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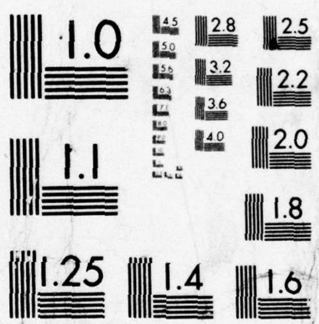

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OCTOBER 1976

FEEDBACK IN PROGRAMMED INSTRUCTION AND TEXT MATERIAL

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10 Raymond W. Kulhavy

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Reviewed by
John D. Ford, Jr.

Navy Personnel Research and Development Center
San Diego, California 92512

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FOREWORD

This study was performed under Work Unit Number ZPN07.30 (Adaptive Experimental Approach to Instructional Design) while Dr. Kulhavy of Arizona State University was a temporary employee of NAVPERSRANDCEN during the summer of 1975. It falls within the Instructional Design Support task area, which focuses on theories and procedures useful in supporting instructional development activities within the Navy. Dr. John Carter served as project director for this work.

J. J. CLARKIN
Commanding Officer

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SUMMARY

Problem

Various feedback procedures are used in Navy training programs to facilitate learning processes. Unfortunately, the mechanisms responsible for such facilitation are frequently misunderstood. As a result, feedback is often used inappropriately, thereby neutralizing any positive effects it might have on student performance.

Purpose

To review the data available on feedback processes and to show how post-response information can best be utilized with written instruction.

Approach

A review was made of studies conducted on the effect of providing feedback with text-based lessons. Results were organized under five topic headings: Feedback Complexity, Feedback as Reinforcement, Effect of High Feedback Availability, Feedback and Learning, and Feedback and Learner Confidence.

Findings

1. The literature review provided no decisive evidence that increases in feedback complexity yield parallel increases in learning or that feedback necessarily functions as reinforcement.

2. High feedback availability negates its facilitation effect, since students merely copy answers and learn little.

3. If feedback availability is controlled and the learner is familiar with subject matter, feedback serves (a) to let the student know when he is right or (b) to correct him (or let him correct himself) if he is wrong.

4. Feedback is most effective when student response confidence is high, whether or not his initial response is correct.

Conclusions

Feedback facilitation is negated if (1) feedback availability is high and he merely copies instead of reading the material or (2) the material studied is so difficult that the student must guess at answers and then try to associate feedback with the question; otherwise feedback acts to confirm correct responses or provides corrective action.

Recommendations

To ensure that feedback provides maximum learning facilitation, it is recommended that instructional designers:

1. Ensure that learners have sufficient entry skills for the lesson.

2. Minimize the opportunity for students to obtain feedback prior to responding.

3. Provide feedback as often as possible during the course of the lesson.

It is further recommended that future research in this area be directed toward the relationship between learner confidence and feedback.

CONTENTS

LIST OF FIGURES

INTRODUCTION

Various feedback procedures are used in Navy training programs to facilitate learning processes. Unfortunately, the mechanisms responsible for such facilitation are frequently misunderstood. As a result, in both research and instructional development, feedback is often used inappropriately, thus neutralizing any positive effects it might have on student performance.

The main purpose of this report is to review, analyze, and interpret results of studies performed on feedback processes, especially as they apply to written instruction and the design of instructional materials. No attempt was made to cover the more task-specific literature dealing with motor learning, simple concept acquisition, or paired-associates, since excellent reviews already exist in these areas (Adams, 1968, Bilodeau, 1966; Bourne, 1966; Renner, 1964).

APPROACH

A review of studies on the effect on providing feedback with text-based lessons was conducted. Results were organized under five topic headings: Feedback Complexity, Feedback as Reinforcement, Effect of High Feedback Availability, Feedback and Learning, and Feedback and Learner Confidence. The section on Feedback and Learning includes information processing approaches and a possible application to automated teaching systems.

FINDINGS

Feedback Complexity

Throughout this report the term "feedback" is used to describe any of the numerous procedures used to tell a learner whether his response is right or wrong. As shown by Figure 1, feedback can range from the simplest "Yes-No" format to the presentation of substantial corrective or remedial information which may extend or add to the response content. Obviously, as one advances along this range, feedback complexity increases until the process takes on the form of new instruction rather than information to the student about response correctness.

Common sense suggests that increments in the complexity of feedback should increase learning. Intuitively, the more information a student has about his response, the better he should understand why he made it. Unfortunately, the literature provides no decisive evidence that increases in complexity yield parallel increases in learning. Rather, research on this point yields inconsistent results. For example, studies comparing the relatively simple feedback in linear programs to more extensive format often found no posttest performance differences (Bisbiscos, 1965; McDonald and Allen, 1962; Merrill, 1965; Roe, 1962). Others found that adding redundant content to a confirmation does little more than create extra work for the writer (Kaufman, 1963; O'Day, Kulhavy, Anderson, and Malczynski, 1971). On the other hand, it is sometimes possible to increase performance by making the feedback so extensive that it constitutes a partial review of the lesson (Block and Tierney, 1974; Merril and Stolurow, 1966) or by simultaneously giving several types of feedback following each response (Gilman, 1969). Clearly, these studies allow no systematic statement about how changes in feedback form or content are likely to influence achievement. Such a statement may be impossible to make because of the numerous ways in which individual differences influence learning from a specific block of material. Consequently, until more definitive research becomes available, it is probably better to treat feedback as a unitary concept, leaving the complexity issue unresolved.

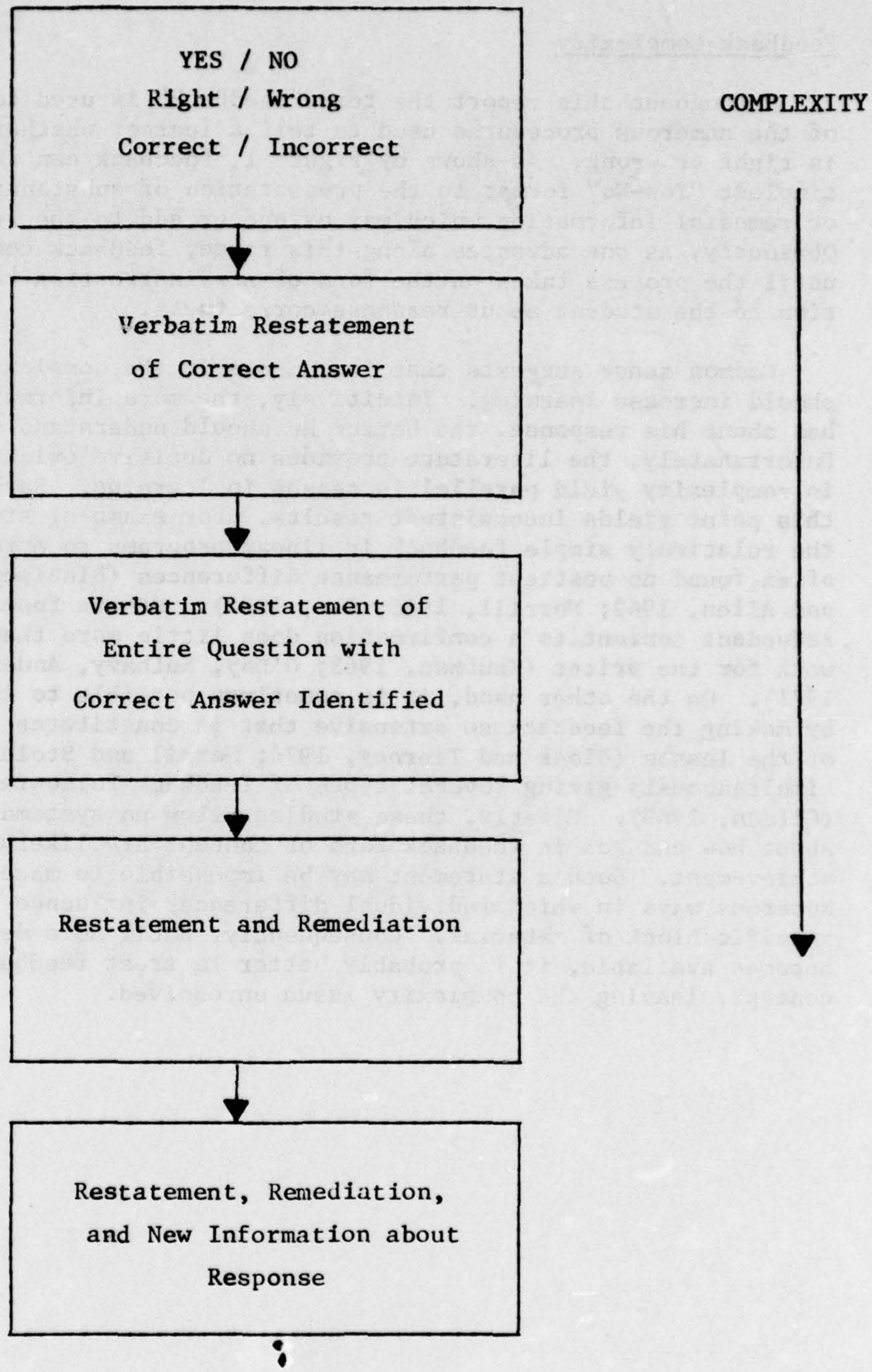

Figure 1. Types of feedback.

Feedback as Reinforcement

It has often been proposed that feedback acts as a reinforcing event. This belief goes back to the early fifties, and the development of programmed instruction materials for classroom use. The principle of immediate feedback found its strongest support among operant psychologists who argued that telling a pupil his answer is right "reinforces" him and increases the likelihood that he will again respond correctly on a future test. In fact, as late as 1968, Skinner himself concluded a discussion on teaching machines with the following observation: "the machine, like any private tutor, reinforces the student for every correct response, using the immediate feedback not only to shape behavior most effectively but to maintain it in strength in a manner which the layman would describe as 'holding the student's interest'" (p. 39). With such positive statements available, it is no surprise that scholars have worked overtime to fit the round peg of feedback into the square hole of reinforcement. Unfortunately, this stoic faith in feedback-as-reinforcement has all too often lead researchers to overlook or disregard alternate explanations when their data failed to meet operant expectations.

The problem, of course, is that behaviorists were a bit hasty in assigning functionally reinforcing properties to feedback. In the laboratory, a reinforcer is defined as some stimulus which increases the probability that the response which it follows will occur again. For example, suppose that a laboratory rat or pigeon is deprived of food and then is required to perform some target response in order to be fed. When the animal responds correctly, he receives a food pellet. To the degree that he will emit the same response again under similar conditions, the pellet assumes reinforcing properties. There is no good reason to believe that this same sequence of events will occur in programmed text. Obviously, classroom learners rarely perform under such contingencies as physical depreviation. Further, the stimulus-response environment of the program is constantly undergoing change, rather than being controlled in the typical laboratory setting. This does not mean that some program stimuli are not functionally reinforcing for some students. However, to assume that the instructional behavior of most pupils is subject to the control of feedback statements is to violate the operant canon itself: only that which reinforces is a reinforcer.

The author has been unable to find evidence that the feedback which follows program frames typically acts in a reinforcing manner. However, despite repeated challenges to the operant position over the years (Anderson, 1967, 1970; Annett, 1969; Smith and Smith, 1966), it still has considerable currency in instructional design and research. This state of affairs seems doubly strange in light of the vast amount of feedback data which prove difficult to handle within a reinforcement framework. For instance, a study by Anderson, Kulhavy, and Andre (1971, Exp. 1) required two groups of college students to learn a 112-frame, computer-controlled lesson about heart disease. In one group, subjects were provided feedback only after correct responses, and in another only after incorrect responses. Both groups made about the same number of errors during learning, and there were no significant differences on the posttest. Actually, the wrong-only learners made higher test scores, in spite of the fact that they received less than one-half the amount of feedback given the right-only group. These results clearly show that feedback does not have its greatest effect on correct responses, a condition implicit in the reinforcement position.

Delay-Retention Effect Studies

Research dealing with the so-called Delay-Retention Effect (DRE) also presents difficulty for a reinforcement interpretation. Studies on the DRE have repeatedly shown that delaying the presentation of feedback for a day or more significantly increases what students remember on a retention test (Moore, 1969; Sassenrath and Yonge, 1968, 1969; Sturges, 1969, 1972). These consistent results sharply oppose those that would be expected if feedback acts as a reinforcer, since one of the surest ways to destroy whatever control a reinforcer has over behavior is to separate it from the response by a lengthy interval (cf. Renner, 1964). In fact, in at least two DRE studies (Kulhavy and Anderson, 1972; Surber and Anderson, 1975) it was shown that people remember correct answers as well when feedback is delayed for a day as when it is given immediately after the response. Kulhavy and Anderson summarize the argument when they say, "The data from this study fail to support the view that feedback acts as reinforcement. If feedback were reinforcing, immediate feedback would be expected to increase the likelihood of repeating initially correct responses. In fact, the probability of repeating correct responses on the final (delay) test was no higher for immediate-feedback groups than for delay-feedback groups."

Feedback Schedule Studies

Earlier it was contended that a preoccupation with reinforcement principles has forced many studies into nonproductive designs. Nowhere is this phenomenon more apparent than with research attempting to replicate the effects of reinforcement "schedules" with programmed texts (Krumboltz and Weisman, 1962; Lublin, 1965; Rosenstock, Moore, and Smith, 1965). Typically, subjects in these experiments receive feedback on only a percentage of the frames studied, and their test performance is then compared with that of learners who see feedback after every frame or not at all. The number of frames after which feedback is given can range from 10 to 67 percent, and the feedback can occur either following a specified number of responses (fixed ratio) or randomly as a percentage of the total program (variable ratio). In spite of the breadth of subject matters and feedback percentages used in this research, not one study showed a pattern of results consistent with what one might expect from work done with intermittent reinforcement. In fact, in discussing these experiments, Anderson (1967) pointed out that it is unclear what studies on feedback schedules hope to accomplish, since the lower ratios are at a clear disadvantage in the first place. However, so powerful was the zeitgeist that one article declared that, "the most prominent reinforcer is the knowlege of results provided by the confirming answer. Providing confirming answers on an intermittent schedule during learning of programmed material may increase retention in the same manner that intermittent reinforcement prolongs responding in less complex learning tasks" (Krumboltz and Weisman, 1962, p. 250). Since data have failed to support these strong expectations, it seems reasonable to conclude that such studies not only provide a weak test of the reinforcement position but also appear to add little to what we know about how feedback works in an instructional environment.

Incentive Studies

A final approach to the reinforcement question comes from studies which have combined some "extrinsic reinforcer" with feedback during the instructional sequence. Such research is not really concerned with how feedback itself influences learning but, rather, with how some tangible incentive, external to the material, interacts with various lesson designs. The traditional argument has been that providing extra-instructional rewards for good performance will lead to increases in test scores, simply because the reward causes students to take maximum advantage of positive variables such as feedback. Predictably, incentive studies first attempted to control study behavior by giving the subjects money for producing at a high level. Moore and Smith (1964) gave undergraduates one penny for each correct response to a prepublication version of the Analysis of Behavior (Holland and Skinner, 1961), but the money had no significant effect on either multiple-choice or constructed response test scores. In a later study, Sullivan, Baker, and Schutz (1967) provided subjects with either $2.50 just for attending the experiment or $4.50 for completing the criterion test with a high score. Again, there were no posttest differences, nor did the performance of incentive groups vary as a function of whether feedback was presented during the lesson. These same authors (Sullivan, Schutz, and Baker, 1971) conducted a second study in which they allowed students to bypass ROTC drill periods in return for high performance with a lesson on The Military Justice System. The subjects responded to short mastery tests during instruction and also received a cumulative final over the content. Although performance resulting from seeing the feedback immediately following mastery tests was superior to that resulting from delaying it a session, there were no reliable effects for the incentive variables nor did it interact with feedback placement. Unfortunately, this experiment contained no group where feedback was not given, so it is impossible to determine if the incentive influenced how effectively subjects used their postresponse information. Results from these three studies supply no evidence that incentives external to the lesson lead to better performance, at least with the type of materials used in this research.

In conclusion, it is difficult to find data indicating that feedback following written instruction functions in the manner predicted by Skinner and others. One is forced to accept the fact that, whatever feedback does, it rarely acts as a reinforcer with text-based materials.

Effect of High Feedback Availability

A number of studies have found that feedback has no effect on learning (Feldhusen and Brit, 1962; Hough and Revsin, 1963; Krumboltz and Weisman, 1962; McDonald and Allen, 1962; Moore and Smith, 1961, 1964; Rosenstock, Moore, and Smith, 1965; Sullivan, Baker, and Schutz, 1967; Sullivan, Schutz, and Baker, 1971; Wentling, 1973). Some research even shows that groups who received no feedback or who never saw the questions during learning performed as well as, or better than, groups who saw feedback after every response (Karraker, 1967; Lublin, 1965). Such results are counterintuitive, and difficult to explain until one looks closely at the materials and procedures used in many of these experiments.

With minor exceptions, researchers who found no effect for feedback used text format which either allowed learners to see the feedback before responding or which were so heavily cued and prompted that students could answer questions correctly after only a cursory reading. It is not surprising, then, that even though there was no effect on learning, some of these studies found that the feedback groups make consistently fewer errors than their no-feedback counterparts (Krumboltz and Weisman, 1962; Moore and Smith, 1964; Rosenstock, Moore, and Smith, 1965); and others, that they took far less time to complete the instruction (Lublin, 1965; Moore and Smith, 1964). One possible reason why the feedback students in these studies made few errors and took minimum time--but learned little--is that they merely copied answers instead of reading test (cf. Anderson, 1970). Alternately, subjects receiving no feedback could not access the correct answers and thus were forced to read the material in order to make a feasible response. Under these conditions, the mere fact that no-feedback students studied the text is sufficient to overcome any advantage that the feedback students might have had on a subsequent posttest.

This argument is supported by the fact that three of the five studies which showed significant learning <u>increases</u> for feedback were conducted using computer-controlled lessons where feedback was impossible to obtain until after the learner had typed his response into the computer (Anderson et al., 1971, 1972; Gilman, 1969). The fourth used a punchboard procedure where feedback was unavailable until a response was actually made (Angell, 1949). In the final experiment, Meyer (1960) actively discouraged looking ahead at answers. In fact, he discarded answers from four students in the experiment because they were caught looking ahead at the answers. The conditions in Meyer's study were quite different from those of many experiments, where the correct answer is printed directly below the question or on the next page within easy reach.

When "answer availability" (the ease with which a learner can locate correct answers without first reading the lesson) is high, students simply copy the responses and bypass most of the instruction--a condition known to yield little learning (Anderson and Faust, 1967). On the other hand, when answer availability is low, students must study the material in order to respond properly. The sequence which relates answer availability and lesson behavior is diagrammed in Figure 2. The availability hypothesis has been directly tested in the Anderson, et al. studies (1971, Exp. 2; 1972) mentioned above. As noted, these studies presented college students with various feedback arrangements using computer-controlled lessons. Both experiments included a condition labeled PEEK, in which the correct answer to each program frame was visible in the lower corner of the computer screen during the entire time that the item was exposed. Subjects in the PEEK groups were repeatedly admonished not to look at the feedback before constructing their response. However, as the succession in Figure 2 predicts, students in the PEEK groups completed the lesson in record time, made few program errors, and learned very little from the experience. In each experiment, subjects who see feedback after every frame, with answer availability controlled, had significantly higher scores on an immediate posttest. The effects of high answer availability are apparent in the comments made by PEEK subjects on a postexperimental questionnaire. For example, one student wrote, "The answers should not be shown immediately, as this causes cheating to be easier" (Anderson, et al., 1971, Exp. 2), and another, "It was difficult for me not to use the answer when the question was difficult for me" (Anderson, et al., 1972). Obviously, even when students are told not be peek at a highly available answer, they are likely to copy anyway, rather than puzzle through a difficult frame.

The evidence concerning answer availability leads to two firm conclusions. First, availability must be low if one hopes to perform valid comparisons among different feedback arrangements. If answers are easily accessible, students will merely copy them, preventing a valid comparison between various feedback conditions. Second, from an instructional point of view, the designers of teaching materials should control answer availability so that feedback works primarily to teach content and not copying.

Feedback and Learning

The preceding discussion outlines some of the reasons why many studies with feedback have failed to produce a decisive result. This section discusses how feedback facilitates learning when such factors as answer availability are controlled (e.g., Anderson, et al., 1971; Gilman, 1969; Meyer, 1960). One can approach this task by evoking concepts used in the study of cybernetics, especially the area of servocontrol systems. Within this context, feedback functions as a means for (1) acquiring data about how accurately a system is working and (2) identifying and correcting error messages (Smith and Smith, 1966). If this is applied to written instruction, feedback will either let the student know when he is right, or correct him (or let him correct himself) when he is wrong. The argument is that this continuous confirmation-correction process is responsible for increases in learning which occur when feedback is present.

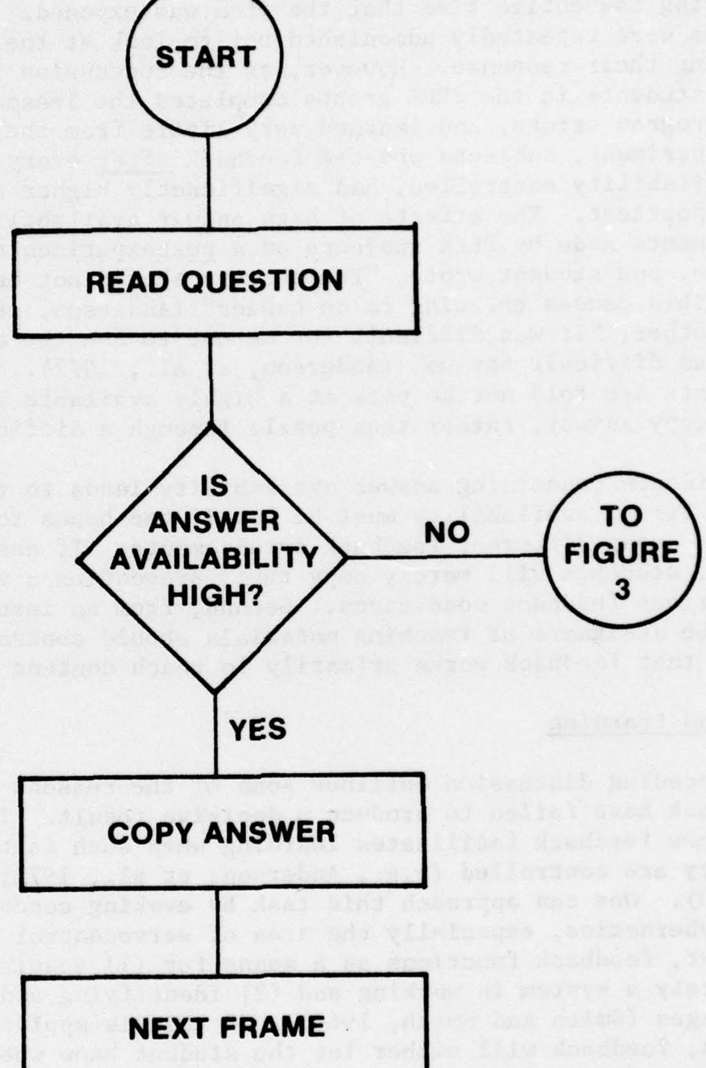

Figure 2. Effect of high answer availability.

Within the configuration of information processing, the student and the lesson are viewed as components of a self-regulating control system which has the terminal goal of transferring information from the text to the learner (Talyzina, 1973). This system assumes that the student possesses, and is capable of using, at least some prior knowledge related to the material being studied. This assumption seems fair, since it is a rare case indeed when learners know nothing about the subject matter on which they are concentrating. Under these conditions, the response to each question is based on both general knowledge related to the item and on specific information covered within the text just read. In other words, the feedback acts to inform the student how accurate his response is relative to the knowledge he already possesses. Obviously, if the material being studied is abstruse or unfamiliar to the student, providing feedback should have little effect on his criterion performance, since he has no way to relate the new information to what he already knows.

Feedback Confirming a Correct Response

When feedback follows a correct response, it tells the learner that his understanding is adequate to that point in the material. Selection of the right answer produces a "match" with the feedback, and the student knows that he interpreted the question correctly. Confirming feedback provides a mechanism within the student-lesson system for informing the controlling unit (student) that the comprehension strategy is achieving the terminal goal of transferring the information from text to learner. This sequence of events satisfies the requirement that the system has a means for furnishing data about goal accuracy.

The comprehension explanation raises the question of whether or not feedback has a direct effect on individual items which are answered correctly. As we shall see later, there are cases where correct test responses appear to be dependent on performance during learning. However, both correct and incorrect answers have a remarkable tendency to perseverate to later tests, regardless of whether or not feedback is available (Kaess and Zeaman, 1960; Kulhavy and Parsons, 1972; Kulhavy and Anderson, 1972). Consequently, since right answers have a proclivity for repeating themselves, any positive effects due to confirmation are probably geared more to overall comprehension than to the clarification of specific items. This interpretation assumes, of course, that the initial responses are based on prior knowledge, rather than a random guess.

Feedback Correcting an Incorrect Response

In terms of increased learning, supplying corrective feedback after an incorrect answer is probably far more important than providing confirmation after a correct one. In the case of a correct answer, no change is required. However, when an incorrect answer is produced, the object is not only to eliminate the wrong answer but also to substitute the correct one. This prescription leads to the seasoned notion that feedback on errors acts primarily as a corrective agent (cf. Anderson, 1967, 1970;

Annett, 1969). Here feedback fulfills the requirement that the processing system has some way of identifying error responses. Once the error is recognized, the student can attempt to eliminate it and replace it with correct information.

One reason why the corrective aspects of feedback have received so little attention is simply because many studies fail to analyze incorrect and correct responses separately. However, when the experimental treatments themselves emphasize error responding, the data consistently indicate a corrective effect. For example, in a series of studies on concept acquisition, Buss and his associates repeatedly found that telling a subject when he was wrong yielded higher criterion performance than confirming correct answers (Buss, Braden, Orgel, and Buss, 1956; Buss and Buss, 1956; Buss, Weiner, and Buss, 1954). The corrective effect of feedback is also apparent in a study by Travers, Van Wagenen, Haygood, and McCormick (1964) who used various feedback combinations to teach school children German vocabulary words. Children who were told that a response was wrong and then were corrected did far better than those who received a simple yes or no following each response. Finally, in the Anderson, et al. (1971) experiment described earlier, posttest scores for groups who saw corrective feedback only after they had given an incorrect response or who were allowed extra study time to determine why they had made wrong responses were not appreciably different from those for the group who saw feedback following each frame. This research suggests that feedback works to correct wrong responses.

An even more decisive argument, however, comes from work done on the Delay-Retention Effect (DRE). As mentioned earlier, studies employing the DRE consistently show that when feedback is delayed for some period following learning rather than being presented immediately, significant increases in learning occur. DRE experiments have five components which can be represented schematically as:

$$R_1 \text{———} d_i \text{———} FB \text{———} r_i \text{———} R_2$$

Where: R_1 signifies initial exposure to the stimuli to be learned, generally involving a response selection on the part of the subject;

d_i, a delay interval of some time t_d;

FB, the R_1 test responses with the correct answer identified (feedback);

r_i, a retention interval of some time t_r; and

R_2, the second presentation of the test stimuli (dependent measure).

The typical DRE design includes two groups who both receive R_1, FB, and R_2. As shown below, the delay group sees feedback following some specified interval after R_1 ($t_d = c$); and the no-delay group, immediately following R_1 ($t_d = 0$). For both groups $t_d + t_r = n$.

DELAY GROUP

$$R_1 \underset{(t_d = c)}{\rule{2cm}{0.4pt}} FB \underset{(t_r = n-c)}{\rule{2cm}{0.4pt}} R_2$$

NO-DELAY GROUP

$$R_1 \underset{(t_d = 0)}{\rule{2cm}{0.4pt}} FB \underset{(t_r = n)}{\rule{2cm}{0.4pt}} R_2$$

In research on the DRE, the delay group consistently outperformed the no-delay group on the R_2 retention measure. This held true with such diverse materials as French vocabulary (Brackbill, Wagner, and Wilson, 1964; Markovitz and Renner, 1966), paired-associated (Sturges, Sarafino, and Donaldson, 1968), multiple-choice items (Sassenrath and Yonge, 1968, 1969; Sturges, 1969, 1972), and prose passages (Moore, 1969; Surber and Anderson, 1975). One factor common to many of these studies was the high error rate exhibited at R_1. This initial high error rate, coupled with the fact that the percentage of correct answers for the no-delay subject changed very little from R_1 to R_2, lead Kulhavy and Anderson (1972) to hypothesize that the DRE occurs because the delay groups are able to rectify R_1 errors over the d_i interval. Essentially, the Kulhavy and Anderson study, which was later replicated by Surber and Anderson (1975) shows:

1. The probability of a student's repeating an initial error on a posttest is significantly lower when feedback is delayed for a 24-hour period.

2. Subjects who made incorrect responses and who attempted to identify their original response while receiving feedback were far less likely to remember errors following a delay interval. (Of course, a delay has the same effect on those giving correct answers but in this case, feedback acts as additional practice.)

3. Subjects spend significantly more time studying feedback if it is not presented immediately after a difficult test.

These findings lead Kulhavy and Anderson to conclude that initial error responses interfere proactively with acquisition of the correct answer when the subject sees feedback immediately simply because the item stems are identical and the responses similar. However, this interference is reduced when students are given a chance to forget their incorrect responses by providing a delay interval between response and feedback. The set of conditions prevailing in the Kulhavy and Anderson study was almost identical to that encountered in list learning experiments used to define the proactive interference paradigm (Underwood and Freund, 1968).

Learner Comprehension

The DRE research clearly shows that feedback not only works to identify errors but, under appropriate conditions, allows the subject to correct them. Interestingly, there are studies in which even the repeated administration of feedback fails to correct error responses (Elley, 1966; Kaess and Zeaman, 1960). However, such results seem to occur only when the experimental materials are so unfamiliar to the subjects that they spend most of their time guessing randomly at answers. In fact, Kulhavy and Parsons (1972) suggest that feedback will have only minimal effect if the learner is unable to comprehend the instruction or fit it into some existing information framework. In such cases, subjects are likely to spend their time trying to rotely associate the feedback with individual items. It is not surprising then that people who learn only that "answer <u>A</u> is correct for question 13" are likely to need several repetitions before they learn the proper paired-associate. The comprehension notion gains even further support from the fact that most research showing strong perseveration effects uses extremely convoluted material, a condition providing minimum information on which to base initial responses. Based on this reasoning, it appears that feedback performs its corrective function effectively only if mistakes result from faulty interpretation rather than lack of understanding. If learners fail to comprehend the material in the first place, feedback will have little effect on performance.

Feedback and Learner Confidence

One feature which most feedback studies have in common is a tendency to measure performance only in binary terms; that is, a given response is considered either absolutely right or absolutely wrong. Such an acute dichotomy makes little sense to people who are sohpisticated test performers. It seems more likely that in making a response to a test item, most students first eliminate obviously wrong choices, and then select from the remaining alternatives the answer which seems most approparite. In fact, at Arizona State trial data has been acquired which indicate that students create a hierarchy of confidence in the alternatives and then choose the most probable right answer. Hence, the usage students make of feedback following a response depends largely on the interaction between their initial level of confidence in their response and the accuracy of the answer. This contention allows one to make predictions about learning, based on a knowledge of how the person perceived the item, and whether or not he answered it correctly.

When response confidence is high and the correct answer is chosen, feedback probably receives only cursory attention since it merely provides confirmation. In fact, it appears that the surer a student is of his response, the less likely he is to request feedback if it is not readily available (Melching, 1966). Hence, if a learner has high confidence in a correct response, he should spend a minimum amount of time studying feedback and, in keeping with the earlier comprehension argument, produce high test performance on such items.

When response confidence is high but the answer chosen is wrong, the situation is markedly different. Instead of briefly scanning the feedback, students are likely to spend substantial time trying to locate the source of their mistake. When a learner was "sure" that he understood the material but responded incorrectly, he probably behaves much as he would in a class examination review; that is, he becomes incensed over missing the question, and pays a great deal of attention to why the answer was incorrect. Consequently, feedback should play its greatest corrective role with high confidence errors, simply because the person spends more time in correcting his misconception.

When response confidence is low, as would be the case when students are unable to understand the material, the question, or both, they spend their time developing associative strategies, rather than integrating new information into existing structures. Under this condition, feedback should have minimal effect regardless of whether or not the response is correct.

The set of predictions relating response confidence and feedback are presented graphically in Figure 3, which represents a right-hand continuation of the events shown in Figure 2. To test this model, a simple two-group study was conducted in our laboratory in which undergraduates worked through a 30-frame program on the structure of the human eye. Subjects in both groups read each frame, answered a multiple-choice questions, and rated their response confidence on a five-point scale. Following the rating, subjects in one group received feedback, and those in the second group merely advanced to the next frame. Finally, all subjects were tested immediately after the learning process and again after a 1-week delay. With minor exceptions, results were as predicted by the sequence shown in Figure 3. High confidence responses followed by feedback were remembered significantly better on the tests regardless of whether or not the initial response was correct. However, there were no major differences between test scores of students making low confidence responses. As shown in Figure 4, students who have high response confidence and who give the right answer spend little time studying feedback, whereas students who have high response confidence and given the wrong answer spend considerable time. Students making low confidence responses fall somewhere in between.

These results clearly show that the interaction between learner response confidence and feedback has a powerful effect on what the student remembers from a lesson. Thus, it appears that both the form and method of presentation of feedback can be manipulated more effectively if they are in some way made contingent on learner confidence, particularly if the lesson parameters are under computer control. As a step in this direction, data are currently being collected on rated confidence across such phenomenon as the DRE, and attempts are being made to define what aspects of the feedback message are important for error correction. This seems to be a prime area for future research.

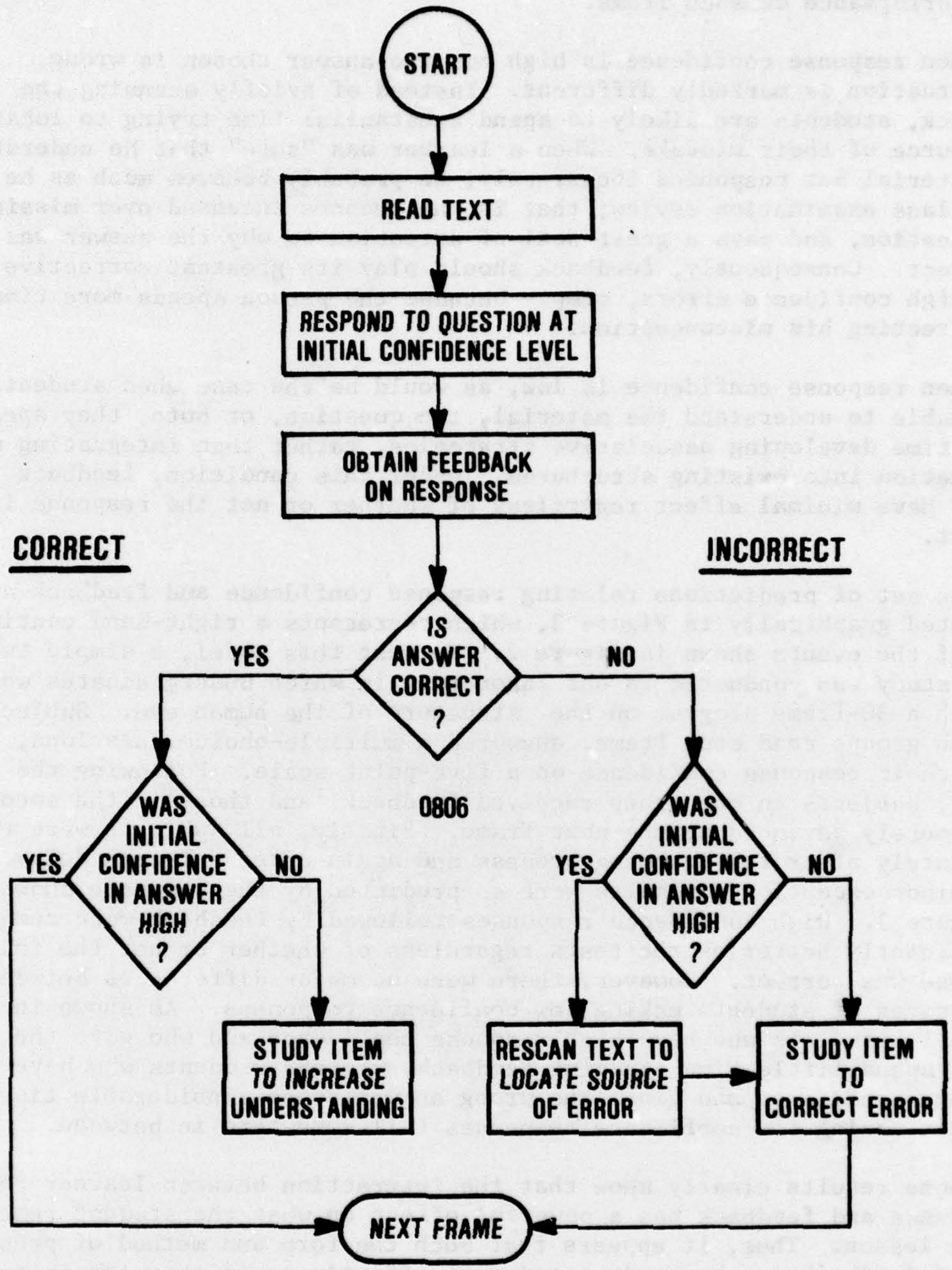

Figure 3. Activities relating feedback and response confidence.

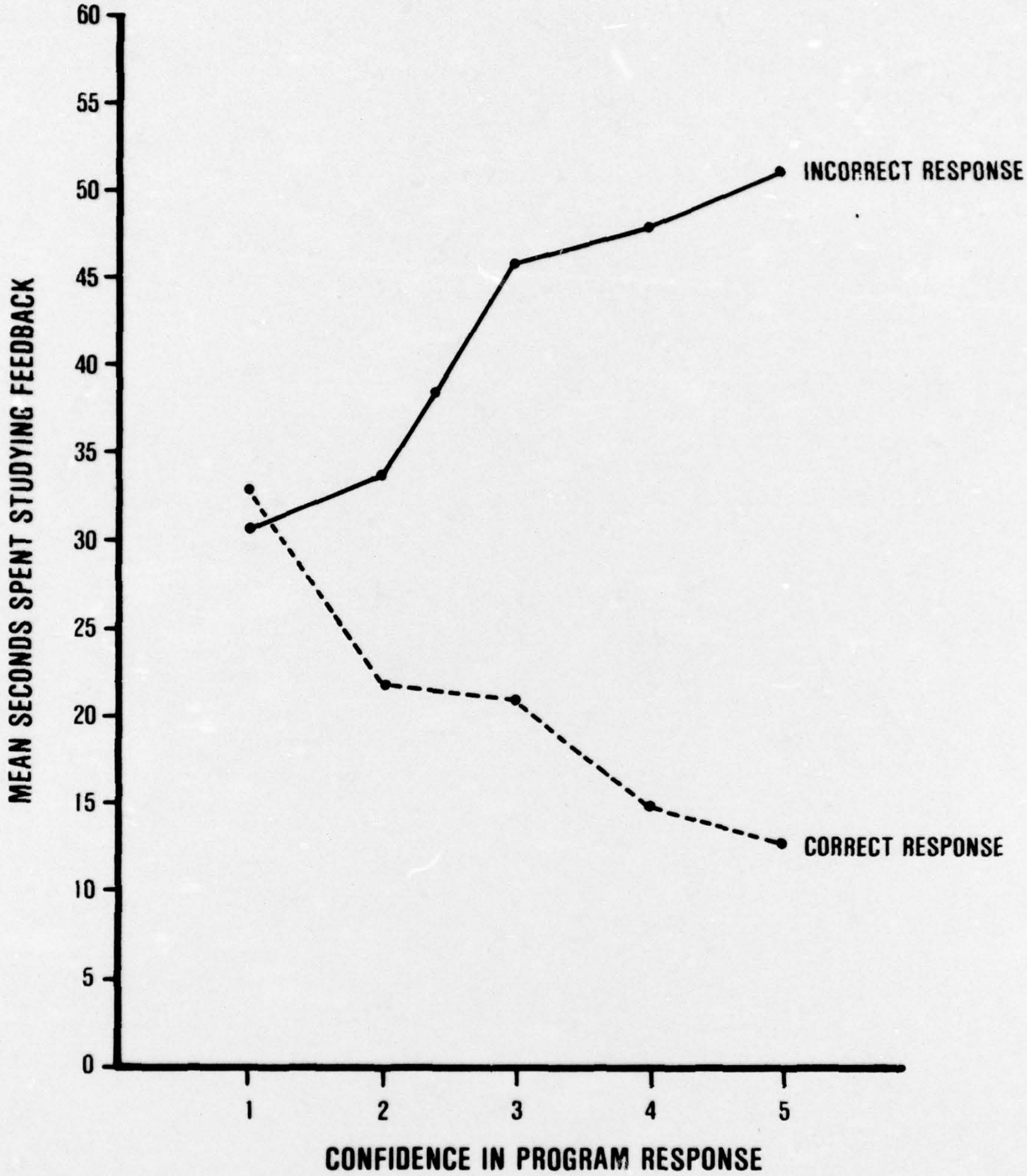

Figure 4. Feedback study times as a function of confidence ratings.

CONCLUSIONS

Feedback following an instructional response appears to facilitate learning only under certain specified conditions. Feedback has little facilitative effect when learners are able to access the correct answer prior to processing the material and responding. In such cases, they are likely to simply copy responses and learn little of the material presented. Only when feedback is unavailable until after responding is there likely to be a facilitative effect. The second case where feedback is ineffective occurs when the material to be learned is very difficult and unfamiliar to the student. Here, learners tend to spend their time guessing at answers, and even if their choice is correct, the amount of learning is limited since initial comprehension was low.

When factors such as copying and low comprehension are controlled, feedback appears to have two primary effects on what is learned. First, it acts to confirm correct responses, telling the student how well the content is being understood. Second, feedback identifies error responses and provides the means for the learner to correct his mistakes. The corrective function appears to be the most important one, and if there is a choice to be made, feedback following wrong responses probably has the greatest positive effect.

The material presented in the final section of the report indicates that how the student perceives his understanding of the material has a great deal to do with what benefit he gets from feedback. In cases where the lesson is well understood and the learner is confident that his initial response is correct, he will tend to get the information correct on a later test. Interestingly, this effect holds regardless of whether the initial response was correct, since students making high confidence wrong responses make maximum use of the corrective function of feedback. These data suggest that how a student evaluates a response has much to do with the use to which he will be able to put feedback. It appears that measures of the student response expectations may be an effective way in which to provide data for use by a computer-controlled system in evaluating what type of information should follow the response.

RECOMMENDATIONS

To ensure that feedback provides maximum learning facilitation, it is recommended that instructional designers:

1. Ensure that learners have sufficient entry skills for the lesson.

2. Minimize the opportunity for students to obtain feedback prior to responding.

3. Provide feedback as often as possible during the course of the lesson.

It is further recommended that future research in this area be directed toward the relationship between learner confidence and feedback.

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