use of the computers, but refused to answer questions about the subject matter. Lesson beginning and ending times were recorded by the lab monitors.

After finishing the lesson each participant was given the posttest, which was completed immediately after the lesson. Each participant was also given a retention test packet which had a completion date (two weeks from the date the lesson was studied)

written on the front. The retention test packet contained a posttest and an extra credit form. An instruction sheet stated that the retention test was to be completed on campus and without assistance. Students were also asked to indicate whether or not they had studied the subject matter between the lesson and the retention test. If the retention test was not returned within three weeks then students were called and reminded to return the completed retention test within the next week (the retention test interval was thus two to four weeks). Extra credit was assigned after the retention test was completed and returned.

CHAPTER 4

RESULTS

The first analysis of the results was done to investigate the equivalency of the feedback groups and learning style groups on the pretest, GPA, and lesson time. Then the main effects of both feedback and learning style were examined. Finally, the interactions between feedback and learning style were analyzed. A p=.05 significance level was used for all analyses.

The pretest means of the six feedback groups were compared with an analysis of variance (ANOVA). The results (see Table 1 for the ANOVA results and Table 2 for the group means and standard deviations) showed that the feedback groups did not differ significantly on the pretest (p=.1028). An ANOVA was also used to compare the feedback groups on GPA and learning style. The results indicated that the feedback groups did not differ significantly on GPA (p=.8965). The feedback groups also did not differ significantly on learning style (p=.3879). These results suggested that the feedback groups were statistically equivalent in many ways.

In addition, there were no significant differences between the feedback groups on lesson time (p=.6981). This suggested that, although the feedback types differed in the length of the feedback

Table 1. Anova Results.

Source of Variation	Dependent Variable	DF	Sum of Square	F	P
Feedback Group	Learning Style	5	207.97095819	1.06	0.3879
Feedback Group	Pretest	5	61.16019238	1.89	0.1028
Feedback Group	Lesson Time	5	267.01153040	0.60	0.6981
Feedback Group	GPA	5	0.82629893	0.33	0.8965
Feedback Group	Lesson Score	5	1022.7817240	6.87	0.0001
Feedback Group	Posttest	5	2236.9152793	9.76	0.0001
Feedback Group	Retention Test	5	1087.3502898	3.76	0.0037
Learning Style	Pretest	2	0.91886508	0.07	0.9353
Learning Style	Lesson Time	2	436.79739813	2.59	0.0801
Learning Style	GPA	2	0.878478517	0.89	0.4143
Learning Style	Lesson Score	2	90.12911192	1.19	0.3091
Learning Style	Posttest	2	22.75683972	0.17	0.8419
Learning Style	Retention Test	2	418.69283288	3.34	0.0394

Table 2. Means and Standard Deviations of the Dependent Measures for the Feedback and Learning Style Groups.

GROUP	PRETEST MEAN	PRETEST SD	LESSON SCORE MEAN	LESSON SCORE SD	POSTTEST MEAN	POSTTEST SD	RETENTION TEST MEAN	RETENTION TEST SD
C(M)F	7.83	2.64	15.11	6.14	25.67	5.05	22.33	7.85
PF	6.29	2.14	15	5.46	21	10.24	19.59	6.6
CF	6.39	2.81	14.24	3.85	18.16	8.31	16.28	7.97
KCR	6.76	2.22	17.28	6.04	13.12	5.29	13.41	5.1
KR	5.28	2.85	23.39	5.17	12.39	5.25	14.5	8.06
NF	6.61	2.48	18.24	5.69	12.17	5.45	12.28	8.46
SR	6.47	2.4	15.91	5.72	16.35	8.42	13.53	7.87
DE	6.67	2.67	18.1	6.97	17.55	8.44	18.49	7.08
C(M)F/SR	7.83	1.47	23.67	3.88	25.17	4.36	19.5	10.82
C(M)F/DE	7.57	3.69	22	6	24.29	5.59	21.57	5.76
PF/SR	6.8	1.64	19.2	5.4	23.6	8.41	20	5.24
PF/DE	5.33	1.36	18.5	7.66	20.5	11.83	19.17	8.35
CF/SR	6.6	2.88	11.4	3.13	15.4	10.16	9	3.08
CF/DE	5.83	3.31	20	5.73	20.17	1.94	20.67	4.46
KCR/SR	6.56	2.83	13.44	3.88	13.56	4.48	12.44	6.58
KCR/DE	7.4	.89	13.4	3.21	9.2	4.09	14.6	2.97
KR/SR	4.75	2.5	12.75	3.69	9.5	5.26	9.5	2.89
KR/DE	6.33	2.31	16.67	7.23	15	5	15	7.94
NF/SR	5.6	2.51	14.8	4.15	10	5.24	9.6	8.05
NF/DE	7.33	2.88	15.83	9.56	12.33	7.94	17	10.68

Note: SD is the standard deviation. C(M)F is corrective misconception feedback, PF is process feedback, CF is corrective feedback, KCR is knowledge of correct response, KR is knowledge of results, NF is no feedback, SR is the shallow, reiterative learning style, and DE is the deep, elaborate learning style.

statements, the length of time to complete the lessons did not vary significantly.

For the two learning style groups, ANOVA indicated that the pretest means did not differ significantly (p=.9353). The learning style groups were also compared to determine if they differed on GPA. The ANOVA showed that the groups did not differ significantly on GPA (p=.4143). There was a near significant difference (p=.0801) between the learning style groups on lesson time (the mean lesson time of the deep, elaborative group was higher than the mean lesson time of the shallow, reiterative group, although the difference was not significant).

The posttest and retention test results were analyzed with repeated measures multivariate analysis of variance (MANOVA). Lesson time was used as a covariate in order to get a less contaminated measure of the effects of the independent variables. The MANOVA results are reported in Table 3. Tukey's studentized range (HSD) test was used for comparing group means.

For the feedback main effect, the repeated measures MANOVA (Wilks' criterion) was highly significant (p=.0001). This indicated that there were differences (considering pretest, posttest, and retention test) among the feedback groups (see Figure 4). The posttest and retention test were then analyzed separately. This was done using gain scores which were computed by subtracting pretest results from posttest results. There were significant feedback

Table 3. MANOVA Results.

Source of Variation	DF	F	P
Feedback Group	10,196	4.54	0.0001
Learning Style	4,202	1.75	0.1412

Note: These analyses included lesson time as covariates.

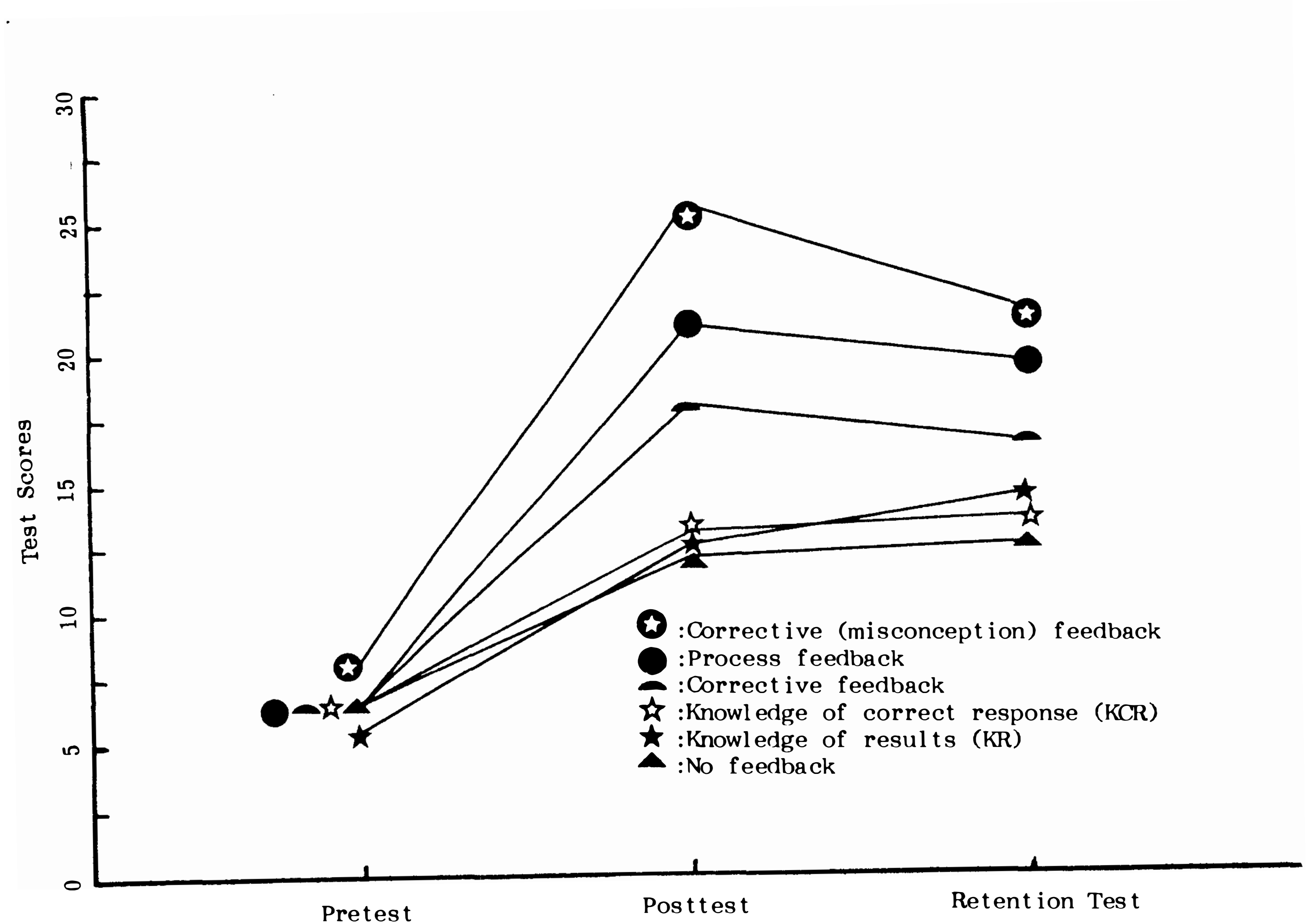

Figure 4. Pretest, Posttest, and Retention Test Scores for the Feedback Groups.

effects on both the posttest gain scores (p=.0001) and the retention test gain scores (p=.0037).

The Tukey's tests (with alpha = 0.05) were conducted to examine differences among the feedback groups. The Tukey's test for the posttest indicated that corrective (misconception) feedback and process feedback were significantly more effective than no feedback, KR, and KCR. There were no other significant differences.

The same comparisons were conducted for the retention test gain scores. The Tukey's test showed that corrective (misconception) feedback resulted in significantly higher gain scores than did no feedback or KCR. Process feedback resulted in significantly higher retention test scores than did no feedback. There were no other significant feedback effects on the retention gain score.

The feedback effects on lesson scores were also analyzed. ANOVA was used to compare the group means. The results showed significant effects (p=.0001). The Tukey's test indicated that corrective (misconception) feedback was significantly more effective than no feedback, KR, KCR, and corrective feedback. There were no other significant feedback effects on the lesson score.

The second dependent variable (learning style) was subjected to the same statistical analyses that were used with the feedback main effect. The repeated measures MANOVA (with lesson time as a covariate) was not significant (p=.1412). When the posttest and retention test results were analyzed separately (using gain scores), the posttest results were not significant (p=.8419), but the retention

test results were significant (p=.0394). On the retention test, the mean score of the deep, elaborative group was significantly higher than the mean score of the shallow, reiterative group (see Figure 5).

The learning style groups were also examined for differences on the lesson scores. The difference between the mean lesson scores was not significant (p=.1029).

The final set of statistical analyses examined the interactions between type of feedback and learning style. Manova indicated that the interaction between feedback and learning style was significant (p=.0001) for the lesson scores, posttest, and retention test.

The comparisons for interactions (see Table 4) resulted in a number of significant differences. For the deep, elaborative learning style, corrective (misconception) feedback was significantly more effective than less informative types of feedback in 4 cases (a case meaning a comparison with one type of less informtive feedback on one performance measure), and process feedback was significantly more effective than less informative types of feedback in 4 cases. For the shallow, reiterative learning style, corrective (misconception) feedback was significantly more effective than less informative types of feedback in 11 cases, and process feedback was significantly more effective than less informative types of feedback in 7 cases. The only difference between learning style groups within a feedback type was for corrective feedback on the lesson scores and the retention test. The possible implications of these results are discussed in the next chapter.

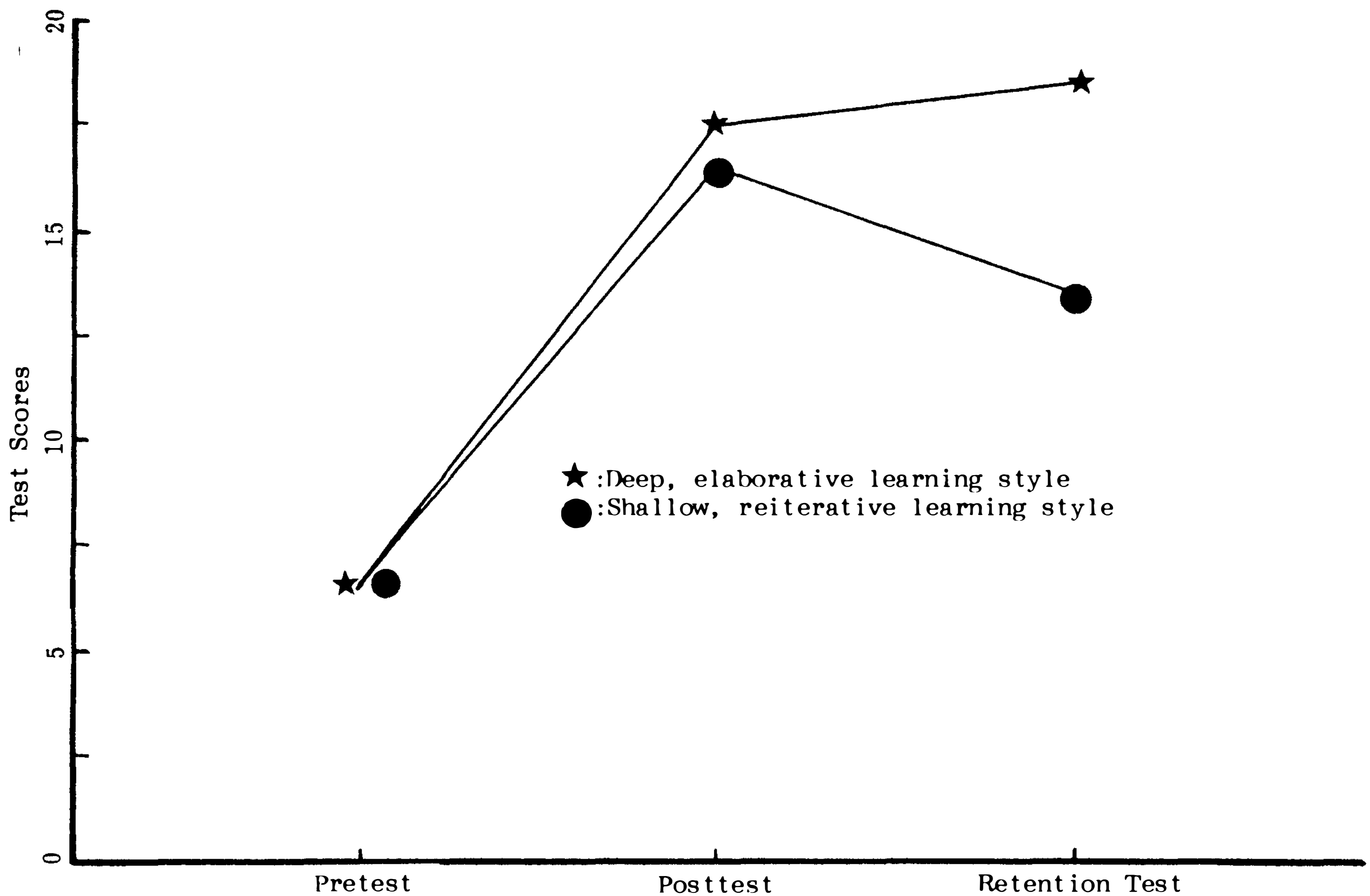

Figure 5. Pretest, Posttest, and Retention Test Scores for the Learning Style Groups.

Table 4. Interaction Comparisons.

Comparison	LESSON SCORE P Value	LESSON SCORE Group with the Highest Mean	POSTTEST P Value	POSTTEST Group with the Highest Mean	RETENTION TEST P Value	RETENTION TEST Group with the Highest Mean
C(M)F vs NF on SR	.0086	C(M)F	.0006	C(M)F	.0271	C(M)F
C(M)F vs KR on SR	.0026	C(M)F	.0008	C(M)F	.036	C(M)F
C(M)F vs KCR on SR	.0006	C(M)F	.0022	C(M)F	.0691	
C(M)F vs CF on SR	.0003	C(M)F	.0233	C(M)F	.0193	C(M)F
C(M)F vs PF on SR	.179		.712		.9099	
PF vs NF on SR	.2047		.0028	PF	.0263	PF
PF vs KR on SR	.0809		.0034	PF	.0342	PF
PF vs KCR on SR	.0614		.0166	PF	.066	
PF vs CF on SR	.026	PF	.0668		.019	PF
CF vs NF on SR	.8324		.2249		.8965	
CF vs KR on SR	.7126		.2144		.9186	
CF vs KCR on SR	.5025		.6371		.3983	
KCR vs NF on SR	.6564		.364		.4852	
KCR vs KR on SR	.8324		.3367		.5024	
KR vs NF on SR	.5761		.9153		.9837	
C(M)F vs NF on DE	.0448	C(M)F	.0028	C(M)F	.2618	
C(M)F vs KR on DE	.1593		.0573		.194	
C(M)F vs KCR on DE	.0084	C(M)F	.0004	C(M)F	.1053	
C(M)F vs CF on DE	.5108		.2921		.8236	
C(M)F vs PF on DE	.2511		.3327		.554	
PF vs NF on DE	.0001	PF	.0033	PF	.0012	PF
PF vs KR on DE	.6351		.2686		.4202	
PF vs KCR on DE	.1255		.009	PF	.3028	
PF vs CF on DE	.6344		.9343		.7291	
CF vs NF on DE	.1885		.0553		.3851	
CF vs KR on DE	.389		.2985		.2737	
CF vs KCR on DE	.0484	CF	.0112	CF	.172	
KCR vs NF on DE	.4625		.4608		.5873	
KCR vs KR on DE	.4136		.2587		.9402	
KR vs NF on DE	.8291		.5907		.6984	
SR vs DE on NF	.7547		.5826		.0965	
SR vs DE on KR	.3489		.3055		.325	
SR vs DE on KCR	.9884		.2667		.5966	
SR vs DE on CF	.0107	DE	.2629		.0096	DE
SR vs DE on PF	.8324		.4656		.6101	
SR vs DE on C(M)F	.5836		.8212		.8504	

Note: The comparisons describe interactions between type of feedback and type of learning style on the three dependent measures: lesson score, posttest, and retention test. C(M)F is corrective (misconception) feedback, PF is process feedback, CF is corrective feedback, KCR is knowledge of correct response, KR is knowledge of results, NF is no feedback, SR is the shallow, reiterative learning style, and DE is the deep, elaborate learning style. The column labled "Group with the Highest Mean" applies only to cases where the p value exceeds the .05 cuttoff established for significance.

CHAPTER 5

DISCUSSION

The results of the study offer important evidence regarding the three hypotheses. These hypotheses were:

1. Informative feedback based on a subject matter error analysis is more effective than other types of feedback.

2. Students who report using deep, elaborative learning strategies learn and retain more than students who report using shallow, reiterative learning strategies.

3. Students who use deep, elaborative learning strategies perform at a higher level when given more informative types of feedback, while students who use shallow, reiterative learning strategies perform at a higher level when given less informative types of feedback that repeat the material to be learned.

The conclusions cited below can only be generalized to general psychology students who participate in extra credit projects, and to the specific subject matter taught by the CAI lessons used in the study.

The six feedback groups did not differ significantly on the pretest, GPA, learning style, or lesson time. The two learning style groups did not differ significantly on the pretest, GPA, or lesson time.

The feedback groups were significantly different on the three dependent measures: the lesson, the posttest, and the retention test. On all three dependent measures, corrective (misconception) feedback, which was designed to fit the most common reasons for difficulty with the subject matter, resulted in significantly better performance than no feedback and KCR. On the posttest, corrective (misconception) feedback was also significantly better than KR. On the lesson, corrective (misconception) feedback was significantly better than no feedback, KR, KCR, and corrective feedback. These results provide support for both the long- and short-term effectiveness of corrective (misconception) feedback with this subject matter and within the population parameters. The results also partially confirmed the first hypothesis, which proposed that the most effective types of feedback would be those that were developed from the subject matter error analysis. Corrective (misconception) feedback was based on identified reasons for errors: misunderstanding about the meaning of the terms "positive" and "negative," and confusion about similar concepts with similar concept names. Corrective (misconception) feedback was found to be more effective than less informative types of feedback which were not based on the error analysis.

Process feedback was the second type of feedback designed to fit the subject matter and the identified reasons for errors. The process feedback described productive problem solving steps and told the learner where he or she presumably went wrong in the problem solving process. On the lesson, process feedback was not significantly

different from any of the other types of feedback. However, on the postest, process feedback was significantly more effective than no feedback, KR, and KCR. On the retention test, process feedback was significantly more effective than no feedback. Process feedback was thus effective with this subject matter and population.

These results supported the first hypothesis: corrective feedback designed to fit the subject matter was more effective than less informative types of feedback. A subject matter error analysis lead to the creation of two types of corrective feedback (corrective [misconception] feedback and process feedback), both of which were shown to be more effective than less informative types of feedback. Compared to the less informative types of feedback, corrective (misconception) feedback and process feedback were more effective on long- and short-term measures (there were no significant differences between corrective [misconception] feedback and process feedback). On one of the short term measures (lesson score), corrective (misconception) feedback was more effective than a form of corrective feedback that was not based on the results of the subject matter error analysis. There were no significant differences between the less informative types of feedback and the form of corrective feedback that was not based on the subject matter error analysis.

In this study, the subject matter error analysis produced the two types of feedback that were clearly the most effective types of feedback studied. This offers evidence for the value of the subject

matter error analysis, and the effectiveness of well designed informative feedback in concept teaching CAI within this population.

The second hypothesis, regarding learning style, was partially supported by the results of this study. While the learning style groups were not significantly different on GPA, lesson time, pretest, lesson score, and posttest, they were significantly different on the retention test. The students who reported using deep, elaborative learning strategies did not perform better on immediate measures (lesson score and posttest), but did retain more of what they learned.

This is consistent with the theories on learning style (Craik & Lockhart, 1972; Craik & Tulving, 1975; Schmeck, 1983), and with many current theories of memory (Loftus & Loftus, 1976; Neisser, 1976; Simon, 1981). Long term memory is theorized to be best when a learner engages in associations and elaborations. Craik and Lockhart (1972) stated that "deeper analysis leads to a more persistent [memory] trace" (p. 677). This was clearly demonstrated in the current study. Compared to students who reported using rote, repetitive learning strategies, students who reported making connections and elaborations performed higher on a retention test, even though measures of immediate learning showed no significant difference.

The third hypothesis involved possible interactions between type of feedback and type of learning style. These interactions were statistically significant (at the p=0.0001 level) for the lesson scores, the posttest, and the retention test. The interaction comparisons were more consistently significant for the shallow,

reiterative learners than for the deep, elaborative learners (there were significant differences for both learning style groups, but there were many more significant differences for the shallow, reiterative learners). The students who reported using shallow, reiterative learning strategies seemed to benefit more consistently from types of feedback designed to address common errors in the subject matter. Compared to the shallow, reiterative learners, the deep, elaborative learners more often did as well (on the retention test) with the less informative types of feedback.

The two learning style groups performed at significantly different levels on only one of the six types of feedback. On the immediate measures (the lesson scores and the posttest), the deep, elaborative group that received corrective feedback performed significantly higher than the shallow, reiterative group that received corrective feedback. In addition, for shallow, reiterative learners (but not for deep, elaborative learners) corrective feedback was significantly less effective than corrective (misconception) feedback and process feedback. The corrective feedback, which was not designed to fit the identified subject matter errors, simply repeated and applied the concept definitions. This type of correction was helpful for deep, elaborative learners, but was not very helpful for shallow, reiterative learners. The deep, elaborative learners made better use of the information in the corrective feedback. These learners may have used the repeated definitions to create their own associations and connections (further research could investigate this in the manner

described below). The shallow, reiterative learners more consistently required the specially designed types of feedback.

The question remains as to how the two learning style groups actually used the feedback statements. The corrective (misconception) feedback and process feedback may have enabled shallow, reiterative learners to process the material at a deeper level. An alternative hypothesis is that corrective (misconception) feedback and process feedback provided a systematic approach for learning the material in a shallow, rote fashion. Additional research should focus on the manner in which learners report using feedback statements. This could be done by administering the ILP after, and in reference to, the learning task, and by interviewing learners (obtaining think aloud protocols) about the processes they use to learn from the feedback.

While the results of this study offer support for the first two hypotheses, a good deal of additional research is needed. Research on feedback in CAI is accumulating. However, more of this research should involve systematic procedures for developing the feedback to fit the subject matter and identified reasons for errors. Subject matter error analysis procedures may provide an effective way of developing corrective feedback that improves learning. Extensive research is needed to examine the benefits of the subject matter error analysis procedures.

Research on other components of CAI instruction might also benefit from subject matter error analysis procedures. For example,

the error analysis could possibly be used to improve advance organizers, pacing of examples, or initial instruction.

At the least, the subject matter error analysis offers a way of describing the subject matter in detail, so that cumulative reviews of research will be able to investigate patterns of interaction between subject matter variables and instructional components, such as feedback. If this is done, it may be possible to specify types of feedback which are, in general, most effective for certain types of subject matter areas. However, much research is required before any such relationships can be specified.

Additional research is also needed to validate the ILP. Efforts should be addressed at investigating the relationships between learning style and general intelligence, and between learning styles and specific types of intelligence (verbal versus visual intelligence, simultanteous versus sequential processing, etc.). At this point only one study (cited in Schmeck, 1983) has addressed the issue of the relationships between learning style and intelligence.

Research on the ILP should address the value of the different scoring systems. One scoring system produces two scores based on less than half of the test items, and the other scoring system produces four scores that may be somewhat interrelated. The reliability and validity of these two scoring systems should be investigated further.

If learning styles are determined to be useful concepts independent of intelligence, the idea of matching instruction to learning style will deserve further attention. Previous research

(Pask, 1976b) has suggested that students may learn the most when instruction is matched to learning style. In the current study there did not seem to be a consistent relationship supporting the idea of matched instruction.

More research is needed to determine the extent of benefit from instruction that is matched to a students' learning style. If matched instruction can be shown to be consistently effective, then computers may provide powerful instructional devices for identifying learning styles and adapting instruction to learning styles. A learning style inventory could be administered and scored immediately before a student runs a CAI lesson. The lesson could include decision rules that modify instructional components (such as feedback) based on identified learning styles. The idea that CAI can adapt to learning style may have potential, but much preliminary research is needed.

Another possiblity is the use of computer programs to help students understand their learning styles. By providing feedback and special instruction it also may be possible to help learners develop more versatile and more effective learning styles. Based on the results of this study, further research and instructional efforts are warranted.

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APPENDICES

APPENDIX A

THE INTRODUCTORY FRAMES FOR THE CAI LESSON

The following information appeared as the introductory frames of the CAI lesson. These frames followed the learners response to two questions, one asking for a code number and the other asking for their name.

Hello, [name]!

This program can help you learn about basic concepts from the field of the psychology of learning.

This program may be able to help you learn these concepts, and may be able to influence your test scores in class.

(Next frame.)

After completing this program you should be able to:

*IDENTIFY AND PRODUCE THE DEFINITIONS OF:
POSITIVE REINFORCEMENT,
NEGATIVE REINFORCEMENT,
POSITIVE PUNISHMENT,
NEGATIVE PUNISHMENT,
RESPONSE COST,
TIME OUT, AND
EXTINCTION.

*IDENTIFY AND PRODUCE EXAMPLES OF:
POSITIVE REINFORCEMENT,
NEGATIVE REINFORCEMENT,
POSITIVE PUNISHMENT,
NEGATIVE PUNISHMENT,
RESPONSE COST,
TIME OUT, AND
EXTINCTION

APPENDIX B

EXAMPLES OF THE FEEDBACK TYPES

The following question was included in the CAI lesson. The question is an attempt to determine if learners are using the concept correctly. If a learner thinks the term "positive" means pleasant then that learner may be more likely to chose answer C (which is what happened during the pilot study).

> Which of the following in an example of POSITIVE REINFORCEMENT?
>
> A). Ronnie used to get in trouble for picking on his 3rd grade classmates. His teacher stopped attending to him when ed picked on kids. Now Ronnie picks on his classmates less.
>
> B). Ronnie used to get in trouble for picking on his 3rd grade classmates. His teacher tried to stop him by yelling and scolding when he picked on kids. Now ronnie picks on his classmates even more.
>
> C). Ronnie used to get in trouble for picking on his 3rd grade classmate. His teacher tried to stop him by being nice to him. Now Ronnie picks on his classmates even more.

When a learner incorrectly chose "C" he or she received one of the following feedback messages:

Corrective (misconception) feedback:

> Incorrect. The correct example of POSITIVE REINFORCEMENT is [alternative B is printed here].
> POSITIVE means the stimlui (scolding) are PRESENTED;
> REINFORCEMENT means an INCREASE in the behavior (picking on kids).

Process feedback:

> Incorrect. To correctly answer questions like these:
> *First identify the behavior in question;
> *Next, look at the direction of the change in the rate of the behavior;
> *Then look at the stimuli (and any change in the stimuli) following the behavior.
> POSITIVE REINFORCEMENT involves an INCREASE in the rate of

the behavior when the behavior is followed by the PRESENTATION of a stimulus.
The example you chose for POSITIVE REINFORCEMENT was incorrect because it did not involve an INCREASE in the rate of the behavior. The example you chose correctly involved the presentation of stimuli following the behavior.

Corrective feedback:

Incorrect. The correct example of POSITIVE REINFORCEMENT is {alternative B is printed here].
POSITIVE REINFORCEMENT involves the PRESENTATION of stimuli (scolding) resulting in an INCREASE in the rate of the behavior (picking on kids).

Knowledge of correct response (KCR):

Incorrect. The correct example of POSITIVE REINFORCEMENT is {alternative B is printed here].

Knowledge of results (KR):

Incorrect.

No feedback:

(No message.)

APPENDIX C

THE TEST

DATE__________

Short Answer Test On Computer Lesson Concepts

1. Write down an example of POSITIVE REINFORCEMENT.

2. Write down an example of NEGATIVE REINFORCEMENT.

3. Write down an example of POSITIVE PUNISHMENT.

4. Write down an example of NEGATIVE PUNISHMENT.

5. Write down an example of RESPONSE COST.

6. Write down an example of TIME OUT.

7. Write down an example of extinction.

8. Write down a definition for POSITIVE REINFORCEMENT.

9. Write down a definition for NEGATIVE REINFORCEMENT.

10. Write down a definition for POSITIVE PUNISHMENT.

11. Write down a definition for NEGATIVE PUNISHMENT.

12. Write down a definition for RESPONSE COST.

13. Write down a definition for TIME OUT.

14. Write down a definition for EXTINCTION.

Multiple Choice Test On Computer Lesson Concepts

1. Read the example and pick the concept that applies best.

Rob the rat lived in an experimenter's cage. There was a lever in the cage and Rob often pressed it. One day a loud noise started. When Rob pushed the lever the noise stopped for a minute and then came on again. This kept up for a while and then Rob stopped pushing the lever. Which concept best fits the change in Rob's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Extinction

(Circle A, B, C, D, E, F, or G.)

2. Read the example and pick the concept that applies best.

Tim used to pinch all the girls at school and when he did they would scream and slap Tim. Then the girls started ignoring Tim completely when he pinched them. after that he started pinching them less often. Which concept best fits the change in Tim's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

3. Read the example and pick the concept that applies best.

A young child has just entered kindergarten. Sometimes when he is made to play with the little girls he plays aggressively. The teacher has started taking the girls away when he plays aggressively. After a few days he plays aggressively with the little girls more often. Which concept best fits the change in the Young child's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

4. Read the example and pick the concept that applies best.

Rufus plays on a well known hockey team that used to play very roughly. Then the league cracked down on violence and instituted a penalty (5 minutes in the penalty box, where they wait until they can play again) for any act of violence. Rufus played less roughly after after the penalty was instituted. Which concept best fits the change in Rufus's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

5. Read the example and pick the concept that applies best.

One day Clyde (a two year old) started saying bad words. Everytime he said a bad word his dad spanked him. The more this happened the more Clyde used bad words and the less he cared about it. Which concept best fits the change in Clyde's behavior (using bad words)?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

6. Read the example and pick the concept that applies best.

Brandon bought a nice hat that was supposed to be in the newest style. Everytime he wore it on the way to work people on the street started giving him quarters for coffee, thinking Brandon was a beggar. The more this happened the less he wore his new hat. Whcih concept best fits the change in Brandon's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

7. Read the example and pick the concept that applies best.

When boys enter Boy Scout troup 64 they are given an "indian stick" holding 10 eagle feathers. Zack entered the troup but often disobeyed instructions. Then the leader started taking eagle feathers from his indian stick each time he disobeyed instructions. Before long Zack disobeyed much less often. Which concept best fits the change in Zack's behavior (disobeying)?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

8. Read the example and pick the concept that applies best.

Paul got a new kitten. He put the kitten in the kitchen to sleep, but one night the kitten started crying loudly in the middle of the night. Finally Paul got out of bed and let the cat in the bedroom. Gradually Paul started letting the cat in as soon as it began crying, and everytime it began crying. Which concept best fits the change in Paul's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

9. Read the example and pick the concept that applies best.

Kenny is a college student who types all of his papers on his dad's old electric typewriter. The typewriter is kind of wierd. Whenever Kenny hits the backspace key the typewriter quits working for a while. As he used the typewriter he gradually used the backspace key less. Which concept best fits the change in Kenny's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

10. Read the example and pick the concept that applies best.

The steering wheel in Greg's car wobbles badly. Last week he noticed that if he drove very fast (faster than usual) the wobble was no longer noticeable. Since then Greg has spent more time driving very fast. Which concept best fits the change in Greg's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

11. Read the example and pick the concept that applies best.

Ranger Dick spent much time watching the local deer. He noticed that the deer came to the meadow to eat wildflowers every morning. In June, when the wildflowers stopped blooming, the deer began coming to the meadow much less often. Which concept best fits the change in the behavior of the deer?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

12. Read the example and pick the concept that applies best.

Gina is a freshman taking her first classes. Whenever she sat near Frank he told her she was cute. Soon she stopped sitting near Frank. Which concept best applies to the change in Gina's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

13. Read the example and pick the concept that applies best.

In Pat's back yard is a hollow tree which is the home of a hard working squirrel. The squirrel stored up a lot of nuts. But then whenever he went more than 20 yards from the tree a crow flew in and stole a nut. Soon the squirrel spent less time going more than 20 yards from his tree. Which concept best fits the change in the behavior of the squirrel?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

14. Read the example and pick the concept that applies best.

Everytime Ralph burps his girlfriend left the room. The more this happened the less Ralph burps. Which concept best fits the change in Ralph's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Extinction

15. Read the example and pick the concept that applies best.

Beth was running a computerized lesson for one of her classes. At first she occasionally made an error. After an error the computer repeatedly flashed the word "Incorrect" in different colors. The more this happened the more often Beth made errors. Which concept best fits the change in Beth's behavior (making errors)?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

16. Read the example and pick the concept that applies best.

Ronnie went to the fair and paid 25 cents to play a game. He won and paid to play again. He kept winning, and kept paying to play again. Then he stopped winning (each time he paid to play he failed to win). Soon he stopped paying to play the game. Which concept best fits the change in Ronnie's behavior (stopping playing)?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

17. Read the example and pick the concept that applies best.

Mrs. Cooper's third grade class enjoys the movies they see during the social studies class, but the children usually get too loud. Then Mrs. Cooper started something new. When a child got too loud he or she was made to take his or her chair to the rear and face the wall (away from the movie screen). This quickly reduced the amount of noise the children make during movies. Which concept best fits the change in the behavior (being too loud) of the children?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

18. Read the example and pick the concept that applies best.

Becky went to a party and tried a number of exotic fruits for the first time. Everytime she took a bite of kiwi she immediately felt ill, with the pain lasting a few minutes. She kept eating other fruits but did not eat anymore kiwi. Which concept best fits the change in Becky's behavior (eating kiwi)?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost

19. Read the example and pick the concept that applies best.

Fred and Wilma just opened a new candy store on Magnolia Avenue. Everytime they both went in the back room at the same time they came out front only to find candy missing. Gradually they stopped going in the back room at the same time. Which concept best fits the change in Fred and Wilma's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Response cost
E. Time out
F. Extinction

20. Read the example and pick the concept that applies best.

Paul got a new kitten. He put the kitten in the kitchen to sleep, but one night the kitten started crying loudly in the middle of the night. Finally Paul got out of bed and let the cat in the bedroom. Gradually the kitten began crying loudly more often, and Paul kept getting up to let the kitten in the bedroom. Which concept best fits the change in the behavior of Paul's CAT?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Response cost
F. Time out
G. Extinction

21. Read the example and pick the concept that applies best.

Lindsey's mother always yelled and screamed. One day, when her mother was yelling, Lindsey yelled back at he mother. When she did that her mother stopped screaming and walked away. This happened once in a while until Lindsey no longer yelled back at her mother. Which concept best fits the change in Lindsey's behavior?

A. Positive reinforcement
B. Negative reinforcement
C. Positive punishment
D. Negative punishment
E. Extinction

22. Which of the following is a definition for positive reinforcement?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the removal or unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

G. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior decreases.

23. Which of the following is a definition for positive punishment?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the removal or unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

G. When a behavior occurs it is followed by the removal of stimuli,

24. Which of the following is a definition for time out?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior decreases.

25. Which of the following is a definition for negative reinforcement?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the removal or unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

G. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior decreases.

26. Which of the following is a definition for response cost?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior decreases.

27. Which of the following is a definition for extinction?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the removal or unavailability of stimuli, and the rate or strength of the behavior decreases.

F. When a behavior occurs it is followed by the unavailability of stimuli, and the rate or strength of the behavior decreases.

G. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior decreases.

28. Which of the following is a definition for negative punishment?

A. When a behavior occurs it is followed by the presentation of stimuli, and the rate or strength of the behavior decreases.

B. When a behavior occurs it is followed by the removal of stimuli, and the rate or strength of the behavior increases.

C. When a behavior occurs it is followed by the absence of formerly reinforcing stimuli, and the rate of strength of the behavior decreases.

D. When a behavior occurs it is followed by the presentation of stimuli, and the rate of strength of the behavior increases.

E. When a behavior occurs it is followed by the removal or unavailability of stimuli, and the rate or strength of the behavior decreases.

APPENDIX D

INVENTORY OF LEARNING PROCESSES

The Inventory of Learning Processes (ILP) was developed by Schmeck, Ramanaiah, and Ribich (1977). The ILP is administered with an answer sheet that lists the numbers 1 to 72, with "T" and "F" (for true and false) written beside each number. The directions on the answer sheet read "Please respond to each item in terms of its usefulness for you in preparing for an assignment or examination. Circle T for true and F for false as the item applies to you." The directions on the ILP state "Do not mark on this inventory." The ILP items are printed below.

1. When studying for an exam, I prepare a list of probable questions and answers.
2. I have trouble making inferences.
3. In general, I think most textbooks are easy to read.
4. I increase my vocabulary by building lists of new terms.
5. I am very good at learning formulas, names and dates.
6. New concepts rarely make my think of many other similar concepts.
7. Even when I feel that I've learned the material, I continue to study it.
8. I have trouble organizing the information that I remember.
9. Even when I know I have carefully learned the material, I have trouble remembering it for an exam.
10. When taking notes, I write down all ideas regardless of whether I think that they're important.
11. I make simple charts and diagrams to help me remember material.
12. I rarely write an outline of the material I read.
13. I do not try to convert facts into "rules of thumb."
14. I do well on tests requiring definitions.
15. I have a lousy memory for "trivia."
16. I usually refer to several sources in order to understand a concept.
17. I try to resolve conflicts between information obtained from different sources.
18. I learn new words or ideas by visualizing a situation in which they occur.
19. I spend less time studying than most of my friends.
20. I learn new concepts by expressing them in my own words.
21. I often memorize material that I don't understand.
22. For exams, I memorize the material as given in the test or class notes.
23. I carefully complete all course assignments.
24. I have difficulty planning work when confronted with a complex task.
25. I "debate" with the material as I study it.
26. I remember new words and ideas by associating them with words

and ideas I already know.
27. I review course material periodically during the quarter.
28. I often have difficulty finding the right words for expressing my ideas.
29. Toward the end of a course, I prepare an overview of all material covered.
30. I can easily handle questions requiring comparison to different concepts.
31. I rarely read beyond what is assigned in class.
32. I have difficulty learning how to study for a course.
33. I rarely sit and think about a unit of material which I have just learned.
34. For me, note taking interferes with comprehension so I take few notes and listen more.
35. I have a regular place to study.
36. I read critically.
37. I "daydream" about things I've studied.
38. I do poorly on completion items.
39. I rarely use a dictionary.
40. I can usually establish the meaning of an unfamiliar word from the context in which it is presented.
41. I learn new ideas by relating them to similar ideas.
42. When learning a unit of material, I usually summerize it in my own words.
43. I maintain a daily schedule of study hours.
44. I think fast.
45. While learning new concepts their practical applications don't usually come to my mind.
46. I get good grades on term papers.
47. I'd rather read about a concept than talk about it.
48. Getting myself to begin studying is usually difficult.
49. I have difficulty locating particular passages in a textbook when necessary.
50. I can usually formulate a good guess even when I don't know the answer.
51. I have trouble remembering definitions.
52. I would rather read a summary of an article than the original article.
53. While studying, I attempt to find answers to questions I have in mind.
54. I can usually state the underlying message of films and readings.
55. I do not usually work through practice exercises and sample problems.
56. I find it difficult to handle questions requiring critical evaluation.
57. When I rehearse something, I usually just repeat it over and over to myself.
58. I have regular weekly review periods.
59. I do well on exams requiring much factual information.

60. Most of my instructors lecture too fast.
61. I rarely look for reasons behind the facts.
62. I cram for exams.
63. I need a summary statement at the end of a lecture.
64. When I study something, I devise a system for recalling it later.
65. I have trouble seeing the difference between apparently similar ideas.
66. I always make a special effort to get all the details.
67. I prepare a set of notes integrating the information from all sources in a course.
68. My memory is actually pretty poor.
69. I am rarely able to design procedures for solving problems.
70. I do well on essay tests.
71. I rarely use the library.
72. I need teachers who give a lot of examples.

APPENDIX E

THE INFORMED CONSENT SHEET

We are asking your permission to take part in research on the effectiveness of error correction procedures in computer assisted instruction. You will be asked to take a brief pretest, to answer questions about learning practices and preferences, and to run a computer assisted instruction lesson that teaches seven concepts from the field of psychology of learning. You will then be given a paper and pencil test on the concepts. You will be asked to return two to four weeks later to take another paper and pencil test. Participation time is estimated to be two to four hours on the first day and up to one hour when you return for the last test.

Your performance and scores will be kept confidential and will be associated with a numerical code, rather than your name. You may withdraw from the investigation at anytime without penalty.

STATEMENT OF PERMISSION

I understand that this research is being conducted by William B. Allen and Dr. Richard Saudargas in the Psychology Department at the University of Tennessee, Knoxville. I have read the project description and understand that it is a truthful representation of what I am requested to do. I consent to participate in this project with the understanding that my consent and/or my data may be withdrawn at any time without penalty. I further understand that my participation in this research is on a voluntary basis. If I have questions regarding my participation, now or later, I can contact any of the persons listed below.

__________ DATE

____________________ SIGNATURE

____________________ PRINTED NAME

William B. Allen
2544 Woodbine Ave., Apt. 2
Knoxville, Tn. 37914
Phone: (615) 637-7153

Dr. Richard Saudargas
308 Austin Peay Building
The University of Tennessee
Knoxville, Tn. 37996-3400
Phone: (615) 974-6846

VITA

William Bruce Allen was born in Dayton, Ohio on October 22, 1958. He moved to Memphis, Tennessee in 1969. In 1979 he earned a Bachelor of Arts degree in Human Development and Learning from Christian Brothers College. He entered the University of Tennessee, Knoxville in 1981. A Master's degree was awarded in August, 1983. He continued in his studies and earned the Doctor of Philosophy degree in June, 1988.

The author has been the Coordinator of School Psychology Services at Cherokee Mental Health Center since August, 1985. He is involved in professional activities and is currently co-chairman of the Professional Standards and Review (Ethics) Committee of the Tennessee Association of School Psychologists.