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ABSTRACT

The reported research was designed to investigate the impact of learner control on performance and anxiety in a computer assisted instruction task. This, the third phase of a project, substituted pictorial mediators for mnemonic devices as the facilitating variable in an instruction program on edible plants. Four experimental groups were formed with the facilitating variable crossed with information on the utilization of learner control. Responses to a state anxiety measure, learner control requests for pictures, and errors committed on segment and final tests were the dependent variables. Measures of individual differences were taken in the areas of task specific memory, locus of control, and achievement via independence. The affect of pictorial mediation was statistically effective, yet learner control, which depended on the facilitating variable, was not statistically different. The achievement via independence measure was able to predict individual differences in learner control behavior. It is concluded that the utility of learner control depends on the instructional situation. (Author/WH)

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AIR FORCE

HUMAN RESOURCES

INDIVIDUAL DIFFERENCES AND LEARNER CONTROL II: INVESTIGATION OF CONTROL OVER PICTORIAL MEDIATORS IN COMPUTER-ASSISTED INSTRUCTION

By

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The reported research was designed to investigate the impact of learner control on performance and anxiety in a computer-assisted instruction task. The research was divided into three phases. The results of Phases I and II are reported in Technical Report AFHRL-TR-74-3, "Individual Differences and Learner Control I: Program Development and Investigation of Control over Mnemonics in Computer-Assisted Instruction," (Judd, O'Neil, and Spelt, 1974). The results of Phase III are reported in this document.

The learning task for Phase III was the identification of edible plants and their critical features and edible parts. Experimental hypotheses centered on the affective advantages of learner control, personality variables which influence the use of learner control, and the instructional effectiveness of pictorial mediators under learner control.

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Three experimental groups were used. A treatment present (TP) group always received a facilitating treatment (pictorial mediators). A treatment absent (TA) group never received the facilitating treatment and the learner control (LC) group had control over the availability of the facilitating treatment.

For performance, there was a significant difference between the TP and TA groups with TP having the highest mean performance. This proved that the facilitating treatment was an effective learning variable to be placed under learner control. Performance of the LC group excelled that of the TA group and did not significantly differ from that of the TP group. The presumed affective advantage of learner control was not shown. Of the two personality measures used, Locus of Control (IE) Scale and Achievement via Independence (Ai) Scale, only the Ai scale was found to predict individual differences in learner control behavior; however, the best predictor of learner control behavior and performance was a task specific measure developed for this project.

SUMMARY

Problem. In response to changing training needs and the challenges of the "Zero Draft" and all volunteer services, the Air Force has placed increased emphasis on individualized training. As part of this emphasis, the Air Force has under development at Lowry AFB the Advanced Instructional System--a large computer-managed instructional system with a capability of supporting at least a 125 terminal, computer-assisted instructional (CAI) component. CAI offers the opportunity to adapt instruction on a moment-by-moment basis, to a student's needs or abilities. This adaptation is usually made by decision rules embedded within the CAI system but can also occur by allowing student (learner) control over sequence of instruction. The benefits of the latter should be increased student affect and simpler system programming. The reported research was designed to investigate the impact of learner control on performance and student affect in a computer-assisted instruction task as related to individual differences.

Approach. The research was divided into three phases. The results of Phases I and II are reported in an interim report (Judd, O'Neil, and Spelt, 1974). The results of the third phase are reported in this document. The first phase entailed the development of two hours of computer-assisted instruction on edible plants--a topic taken from the area of Air Force Survival Training. The instruction was run on an IBM 1500 instructional system. Phase II was experimentation to determine the effectiveness of learner control (LC). An essential element of the experimental design was to prove that the learning variable placed under LC was generally facilitating. Two experimental groups were used to test this condition. A Treatment Present (TP) group always received a presumably facilitating treatment while a second group, Treatment Absent (TA), never received this facilitating treatment. In Phase II, the facilitating treatment was mnemonic aids relating plant names to their critical features. In Phase II, the TP group was not significantly different from the TA group. This result lead to a reformulation of the experiment for Phase III. The experimental paradigm was still considered sound, but a new facilitating treatment was devised. This facilitating treatment was access to plant photographs. In addition to the TP and TA groups, there was a learner control (LC) group which controlled the frequency of access to the facilitating treatment. Measures of individual differences were taken in the areas of task specific memory, Locus of Control (IE), and Achievement via Independence (Ai). These latter two measures are respectively measures of perceived self-control and independence. Hypotheses were generated relating these measures with the utilization of LC. It was anticipated that students who were rated internal on Locus of Control and high on Achievement

via Independence would make more frequent use of the learner control option and would properly adjust their LC behavior in accordance with their performance on sections of the instruction. A significant part of Phase III experimentation was to investigate the affective advantages of LC. It was hypothesized that the LC group would exhibit less state anxiety than the TP group.

Results and Conclusions: For performance, there was a significant difference between the TP and TA groups with the TP having the highest mean performance. These results prove that the treatment which was to be placed under LC was in fact generally facilitating. A comparison of TP and LC groups showed that there were no significant differences between the two groups with the TP group having higher performance scores. Positively stated, LC did not have a detrimental effect and would be a cost-effective strategy in relation to always presenting the facilitating treatment. The presumed affective advantage of LC was not shown. Of the two personality measures used, Locus of Control (IE) Scale and Achievement via Independence (Ai) Scale, only the Ai scale was found to predict individual differences in learner control behavior. In addition, the best predictor of learner control behavior and performance was a task specific measure developed for this project.

Recommendations: Learner control still seems to be a viable instructional alternative; however, its full impact and limitations await results from its use in operational contexts. On the basis of this one study, it cannot be said that LC makes students feel better in the sense of being less anxious. In the area of individual differences, there is sufficient indication that a specific measure of LC behavior as related to the instructional setting is a desirable focus for further research. Finally, the present research illustrates the impact of sound instructional design on the effect of an instructional strategy basically derived to accommodate individual differences. Learner control cannot yet be accepted as the way of individualizing instruction, but still needs to be validated in terms of each instructional situation to which it is to be applied.

Preface

The authors wish to express their appreciation to the members of the University of Texas Computer-Assisted Instruction Laboratory for their invaluable assistance throughout this project. Special thanks are due to Kathleen Daubek, Claire E. Weinstein, Jody Fitzpatrick, and Richard Shocket for their aid in the conceptualization and execution of the two experiments. They should also like to thank John Craghead and Susan Whitmore for performing the data analyses.

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Introduction

This document is the final report for Air Force Contract F41609-73-C-0032 entitled "Learner Control of Computer-Assisted Instruction." The technical requirements of this project consisted of three stipulated phases. Phase I consisted of a review of previous research on learner control, the design of an experiment to be conducted in the context of a practical instructional program, and the development of a computer-assisted instructional program for this purpose. Phase II consisted of an experiment, the purpose of which was to investigate personality variables which affect the use of learner control, the mediational effectiveness of instructions on the use of learner control, and the presumed affective advantages of learner control. In Phase III, a number of questions and problems which had arisen in the Phase II experiment were investigated. The affective advantages of learner control and personality variables which influence the use of learner control received additional study and in addition the instructional effectiveness of pictorial mediators was examined. An interim report (Judd, O'Neil, & Spelt, 1974) discussed progress to date on Phases I and II. Therefore, the focus of this final report will be on Phase III.

The report is organized into six major sections. This Introduction includes a very brief summary of the literature review, the specific experimental problems which were identified by this literature review, and the design and results of the Phase II experiment. The second section describes the computer-assisted instructional program and a task specific prediction instrument as they were revised following the Phase II experiment. The remainder of the report--Statement of the Problem, Method, Results and Discussion, and Conclusions--addresses the Phase III experiment. Appendix A describes the instructional program by means of a detailed flowchart.

In order to provide some background for the Phase III experiment, previous research concerning learner control and the specific personality variables investigated are summarized below. The interested reader is referred to the interim report (Judd, O'Neil, & Spelt, 1974) for a more extensive review of this research.

Background on Learner Control

Research on learner control has occurred only relatively recently in the history of computer-based instruction. The early research in this area was predicated on the assumptions that: (1) the student has a sufficient comprehension of his own state of learning to determine, in most instances, what his instruction should be; and that (2) allowing the student control over his progress will make the learning situation more "attractive." These authors expected that learner control would result in: (a) increased mastery of subject matter; (b) equivalent mastery in a shorter period of time, and/or (c) increased self-direction in the student's approach to learning. In addition, in those experiments using computer-based educational techniques, the experimenters anticipated that learner control would result in an increased tendency for students to view the computer as a tool for learning, rather than as a dictatorial tutor. However, more recent research, which introduced greater control over the learning situation in general and over the specific learner control options in particular, has failed to confirm these optimistic predictions. In general, the learner control literature might be characterized as promising but confused.

One reason for the confused state of the literature is that there is no consensus on the definition of "learner control." Research to date has included learner control over a variety of variables in the learning situations: content area, sequencing of context units, pacing, redundancy/review of material, detail of material, and even media for presentation of the material. It is virtually impossible to find agreement on the factors over which learners are given control. Furthermore, almost never have the instructional variables placed under learner control been demonstrated to have any appreciable effect on learning.

In the two experiments conducted in this research project, the experimental paradigm incorporated an empirical check of the instructional efficacy of the variables over which subjects were given learner control. In addition to one or more learner control groups, this paradigm requires two experimental control groups. The first of these never receives the presumably facilitating treatment over which learner control subjects are given control while the second always receives the treatment. Only if the performance of the second of these control groups excels that of the first may it be concluded that learner control subjects were given control over a generally facilitating instructional variable.

Individual Differences and Learner Control

One of the primary criticisms of the past research on learner control has been the failure of many of the researchers to take into account possible individual differences in response to the availability of learner control. Since learning psychologists have for some time been aware of individual differences in learning strategies, it appears quite likely that different individuals would respond differently to learner control. If the personality variable or variables which may account for these differences could be identified, it is quite likely that many of the conflicting results in previous learner control studies could be explained. Thus, one might find that certain types of individuals benefit greatly from certain types of learner control, while others need more specific guidelines or cues in order to improve their performance through learner control.

One general personality trait which would appear to be related to the efficient use of learner control is the independence of the student. Early proponents of learner control argued that the individual student is more aware of his own weaknesses and strengths than is the instructor and is thus better able to guide or direct his own learning if given the opportunity. While the results of studies of various learner control options have been inconclusive concerning this hypothesis, this may be the result of failure to control for personality variable differences. Thus, an independent student who is aware of his learning needs may act to operationalize his knowledge. The more dependent student who normally depends on an instructor to guide him may, however, require more specific guidelines in order to become cognizant of his own needs.

Two scales have been chosen to measure the general personality variable of independence. The first measure concerns the personality construct locus of control, or internality-externality (IE). This construct is viewed as a generalized expectancy about control over the environment, operating over a wide variety of situations. Internal control refers to the individual's belief that an event is contingent on his own behavior or characteristics. On the other hand, an individual characterized by external control attributes the occurrence of a significant event to fate, luck, or to the control of others, or as being unpredictable (Rotter, 1966).

Based on the extensive research that has appeared since Rotter's formulation (see review in Judd, O'Neil, & Spelt, 1974), it appears that the external subject could be analogous to the student who has depended on the instructor or some other external agent to guide his learning and has not perceived his opportunities for control. He, therefore, requires more specific guidelines than the internal subject in order to perceive his own needs and take the opportunity for control. It appears that increasingly well-defined task instructions provide a missing cognitive link for externals which helps them to improve their performance.

Also, in information-seeking tasks, internals request significantly more information than externals, probably resulting from their greater ego involvement in learning tasks. This finding further supports the hypothesis that internals would make greater use of learner control options than would externals.

The second scale used in this project is the Achievement via Independence (Ai) scale of the California Psychological Inventory (CPI). According to the CPI manual (Gough, 1957), the Ai scale measures those factors of interest and motivation which facilitate achievement in any setting where autonomy and independence are positive behaviors. High scorers are characterized as being mature, independent, self-reliant, and having superior intellectual ability and judgment, whereas low scorers are seen to be cautious and reliant on others. For the proposed research, it was postulated that the high scorers would take advantage of and benefit more from learner control options. The personality characteristics of the high scorer appear to be congruent with the maturity and inquisitiveness characteristics of subjects who benefit most from learner control.

The studies reviewed in Judd, O'Neil, and Spelt (1974) and the operational definition of Achievement via Independence suggest that this measure would be a valid predictor of individual success with learner control in that it is a specific measure of independence in a learning environment.

Effect of Learner Control on State Anxiety

While the variables of mastery and time to completion are sufficiently specific, the presumed affective advantages of learner control, perhaps its most promising aspect, have been ill-defined. The use of attitude scales has resulted in few clear-cut findings. This research operationalized the dependent variable of affect as scores on state anxiety scales (Spielberger, Gorsuch, & Lushene, 1970) administered on-line during the learning task. Based on the data presented in Judd, O'Neil, and Spelt (1974), anxiety appears to be an important affective variable related to learner control. It was hypothesized that a student's anxiety would be raised if he felt that he had no control whatsoever over the learning situation, while, conversely, as the student's perceived control was increased, allowing him to manipulate the learning material according to his individual strengths and weaknesses, his anxiety would be greatly reduced.

The utility of the previously described experimental paradigm, and the impact of learner control on performance and state anxiety were investigated as functions of the individual difference measures discussed previously in the first experiment conducted under the auspices of this project. This experiment is summarized in the following paragraphs. A complete description of the experiment and the development of the experimental instructional materials is available in Judd, O'Neil, and Spelt (1974).

Investigation of Learner Control over Mnemonics

In this initial experiment, subjects were presented with information on 10 edible wild plants native to central Texas. The subjects' task consisted of learning to identify the name, critical features, and edible part(s) of these various plants. In order to identify a supportive treatment over which to provide learner control, the behaviors, and hence the subskills required for the performance of the task, were determined by analyzing how an expert would perform the task. The cognitive operations required were determined by asking an expert to think out loud while performing the task, resulting in a concrete, logical representation of the expert's problem solving process. This representation provided three types of information required for the instructional design: (1) a detailed description of the behaviors defined by the terminal objectives; (2) a definition of the prerequisite behaviors; and (3) an indication of the cognitive skills which were likely to impact the instructional process. This information processing analysis revealed that the task was heavily dependent on visual/verbal memory. Therefore, it was anticipated that increasing the subjects' mediational activities in linking the various visual and verbal stimuli to the required verbal responses would provide support for the cognitive processes on which the task was heavily dependent. To accomplish this, a series of mnemonic devices linking the plant names to their characteristics was created. A task specific memory test was also designed and used as a covariable.

Upon completion of these preliminary steps, and once the CAI program was written and tested, subjects were recruited for the experiment. Four groups were defined--two control and two learner control groups. One control group, treatment absent (TA), never received the mnemonics during instruction while the other control group, treatment present (TP), always received them. A significant performance difference between these two groups would establish the instructional efficacy of the variable to be placed under learner control. Two learner control groups were able to choose whether or not they wanted to see the mnemonic for any particular plant. They differed, however, in the type of instructions they received. One group, LCI, received extended instructions on the beneficial use of this option while the other group, LC, received relatively brief instructions.

In addition, the relationship between the individual difference variables previously described and learner control was investigated. The two individual difference scales (IE and Ai) were administered prior to the student's introduction to the computer, along with a specially created memory test. Affective advantages were measured by the state anxiety scale, described above, which was administered on-line during the program.

The dependent variables were affect and performance on two embedded tests and a final performance measure. Subjects were 162 University of Texas undergraduate student volunteers who were paid for their participation.

The results showed that the presentation of mnemonic devices did not have the desired general facilitating effect indicated by the pilot tests. Although the mnemonics did facilitate the performance of a few experimental subjects, those with particularly good associative memories as measured by the task specific memory test, they were ineffectual or debilitating for the majority of subjects. Thus, it was not surprising that providing subjects access to the mnemonics via learner control did not have the hypothesized effect of reducing state anxiety.

The effect of the extended learner control instructions was to cause a slight (marginally significant) increase in the number of mnemonics requests made in the first half of the instructional program by the subjects receiving these instructions. This effect washed out in the second half presumably due to the subjects' experience with the limited utility of the mnemonics. No performance differences were found. The extended instructions did not have the hypothesized effect of increasing externally rated subjects' use of learner control but, again, this conclusion must be tempered by the fact that the mnemonics were not facilitating for most subjects. Similar results were found for those subjects high in Achievement via Independence.

Consideration of these results led to the conclusions that, while the experimental paradigm was still considered to be sound, revision of the instructional materials and the determination of a new facilitating treatment would be required to provide a valid test of any hypothesis concerning the affective advantages of learner control. With regard to the individual difference measures of IE and Ai, emphasis was shifted from the role of instructions in the use of learner control to the effect of subjects' previous experience with the task on their subsequent use of control.

The next section of this report describes the alterations made to the instructional program and the task specific memory test used as a performance predictor. The statement of the problem addressed by the current experiment is then presented in the following section.

Revision of Learning Materials and Prediction Instrument

Learning Materials

As discussed in the previous section, initial experimentation with the edible plants program revealed a number of problems. Not only did the mnemonic devices not constitute a generally facilitating treatment, the overall difficulty level of the program was much lower than had been anticipated. That is, subjects run under the treatment absent condition (no access to the mnemonic memory aids) made relatively few errors on the two embedded tests and the final test. Subjects' performance on these tests was so good, as a matter of fact, that the distributions of error scores were substantially skewed in the positive direction for all three tests. These results raised the question of why the learning task had proved to be so much less difficult than had been anticipated.

In the post-experimental interviews with subjects, the instructional value of the plant photographs was mentioned repeatedly. These comments were considered in a reanalysis of the task. As a result of this reanalysis, the task and experimental conditions were revised so as to make the presence of the plant photographs the major component of the facilitating treatment. That is, the treatment absent condition did not include any photographs of plants in the instruction. Under the treatment present condition, photographs of the plant in context, of the plant's critical features, and of its edible parts were all presented at appropriate points in the instructional sequence. Under the learner control condition, subjects were given control over access to these photographs.

As is discussed in the Statement of the Problem section, the design of the current experiment required the presence of a second learner control option. For this purpose, a brief review of the plant's critical features, including the corresponding photographs, was added to the instruction for each plant. This review was always provided to subjects run under the treatment present condition, never provided for treatment absent subjects, and available as an option for subjects run under the learner control condition.

A number of other modifications were made for the purpose of increasing program difficulty. The majority of the active responding was deleted from the instruction, reducing the instructional segments to primarily expository sequences. The number of plants to be learned was increased from 10 to 12. The four plants which had been shown to be the least difficult were placed together in the first instructional segment and were tested immediately following this segment. The eight more difficult plants were placed together in the second instructional segment but there was no test immediately following this segment. Instead, instruction on the plant identification strategy which, due to the nature of the tests, was actually irrelevant to the performance on the tests, was moved from its original position at the beginning of the program to a position following the second instructional sequence. A final test over all 12 plants followed this identification strategy module. Thus, the module took on the role of an intervening and, hopefully, interfering task for all subjects. The performance variable of major interest became the number of errors on the final test, and, particularly, the number of errors on the fifth through the 12th plants--those presented in the second instructional segment. The program is described in more detail in the Experimental Procedure section.

Task Specific Memory Measure

The experimental paradigm employed in both the initial and current experiments required the presence of an instructional treatment which was generally facilitating with respect to the task's demands on associative memory. Therefore, a second independent measure of individual differences in associative memory was required. Prior to the initial experiment, a number of associative memory tests which appeared to have desirable characteristics (Guilford, 1967) were examined, but none were considered adequately specific. Therefore, the decision was made to develop a task specific paper and pencil test, the characteristics of which would be similar to the memory demand characteristics of the task itself.

The initial task analysis indicated that the component of the learning task involving the heaviest memory load concerned associating the plants' critical features with their names. The test developed had this same format but a different content area. It consisted of a practice example and two identical components. In each component, the subject was given a list of five men's names and descriptions of two or three articles of clothing which each was wearing. On successive pages of the test, subjects were then given a single man's name and asked to select (from a list of five) the articles of clothing described for that man. On the following two or three pages, the correct articles of clothing were supplied and the subject was to select the correct description of that article.

Results of the first experiment indicated that while there was a substantial correlation between number of errors on the test and errors committed in the task, the overall error rate for the memory test was too low. That is, relatively few subjects made a substantial number of errors on the test, resulting in a positively skewed distribution of error scores.

None of the subsequent revisions to the instructional program were considered to have altered the basic relationship between the learning task and the predictive instrument. It was concluded that the instrument would still be an appropriate predictor if it could be revised to produce a more normal distribution of error scores; that is, if the overall difficulty level of the test could be increased. To this end, the format of the test was revised. Rather than presenting the test items in two groups of five each, all 10 items were presented at once. Each man's name and the description of his clothing was presented on a separate page. Subjects were allowed only six minutes to study all 10 pages and were not allowed to turn back to a previous page. Pilot work with the revised test and program indicated that the test did produce a relatively normal distribution of error scores and correlated substantially with performance on the task.

Statement of the Problem

A basic supposition of this research project has been that the investigation of learner control and, in particular, of its presumed affective advantages, can only be fruitful if the learner control options provided to the student are instructionally relevant to him. Eventually, it would be hoped that the instructional alternatives made available via learner control would allow the student to adapt the instruction to his own particular strengths and deficiencies. However, at this stage of research on learner control, and considering the problems inherent in more conventional aptitude by treatment interaction research, this project has adopted the more conservative approach of employing a learner control option of access to a generally facilitating instructional treatment. Therefore, a basic assumption of the design employed in this experiment is that the presence of the photographs of the plants and their various features would be an effective, generally facilitating instructional treatment as contrasted with the absence of such pictures. It was not anticipated that review of the critical features would necessarily be generally facilitating but, as will be discussed below, the inclusion of review was necessary to provide a second learner control option. For the sake of maintaining the number of experimental groups at a minimum, the presence of pictures and review were coupled together and treated as a single instructional treatment.

Since the first instructional segment included only a small number of relatively easy plants, it was not anticipated that the presumed facilitating effect of the instructional treatment would necessarily be demonstrated on the test following this segment. Similarly, previous research had shown the identification of the plants' edible parts to be a relatively easy task. Again, therefore, it was not anticipated that the effect of the instructional treatment would necessarily be shown with respect to subjects' performance on this component of the tests. Evaluation of performance differences resulting from the presence or absence of the presumably facilitating instructional treatment was therefore limited to the comparison of error scores on the critical features and identification components of the final test. Thus, validation of the experimental paradigm requirements may be summarized as stated in Hypothesis 1.

> Hypothesis 1: Subjects run under the treatment present condition will make fewer errors on the critical features and identification portions of the final test than will subjects run under the treatment absent condition.

For learner control to be a viable alternative to nonadaptive instruction or program control, it is essential that students make effective use of the options available to them. For this particular experiment, this assumption implies that subjects given learner control over the generally facilitating treatment would elect to use this option with sufficient frequency to substantially improve their performance relative to the performance of subjects who were denied access to the treatment. This assumption may be summarized as stated in Hypothesis 2.

> Hypothesis 2: Given that Hypothesis 1 is supported, subjects run under the learner control condition will make fewer errors on the critical features and identification portions of the final test than will subjects run under the treatment absent condition.

The dependent variable of major interest in this research has concerned affect rather than performance. The specific affective measure employed was the short (five-item) form of the state anxiety scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). Since it was anticipated that the effects of the different experimental treatments would be most pronounced in comparisons of the groups' performance on the final test, the state anxiety scale was administered immediately following this test. As is discussed elsewhere, the scale was administered a total of four times but the post-final administration was the dependent variable of major interest.

Previous research with this scale (O'Neil, 1973) has indicated that, in general, expressed state anxiety tracks task difficulty. Thus, in the current research it was anticipated that, if the presence of photographs of the plants was indeed generally facilitating, subjects run under the treatment present condition would express less state anxiety than would subjects run under the treatment absent condition. Although this supposition was not directly related to the question of the effect of learner control, it was investigated as a means of further substantiating the presumed generally facilitating effect of the plant photographs. This supposition is summarized in Hypothesis 3.

> Hypothesis 3: Given that Hypothesis 1 is supported, subjects run under the treatment present condition will express less state anxiety following the final test than will subjects run under the treatment absent condition.

If learner control per se does indeed have positive affective characteristics, then having control over an instructional treatment which has been shown to be instructionally facilitating should serve to reduce subjects' task-related anxiety. That is, it would be expected that the anxiety expressed by subjects given learner control over the treatment would be even less than that expressed by those subjects for whom the treatment is always present. This is summarized by Hypothesis 4.

> Hypothesis 4: Given that Hypothesis 1 is supported, subjects run under the learner control condition will express less state anxiety following the final test than will subjects run under the treatment present condition.

On the basis of previous research on Rotter's (1966) Internal-External (IE) Locus of Control scale, it was postulated that subjects who were rated on this scale as being relatively externally controlled would make less use of learner control than would subjects who were rated as being more internally controlled. On the basis of the initial experimentation with the edible plants program, it was further postulated that internally controlled subjects would be more adaptive in their use of learner control than would externally controlled subjects. More specifically, it was anticipated that, given appropriate conditions, internally controlled subjects would increase or decrease their use of the available learner control options as a function of their performance on previous portions of the program.

Since the basic facilitating treatment of presenting photographs of the plants during their description had been designed to be as potent as possible, it was anticipated that almost all of the learner control subjects would elect to see the photographs for all or almost all of the plants. Thus, little variability could be expected in the frequency of use of this option. This problem necessitated the introduction of the second learner control option--access to review over each plant's critical features. Although such review was considered to be facilitating for most subjects, the assumed "cost" of the review relative to its assumed effectiveness was considered to be sufficiently high to result in a lower proportion of the subjects electing to exercise this option. As opposed to the plant photographs, the decision to review the plant's critical features required additional time. The review itself was placed fairly close in time to the original instruction on the critical features.

The two points concerning frequency of use of learner control as a function of subjects' ratings on the Locus of Control scale are operationalized in Hypotheses 5 and 6.

Hypothesis 5: Learner control subjects rated as being more "Internally controlled" on the IE Scale will request review of plants' critical features more frequently during the second instructional segment than will subjects rated as being more externally controlled.

Hypothesis 6: Learner control subjects rated as being more "internally controlled" on the IE Scale will increase or decrease the number of their requests for critical features review during the second instructional segment relative to the first instructional segment as a positive function of the number of their errors on the test following the first segment. The change in frequency of requests will, on the other hand, be unrelated to performance on the first test for more externally controlled subjects.

As was the case for the IE scale, previous research concerning the Achievement via Independence (Ai) scale of the California Psychological Inventory (Gough, 1957) and the initial research with the edible plants program led to the prediction that subjects who registered relatively high scores on the Ai scale (indicating a high need for achievement via independence) would make greater use of the learner control options than would subjects with lower Ai scores. Again, as was the case for the IE scale, results from the initial experimentation with the program also led to the prediction that high Ai score subjects would be more adaptive in their use of learner control. That is, it was anticipated that high Ai score subjects would increase or decrease their use of the learner control options as a function of their performance on previous portions of the task more than could low Ai score subjects. Thus, two hypotheses were generated which were parallel to the two hypotheses pertaining to the Locus of Control variable.

Hypothesis 7: Learner control subjects with higher scores on the Ai scale will make more requests for critical features review during the second instructional segment than will subjects with lower Ai scores.

Hypothesis 8: Learner control subjects classed as being relatively "achievement oriented" on the Ai scale will increase or decrease the number of their requests for critical features review during the second instructional segment relative to the first instructional segment as a positive function of the number of their errors on the test following the first segment. The change in frequency of requests will, on the other hand, be unrelated to performance on the first test for less achievement oriented subjects.

Method

Subjects

The subjects were 139 male and female undergraduate students drawn from the student population at the University of Texas at Austin. To recruit subjects, daily advertisements were placed in the student newspaper. Each participant received a four dollar remittance. Subjects were scheduled in groups of not more than eight, and, within each group, were randomly assigned to one of the three experimental conditions. Nine subjects were rejected from consideration due to lack of naivety about the program content or failure to follow directions. The final group of 130 subjects consisted of 60 males and 70 females.

Apparatus

All instructional materials and instruments were presented on the computer system of the Computer-Assisted Instructional Laboratory at the University of Texas at Austin. The CAI Laboratory instructional computer facility consists of an IBM 1800/1500 system, supported by five 1810 disk drives, two 2402 tape drives, a 1442 card read/punch, and a 1443 printer. There are nine 1510 cathode ray tube (CRT) terminals with 1512 image projectors and light pens and three 1518 typewriter terminals. Four of the CRT terminals also include 1506 audio units. Eight of the CRT terminals with associated image projectors and two of the typewriter terminals are located in a special terminal room in Sutton Hall at the University of Texas. The CAI terminals are placed in individual, acoustically treated carrels, while the typewriter terminals are located in a separate section of the room, available for general access. The 1500 system itself and the remaining terminals are located in a specially constructed machine room and an adjacent programming area. The system is available for use daily with a proctor on duty in the terminal room. In this particular study, all subjects were run on the CRT terminals with image projectors in the carrels.

Individual Difference Measures

(a) Task Specific Memory Test: The memory test developed for this study was previously described in this document under the heading

Task Specific Memory Measure. This is a paper and pencil measure and subjects' answers were indicated by check marks in the test booklet.

(b) MA-3 (French, Ekstrom, & Price, 1963): The MA-3 is a standardized, timed, short-term associative memory test published by the Educational Testing Service, Princeton, New Jersey. It was adapted from the First Names Test by L. L. Thurstone, and served as a construct validation measure for the Task Specific Memory Test. It is a paper and pencil measure and subjects responded by writing in the test booklet.

(c) Locus of Control Measure: This personality variable was measured by the internal-external locus of control scale developed by Rotter (1966). Subjects' answers were indicated on an Optical Scanning Form, Standard Answer Sheet A.

(d) Achievement via Independence Measure: This personality variable was measured by the Achievement via Independence (Ai) scale of the California Psychological Inventory (CPI) (Gough, 1957). Answers were indicated on an Optical Scanning Form, Standard Answer Sheet A.

(e) Anxiety Measure: State anxiety was measured by the short five-item form of the State Anxiety Scale (Leherissey, O'Neil, & Hansen, 1971) of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). The scale was administered and answers were entered on-line at the terminal at four points in the instructional program.

Experimental Procedure

All subjects were assigned a unique four character number which served to identify them for purposes of both the experimental program and the individual difference measures. The first character (J, K, or L) designated the specific experimental treatment. The last three characters were numeric and sequential numbers were randomly assigned to the three experimental treatments in the ratio of 1:1:2, resulting in twice as many subjects being assigned to the learner control condition as to each of the other two conditions.

Upon entering the student terminal room in groups of three to eight, each subject was assigned his identification number on a sequential basis. All subjects were seated at a large table and were asked to complete two copies of a subject identification form. One copy, which contained the subjects' name, provided a basis for their remuneration. The second, which bore only the identification number, served as a record for the subject's responses from a post-experimental interview.

At this time, the experimenter assured the subjects that their performance on the program and their scores on the paper and pencil measures would be held in strict confidence. Subjects were then administered the timed MA-3 test and the timed study portion of the memory test as a group. Subjects were then allowed to complete the response portion of the memory test and the Ai and IE scales at their own pace. Subjects' responses to all scales were identified by their unique numbers.

As subjects completed the paper and pencil measures, the experimenter signed them onto the computer terminals by their identification numbers. They were told that the program would be self-explanatory and any questions regarding the content of the program were deferred until its completion.

A flowchart of the complete instructional computer program is presented in Figure 1. A more detailed flowchart is presented in Appendix A. The interested reader may wish to consult one of these two flowcharts while following the description of procedures given below.

The introduction to the program consisted of the title of the program, "Edible Plants of Central Texas," and a one sentence description of its content. For all subjects, this was followed by a module instructing them in the use of the computer terminal. Instruction included the use of the relevant control keys, the meaning of the display codes "S" (press the space bar) and "K" (type and enter a response), how to enter, and how to correct a response. This was followed by a program overview in which the subject was told what it was he was going to learn. He was told that he would be taught to identify 12 native edible plants. These 12 plants would be divided into two groups: a first group of four, and a second group of eight. The first instructional segment would be followed by a test over the four plants in that group and the subject was to evaluate his own performance on that test as a means of judging how well he was learning the material. Following instruction on the second set of eight plants, he would be taught a general strategy for identifying edible plants. Finally, he would be given a final test over all 12 plants. The subject was told that at several points in the program he would be asked to indicate how he felt. This last reference was to the task-embedded state anxiety scales.

Immediately following the overview, the state anxiety scale was administered for the first of four times. It was reasoned that different subjects might react differently to the novel computer-assisted instruction situation regardless of their particular experimental treatment, and this first administration of the scale, prior to any experimental manipulations, provided a baseline measure. Following an explanation of how he was to respond to the scale, i.e., "Indicate how you feel right now," the subject was shown a series of five statements in the present tense, e.g., "I feel calm," "I feel tense," etc. and

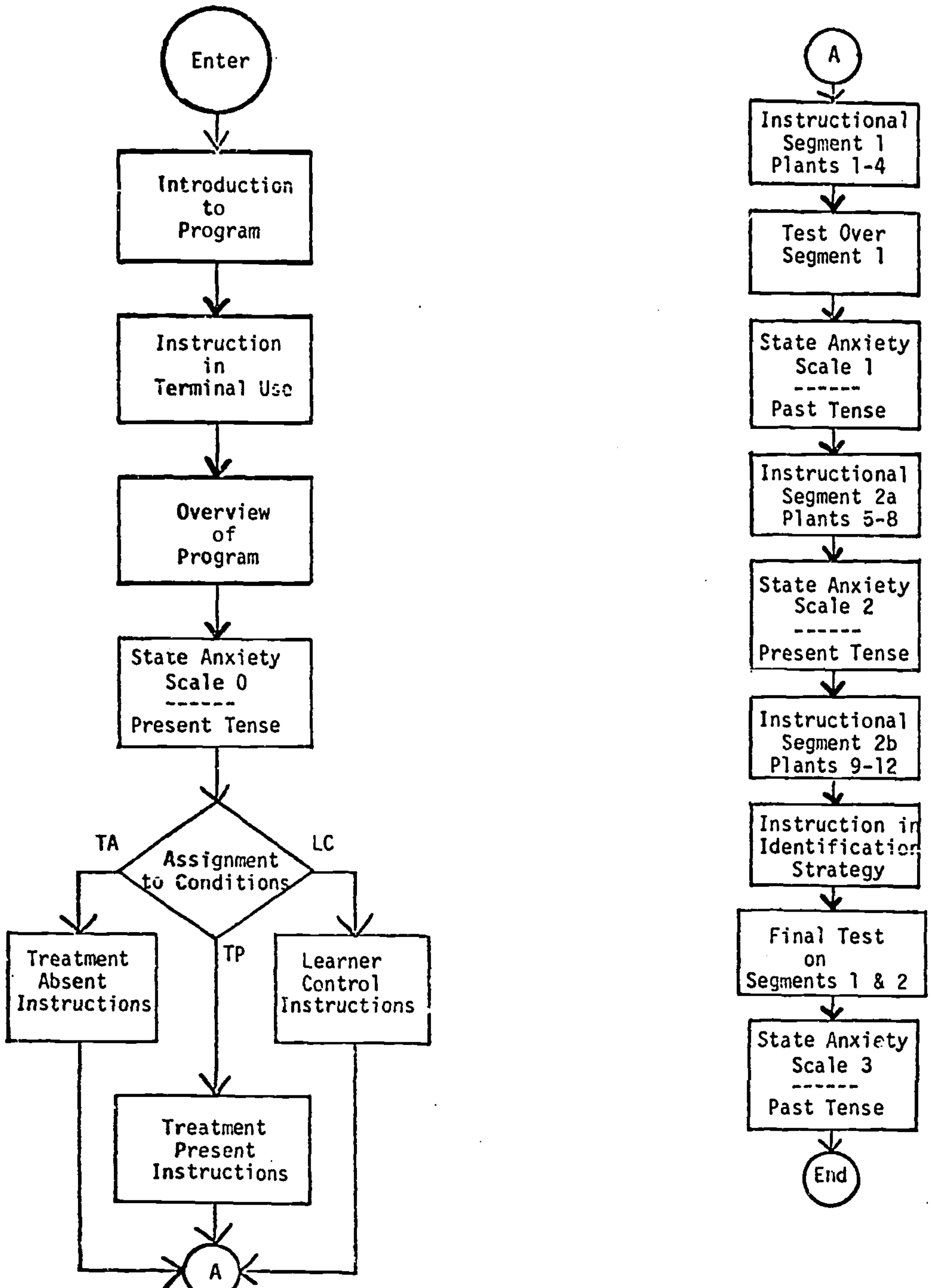

Figure 1
Overall Program Structure

requested to type in a number from 1 to 4 indicating the degree to which that statement reflected his feelings, e.g., "1" equaled "Very much so," and "4" equaled "Not at all."

All subjects then received the following common set of instructions on the CRT:

> Before you begin the course, we would like to remind you that you will be asked to learn the name, critical features, and edible parts of many different plants. This is a complex task as there are often similarities among the plants you are to learn.

At this point in the program, subjects assigned to the three different experimental groups were first given differential treatment. Subjects assigned to the treatment absent (TA) condition were administered the following set of instructions:

> As you are presented the instruction on each plant, study all of the critical features so that you will be able to associate them with that plant. In this way, you can make the best use of the learning material.

Subjects assigned to the treatment present (TP) condition received the following alternative set of instructions concerning the pictures of the critical features and their review:

> When a plant's characteristics are described, you will also be shown pictures of the corresponding parts of the plant to help you remember the critical features. A few moments later, you will be shown the critical features and pictures again. Study these critical features so that you will be able to associate them with the plant's name.

Subjects assigned to the learner control (LC) condition received the following set of instructions concerning the availability of the pictures and reviews of critical features:

> At the beginning of the instruction for each plant, you will have an opportunity to ask to see pictures of the plant, its critical features, and its edible parts, as they are described in the instruction. Study these critical features so that you will be able to associate them with the plant's name. A few moments later, you may ask to see the critical features and related pictures a second time.

Finally, subjects assigned to the TP and LC conditions were administered the following set of common instructions:

> When the pictures are presented, you will see them on the image projector while the characteristics are being described on the CRT. Try to locate the features in the pictures so you will be able to remember them for the tests later. During the tests, try to remember the pictures of the critical features. This should help you to remember the descriptions of these features.

All subjects then began work on the first instructional segment, containing four of the 12 plants. The instructional sequence for each of the four plants in the segment was essentially the same and began with the presentation of the plant name and a description of its habitat. For TP subjects, a photograph of the plant in context was shown simultaneously on the image projector. At this point, subjects assigned to the LC condition were asked whether or not they wished to see photographs of that plant during instruction. They were instructed to type an "m" if they wished to have the photographs presented and otherwise to simply press the space bar and continue. If they typed "m", the context photograph of the plant was displayed while the introductory description of the plant was retained on the CRT. They were also shown all subsequent photographs of that plant in the same manner as TP subjects. For all treatment conditions, the descriptions of the plants were worded in such a way as to make no reference to the photographs.

Two or three critical features (identifying characteristics) of that plant were then described on successive displays. Photographs of each of the critical features being described were shown to TP subjects and those LC subjects who had requested pictures. The plant's edible part(s) were then described and, again, corresponding photographs were shown as appropriate.

Next, the subject was requested to type in the name of the plant he was currently studying. Following the first incorrect response, he was shown the correct name, the name was erased, and he was asked to respond again. Following a second or subsequent incorrect response, the correct name was displayed and the subject was instructed to copy it. A correct response elicited positive feedback.

Learner control subjects were then asked whether they wished to review the plant's critical features. Those who stated that they did (by typing an "m") and all TP subjects were shown an abbreviated version of the critical features instruction together with the corresponding photographs. Learner control subjects who indicated that they did not want the review and all TA subjects simply skipped this portion of the program.

Next, all subjects were asked to select, from a list of five plant parts, a part of that plant which was edible. A first incorrect response elicited feedback without correction and the subject was required to try again. Following a second incorrect response, the subject was told the name of an edible part. A correct response elicited appropriate confirmation. Subjects were then asked to select a second edible part or to select the alternative "No more edible parts." This same sequence continued until the subject stated correctly that all edible parts had been identified or made two consecutive errors. In the latter case, feedback consisted of displaying all edible parts. This completed the instructional sequence for a single plant. The sequence was repeated for each of the four plants in the first instructional segment.

This segment was followed by a test over the four plants. The segment test began by requiring the subject to identify a particular plant's critical features. A list of five plant parts was shown and the subject was requested to select a plant part which contained a critical feature. Any incorrect response elicited negative feedback without correction. A correct response elicited a list of four different descriptions of that plant part. Again, any incorrect response resulted in simple negative feedback without correction. At neither of the two levels of the test was there any limit on the number of incorrect responses which a subject could make, nor were his previous choices indicated. Thus, the subject was always required to eventually make the correct response. A correct response returned the subject to the display of the five plant parts to which a sixth alternative, "No more critical features," had been added. The subject remained in the loop until he had correctly identified each of the plant's two or three critical features and had then correctly stated that the plant had no more critical features.

The subject was then shown the same list of five plant parts and required to identify the edible part(s) of that same plant. A correct response elicited confirmation, while an incorrect response elicited noncorrective feedback. In either case, the alternative "No more edible parts" was then added to the display of five plant parts and the subject was required to select another part or state that all parts had been identified. Again, the correct identification of an edible part was confirmed, the incorrect identification of an edible part received simple negative feedback, and the correct selection of "No more edible parts" terminated this portion of the test. This two-part sequence of identifying the plant's critical features and edible part(s) was repeated for each of the four plants.

The subject was then shown a context photograph of one of the four plants and asked to type in the plant's name. A correct response was confirmed. The first incorrect response received negative feedback without correction. A second incorrect response was corrected and terminated the sequence. This procedure was repeated for all four plants, in a different order than had been used for the first portion of the test. The identification of the fourth plant completed the first test.

This test was followed immediately by the second administration of the state anxiety scale. The procedure was identical to the first administration of the scale with the exceptions that subjects were instructed to indicate how they felt while taking the test and the descriptive statements were in the past tense; e.g., "I felt calm." Note that this was the first administration of the scale following the introduction of differential experimental treatments. Although major differences between the experimental groups were not necessarily expected at this point in the program, it was anticipated that responses to the scale might reflect more substantial differences obtained on the fourth administration of the scale, following the final test.

Instruction on the remaining eight plants was then presented. The instructional format and learner control options were exactly the same as were described for the first instructional segment. The third administration of the state anxiety scale, phrased in the present tense and requesting subjects to indicate how they felt right then, was inserted between the instruction for the eighth and ninth plants. Administration of the scale at this point was strictly for exploratory purposes and no particular differences between groups were necessarily anticipated.

The second instructional segment was followed by an instructional module concerning a general plant identification strategy which has been described by Judd, O'Neil, and Spelt (1974). The purpose of placing the module at this point in the program was simply to provide an intervening and, hopefully, interfering task between the second instructional segment and the final test.

The identification strategy module was followed by the final test over all 12 plants. The order in which the plants were tested was randomized. The format of the test was similar to that of the first test but was altered in a number of details for the purpose of increasing its difficulty. It began by requiring the subject to identify each of the 12 plants on the basis of a context photograph. None of the photographs displayed had been shown previously in either an instructional sequence or during the first test. An initial incorrect response elicited negative feedback without correction. A second incorrect response or a correct response resulted in the subject's being routed to the next plant with no additional feedback.

When identification of all 12 plants had been tested, the subject was routed to the critical features and edible parts component of the test. In the critical features component, the subject was shown a list of five plant parts, as in the first test. Selection of a correct part elicited a list of four descriptions of that part. Any response to this display, correct or incorrect, returned the subject to the display of plant parts to which the sixth alternative, "No more critical features," had been added. The same process was then repeated with the exceptions that selection of a previously selected plant part or premature selection of the "No more critical features" alternative elicited appropriate negative feedback. The critical features component of the test for that plant was terminated only when the subject correctly selected the "No more critical features" alternative.

The subject was then required to identify the edible part(s) of that same plant. Again, no corrective feedback was given, and the test component was terminated only when all edible parts had been identified and the subject then selected the "No more edible parts" alternative. The subject was then tested on the critical features and edible part(s) of the next plant.

When all 12 plants had been tested, the fourth and final state anxiety scale was administered. The administration of this scale, which was anticipated as being the most sensitive to differences between the experimental groups, was phrased in the past tense and subjects were instructed to indicate how they felt while taking the final test.

The subject was then thanked for his participation and advised that the program should be considered to be only an introduction to the identification of edible plants. The program concluded by requesting the subject to leave the terminal and contact the experimenter. The experimenter then administered a standardized post-experimental interview, thanked the subject for his participation, answered questions concerning the program, and cautioned him not to discuss the content of the experiment with his acquaintances.

Results and Discussion

Data resulting from subjects' performance on the first segment test, the final test, responses to the four state anxiety questionnaires, and learner control requests for plant photographs and review sequences were all recorded on magnetic disk during the experiment. At the conclusion of the experiment, these data were automatically punched. Subjects responded to the IE and Ai scales by means of machine scorable, mark sense sheets. Punched card reproductions of each subject's responses to each scale were produced by machine and automatically scored. Responses to the task specific memory test and the MA-3 associative memory test were not amenable to machine scoring. These tests were hand scored and the data were manually recorded on punched cards.

As a first step in the data analysis, all data were submitted to a program (DISTAT, Veldman, 1967) run on the University's CDC 6600 system which computed distribution statistics for all variables for each of the three experimental groups and for the total group of 130 subjects. A similar descriptive analysis of the data resulting from the first experiment had indicated that all of the performance measures and subjects' scores on the task specific memory test were severely skewed in a positive direction. That is, there was a preponderance of subjects who made very few errors while relatively few subjects made a fairly large number of errors. This characteristic of the data necessitated the use of $\log_{\epsilon}$ transformations prior to the data anlyses. As was previously discussed, these low error rates were taken into consideration during the revision of the experimental task and the task specific memory test. Examination, via program DISTAT, of the data resulting from the current experiment indicated that the revisions had produced the desired effects. While the performance data and the data resulting from one of the four anxiety measures were slightly skewed in a positive direction, and the IE and Ai data were slightly negatively skewed, in no case was the degree of skewness considered to be sufficient to require that the data be transformed. Neither the task specific memory test data, the MA-3 data, nor the number of learner control review requests were appreciably skewed. As had been anticipated, the number of learner control requests for pictures was strongly skewed in the negative direction but these data did not enter into any of the analyses. Consequently, raw data were employed as dependent variables and covariables in all of the analyses and in all of the tables and figures presented.

Evaluation of Task Specific Memory Test

The task specific memory test was evaluated through two different approaches: its correlation with the established test of associative memory, the MA-3, and its correlation with subjects' performance in the three different experimental groups on the task's final test.

Since both tests were scored in terms of errors, it was anticipated that task specific memory test score would be positively correlated with MA-3 score. For all 130 experimental subjects, the correlation between the task specific test and the MA-3 was .46 ($p < .005$). This indicates that the task specific test did measure individual differences in at least some components of those processes which have traditionally been termed associative memory. Although significant, the correlation was not as high as had been anticipated.

The task specific test was designed to simulate the memory problem presented to subjects in the treatment absent (TA) group in their recall of the plants' critical features. As anticipated, the number of errors on this component of the final test was positively correlated with score on the task specific test for subjects in this experimental group ($r = .38$, $p < .025$). By contrast, the correlation between critical features errors on the final test and MA-3 errors was nonsignificant ($r = -.08$). Although the degree to which the task specific test predicted errors on the final test was not as high as had been anticipated, it was obviously a much more valid predictor than was the more pure test of associative memory.

It was further anticipated that the introduction of pictures as memory aids in the treatment present (TP) and learner control (LC) groups would reduce the correlation, as compared to TA condition, between the scores on the task specific test and the critical features component of the final test. Although there was a trend in the anticipated direction, the obtained correlations being .30 ($p < .05$) for TP subjects and .31 ($p < .05$) for LC subjects, these correlations were not significantly smaller than that obtained for TA subjects. As with the TA condition, in neither case did the correlation between final test errors and score on the MA-3 approach significance for TP or LC subjects.

Although the processes involved in the identification component of the task were quite different from the processes required by the task specific test (production of a verbal label given a visual stimulus as opposed to the production of a verbal identifying characteristic given a verbal label), it was anticipated that some degree of positive correlation would be found between the two measures for at least subjects in the TA group. The correlation obtained between this component of the final test and the task specific measure was .33 ($p < .05$) for TA subjects. The corresponding correlation with the MA-3 was -.07. For the

TP and LC groups, the correlations obtained were r = .13 (not significant) and r = .24 (p < .05), respectively. Again, for TP and LC subjects, the correlations between performance and the MA-3 did not approach significance.

Neither the task specific test nor the MA-3 predicted performance on the edible parts component of the final test for any of the three experimental groups.

Although the correlations between the task specific memory test and the various performance measures were not as high as had been anticipated, they were considered to be sufficiently substantial for the critical features and identification portions of the task to retain the task specific test score as a covariable in analyses treating these dependent variables. For the sake of consistency, score on the task specific test was also employed as a covariable in analyses dealing with the edible parts components of the task. In each instance, the data were first examined for interactions between the covariable and the experimental treatments. In the absence of such an interaction, score on the task specific test was then used as the covariable in an analysis of covariance.

Validation of Experimental Paradigm Requirements

A requirement of the experimental paradigm employed was that the treatment to be placed under learner control be independently shown to have a generally facilitating effect on performance in the task. Thus, it was hypothesized that, in general, subjects run under the TP condition--presence of pictures during the description of the plant, its critical features, and edible parts, and review of the critical features--would make fewer errors on the final test than would subjects run under the TA condition--no pictures or review. It was further hypothesized that subjects run under the condition of learner control over the availability of pictures and review would also make fewer errors than would subjects run under the TA condition.

The relationships between the three groups in terms of overall final test performance (total error score summing over the critical features, identification, and edible parts components of the test) is illustrated in Figure 2. No significant interaction was found between the experimental conditions and the memory covariable. Thus, the regression lines could be considered to be parallel, meeting the necessary assumption for analysis of covariance. Analysis of covariance indicated a significant difference between groups (F = 6.73, df = 2/126, p = .002).

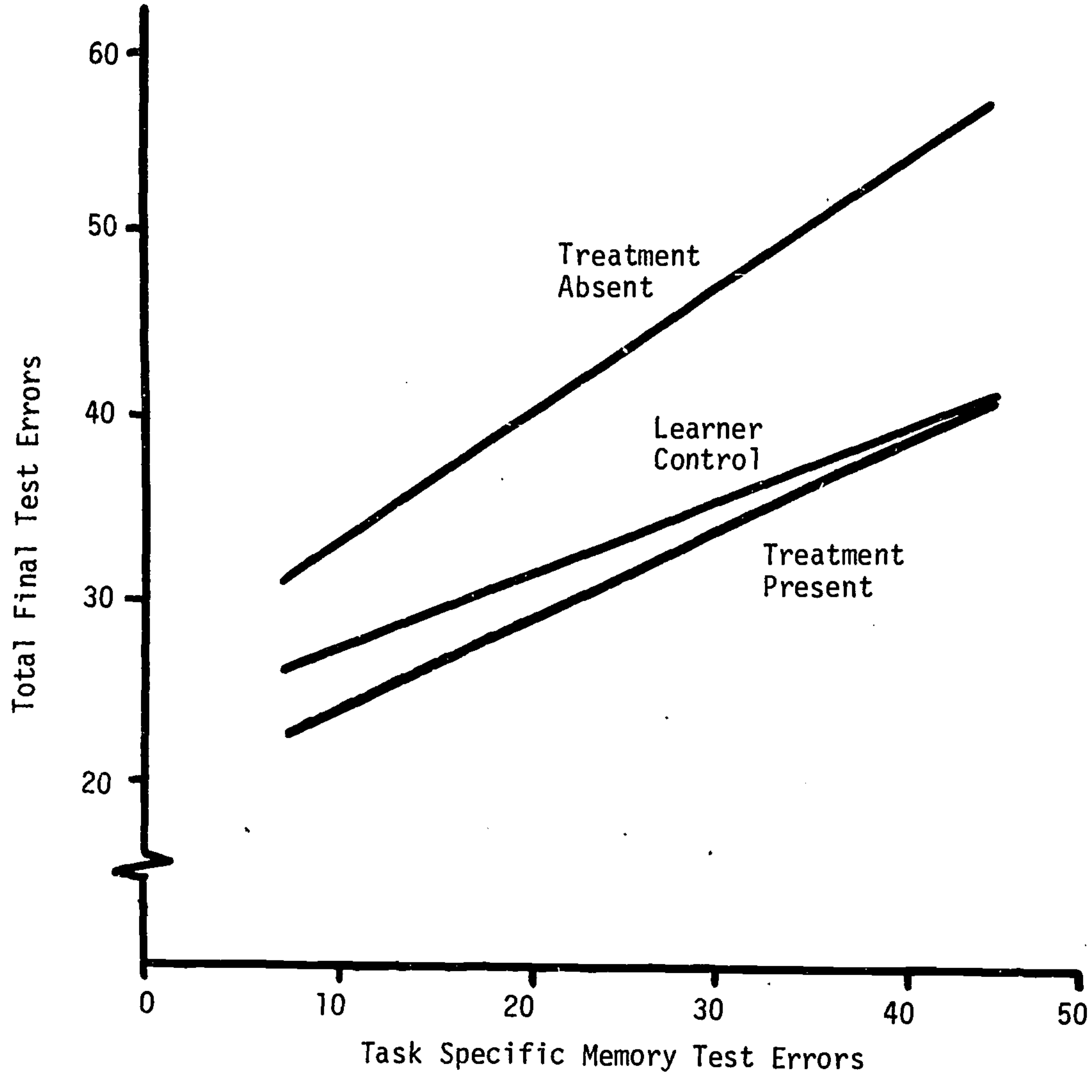

Figure 2: Total Number of Errors on the Final Test for each of three Experimental Groups as a Function of Error Scores on the Task Specific Memory Test.

Given that the mean number of errors for the TA subjects was 44.5 and that the mean number of errors for the TP and LC groups were 31.0 and 33.6, respectively, it may be concluded that requirements of the experimental paradigm were indeed met. These results, summarized above, will now be examined and discussed in greater detail. For the reader with only limited interest in the details of the validation of the paradigm, the results pertaining to the second hypothesis, concerning the effects of learner control on performance are presented on page 30.

Specifically, Hypothesis 1 stated that subjects run under the TA condition would commit more errors on the critical features and identification components of the final test than would subjects run under the TP condition.

It will be recalled that each component of the final test consisted of two types of items: items referring to the four plants presented in the first instructional segment, on which subjects had already been tested once; and items pertaining to the eight plants presented in the second instructional segment, for which this was the first test. Since the first test could be considered a source of review for the first four plants, these two types of items were analyzed separately in addition to the overall analysis of error scores for all 12 plants. Although differences between the groups were not necessarily anticipated, error scores on Test 1 were also compared. Means and standard deviations of the TA and TP subjects' error scores on Test 1, on the final test for the first four plants (Final A), on the final test for the last eight plants (Final B), and the total error score on the final tests are presented in Table 1.

In the case of only one of the analyses to be discussed further was a significant interaction found between the experimental conditions and the covariable of score on the task specific memory test. Thus, the requirement that the experimental treatment be <u>generally</u> facilitating was met as were (with one exception) the necessary assumptions for analysis of covariance. Discussion of the obtained results will therefore center on mean differences between groups.

Turning first to the critical features component of the total final test, the mean number of errors committed by subjects run under the TA condition was 19.8 while the corresponding mean for TP subjects was only 13.2. This difference was significant ($F = 7.75$, $df = 1/61$, $p = .007$). When the test is broken into its two types of test items, only those items referring to the eight plants presented in the second segment (Final B) registered a significant difference between groups ($F = 14.11$, $df = 1/61$, $p = .001$). For the first four plants, the difference was in the hypothesized direction but did not obtain significance. Similarly, the difference between groups, although in the hypothesized direction, was not significant for the data resulting from Test 1.

Table 1

Means and Standard Deviations of Error Scores on Three Components of Final Test and Test 1 for Three Experimental Groups

	Treatment Absent		Treatment Present		Learner Control	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Number of Ss	30		34		66	
Critical Features						
Final Test	19.8	9.8	13.2	7.8	14.9	7.9
Final A	6.8	4.6	5.6	4.6	5.8	3.8
Final B	13.0	6.5	7.6	4.4	9.1	4.9
Test 1	5.3	5.0	3.6	4.1	5.2	5.2
Identification						
Final Test	12.5	4.2	8.3	4.6	9.7	4.2
Final A	3.2	2.1	1.8	1.8	2.2	2.0
Final B	9.3	3.1	6.5	3.2	7.5	2.9
Test 1	2.0	1.3	1.3	1.1	1.1	1.2
Edible Parts						
Final Test	12.5	7.1	9.4	6.6	9.0	5.2
Final A	4.6	3.5	4.5	3.1	3.9	3.0
Final B	7.9	5.1	5.0	4.6	5.1	3.3
Test 1	3.6	2.0	3.3	1.6	3.8	2.1

Again, considering the final test over all 12 plants as a unit, a significant advantage was demonstrated for TP subjects in terms of their lower number of errors on the identification component of the test (F = 12.76, df = 1/61, p = .001).

The one instance of a significant interaction between experimental conditions and the task specific memory test covariable occurs when items pertaining to the identification component for the first four plants are considered separately (F = 4.56, df = 1/60, p = .035). In addition to the fact that they committed a lower mean number of errors, the performance of subjects in the TP group was essentially unrelated to their score on the task specific test. Subjects run under the TA condition demonstrated the usual positive relationship between the two measures. Although it was not significant, a similar pattern of interaction was displayed for these same four plants on Test 1. Apparently, the presence of the pictures during the description of the plant and review of the critical features was sufficient to largely compensate for individual differences as measured by the task specific test for these four, less difficult plants. That the treatment was not sufficient to compensate for individual differences in learning the eight more difficult plants presented in the second instructional segment is demonstrated by the absence of an interaction for the final test items pertaining to these eight plants.

In the case of the final test items pertaining to the identification component for the last eight plants, analysis of covariance was again appropriate and, again, a significant advantage was found for subjects in the TP group (F = 11.56, df = 1/61, p = .002). Although it had not necessarily been anticipated, a significant advantage was also demonstrated for TP subjects on the identification component of Test 1 (F = 4.95, df = 1/61, p = .028).

Although it was not anticipated that the experimental manipulations would have any appreciable effect on the edible parts component of the final test, these data were also examined. There were no significant differences between groups when the final test items pertaining to all 12 plants or to just the first four plants were considered. A significant advantage for TP subjects was indicated for those final test items pertaining to the last eight plants (F = 5.04, df = 1/61, p = .027). No significant difference was found between groups in terms of performance on Test 1.

Thus, as was mentioned above, it may be concluded that the strategy of providing photographs of the plant while the plant's various features were being discussed and a review of the critical features did prove to be an instructionally effective treatment. Those subjects who received the pictures and review made substantially and significantly lower error scores on both the critical features and identification components of the complete 12 plant final test. The differences between groups were more marked for the eight more difficult plants presented in the second instructional segment and there was only one instance in which the groups differed with respect to their error scores on the relatively easy Test 1. Given these results, it may be concluded that the necessary condition of a generally facilitating instructional treatment was present for the investigation of learner control over this treatment.

Effect of Learner Control on Performance

Comparison of Treatment Absent and Learner Control. Hypothesis 2 stated that subjects run under the learner control condition (LC) would commit fewer errors on the critical features and identification components of the final test than would TA subjects.

Again, in addition to analyses treating all items in each component of the final test as a unit of analysis, data resulting from items pertaining to the four plants presented in the first instructional segment and from the eight plants presented in the second instructional segment were examined separately. Data resulting from Test 1 were also examined. Means and standard deviations of the TA and LC subjects' error scores are presented in the first two and last two columns of Table 1. No significant interactions between the experimental variable and the covariable of score on the task specific memory test were found for any of the comparisons to be discussed. Hence, the necessary assumptions for analysis of covariance were met in all instances.

Beginning again with the critical features component of the total final test, the mean number of errors committed by the TA subjects was 19.8 while the corresponding mean for LC subjects was only 14.9. This difference was significant ($F = 6.86$, $df = 1/93$, $p = .01$). When the test was broken into its two types of test items, there was a significant difference between groups for only those items pertaining to the eight plants presented in the second instructional segment, part B of the final test ($F = 10.51$, $df = 1/93$, $p = .002$). There was no significant advantage demonstrated for the LC group on Test 1.

With respect to errors on the identification components of the tests, a significant advantage was found for the LC subjects in all four comparisons. On the complete final test, LC subjects made a mean of 9.7 errors as opposed to a mean of 12.5 errors for TA subjects ($F = 9.06$, $df = 1/93$, $p = .004$). When final test items pertaining to the first and second instructional segments were examined separately, the results of the analyses of covariance were F = 4.17, df = 1/93, p = .041; and F = 7.55, df = 1/93, p = .007, respectively. A significant difference was even found between groups on Test 1 (F = 10.74, df = 1/93, p = .002). The means corresponding to these tests are shown in Table 1.

A weaker advantage was found for the LC subjects with respect to the data resulting from the edible parts component of the tests. The advantage was significant for the complete final (F = 7.43, df = 1/93, p = .008). This difference was due primarily to those items pertaining to plants from the second instructional segment. The difference between groups was not significant for items from the first instructional segment but was for items from the second segment (F = 10.08, df = 1/93, p = .002). TA and LC subjects did not differ significantly on Test 1.

Comparison of Treatment Present and Learner Control

Although no specific hypothesis was stated, it is of interest to compare the performance of the learner control (LC) subjects with that of the treatment present (TP) subjects. In addition to exceeding the performance of the TA subjects, it would be desirable if the performance of LC subjects at least approached that of TP subjects. Such a finding would indicate overall effective use of the learner control options. As may be seen from the comparison of the means in the third and fifth columns of Table 1, there were only two instances in which LC subjects registered fewer errors than did TP subjects but analyses of covariance (no significant interactions were found) indicated that none of the differences between groups were significant. That is, no deleterious effect resulted from giving subjects control over an instructional treatment proven to be generally facilitating as opposed to providing the treatment to all subjects.

Effect of Experimental Treatments on State Anxiety

Means and standard deviations of the three experimental groups' scores on the four administrations of the State Anxiety Scale are shown in Table 2. Analysis of these data began with a comparison of the three groups' scores on the first administration of the scale. Since this administration took place prior to any experimental manipulations, it was anticipated that no differences would be found between groups. As was the case for the previously discussed analyses, score on the task specific memory test was used as a covariable. As expected, no significant interactions were found between experimental group assignment and the

Table 2

Means and Standard Deviations of State Anxiety Scores for Three Experimental Groups

	Treatment Absent		Treatment Present		Learner Control	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Number of Subjects	30		34		66	
Pre-Experimental Measure	9.1	3.1	8.9	2.7	9.0	2.9
Following Test 1	9.2	2.9	7.8	2.8	8.5	2.9
During Second Instructional Segment	8.1	3.2	8.0	3.0	7.4	2.9
Following Final Test	10.8	3.6	8.9	3.3	9.6	3.8

covariable. Overall, there was a slight positive relationship ($r = .17$, $p < .05$) between expressed state anxiety and number of errors on the task specific memory test. Results of the subsequent analysis of covariance indicated no mean differences between groups. It may be concluded that subjects were randomly assigned to experimental conditions with regard to the variable of state anxiety.

Of the three within task administrations of the scale, the third, immediately following the subject's completion of the final test, was considered to be most relevant to the purpose of the experiment. A graph of subjects' responses to this administration of the scale as a function of experimental condition and the covariable of score on the task specific memory test is shown in Figure 3. The most striking aspect of this graph is the markedly different relationship between state anxiety and score on the task specific test indicated for subjects run under the treatment absent condition. A test for homogeneity of regression indicated a significant interaction between experimental conditions and the covariable ($F = 3.51$, $df = 2/124$, $p = .032$). While, as expected, a positive relationship was indicated between number of errors on the task specific memory test and state anxiety for TP and LC subjects, a negative relationship was indicated for TA subjects.

The second aspect of the graph which is of interest concerns the relative magnitude of the state anxiety scores of the TP and LC subjects. Contrary to what had been hypothesized, the expressed state anxiety levels of LC subjects were not lower than those of TP subjects. These data will now be examined in greater detail.

Comparison of Treatment Absent and Present Conditions. Hypothesis 3 stated that subjects for whom pictures of the plant were present during the description of the plant's various features and who received subsequent review of the critical features (TP subjects) would express less state anxiety following the final test than would TA subjects who did not see these pictures nor receive the review. Analysis of the state anxiety data of just these two groups confirmed the results indicated by Figure 3. Again, a significant interaction was found between the experimental conditions of treatment absent and present and the covariable of error score on the task specific memory test ($F = 5.74$, $df = 1/60$, $p = .019$). Although no specific hypotheses had been stated concerning these measures, data resulting from the state anxiety scales administered following the first test and during the second instructional segment were also examined. Similar interactions were indicated for both administrations: $F = 4.88$, $df = 1/60$, $p = .029$ following Test 1; and $F = 5.55$, $df = 1/60$, $p = .021$ for the scale administered during the second instructional segment. Thus, the observed interaction was consistent over all three administrations of the scale.

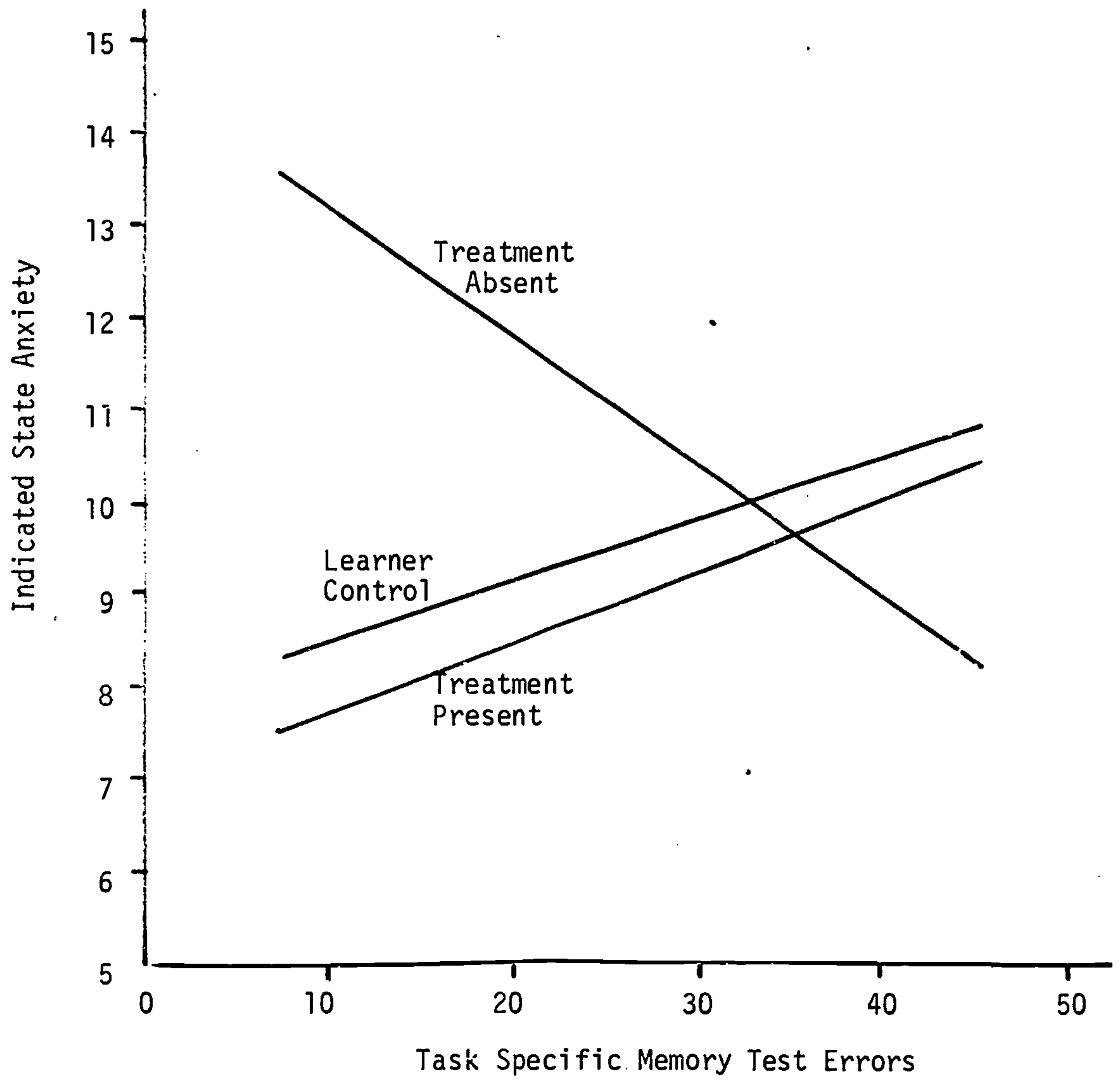

Figure 3. Indicated state anxiety following the final test for three experimental groups as a function of number of task specific memory test errors.

The correlation between expressed state anxiety and task specific test error score was positive for TA subjects at the time of the pre-experimental scale administration ($r = .31$, $p < .05$). The correlation, although nonsignificant, reversed to the negative direction for the next administration of the scale, immediately following Test 1 ($r = -.29$). This negative correlation was maintained for the scale administrations during the second instructional segment ($r = -.33$, $p < .05$) and following the final test ($r = -.37$, $p < .025$). Conversely, positive but nonsignificant correlations were maintained across all four administrations of the scale for TP subjects ($r = .16$, $r = .26$, $r = .25$, and $r = .21$, respectively).

In an effort to learn more about the relationships implied by these interactions, the data were reanalyzed with score on the pre-experimental administration of the anxiety scale used as a covariable. For the scale administration following the final test, no interaction was indicated and analysis of covariance found a significant difference between the mean state anxiety scores of TA and TP subjects ($F = 5.03$, $df = 1/61$, $p = .027$). For the scale administration following Test 1, the interaction between experimental conditions and the covariable approached significance ($F = 3.52$, $df = 1/60$, $p = .062$). In this case, there was a stronger positive relationship between the two state anxiety scores for TP subjects ($r = .58$, $p < .005$) than for TA subjects ($r = .19$, not significant). If it is assumed that the two regression lines were indeed parallel and that analysis of covariance was appropriate, the mean difference between groups also approached significance ($F = 3.72$, $df = 1/61$, $p = .055$). For the data resulting from the scale administered during the second instructional segment, neither the interaction nor the means differences approached significance.

The consistent positive relationship between expressed state anxiety and the memory covariable found for TP subjects would be expected. The problem is posed by the reversal of this relationship for TA subjects. There is no obvious explanation for the observed interaction. The available individual difference measures of IE and Ai appeared at first to offer promising leads to the clarification of the phenomenon but further analyses failed to reveal substantive relationships. Any attempt at explanation of these results would be purely speculative at this point and must await further investigation and, particularly, replication. The results obtained when pre-experimental anxiety was employed as a covariable are considered to provide at least tangential support for the hypothesis and it may be concluded that, subject to the restrictions implied by the interaction with the memory covariable, those subjects who received the facilitating treatment did express less state anxiety following the final test than did those subjects who did not receive the treatment.

Comparison of treatment present and learner control conditions. Hypothesis 4 stated that LC subjects, who had control over access to photographs of the plants' various features and to review of the critical features, would express less state anxiety following the final test than would TP subjects, to whom this instructional treatment was routinely administered. As was indicated by the mean anxiety scores shown in third and fifth columns of Table 2, this hypothesis was not supported. The observed mean state anxiety score of the LC subjects (9.6) was slightly greater than that of the TP subjects (8.9). No significant interaction was found between experimental treatments and the covariable of error score on the memory test, and thus an analysis of variance was conducted. The results of this analysis indicated that there was no significant difference between the two groups. The same results were obtained from analyses of anxiety scores from the scale administrations following the first test and embedded in the second instructional segment--no significant interactions or mean differences between groups.

It must be concluded that giving subjects learner control over access to the facilitating treatment did not result in expressed state anxiety levels which were lower than those resulting from the constant presence of the treatment. That is, learner control per se did not have the anticipated affective advantage. It should also be noted, however, that neither did the presence of learner control result in a significant increase in expressed state anxiety. In the course of the program, LC subjects were required to make a total of 24 instructional decisions and it might have been argued that this requirement would have resulted in significantly higher levels of state anxiety. Placing the burden of these decisions on the subjects did not, in this particular instance, have the effect of increasing their anxiety.

Use of Learner Control as a Function of Locus of Control and Achievement Orientation

As had been anticipated, almost all subjects in the LC group chose to view photographs of almost all of the 12 plants. Overall, the mean request rate for pictures was 99 percent in the first instructional segment and 97 percent in the second. More specifically, 64 of the 66 subjects elected to view the photographs for all four plants in the first segment and 54 chose to view the photographs of all eight plants in the second segment. No subject elected to view less than one-half of the photographs in either instructional segment.

The request rate for review of the critical features was much lower. Overall, the mean request rate was 55 percent in the first instructional segment and 43 percent in the second. In this case, the frequency of requests was approximately bimodally distributed. In the first instructional segment, 22 of the 66 subjects requested review of all four plants, while 17 subjects never requested review. Similarly, in the second instructional segment, 21 subjects requested review for seven or eight plants while 27 either never requested review or requested it for only one plant. Thus, the tactic of including review as a learner control option served its purpose of providing a more variable measure of learner control activity than was provided by the option of requesting plant photographs.

As was previously discussed, it was anticipated that, as an instructional treatment, reviews of critical features would be only moderately facilitating. This treatment was confounded with that of presenting photographs of the plants in comparisons of TA and TP subjects' performance. Thus, there was only an indirect means of evaluating the facilitating nature of the treatment. Facilitation would be indicated by a negative correlation between the number of learner control review requests and the subsequent number of critical features errors committed. A facilitating effect was indicated for the first instructional segment ($r = -.27$, $p < .025$). In the second instructional segment the correlation was reduced to -.13 (not significant), indicating little or no positive effect from the review.

Learner control as a function of IE. All 130 subjects run in the experiment were rank ordered on the basis of their scores on Rotter's (1966) Locus of Control (IE) scale. The median for the total group was found to fall at 12.45. The 66 LC subjects were divided into two groups on the basis of a median split about this score. Subjects with scores less than or equal to 12 ($N = 38$) were classed as being relatively internally controlled. Subjects with scores greater than or equal to 13 ($N = 28$) were classed as being relatively externally controlled.

Hypothesis 5 postulated that LC subjects who were rated as being relatively internally controlled would make more requests for critical features review during the second instructional segment than would subjects rated as being externally controlled. The mean number of review requests made during the second instructional segment by subjects rated as being internally controlled was 3.3 ($\sigma = 3.1$). The corresponding mean for externally rated subjects was 3.7 ($\sigma = 3.4$). With error score on the task specific memory test used as the covariable, the test for homogeneity of regression indicated no significant interaction between the covariable and Locus of Control rating. Analysis of covariance indicated that there were no significant differences between groups.

It must be concluded that the hypothesis was not supported. In fact, there was a slight, nonsignificant tendency for externally rated subjects to make more review requests. This same tendency, although again nonsignificant, was observed in the first instructional segment.

Hypothesis 6 stated that internally controlled LC subjects would increase or reduce the number of their review requests during the second instructional segment relative to the first segment as a positive function of the number of their errors on the test following the first segment. For externally controlled subjects, on the other hand, the change in frequency of requests would be unrelated to first test performance. That is, it was postulated that LC subjects who were rated as being relatively internally controlled would tend to increase the number of their review requests in the second instructional segment relative to the first if they did poorly on the test following the first instructional segment and to decrease the number of their requests if they did relatively well on the test. On the other hand, the relative frequency of second segment review requests (as compared to the frequency of first segment requests) was expected to be essentially unrelated to their performance on the first test for externally rated subjects.

It will be recalled that LC subjects had four opportunities to request reviews during the first instructional segment and eight opportunities for such requests during the second segment. In order to determine a change score for each subject, the number of requests made during the first segment was multiplied by two and subtracted from the number of requests made during the second segment. Total number of errors on the first test (the sum of the errors committed on the critical features, identification, and edible parts component of the test) was then used as a covariable in the subsequent analyses. Support of the hypothesis would be indicated by a significant interaction between the covariable and Locus of Control rating in which the change score was positively related to first test errors for internally controlled subjects and unrelated for externally controlled subjects. The hypothesis was not supported. There was a slight tendency in the hypothesized direction but it did not approach significance.

Since homogeneity of regression was indicated, an analysis of covariance was conducted. The results of this analysis indicated that the difference between the mean change scores of the two groups was marginally significant ($F = 3.03$, $df = 1/63$, $p = .083$). There was a tendency for all subjects, regardless of Locus of Control rating, to reduce the proportion of plants for which they requested review in the second instructional segment. This tendency was slightly greater for the externally rated subjects (a reduction of 1.6) than for internally rated subjects (a reduction of 0.4) but, as was discussed previously, this difference only approached significance.

There was also a tendency for internally controlled subjects who performed poorly on the test to increase or at least maintain their rate of review requests while externally controlled subjects with similar, poor first test performance records reduced their rate of requests. As indicated by the lack of a significant interaction, however, this tendency was so slight that it cannot be interpreted as support for the hypothesis. Under the relatively restrictive conditions present in the current experiment, it must be concluded that the Locus of Control scale was either inappropriate or insufficiently sensitive to predict differential learner control behavior.

<u>Learner control as a function of Ai</u>. Hypothesis 7 stated that LC subjects who registered relatively high scores on the Achievement via Independence (Ai) scale of the California Personality Inventory (Gough, 1957) would make more requests for critical features reviews during the second instructional segment than would subjects who registered relatively low Ai scores. Again, LC subjects were divided into two groups on the basis of a split around the median Ai score (18.8) for all 130 subjects in the experiment. Subjects with scores less than or equal to 18 (N = 34) were classed as being relatively low in Ai while subjects with scores greater than or equal to 19 (N = 32) were classed as being relatively high in Ai.

For high Ai subjects, the mean number of review requests during the second instructional segment was 3.2 ($\sigma = 3.3$). The corresponding mean for low Ai subjects was 3.8 ($\sigma = 3.2$). With error score on the task specific memory test used as a covariable, the test for homogeneity of regression indicated no significant interaction between the covariable and Ai rating. Analysis of covariance indicated that the difference between the groups' mean scores was not significant. A parallel set of analyses for the number of review requests during the first instructional segment also resulted in the finding of no interaction and no mean differences. In this case, the mean numbers of review requests for the two groups were almost exactly identical: 2.2 ($\sigma = 1.7$) requests for high Ai subjects; and 2.1 ($\sigma = 1.6$) for low Ai subjects. It must be concluded that the hypothesis was not supported and that achievement orientation, as measured by the Ai scale, did not predict the absolute level of learner control use.

Hypothesis 8, which was parallel in form to Hypothesis 6, stated that LC subjects who registered relatively high scores on the Ai scale would increase or reduce the number of their review requests during the second instructional segment relative to the first segment as a positive function of the number of their errors on the test following the first segment. For subjects with relatively low Ai scores, it was anticipated that any change in the frequency of requests would be unrelated to first test performance. The same procedures as were followed for testing Hypothesis 6 were also followed in this case. That is, a change score was computed for each subject by multiplying the number of his first segment review requests by two and subtracting this value from the number of his second segment review requests. In the analysis, total number of errors on the first test was again used as the covariable.

A significant interaction was found between Ai score classification and the covariable of number of Test 1 errors ($F = 4.02$, $df = 1/62$, $p = .047$). The form of this interaction is illustrated in Figure 4. For the sake of clarity, the degree of change in review requests is shown as a percentage increase or reduction rather than in terms of the equivalent but rather confusing change scores employed in the analysis itself.

High Ai subjects who performed well on the first test substantially reduced the proportion of plants for which they requested review in the second instructional segment. Similar high Ai subjects who performed quite poorly on the test, making a large number of errors, maintained or increased their number of review requests. On the other hand, low Ai subjects tended to reduce the number of their requests regardless of their Test 1 performance. In fact, there was a very slight tendency for those low Ai subjects who performed poorly on the test to reduce their request rate even more than similar subjects who performed relatively well. In terms of the group means, a greater reduction was indicated for high Ai subjects (-1.3, $\sigma = 2.9$; a reduction of 16 percent) than for low Ai subjects (-0.5, $\sigma = 2.1$; a reduction of 7 percent).

It may be concluded that the hypothesis was supported in that high Ai subjects were found to be more adaptive in their use of the learner control review option than were low Ai subjects. If the negative correlations between the frequency of review requests and subsequent critical features test scores are interpreted as indicating a mildly facilitating effect for review, then the behavior of the high Ai subjects with respect to their use of this review option was more appropriate than the behavior of the low Ai subjects. It is of particular interest to contrast this conclusion with the finding that there was not a significant difference between high and low Ai classed subjects in their overall level of use of the review option. That is, Ai did not predict simple frequency of use of the option. Neither did low Ai subjects reduce their use of the option in the second instructional segment more than Ai subjects. It was only with respect to the degree to which subjects modified their use of the option in an attempt to improve their performance or, presumably, to save time that the high and low Ai subjects differed.

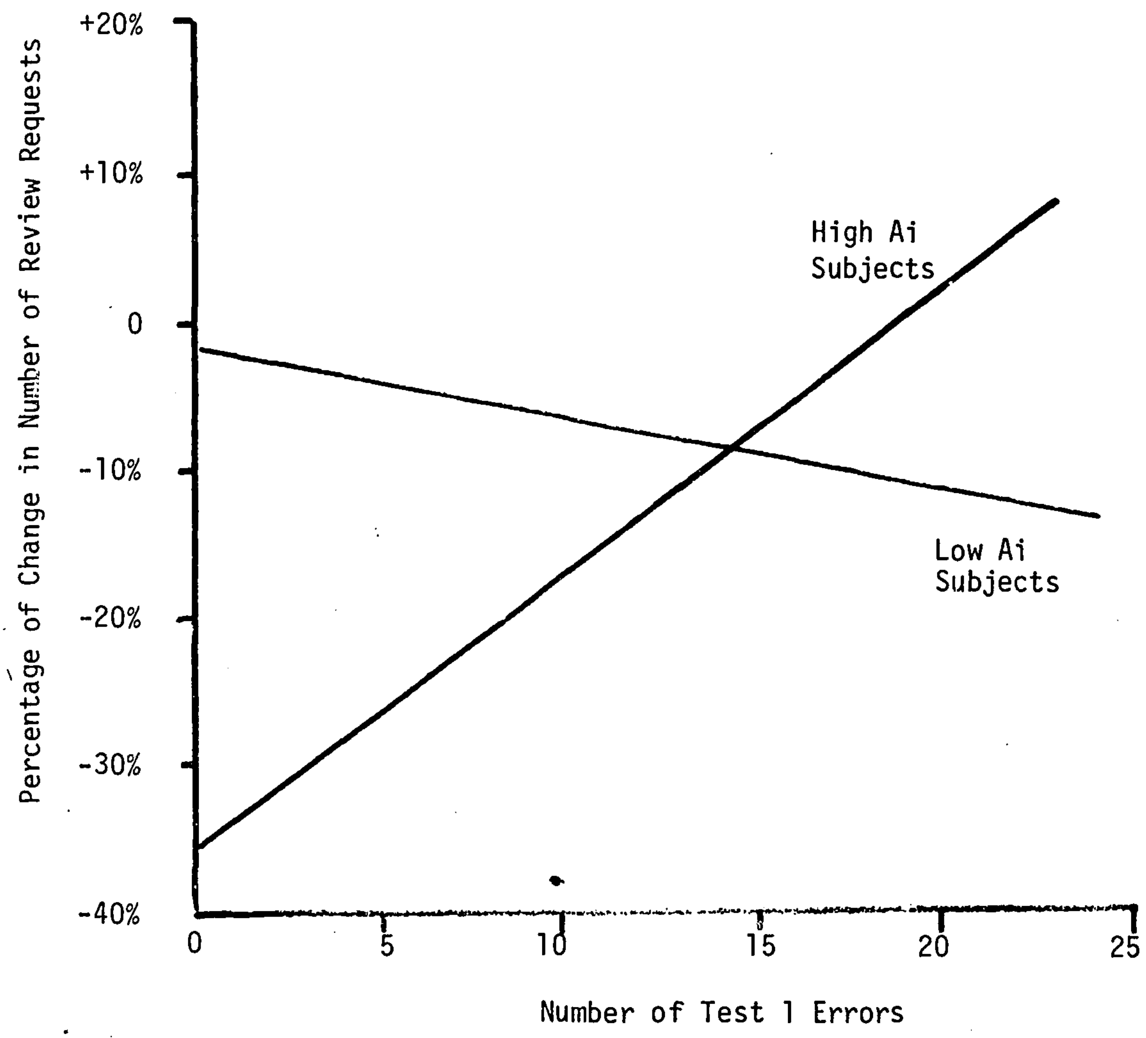

Figure 4: Percentage of change in Learner Control Review Requests from the First to the Second Instructional segment for High (Ai $\geq$ 19) and Low (Ai $\leq$ 18) Achievement Oriented subjects as a function of Test 1 errors.

Conclusions

The reanalysis of the learning task, based on the results of the first experiment, and the consequent use of photographs of the various plant parts as an instructional treatment did meet the requirements of the experimental paradigm. On the final test, the total number of errors committed by treatment present subjects, who were always shown these photographs, was only two-thirds that of the treatment absent subjects, who never saw them. This difference, together with the finding that there was no interaction between these experimental treatments and the task specific memory measure, demonstrates that the treatment of providing the photographs was indeed generally facilitating.

It is of interest to contrast this result with the results of the first experiment conducted for this project in which mnemonics were employed as the presumably facilitating treatment. The original task analysis indicated that the most difficult portion of the task would be the association of the plant's critical features with its name. On the basis of an extensive literature indicating the facilitating effect of such imagery mnemonics (e.g., Bower, 1970), it appeared to be fairly certain that their use would provide the desired generally facilitating treatment. In the initial study, photographs of the plants were included for all subjects because of their assumed instructional utility. As was previously described, the mnemonics were not found to be generally facilitating in this context. On the basis of the low error rates of the treatment absent subject and subjects' comments concerning the photographs, attention was shifted to the mediational properties of the plant photographs, resulting in their use as the experimental treatment in the current experiment.

The different results obtained in the two experiments illustrate an example of the type of problem facing instructional designers at this stage of the "art." There is no reason to conclude that the task analysis was incorrect but the available literature was misleading with respect to which of two instructional treatments would be the most efficacious in mediating the difficult associations indicated by the task analysis. Whether or not the mnemonics would have had their anticipated effect in the absence of photographs is still an open question and must await further research. When instructional design, whether for the purpose of practical instruction or applied research, draws on the basic research literature, interactions resulting in such conflicting results must continue to be expected. In addition, it is suggested that the impact of individual difference variables on learning are substantially reduced by carefully designed instruction.

With the demonstration of a generally facilitating treatment, the conditions required by the paradigm for the investigation of subjects' use of learner control were present. With regard to performance, learner control subjects were found to excel treatment absent subjects and to not differ significantly from treatment present subjects. Since the treatment over which subjects were given control had been shown to be _generally_ facilitating, there was no reason to expect that the performance of the learner control subjects would exceed that of subjects who were always administered the treatment. In this particular task, allowing subjects to determine whether or not they received the instructional treatment was not detrimental. This finding would not, however, necessarily generalize to other instructional settings or other treatments, particularly those treatments designed to interact with individual differences in specific aptitudes.

If it had been the case that the administration of the facilitating treatment had involved a significant cost, in either time or dollars, some savings would have resulted from the use of learner control as compared with always administering the treatment. Further, this savings in time or dollars would not have been reflected in poorer performance on the part of the learner control subjects.

The major focus of the current experiment concerned the presumed affective advantages of learner control, specifically the level of state anxiety indicated by subjects following the final test. In contrast to the Phase II experiment, the experimental paradigm requirement of a generally facilitating treatment over which subjects were given control was present. Given the results obtained, it must be concluded that the presumed affective advantage of learner control was not demonstrated. The levels of state anxiety indicated by the learner control subjects were less than those of subjects who did not receive the facilitating treatment but did not differ from the anxiety levels indicated by those subjects who always received the treatment. Thus, state anxiety was not reduced by the presence of learner control _per se_.

This result is in conflict with the previous research on which the current experiment was predicated, i.e., Collier, Poynor, O'Neil, and Judd (1973), in that Collier et al. did find that learner control over a generally facilitating treatment reduced state anxiety levels relative to the levels indicated by subjects who always received the treatment. The number of dimensions on which the two experiments differ, however, is so large that speculation as to which variable or variables would account for the difference would not be fruitful. For example, in the Collier et al. experiment, the learning task involved concept identification as opposed to the paired-associate nature of the present task. Although it is not possible to make quantitative comparisons, the Collier et al. task appeared to be much more difficult than the present task. Collier's subjects were drafted from an introductory psychology class while the current study employed volunteer subjects who were paid for their participation. The subject matter of the current task was intrinsically interesting while Collier's task involved abstract, content free concepts. The major difference between the two situations might lie in the fact that the current task was designed as an instructional program while Collier's task consisted of the simple presentation of stimuli and confirmation or negative feedback following the subjects' responses. Any determination of the relevant differences between the two experiments must await further research.

Although it was not central to the purpose of the experiment, the interaction obtained between the presence or absence of the instructional treatment and score on the task specific memory test with respect to state anxiety is particularly interesting. No definite explanation for this interaction could be determined on the basis of the available data but the finding might well provide a pertinent focus for future research.

The task specific memory measure, developed on the basis of analysis of the learning task, was found to be a more useful instrument for predicting performance and for evaluating the effect of the various treatments than was the associative memory (MA-3) measure. This result is in congruence with the implications derived from reviews of the aptitude by treatment interaction literature (Bracht, 1970; Cronbach & Snow, 1969). That is, the findings support the contention that more task specific measures will be better predictors, and hence more sensitive to the effects of experimental treatments, than more traditional general ability measures.

The same line of reasoning may offer an explanation of why the Achievement via Independence (Ai) scale of the California Psychological Inventory was found to predict individual differences in learner control behavior while the Locus of Control (IE) scale failed to predict the behavior. The construct of internal-external locus of control is characterized as a generalized expectancy operating across a wide variety of situations. On the other hand, a number of studies evaluating the predictive validity of the Ai scale (Domino, 1969; Eft, 1969; Evans, 1969; Parloff & Datta, 1968) suggest that Ai may be more task related. Neither of the scales, of course, were as specific to the present task as was the memory scale developed on the basis of an analysis of the task. Correspondingly, even the Ai scale did not appear to be as valid a predictor as was the task specific memory test. The implication is that the most fruitful course of future research concerning individual differences in response to learner control may well lie in the development of a scale designed specifically for this purpose.

It is also of interest to note that neither the IE nor the Ai scale predicted the absolute level of use of the learner control options. Ai did predict how subjects altered their use of the learner control options in response to their previous performance. This suggests that future research on individual differences in response to learner control will have to deal with a situation which is much more complex than was originally envisioned.

Learner control is by no means a panacea for the problems of individualization faced by the instructional designer. It may indeed be a useful instructional tool in some situations but the specific situations for which it is appropriate remain to be determined. The affective advantages which earlier researchers suggested would accrue from learner control and which have been specifically demonstrated in one particular situation (Collier et al., 1973) were not substantiated by the present research. Such affective advantages may well be much less general than was originally expected.

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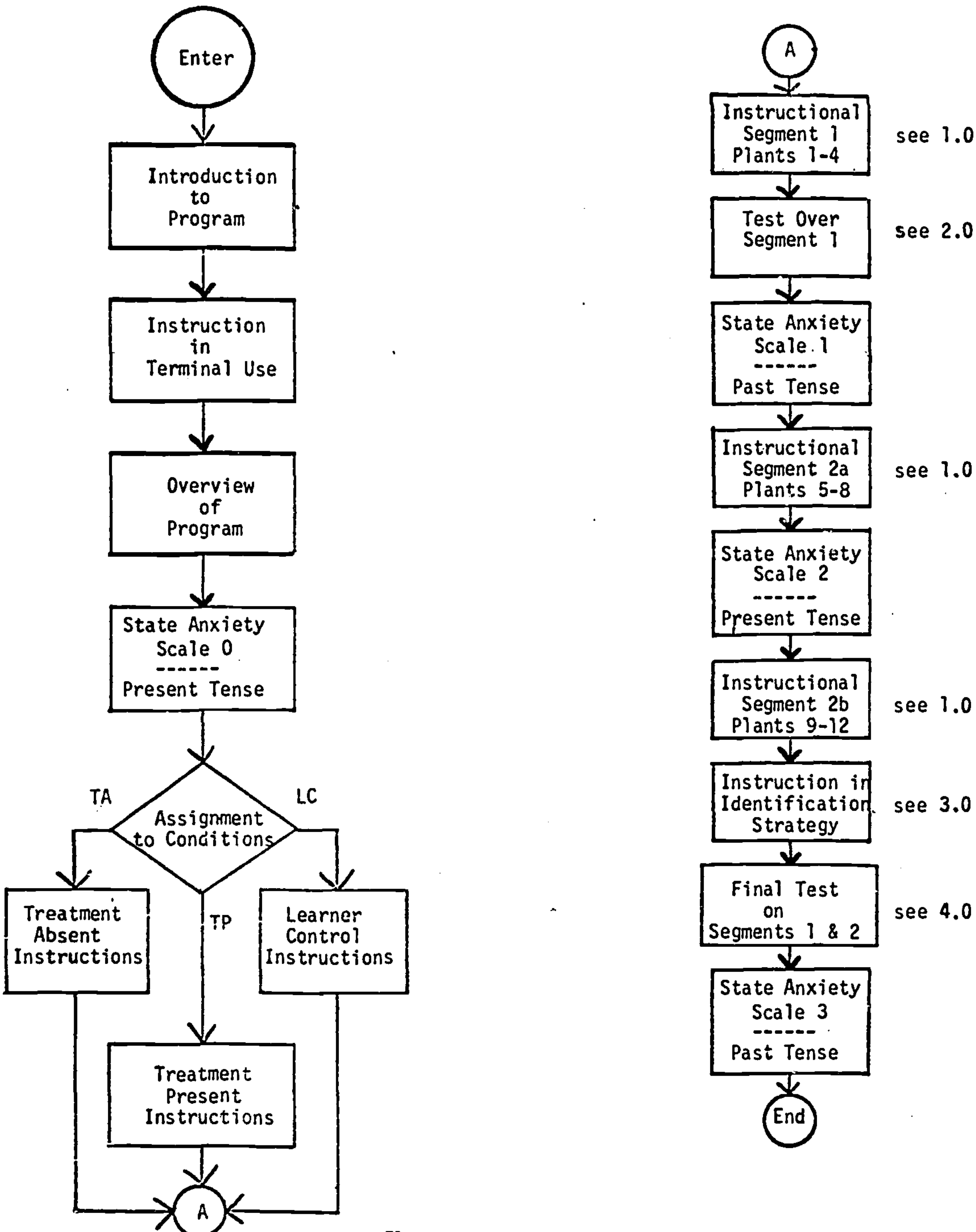
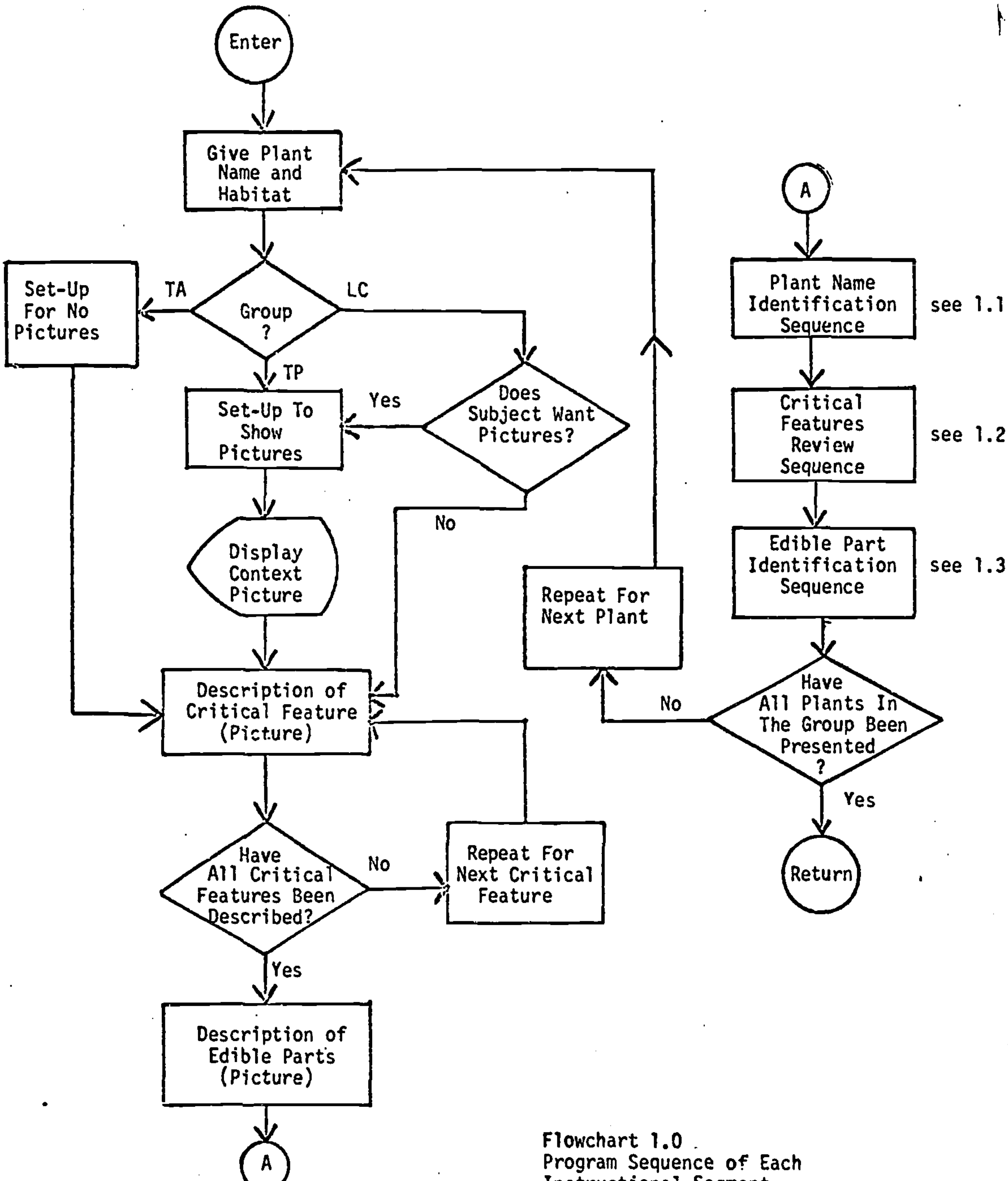
APPENDIX A



Flowchart 0
Overall Program Structure



Flowchart 1.0
Program Sequence of Each Instructional Segment

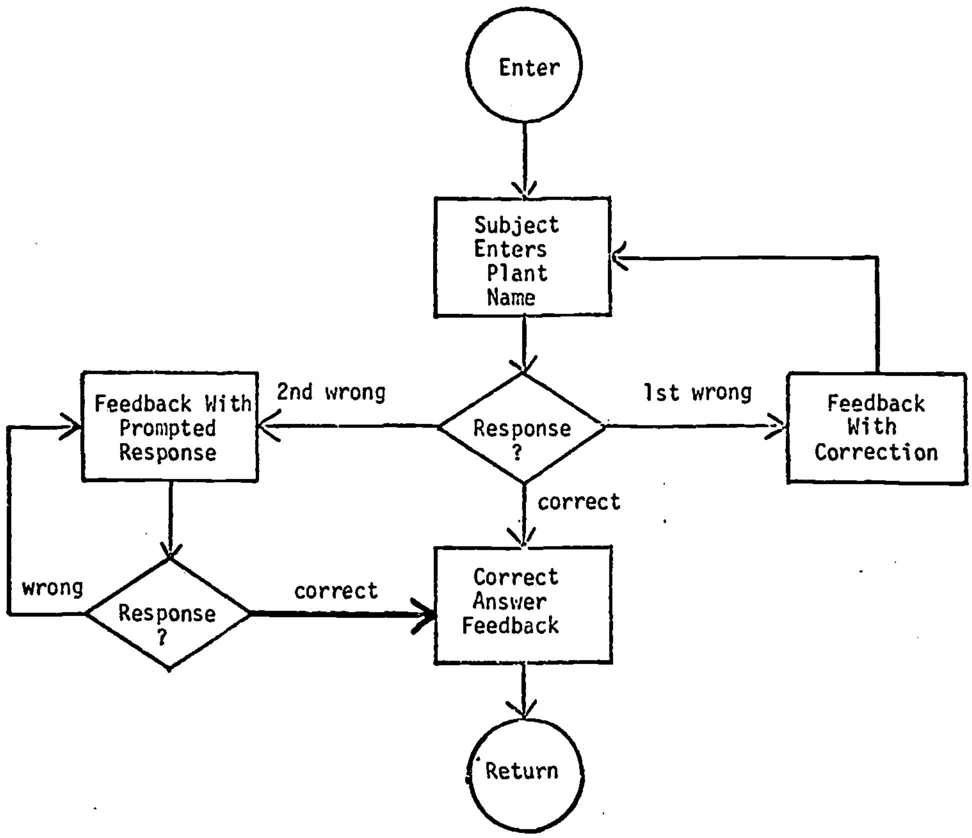
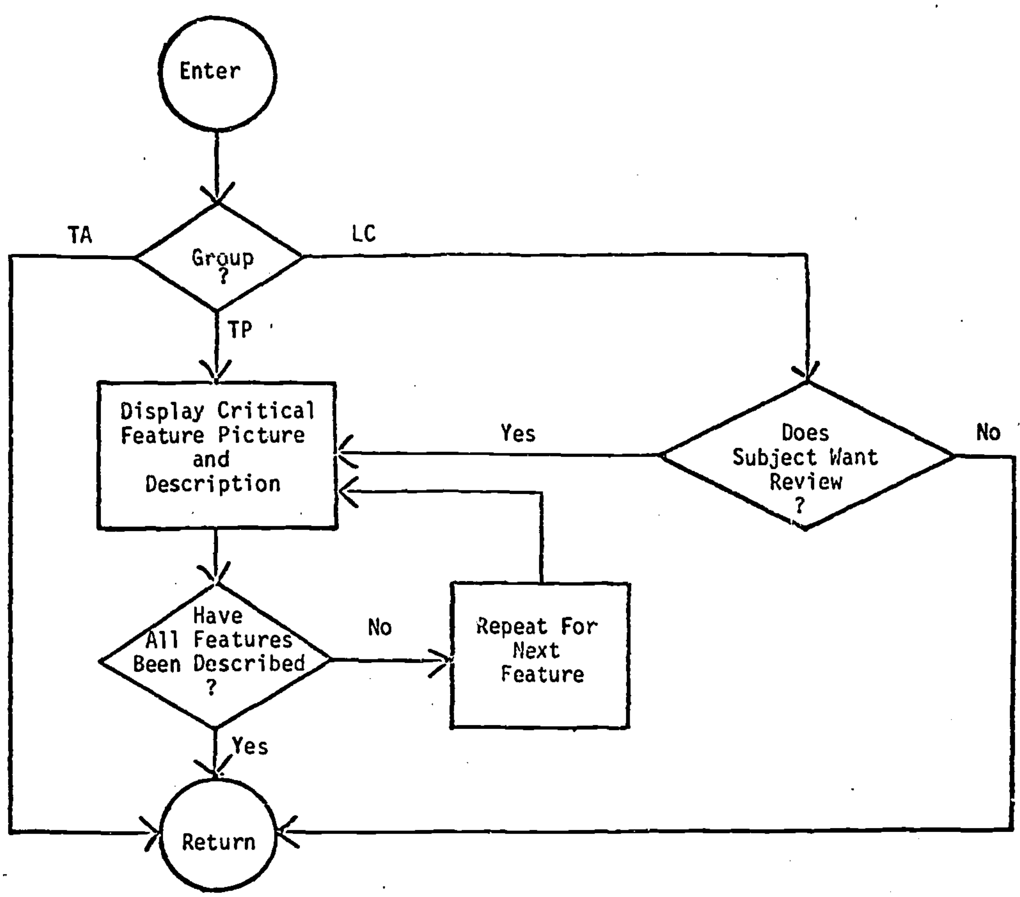
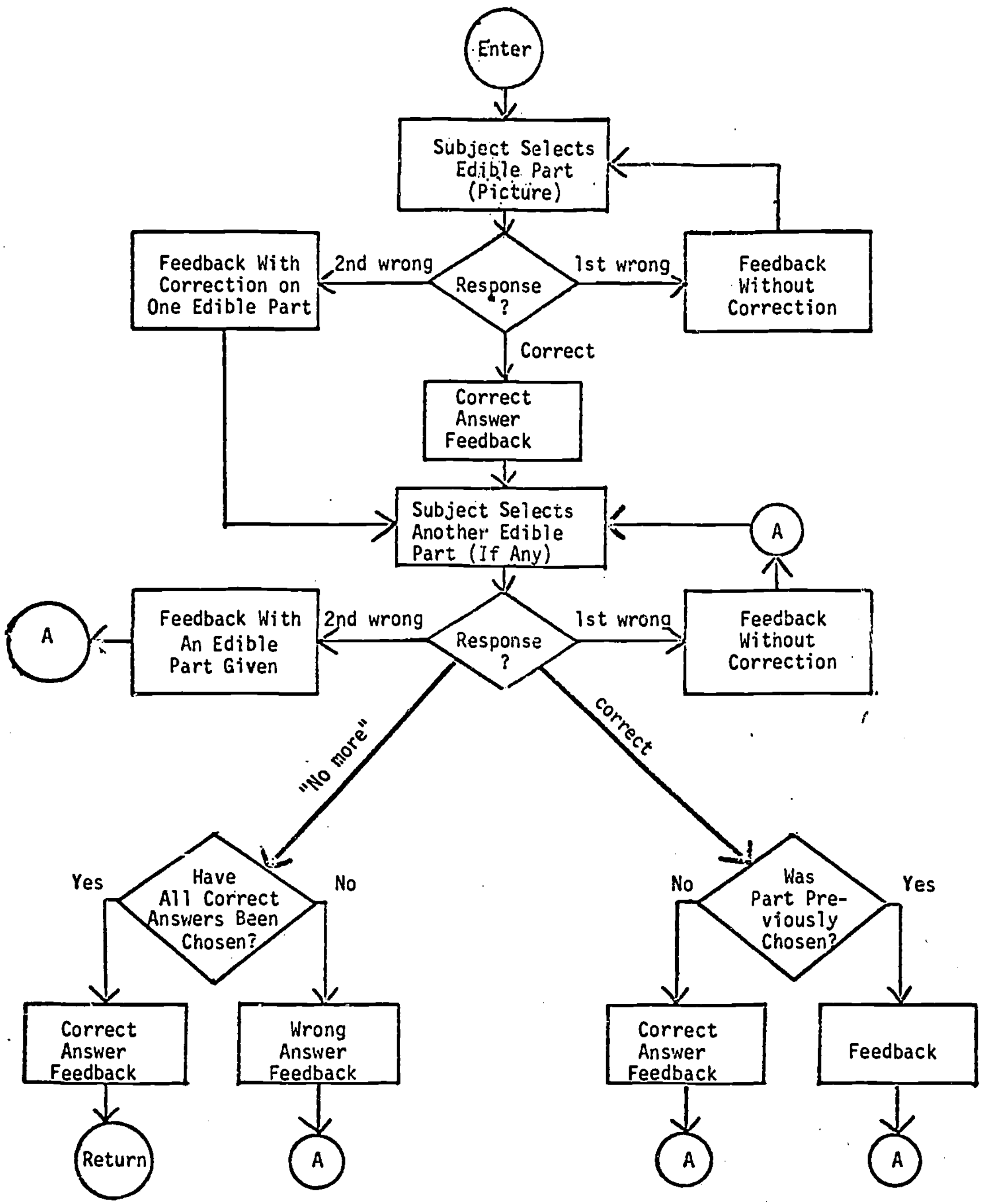


Figure 1.1
Plant Name Identification Sequence--Instruction

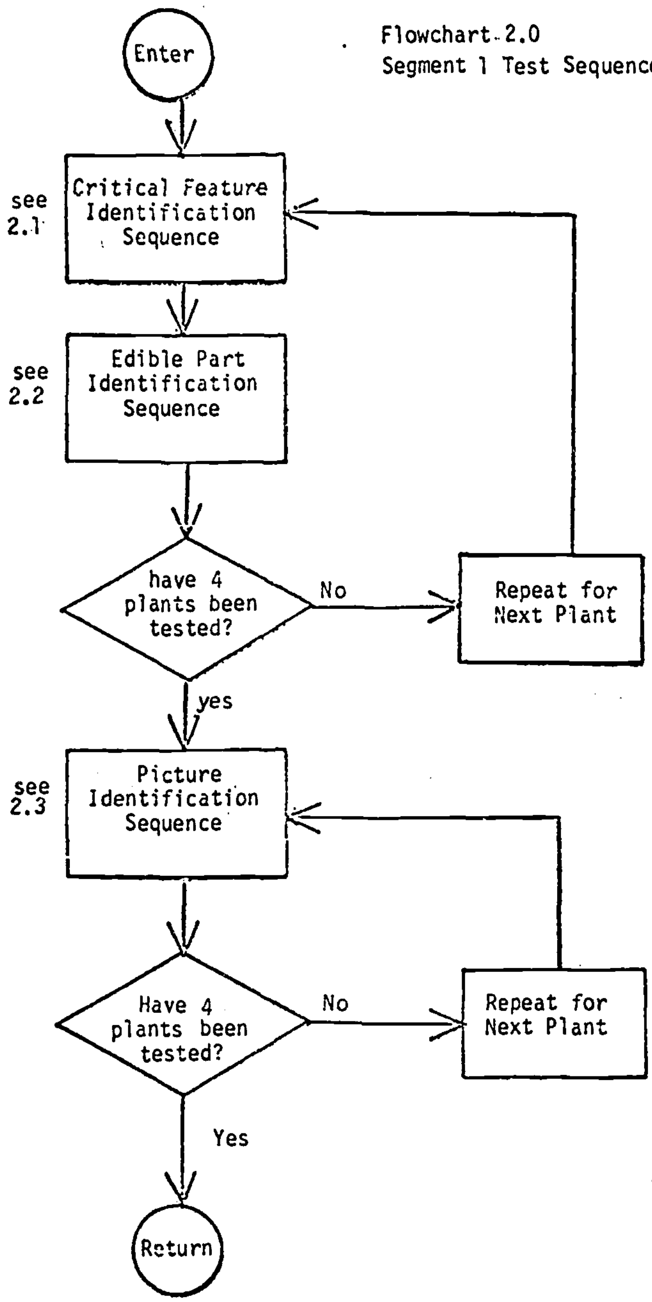


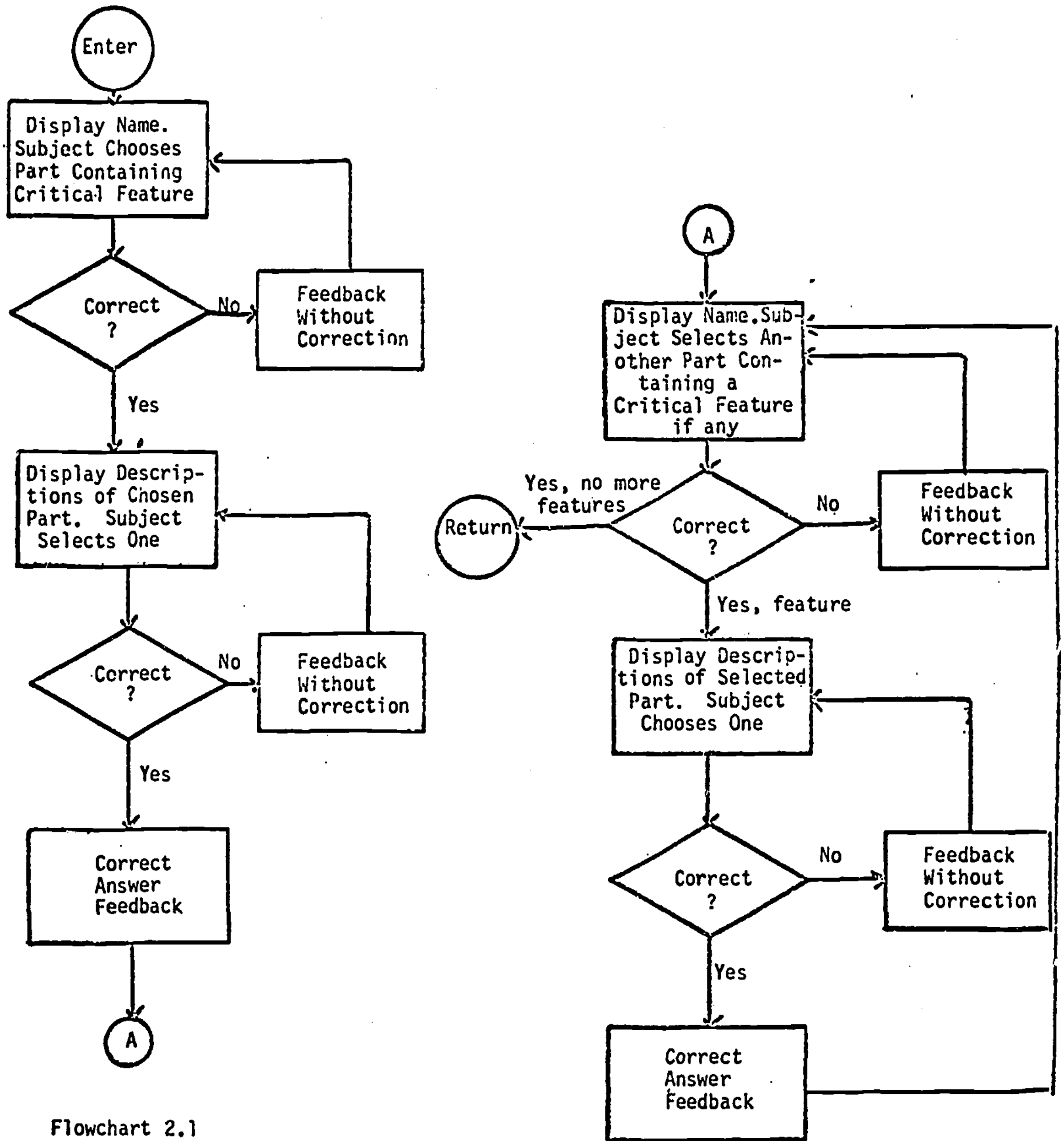
Flowchart 1.2
Critical Features Review Sequence



Flowchart 1.3
Edible Part Identification Sequence--Instruction

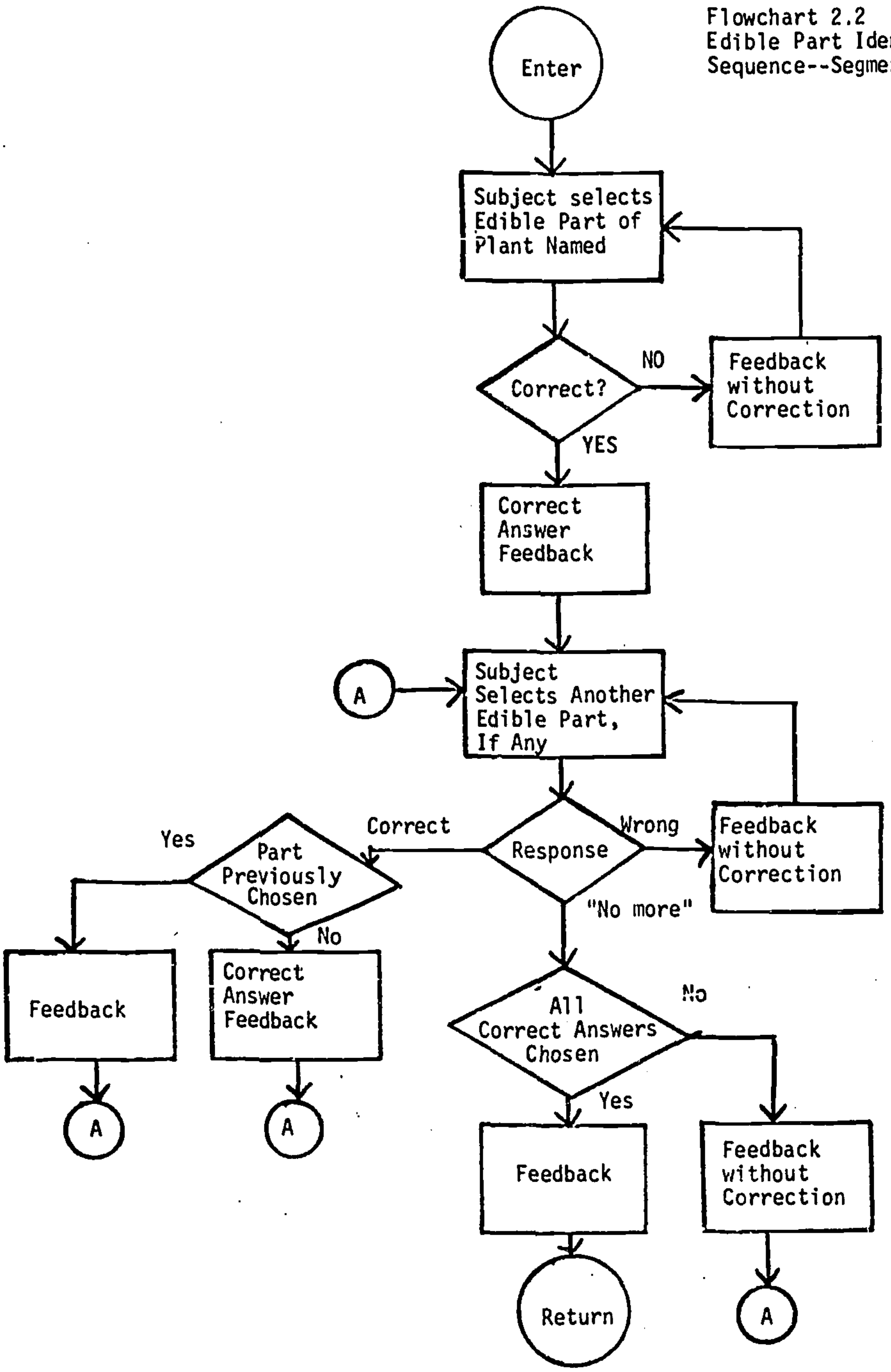
Flowchart 2.0
Segment 1 Test Sequence



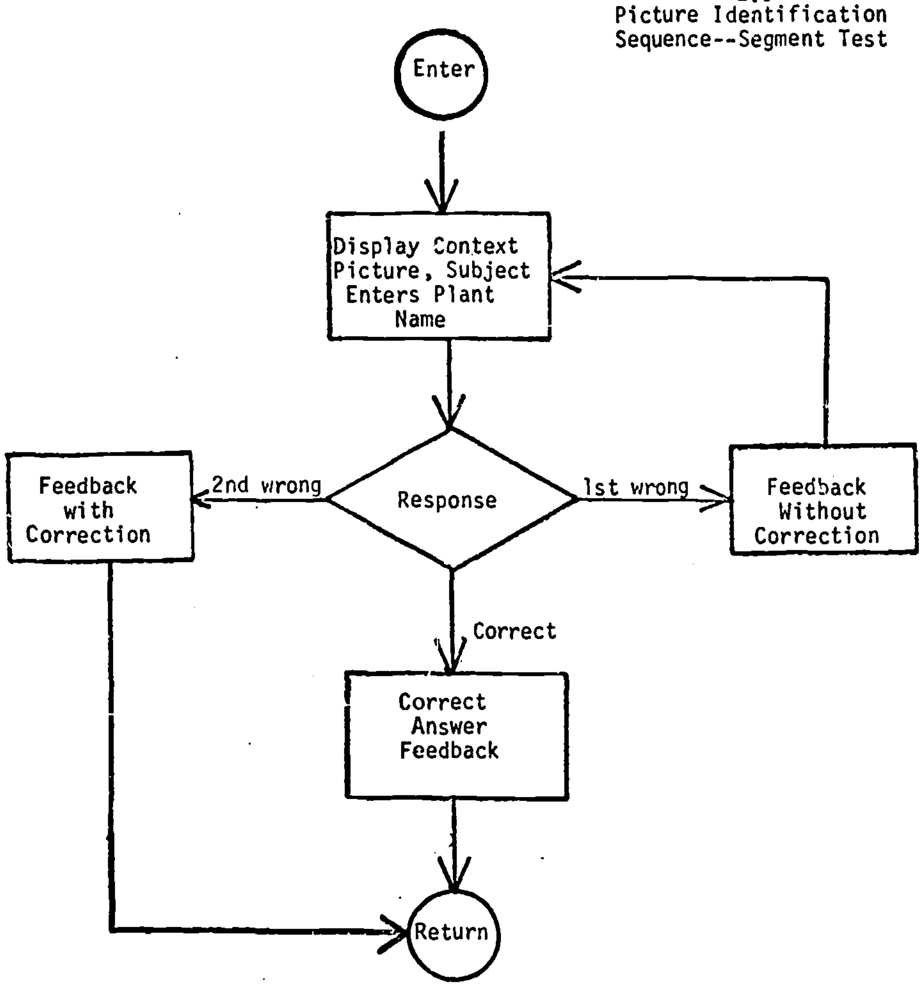


Flowchart 2.1
Critical Feature Identification
Sequence--Segment Test

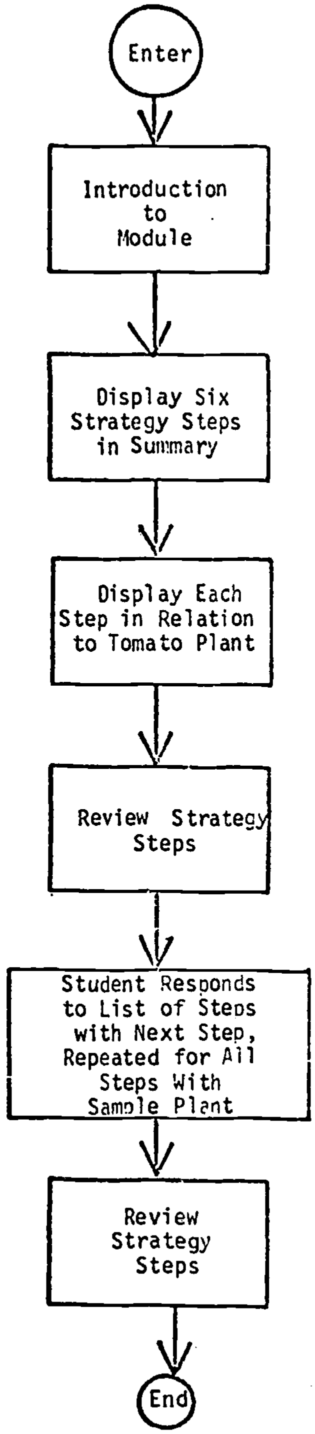
Flowchart 2.2
Edible Part Identification
Sequence--Segment Test

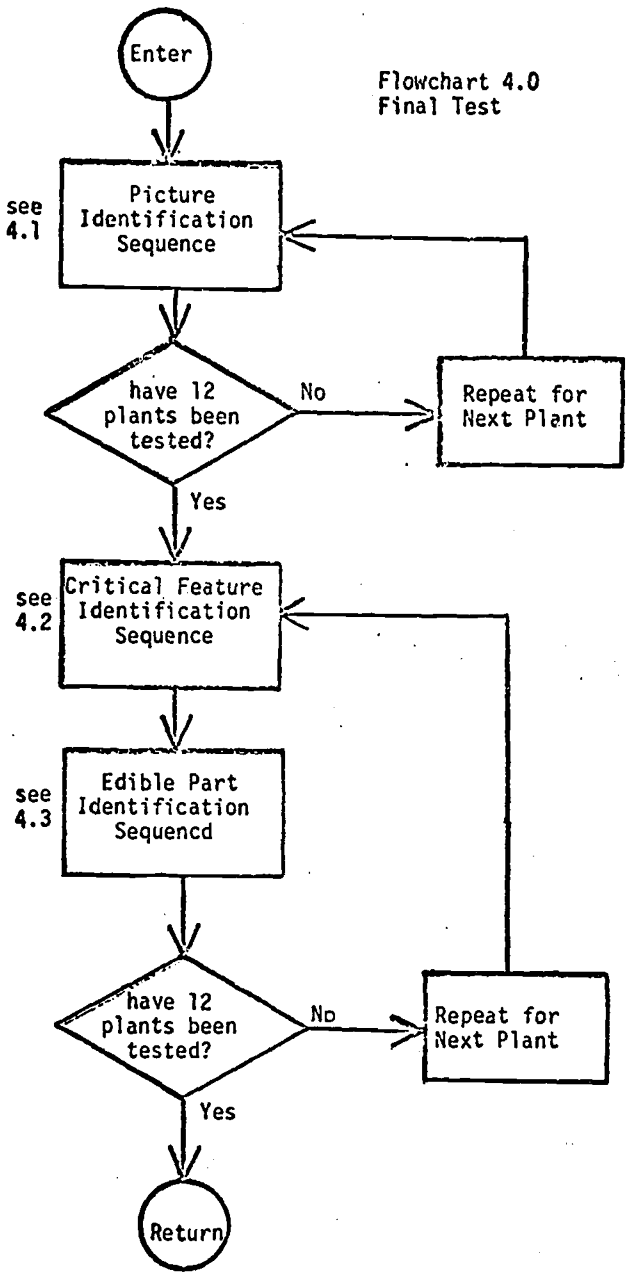


Flowchart 2.3
Picture Identification
Sequence--Segment Test

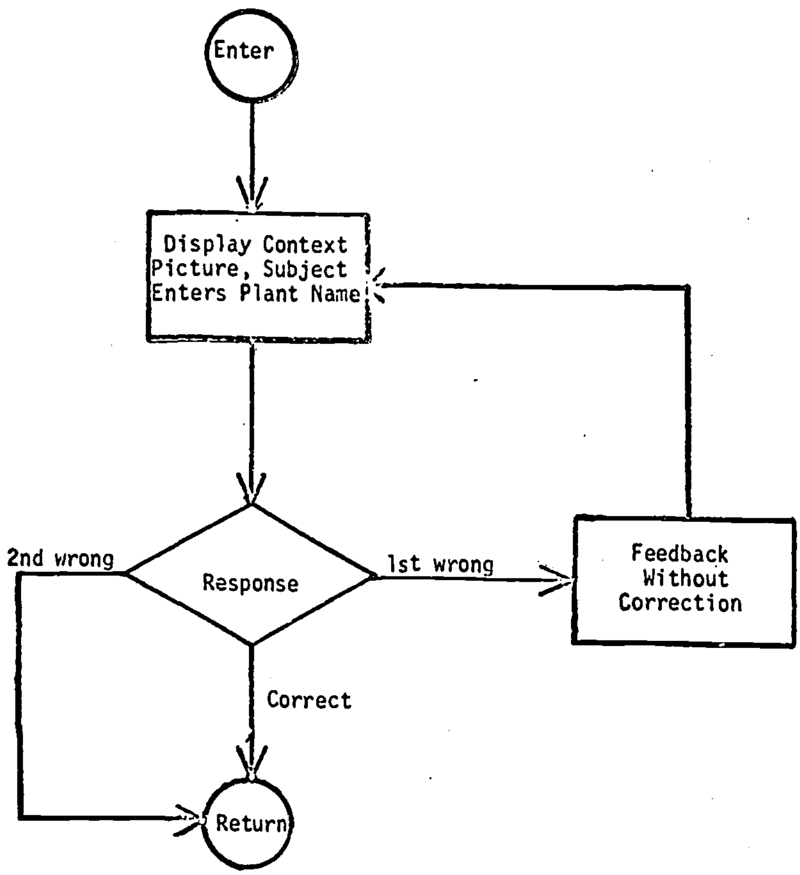


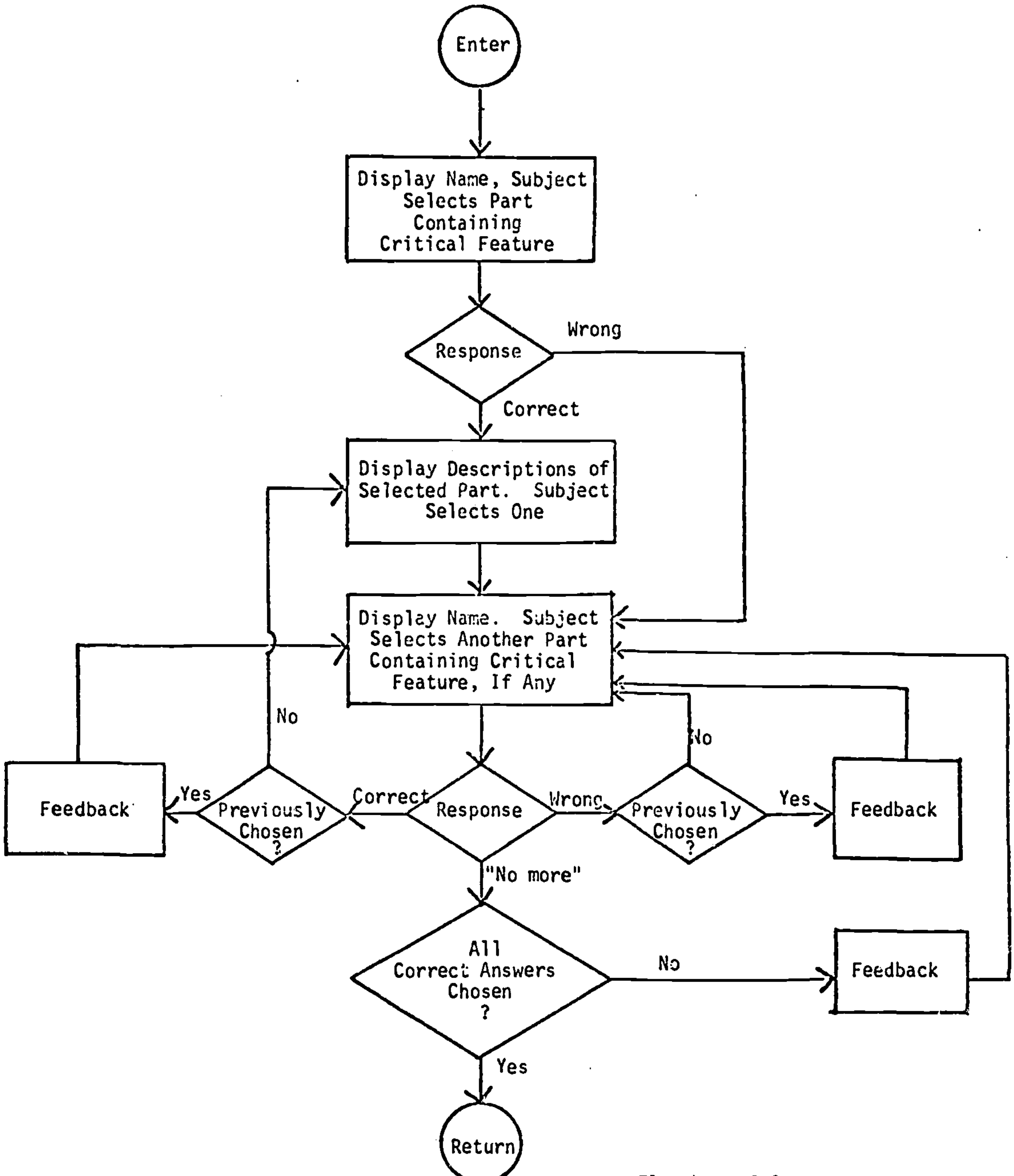
Flowchart 3.0
Plant Identification
Strategy Module




Enter
Flowchart 4.0
Final Test
see
4.1
Picture
Identification
Sequence
have 12
plants been
tested?
No
Repeat for
Next Plant
Yes
see
4.2
Critical Feature
Identification
Sequence
see
4.3
Edible Part
Identification
Sequencd
have 12
plants been
tested?
No
Repeat for
Next Plant
Yes
Return

Flowchart 4.1
Picture Identification
Sequence--Final Test





Flowchart 4.2
Critical Feature Identification
Sequence--Final Test

Flowchart 4.3
Edible Parts Identification
Sequence--Final Test