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ABSTRACT

A computer-assisted simulation of experiments in eyelid conditioning was conducted as part of an introductory psychology course. This instructional format was then compared with a traditional instructor-led seminar and with a seminar in which computer-produced information obtained elswhere was used. A total of 120 students participated in 11 groups. Groups were composed on measures of factual content, skills of experimental design and analysis, attitudes toward science and computers, and evaluation of learning experience. Results indicated no significant differences among groups on mastery of factual content or attitude change toward science or computers. In the learning of skills associated with the appropriate labeling of variables and controls in an experiment and with the recognition of relations in graphed data, results favored those groups which used the computer-assisted simulation of experiments. However, none of the groups could generalize principles of scientific analysis to other contexts. Students rated the computer-assisted simulations as favorably as the instructor-led seminars and expressed a significant preference to continue the computer-assisted experience. A comparison of relative costs indicated that computer simulations could provide low cost experience with complex experimental data and design. (Author)

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EVALUATION OF COMPUTER SIMULATION OF EXPERIMENTS IN TEACHING SCIENTIFIC METHODOLOGY

June 15, 1973

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education

National Center for Educational Research and Development
Regional Research Program
Region V

ABSTRACT

A computer-assisted simulation of experiments in classical eyelid conditioning was conducted as a two-week seminar component in an introductory psychology course, and compared with two other instructional formats on the same subject: a traditional instructor-led seminar, and a seminar in which computer-produced information was used but was not obtained in computer-assisted instruction. A total of 102 students participated in eleven groups over two semesters. Groups were compared on measures of factual content, skills of experimental design and analysis, attitudes toward science and computers and evaluation of learning experience. The results indicate no significant differences among the groups in the mastery of factual content or attitude change toward science or computers. In the learning of skills associated with the appropriate labeling of variables and controls in an experiment and with the recognition of relations in graphed data, results favor those groups which used the computer-assisted simulation of experiments. However, none of the groups demonstrated ability to generalize principles of scientific analysis to other problems of contexts. Students evaluated their experience with computer-assisted simulations as favorably as traditional instructor-led seminars and expressed a significant preference to continue the computer-assisted experience. A comparison of relative costs indicates that computer simulations provide low cost experience with complex experimental data and design.

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U.S. Department of Health, Education, and Welfare
Office of Education
National Center for Educational Research and Development
Region V

1. Co-Director of Project from April 15, 1972, to July 31, 1972
2. Co-Director of Project from August 1, 1972, to June 15, 1973

PREFACE

This instructional evaluation project directly involved three faculty project co-directors, a principal computer consultant, a fourth faculty member as instructor of two of the instructional groups, five student assistants, 116 student subjects who participated in the instructional groups as part of the Orientation to Psychology course at Macalester College, a number of people who attended project demonstrations, and several additional staff members who at various times assisted this research.

The authors of this Report gratefully acknowledge the special contributions of: Paul Anderson (Political Science), Phillip Bayt (Psychology-Mathematics), Renae Broderick (Psychology), Robert Desimone (Psychology), and Jane Eastwood (Psychology), the student members of the teaching-research team who shared in the design, implementation, accomplishments, and disappointments of the instructional groups; Richard Nussloch, Department of Psychology, University of Michigan, the author of PAVCO, project computer consultant, and sensitive advisor on instructional alternatives; Dr. David Mack, Department of Social Science, University of Technology, Loughborough, England, who shared in the initiation of this Project, and was its co-director from April 15 to August 1, 1972, and contributed his insightful planning and sound advice; Dr. Kenneth Goodrich, Vice President and Provost, Macalester College, for his encouragement and support both professionally and administratively; Ms. Betty Bland, Administrator of the Orientation to Psychology course, for her general assistance and coordination of this teaching-research project with an on-going course, and the faculty of Orientation to Psychology, Professors Charles Torrey, Raymond Johnson, Marilla Svinicki, and Hans Wendt, for their cooperation.

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INTRODUCTION

The use of computer-assisted instruction (CAI) has been heralded as the beginning of a major revolution in educational practice (Gerard, 1967a, 1967b). The most optimistic of the forecasters anticipated that a happy combination of programmed instruction and computer technology would transformall educational institutions into efficient student-machine-media interaction systems. While a few new institutions have been designed to exploit computer-managed learning, no real revolution has occurred. Critics and opponents of educational technology have signaled the passing of another fad. It is more appropriate, however, to interpret the situation as one of transition from the exciting but exaggerated era of early promotion to a more realistic but no less exciting era of exploring the special capabilities of the computer in assisting the learning of a variety of competencies and contents in a variety of instructional contexts.

There is no question about the unique capacities of the computer in the management of learning. Caffrey and Mossmann (1967) list the following:

> Self-pacing -- the student moves as rapidly as he can or wishes to;
>
> Interaction with an observant and tireless "tutor";
>
> Presentation of instructional sequences based on prior responses and other available history;
>
> Diagnosis of weaknesses in skills and abilities that often are overlooked by human evaluators;
>
> Basic and remedial sequences that may employ auxiliary media;
>
> Immediate access to statistical data reflecting individual and group performance.

These capabilities can be exploited in instructional presentation, monitoring of student progress and evaluation of educational methods and techniques.

Most frequently cited as a special advantage of the computer in instruction is the individual relationship that can be arranged between student and computer. Stolurow (1969) indicates five modes of interaction:

The problem-solving mode which makes use of the computer's computational capability;

The drill and practice mode in which programmed practice and test materials are presented in sequence;

The inquiry mode in which students ask questions of the system in their natural language;

The tutorial mode in which the system is programmed to generate instructional formates determined by the progress and ability of the student;

The author mode in which the system generates learning materials out of primitives and rules of combination.

All of these modes make use of the computer's speed and capacity to perform essentially traditional instructional tasks in more efficient and individualized ways. The computer can be a complex "teaching machine" and can manage the contingencies of programmed instruction (Skinner, 1968). The computer can control many presentation devices and provide quick access to a variety of media for the student. The computer can monitor performance and produce rapid feedback which can be diagnostic and corrective. Many of the special capabilities of the computer in instruction, however, remain to be explored.

Demonstration computer programs have generally indicated that computer-assisted instruction is as effective as or slightly superior to traditional methods of instruction when assessed by objective measures of achievement at the conclusion of the instructional period. Since this slight superiority has been purchased at considerable cost of development, there are serious questions about the application of computer-assisted instruction in most learning situations. Most of the concern is directed toward the problems of public educational policy and this concern and the accompanying controversy may lead to misconceptions about the application of computer-assisted instruction in more limited learning situations. The most famous and complex demonstration programs have performed essentially a drill instructor role in the teaching of subjects like language and arithmetic (Suppes and Morningstar, 1969; Stolurow, 1969; Alpert and Bitzer, 1970). There have been, however, many other uses of computer-assisted instruction within the demonstration programs and elsewhere. Hammond (1971) describes a program designed to assist in learning how to apply knowledge in situations requiring judgment. Oettinger (1969) describes a program for teaching analytic geometry. Both of these applications take the computer far beyond the role of drill-master or librarian.

Many applications of computer technology to instruction have extended or replaced functions served by tests, lectures or other forms of programmed instruction. The laboratory is considered to be the necessary support of science education and it is the role of the computer in the support of laboratory experience that this project has explored. The purpose of the laboratory in science teaching is to promote learning by bringing the student into contact with actual objects and events. Concepts can be given objective meanings through the observation and measurement of changes in variables which can be manipulated by the student. It also is assumed, as Gagne (1964) asserts, that the laboratory can teach certain strategies and methods of science such as formulating hypotheses, making operational definitions, controlling and manipulating variables, conducting experiments, designing "models", and interpreting data.

In most sciences there is usually a considerable gap between the sophisticated experimentation on which the principles taught in introductory courses are based and the kind of laboratory experiences that are available to students. Certainly, many introductory laboratory experiences provide little opportunity to emulate the scientist except in trivial ways. Partly this may be due to the assumption of many instructors that introductory level students are not yet ready to perform sophisticated experiments, but this also may reflect the unavailability of some laboratory opportunities because of cost, complexity or delicacy of instruments of design. The beginning laboratory may be used to demonstrate, which can be a useful instructional technique, but usually not to duplicate the kind of experimentation on which the exposition in texts is based.

In psychology, classical conditioning provides a foundation for all treatments of the psychology of learning. Practically all major texts present the data of Pavlov's experiments and the more recent studies of the classical-conditioning of eye-blink responses in humans. A representative introductory text (Dember and Jenkins, 1970) devotes a full chapter of 44 pages to the events and relationships of classical conditioning and the application of conditioning concepts to other problems of learning. However, few, if any, beginning psychology students have ever performed an experiment in classical conditioning or even seen the apparatus which is used.

An interesting attempt to simulate classical conditioning phenomena has been reported by Hoffman (1962). His device provides electronic circuits that register a range of experimental events and read out, by meter pointer, values that reflect systematically the manipulation of variables. It is relatively inexpensive and simulates simple phenomena in a reliable way. It is limited in the range and complexity of phenomena which it can simulate, however. A computer simulation is not limited in the same way and can provide exercises in experimental design and hypothesis testing which are as complex as any authentic laboratory experiment. Such a computer simulation is the instructional device which has been evaluated in this project.

In the Spring of 1969 a proposal was made to the Office of Educational Research at Macalester College for financial support to develop a program to simulate classical conditioning phenomena by means of a computer for instructional purposes. The request was granted and during the summer of 1969, Richard Nussloch, a student assistant in the Department of Psychology, examined model experiments that would provide good examples of classical conditioning phenomena. Once the selection of model experiments was made, programs were written that permitted the generation of results that reflected the manipulation of experimental variables. The program was adapted initially to an IBM 1130 computer.

In the Fall of 1969, the program was tried with a group of students from a section of the beginning psychology course who were participants in an optional seminar in experimental methods. In the spring of 1970, the simulation program, now augmented by a programmed introduction to the computer, was tried with a second group of students. In the academic year 1970-71, the Psychology Department redesigned its beginning course and converted it to a modified contingency-managed course (Keller, 1968).

Students complete a textbook in an independent self-paced way, assisted by a workbook and a series of unit tests of mastery. The student also is able to select from a variety of two-week seminars, laboratories and other activities in order to compile participation credits toward a final grade. The simulation of classical conditioning, now known as PAVCO (PAVlovian COnditioning) seemed ideally suited to the new format the was offered as one of the participation options to a group of ten students.

For the Spring Semester, PAVCO was modified for use with an SBC Call/360 terminal. This approach was much more satisfactory than the IBM 1130 version since an interactive program could be used which did not require any special computer-use skills by the program user. The program was run with three groups of students comparing instructional variations. The comparison was part of the Honors research of Mr. Nussloch, who had developed the program. The results of the preliminary evaluation of the program have been reported elsewhere (Nussloch and Mink, 1971).

The advantages of the computer simulation program lie in its capacity to provide experience with sophisticated research problems and experimental design, the associated teaching of content in a basic area of psychology, the efficiency and speed with which it gives the student access to a range of experiences, the high degree of management of the conditions of learning that are possible, and the intrinsic interest that the interaction with a computer has for the learner. However, the superiority of computer simulation to other methods of instruction is not clearly established and the cost-efficiency of the simulation method has not been determined in proper relation to alternative methods. The evaluation of the PAVCO simulation as a model of computer simulations of laboratory experiments is the purpose of the project which is described in this report.

The particular choice of simulation and the format in which it is used require additional elaboration. There are a variety of experimental programs that could be simulated for instructional purposes, many of which would be more intrinsically interesting or more reflective of current investigations than the PAVCO simulation. However, it is not a challenging instructional task to take a subject that is already attractive to students and put it in an even more attractive setting. A sterner demand is made when a topic is considered to be essential knowledge in the field yet is viewed by students as uninteresting or unrelated to their concerns. Certainly most instructors of introductory psychology courses would agree that classical conditioning does not elicit great enthusiasm from students. The topic of classical conditioning, then, provides a fairly typical problem in instructional design.

The format in which the PAVCO simulation has been used was chosen because it seemed practical and applicable in a variety of learning situations. A modest kind of computer-assisted instruction that take over a portion, though not all, of the tasks of instruction brings application within the reach of many types of institutions and instructional programs.

The project reported here was designed to evaluate the instructional benefits of using a computer based simulation of experiments in classical conditioning as a component of an introductory course in psychology. The instruction and research was conducted over two academic semesters. The general design and procedures were similar for both semesters but the second semester design was not a complete replication of that of the first semester. The experience obtained during development and application in the final semester led to some alterations of materials, a modification of design and a sharpening of focus of the instructional units. These differences will be appropriately emphasized in the discussion of method and the interpretation of results.

PROCEDURES AND METHODS

The PAVCO Program.

The PAVCO program is the basis of the computer-assisted instructional component of the project. PAVCO was originally written in $FORTRAN_4$ and later was transcribed in BASIC. There are two operational versions of PAVCO, one for batch processing use with an IBM 1130 computer, the other for a conversationally-interactive use with a Call/360 terminal. The Call/360 interactive version is the one which was used in this study. PAVCO is based on C. L. Hull's analysis of learning in Principles of Behavior (Hull, 1943) and the eyelid conditioning experiments of K. W. Spence and his associates (Spence, 1956).

The program provides simulated experimental data for five conditioning phenomena: acquisition, extinction, generalization, differential conditioning (discrimination) and higher order conditioning. The program permits the entry of values of such independent variables as inter-trial interval, interstimulus interval, unconditioned stimulus intensity, a drive or anxiety factor and other independent variables appropriate to the specific phenomenon being explored. The dependent variable is an ordered pair, consisting of all the number of ten trial blocks paired with a group mean response percentage. The number of ten trial blocks (from 1 to 30) and the number of subjects (from 1 to 1000) can be specified for each simulated experiment.

There are several values for each independent variable. The student operating the program may explore the effects of varying one independent variable, while holding the others constant, or may permit more than one independent variable to change concurrently with another independent variable. In this way a student may develop simple one variable designs or multiple variable interactive designs. It is also possible to determine the effects of changing the value of a variable across several phenomena. The program permits not only the investigation of simple parametric relationships but also supports the testing of experimental hypotheses about relationships inferred from observations of the operation of the program.

The Call/360 version of the program provides instruction in terminal usage and simple experimental methodology so that a student unacquainted with either computers or eyelid conditioning research can simulate simple experiments during the first experience with the computer terminal. The data provided by the computer terminal for each simulation is printed in a form which can be converted into graphs in which group mean response is plotted as a function of trials. These curves provide a good approximation of published experimental results though a randomizing factor in the program ensures that outcomes are not identical for repetitions using the ame value of an indepedent variable.

Subjects.

The study was run during the academic year 1972-73. The beginning course in psychology, titled Orientation to Psychology is one semester in length and is offered during both semesters of the academic year. The course is open to students of all levels but enrolls mostly freshmen. Approximately 250 students were enrolled during the Fall Semester and 150 students were enrolled during the Spring Semester. At the beginning of each semester at a regular meeting of the full class, the project director invited students to participate in an "instructional research project" which was being conducted by the Department of Psychology. No specific information was given about the general design of the study but students were told that if they were selected they would be assigned to a two week seminar which would be conducted as part of the regular seminar program of the course. A series of two week seminars are run throughout the course. Students may select seminar participation as an optional activity for credit in the course in addition to a self-paced textbook-examination format For their participation they were told that they would receive credit toward their final grade in the course in the same way that they might receive credit in any other seminar.

Approximately half of the class volunteered in each semester. From the pool of names obtained in this manner students were randomly assigned to the groups required by the design. Twelve to fifteen students were assigned to each group with the expectation that attrition would not reduce the groups to less than ten each. The expectation was not confirmed in two groups where students dropped out with no opportunity for replacement and the size of the completed group decreased to seven. A total of 73 students participated in seven groups during the Fall Semester and 43 students participated in five groups during the Spring Semester.

Design.

The problems of design and control in instructional research are frustrating and perplexing. Whatever the variables under investigation there are, unavoidably, sources of confounding which are recalcitrant to control. In this project the main concern has been with the evaluation of a computer-assisted approach to learning scientific content and methodology. The experimental groups of the studies, therefore, are groups in which a simulated experimental program is used in conjunction with an interactive computer terminal. In both semesters of the study two experimental groups were used. In the first semester the two experimental groups differed in whether the experience with the computer was used as a reinforcer for accomplishing instructional goals or occurred as a consequence of the regular time schedule of the seminar.

In the second semester the two experimental groups differed in the use of social interaction to facilitate use of the experimental simulations. One group was subdivided into small research teams and used the computer program to support their team investigation. The other group members worked independently with each student managing his own investigation.

In the design of control groups, two obvious controls are required. First, a group is needed which is evaluated on all the measures that are used with the experimental groups but which receives no special instruction or experience. Since the topic of classical conditioning is covered briefly in the text materials used by all students in the course, a group that is used only for obtaining responses on the assessment devices should control for incidental course exposure to the topic of the instructional research seminars. One control group of this kind was obtained each semester. The other obvious control group is one in which special instruction is given in a traditional manner without use of computer assistance. A lecture-discussion format was chosen similar to that used in most of the other two-week seminars which are conducted in conjunction with the course. In order to make an appropriate comparison a colleague was selected to conduct the traditional instructional group who was both the most experienced person in the department in the literature of classical conditioning and, by common agreement, the most masterful and dedicated teacher. While it is likely that much traditional instruction is not conducted by teachers of such knowledge and talent it seemed appropriate to provide control groups which were conducted in a way that would recognize the expressed values of those who approach instruction in a more subjective way. One traditional control group of similar size as the experimental groups was conducted each semester.

It is possible to generate bases for a large number of additional control groups. It seemed most reasonable, however, to design a control group which was as similar as possible to the computer-assisted groups but which did not include direct experience with the computer-based program. A modified programmed-learning approach was developed in which the data of the PAVCO program was made available to students but not by means of interaction with the computer terminal. In the fall semester an index of results which duplicated the stored results in the PAVCO program was available. Students obtained the equivalent of the PAVCO printout by entering the index (Master Data Tables). In the pring Semester a member of the instructional staff operated the computer console and obtained results for students which were returned to them the day following the request. These control groups provided a basis for evaluating the use of the computer interaction mode since the control groups were otherwise making full use of the PAVCO simulation to obtain their data.

When one aspect of instruction is allowed to vary it is important to control or balance other aspects of instruction as much as possible. Since any relevant factors in instruction in natural setttings are hard to isolate it would be presumptious to claim any real rigor in control. However, a serious attempt was made to see that common instructional goals were set for each group and common content was used. All groups received the same printed instructional materials which described the basic phenomena of classical conditioning and introduced the technical terminology of the area. Each group also received the same printed materials on the design of experiments and interpretation of data. The control groups worked with representations of experimental results and designed studies to explore relationships just as the experimental groups did. All groups were acquainted with extensions of classical conditioning methodology to other fields and made use of the same supplementary readings.

The instructional staff for all of the groups except the traditional instructional groups consisted of five upperclass majors in behavioral sciences. They developed the instructional materials, maintained the computer programs and supervised the participating students. The use of students as an instructional research team has special benefits which will be discussed later but the major reason for using students was the assumption that computer-assisted instruction should not require the same involvement of faculty members in an instructional role that traditional instructional methods do.

The fall semester seminars provided three computer-assisted experimental groups which differed in whether access to the computer was based on proficiency requirements or in a non-proficiency based time schedule, a traditional lecture-discussion based control group, and a programmed non-computer-assisted control group and a control group which received no special instruction.

Some modifications were made in the experimental design for the second semester. The major change was made in recognition of the role of social interaction in the general instructional process. The computer-assisted groups of the first semester were designed to foster independent learning. However, the groups differed in the amount of interaction with staff and other students which was available. The traditionally instructed group was organized around instructor-student and student-student interaction. While the role of social interaction did not appear to be obvious in differentiating groups in the first semester it did seem worthwhile to devise a design that might provide some information on this dimension. The other changes in design reflected the change in the instructional program from a central emphasis on hypothesis formation and testing to a more limited exploration of the relationship of variables in the PAVCO program.

In the spring semester, then, two computer-assisted groups differed on a dimension of social interaction with one group using a small research team approach to the operation of the PAVCO system and the other group using an independent individual approach to the operation of the system. The two control instructional groups were organized to provide non-computer assisted social interaction in the traditional instructional group and to provide a group differing from a computer-assisted independent study group only in the availability of the computer terminal.

The groups which made up the study and the procedures which were used with them are summarized as follows:

<u>Fall Semester</u>

Pilot Group: (N=14)	Computer-assisted; standardization of procedures, materials, and instrumentation.
Group I: (N=10)	Computer-assisted; scheduled access to computer as part of instructional program; staff directed discussion of computer procedures, experimental design, preparation of graphs, and data interpretation; each student designed, simulated, and interpreted an experiment. Staff actively available.
Group II: (N=9)	Computer-assisted; access to computer after demonstrated proficiency in designing appropriate parametric study of independent variable (access as reinforcer for developing an experimental design); staff assistance available upon request. (Information provided in printed manual.)

Group III: (N=9)	Same as Group I.
Group IV: (N=13)	No computer assistance; traditional instruction in small group lecture-discussion format.
Group V: (N=9)	No computer assistance; students worked independently to design experiments (information provided in printed manual) and to determine results from Master Data Tables prepared from PAVCO output; staff assistance available upon request.
Group VI: (N=9)	Control; post-test only.

Spring Semester

Group I: (N=10)	Computer assisted; social interaction format with "research teams of 3-4 members, designing, simulating and interpreting experiments; staff actively available.
Group II: (N=7)	Computer-assisted; independent work format with students individually designing, simulating, and interpreting experiments; staff actively available.
Group III: (N=10)	No computer assistance; traditional instruction in small group lecture-discussion format.
Group IV: (N=7)	No computer assistance; same format as Group II with results obtained the day following submission of appropriate experiment; terminal operated by staff on "batch" basis; staff actively available.
Group V: (N=9)	Control; post-test only.

Assessment.

There are many forms that evaluation can take in assessing the value of an instructional program that is designed to teach scientific content and skills. First, but not necessarily most important, learning of subject matter content can be evaluated. Objective acquisition of terms and identification of facts can be used to assess the mastery of content. Second, more general changes in scientific behavior can be evaluated. Admittedly this is a far more difficult problem since it is harder to specify criterial behaviors. Conventionally accepted indicators are such measures as increases in the production of hypotheses, the design of experimental tests of hypotheses, the generalization of results, and the transfer of skills to other content areas of scientific investigation. Third, it is usually hoped that succesful science instruction will affect attitudes toward the specific subject, the discipline involved and more generally toward the field of science, its methods, and its goals.

All groups, except the controls, which were not members of seminars (Fall Group VI; Spring Group V), were given a battery of assessment instruments on the first day of the seminar and again on the last day of the seminar (a twelve day interval). The Pre-test battery given during the first semester consisted of the following items:

1. General information form. This form provided identifying information for each subject.

2. "Syllabus-Bound" questionnaire (Hudson, 1970). This scale has been used to assess student preferences for structured learning experiences.

3. "Social Attitudes Toward Computers" (Lee, 1970). This scale purports to measure attitudes toward computers on three factored dimensions.

4. "Attitudes Toward Science" (McInish & Coffman, 1970). This measure consists of 40 5-point scales assessing statements about science.

5. Content Test. This measure was comprised of a selection of objective multiple-choice and true-false items and an essay item dealing with facts of classical conditioning and experimental design.

6. Hypothesis Generator. This item is a description of an unusual relationship which is open to a variety of interpretations. Students were asked to propose as many possible hypotheses as they could and to describe a way of testing one of them.

These same pre-test measures with minor format modifications were used during the second semester. In addition, an experimental labeling test was used in which, on the basis of a brief abstract of an experiment, students were asked to identify variables and controls.

The Post-test battery given during the first semester contained the following devices:

1. Social Attitudes Toward Computers (Retest)

2. Attitudes Toward Science (Retest)

3. Content Test. Items from the pretest were repeated and the test was expanded in length.

4. Hypotheses Generator (Alternate form)

5. Labeling Test (For the second semester group this was a retest.)

6. Sequential Hypothesis Formation. In this item subjects were given successive amounts of information about some experimental relationships and were asked to form a hypothesis to account for the relationship.

7. Course Evaluation Form. A general evaluation form was used to measure attitudes toward the seminar, its content and the instructional staff.

For the second semester group the Sequential Hypotheses Formation measure was dropped and an additional measure was included which asked for the appropriate labeling of the axes and the general function of graphs representing the classical conditioning phenomena which had been studied in the seminar.

Copies of the pre-tests and post-tests that were used during the second semester are included in the Appendix.

RESULTS

The design of the study permits two general types of comparison. Comparisons across groups can be made on the basis of common measures taken at the completion of the period of instruction. On those measures where both pre-instructional and post-instructional testing was done, within-group comparisons can be made. The two sets of comparisons permit assessing the degree to which the groups differ in relation to instructional treatment and the degree to which changes over the instructional period are related to treatment.

The comparisons of results will be organized in the following manner: First, to be presented is the area of mastery of subject matter content as assessed by objective tests of terms and facts of classical conditioning and experimental design. Second, the achievement of general acientific skills such as hypothesis formation, interpretation of experiments and generalization of knowledge to other areas will be considered. Third, comparisons of attitudes toward science and computers will be presented. Fourth, evaluations of the instructional experience will be contrasted. Finally, brief comparisons of costs for the various instructional procedures will be presented. Results obtained from each of the two semesters will be treated separately because of some treatment variations as described in the previous section.

At the outset it must be said that compelling differences related to instructional method have not been found. This conclusion, common in instructional research (e.g. Dubin and Taveggia, 1968; McKeachie, 1970) is not surprising considering the complexity of interactions and the constraints imposed by imprecise and incomplete analysis of determining factors. This means, however, that much of the language of interpretation of results will overuse terms like "interesting trend" and "promising possibility". Observations and conjecture that have grown out of experience with the project will be expressed freely and without embarrassment but will be presented separately in a later section of this report.

Content Mastery.

The groups of the first semester can be compared on the basis of a total score on a post-test of content information. A perfect score of thirty-three points could be obtained on a combination of multiple-choice, true-false and identification items. Fifteen items on the post-test also appeared on the pre-test and a comparison can be made of improvement on these items. The results for the groups are shown in Table 1.

TABLE 1

Mastery of Factual Content

Common Items

	Pre-test Mean	Pre-test Variance	Post-test Mean	Post-test Variance	Difference Mean	Difference Variance	Post-test total Mean	Post-test total Variance
Fall Semester								
Group I (N=10)	8.1	3.7	8.2	6.2	0.1	6.9	24.4	13.8
Group II (N= 9)	7.8	4.8	10.2	4.6	2.4	7.1	24.4	44.7
Group III (N= 8)	8.9	2.9	9.9	1.9	1.0	2.0	23.1	9.3
Group IV (N=15)	8.3	6.0	9.9	4.2	1.6	4.9	27.9	16.2
Group V (N= 9)	8.4	3.8	9.7	3.3	1.2	5.4	23.8	30.4
Group VI (N= 7)							23.8	4.8
Spring Semester								
Group I (N-10)	12.6	9.4	17.3	5.8	4.7	11.0	38.3	13.2
Group II (N= 6)	11.8	3.0	15.5	7.0	3.7	7.6	35.3	39.0
Group III (N=10)	14.5	3.6	16.4	2.9	1.9	2.7	35.7	29.6
Group IV (N= 7)	12.6	9.3	16.4	3.7	3.8	8.3	36.7	11.2
Group VI (N= 9)							33.4	62.3

The traditionally instructed group (Group IV) shows a slight though not significant superiority in performance on the post-test. Even the control group (Group VI) that received no special instructions did as well as the instructional groups on the post-test. This group was tested late in the course so that a fair estimate of non-specific learning about classical conditioning could be made. It appears that normal exposure to textbook material is as effective as special instructional formats in determining performance on a content test of general information about this topic.

The content mastery test was modified for the second semester to provide for a greater range of response and to allow for more systematic pre-and post-test comparisons. These results are also presented in Table 1. The post-test scores are the total of scores on 25 multiple-choice items, ten true-false items and nine identification items responded to by a yes/no choice. Twenty items occurred on both pre-test and post-test. Analyses of the post-test scores and difference scores yield no statistically significant differences related to method of instruction. As with the first semester groups, the control group that received no specialized instruction performed almost as well as the instructional groups. The computer-assisted, social interaction group (Group I) did slightly better than the rest. The results can be interpreted to indicate that the specialized instructional experiences of the groups in this study did not result in clearly superior mastery of material that was also available in a more routine way. The post-test results suggest that content mastery expectations were reasonably well-met for all groups. The lack of consistent differences suggests that goals of content mastery can be met for most students by a variety of instructional formats.

Achievement of General Scientific Skills.

The measurement of general scientific behaviors is difficult. There is no consensus on criterial behavior and a review of available standardized tests (Buros, 1967) did not reveal any that were applicable to this project. Eventually, four devices were developed for Fall Semester groups. Of these, only two will be included in the analysis. One of the two to be included was a device which allowed students to generate as many hypotheses as possible to account for a relationship; the other was a labeling task where students were asked to identify variables from a published abstract of an experiment. Of the two measures not included, one was an attempt to assess hypotheses formation as related to successive increments of information. This measure proved to be too difficult for the students under the testing conditions and was dropped from use in the second semester. The other measure was designed to test the ability to apply principles of classical conditioning in a practical situation (e.g. treatment of enuresis). This task also proved to be too difficult to permit meaningful differences among groups since practically all subjects gave incorrect responses.

The results for the Fall Semester groups on the measures of hypothesis formation and labeling are displayed in Table 2. The groups did not differ significantly in the number of hypotheses that were generated in the post-test condition. When comparison is made between pre-test and post-test results, again, the groups are not clearly differentiated but there is a consistent decrease in the number of hypotheses generated by the instructional groups. On the labeling task, the instructional groups are not differentiated but the non-instructional control group does much more poorly.

The Fall Semester results indicate that skills and methods more broadly applicable to the analysis and testing of scientific problems are not easily inculcated by the instructional procedures used in this project. At best, the students in these groups show limited range in devising and testing of hypotheses and demonstrate difficulty generalizing information beyond the context in which it is received. Since the instructional emphasis in the first semester was on scientific hypothesis testing, these results indicate that either criterion expectations were set too high or instructional procedures were insufficient to noticeably raise the level of performance.

For the second semester the emphasis of instruction and measures was on more practical and less complex criteria of scientific behaviors. Emphasis on hypothesis generation and testing was still maintained but test examples were more closely related to the context of instruction. The hypothesis general task of the previous semester was retained on a pre- and post-test basis. The labeling task was changed to one in which the experiment which was abstracted involved an application of classical conditioning methodology to test a hypothesis derived from learning theory. The labeling task was used on a pre- and post-test basis as well. Essay items involving interpretation of the application of the classical conditioning procedures to other situations were included in the post-test. Also a set of graphs representing basic phenomenon of classical conditioning were presented in the post-test and students were required to identify the phenomenon and label appropriately the axes of the graph. Results for the Spring Semester are also included in Table 2.

TABLE 2

Scientific Skills

		Hypotheses			Experimental Labeling						Analysis of Graphs	
		Pre-Test Mean	Post-Test Mean	Dif-ference Mean	Pre-Test Mean	Vari-ance	Post-Test Mean	Vari-ance	Dif-fer. Mean	Vari-ance	Mean	Variance
Fall Semester												
Group I	(N=10)	4.2	1.9	-2.3			2.8	2.0				
Group II	(N= 9)	2.6	2.4	-0.1			3.0	1.6				
Group III	(N= 9)	2.9	2.4	-0.5			2.7	2.0				
Group IV	(N=15)	4.4	3.4	-0.9			2.7	2.1				
Group V	(N= 9)	3.7	2.0	-1.7			3.1	1.9				
Group VI	(N= 7)		2.0				1.7	1.1				
Spring Semester												
Group I	(N=10)	2.5	1.8	-0.7	1.6	1.2	3.9	1.9	2.3	2.0	10.3	4.2
Group II	(N= 7)	2.6	2.1	-0.4	2.0	2.0	3.4	1.8	1.4	3.7	10.7	7.2
Group III	(N=10)	2.7	2.1	-0.6	1.8	0.4	2.9	0.4	1.1	0.5	9.4	4.2
Group IV	(N= 7)	1.9	2.7	-0.8	1.7	2.8	2.[illegible]	3.2	0.9	2.3	7.3	12.3
Group V	(N= 9)		2.1				2.0	1.3			4.4	14.6

As noted in the first semester comparisons, the groups did not differ in the number of hypotheses which were generated in the post-test situation. Also, as in the first semester, there is a decline in the number of hypotheses generated in the post-test session when compared to the pre-test session with the exception of Group IV. While the differences are not significant, the trend is consistent enough to suggest that one of the effects of instructional emphasis is to reduce the range of hypotheses which a student will propose to account for a relationship. This result in turn permits several interpretations but leaves uninterpreted the <u>quality</u> of hypotheses.

The comparisons of the experimental labeling task and graph interpretation task are a bit more encouraging to a search for instructional effects. In the labeling task, the computer-assisted groups are superior to the non-computer-assisted groups and all instructional groups are superior to the non-instructional control (Group V). An analysis of variance approaches but does not reach significance at the 5% level (F=2.51; df. 4, 38). The pre-test and post-test comparisons show the same order of relationships. The analysis of graphs also shows superior performance for the computer-assisted groups with all instructional groups performing better than Group V. An analysis of variance is significant at the 5% level (F=3.69; df. 4, 37).

The essay items again proved to be too difficult for the students, and not enough correct answers were given to permit comparison. These performances stand in contrast to results of the content tests. Apparently students can adequately master the content of the topic but what they have learned does not permit clear transfer to quite similar situations.

Generally, the measures of application of scientific behaviors and skills show that improvement in the labeling of variables and the analysis of graphic representation of data occurs in relation to instructional mode with computer-assisted groups showing the best performance. The number of hypotheses generated to account for a relationship decreases in instructional groups but in a way that is not significantly related to mode of instruction. The transfer of skills of analysis and interpretation to other contexts is not demonstrated for any of the groups, and performance on tests of these behaviors is consistently poor for all groups.

<u>Attitudes</u>.

The results of research in attitude change indicate that any lasting shift in attitudes would be unlikely under such non-manipulative and temporally brief conditions as those in the instructional seminars. Nevertheless, it is worthwhile to see whether short-term shifts in attitudes are associated with a specialized instructional experience. The results obtained with attitude measures are summarized in Tables 3 and 4. The scores on the Attitude Toward Science measures are based on total scale scores for the forty scales which make up the measure. The scores on the Social Attitudes Toward Computer measure are given in terms of two factors which have been analyzed from the measure labeled "A", "Awesome Thinking Machine Perspective" and "B", "Beneficial Tool Perspective" (Lee, 1970). The results for both semesters do not indicate any systematic group differences or changes in attitude on either measure. No test-retest reliability data is available on either instrument but it is likely that what shifts are observed are within the expected limits of test-retest variance.

Evaluations.

The evaluation form which was given to all of the instructional groups at the conclusion of the seminars provided both information about perceived effectiveness of the instructional process and hedonic assessment of the worth of the experience. A summary tabulation of responses to the evaluation form is presented in Table 1A in the Appendix. The results of the evaluation of the first semester seminars were influential in determining procedures for the second semester, most notably in clarifying the expectations of the traditionally instructed group. Generally the procedural characteristics were evaluated at the same level of adequacy for all of the instructional groups so any differences in other measures cannot be attributed to uncontrolled biasing in the way in which the groups were conducted.

Two interesting items in the evaluation for across group comparisons are Item 9("...how would you rate the seminar?") and Item 16 ("Would you do something like this seminar again?"). The responses to the questions by group for both semesters are presented in Table 5. In the Fall Semester the computer-assisted groups are evaluated at a higher level than the groups without computer assistance. The same advantage for computer-assistance is also shown in the expression of interest in having further experience like that in the seminar. A analysis of the evaluation is not significant but χ^2 analysis of the preference for further experiences is significant at the 5% level ($\chi^2 = 10.67$; df = 4).

In the second semester, the computer-assisted groups do not receive evaluations as favorable on the average as the traditionally instructed group nor is the advantage in interest in further experience

TABLE 3

Attitudes Toward Science

		Pre-Test Mean	Pre-Test Variance	Post-Test Mean	Post-Test Variance	Difference Mean	Difference Variance
Fall Semester							
Group I	(N= 9)	155.7	408.9	165.6	315.3	9.9	120.1
Group II	(N= 9)	154.7	427.5	156.1	691.6	1.4	214.8
Group III[1]							
Group IV	(N=15)	141.8	1656.4	145.9	1712.6	4.1	97.5
Group V	(N= 9)	153.0	454.0	148.8	413.1	-4.2	55.5
Group VI	(N= 7)			148.6	271.5		
Spring Semester							
Group I	(N= 9)	149.2	369.5	151.4	512.37	2.2	47.8
Group II	(N= 7)	149.7	129.1	152.0	283.7	2.3	209.85
Group III	(N=10)	157.5	234.6	164.9	237.1	7.4	144.7
Group IV	(N= 7)	141.2	308.3	134.2	521.3	-7.0	81.71
Group V	(N= 9)			153.9	424.9		

1. Incomplete data obtained for this group.

TABLE 4

Attitudes Toward Computers

		Pre-test Means		Pcst-test Means		Difference	
Fall Semester		Factor A	Factor B	Factor A	Factor B	Factor A	Factor B
Group I	(N= 9)	2.0	6.2	2.2	6.3	0.2	0.1
Group II	(N= 8)	2.1	5.3	3.0	5.5	0.9	0.1
Group III	(N= 9)	1.3	6.0	1.4	6.0	0.1	0.0
Group IV	(N=15)	1.7	5.5	1.5	6.1	-0.2	0.6
Group V	(N= 9)	1.7	5.4	1.4	5.7	-0.2	0.3
Group VI	(N= 7)			1.6	5.4		
Spring Semester							
Group I	(N=10)	1.2	5.7	1.0	6.3	-0.2	0.6
Group II	(N= 7)	2.4	5.3	2.0	5.7	-0.4	0.9
Group III	(N=10)	2.3	6.2	1.9	6.0	-0.4	-0.2
Group IV	(N= 6)	1.5	5.5	1.2	5.5	-0.3	0.0
Group V	(N= 9)			2.2	5.7		

TABLE 5

Attitudes Toward Instruction

	Item 9 Mean Rating	Item 16 Yes	Item 16 No
Fall Semester			
Group I (N=10)	2.9	9	1
Group II (N= 9)	2.3	8	1
Group III (N= 9)	2.9	8	1
Group IV (N=15)	3.6	9	6
Group V (N= 9)	3.7	3	6
Spring Semester			
Group I (N=10)	3.4	5	5
Group II (N= 7)	3.7	4	3
Group III (N=10)	3.0	7	3
Group IV (N= 7)	4.0	2	5

maintained at as high a level. Generally, Spring Semester evaluations and expressions of interest are less enthusiastic than Fall Semester evaluations and may reflect the different contexts of the two semesters which instructors so frequently mention in anecdotal observations.

Some other observations based on the evaluation questionnaires will be mentioned in a discussion section of this report. On those questions most relevant to the evaluation of the popularity of the instructional modes with students, it appears that students generally are at least as pleased with computer-assisted instruction as with professor-assisted instruction and are as likely to want to continue the experience. Groups, however, that are provided the same instructional organization but without computer assistance are consistently evaluated as less worthwhile and less interesting to continue than computer-assisted or traditional instruction.

Costs.

The estimated 'cost' of each PAVCO experiment is $1.00 in the interactive mode. This figure includes normal terminal familiarization and normal "error" time for a student user. More proficient users can run PAVCO experiments in the $.65-.80 range using programmed by-passes. The terminal operation includes assignment of values and receipt of results but does not include any additional statistical analysis of the data.

Using the terminal in its conversational mode and comparing it with the traditional lecture-discussion format used as part of this study, several "instructional cost" contrasts can be made. Taking an average compensation figure for an associate professor at Macalester College, the traditionally delivered two-week seminar unit "costs" $350.00 (excluding materials and institutional overhead). Assuming a seminar size of twelve students and requiring in the computer-assisted sections the completion of fifteen simulated experiments, (about the average in this project) selected comparisons are indicated in Table 6.

Variations can include a "passive" staff mode in which only one student assistant is available, thus reducing seminar cost by $50.00 to $235.00; forming "research teams" of seminar participants and budgeting "team" experiments at some lower number (for example limiting teams to 30 experiments would reduce seminar costs by $60.00); or using the "batch" seminar mode with a highly proficient student-assistant terminal operator reduces per experiment costs to the

TABLE 6

Estimated Cost Comparisons

CAI (individual study active staff mode)		Lecture-Discussion		Eyelid Conditioning Laboratory	
Instruction:		Instruction:		($2500-3000 for laboratory set-up)	
2 student assistants ($2.50 x 20 hours)	$100.00*	1 Associate Professor (2 week module)	$350.00*		
Experiments:		Experiments:		Experiments:	
(12 students x 15 experiments @ $1.00)	180.00	None		(12 students x 15 experiments - subject cost $2.00/hr; 1 1/2 hr/exp.)	$540.00
computer record keeping (per 2 week module)	5.00				
TOTAL	$285.00		$350.00		$540.00

*does not include institutional overhead

**does not include institutional overhead nor research assistants' costs

$.65-.75 range. With an "active staff" mode (two highly available student assistants) and 12 seminar members a "budget" equivalent to the lecture-discussion mode would permit 20 experiments per student ($20.00). It should be noted that a proficient student can reduce "per experiment cost" and r more than 20 PAVCO experiments for his $20.00.

With three years of development experience the PAVCO programs are relatively simple and highly efficient. Application of more complex experimental simulations such as the University of Michigan Experimental Simulations in Psychology (Main, 1971), or Earlham College's Datacall Series (Johnson, 1971), suggests that for developed versions of these programs, $5.00 per completed experiment is a realistic planning figure.

Comparing the PAVCO simulation to the operation of an actual eyelid conditioning laboratory may also be useful for a general perspective. Seldom, if ever, are eyelid conditioning facilities available for undergraduate instruction. In addition to the capital outlay necessary for equipping such a laboratory ($2500-3000 for a basic research style eyelid conditioning system), human resource costs (e.g. subject availability, time, and fees, and experimenter time) make such use impractical. As noted earlier, development costs for the current version of the PAVCO programs have been less than setting up even a basic eyelid conditioning laboratory.

Comparison of a typical experiment with a PAVCO simulation further emphasizes one set of advantages of simulated experiments. In an eyelid conditioning experimental program, running 60 trials would consume 90 minutes of subject time and would achieve one data point. Assuming one student research assistant at $2.00/hr (two hours preparation and run time) and subject rate also at $2.00/hr (90 minutes) the "cost", excluding original equipment outlay and institutional overhead for a single data point is $7.00. To approximate the ten experiment set (two values each for the five conditions possible in the PAVCO program) for 12 students using their own subjects would require about 180 subject hours ($360.00 in subject costs) and for the fifteen experiment target suggested as reasonable in the PAVCO program, 270 subject hours ($540.00) are consumed. Assuming subjects could be recruited and sufficient time to run them arranged (it is unlikely that this could be accomplished in a two week module) the data generated remains sparser than that produced by the PAVCO simulation with the computer as a relatively cheap and immediately available pool of "artificial subjects."

DISCUSSION

Instructional evaluation research, perhaps more than other scientific inquiries, is productive of observations and conjectures that are not based entirely on the data generated by the assessment instruments. In this section we review some observations, suggestions, and proposals that have grown out of this project regarding general instructional and research strategies and specific experience with simulated experiments.

While instructional research seldom yields the clear-cut results that investigators hope for, the process of engaging in research frequently results in a clearer and more precise appreciation of the interactions which are involved. Such has been the case in this project.

The testing of an instructional research design requires the continuing monitoring of students' behaviors and the instructional process. While all of the observations and discussions that resulted from such intensive monitoring cannot be reported here, the effect has been to alter the research and instructional styles of all those associated with the project.

Inevitable biases enter into designs when one method of instruction is compared with another. While every possible attempt was made to avoid involving the members of the instructional group in competition with each other, it was obvious that the student-staff of the project and at times some of the investigators, viewed the study as a man versus computer challenge. In retrospect this seems silly but such is the cultural context in which research occurs. Obviously, the fundamental question at this time is not "What approach is better?" but rather it is "What works at all?"

Teaching Scientific Methodology.

One of the sobering aspects of the outcome of this project is the difficulty in instructing in scientific methodology in a way that leads to outcome approximating actual performances of scientists. It is not too hard to specify what it is that scientists do that is characteristic of scientists though there is some disagreement here, and it is not too hard to identify when students do those things well if given the opportunity. However, it is very difficult to identify the instructional correlates of scientific behaviors in a satisfactory way. It must be said that this aspect of the research remains unsatisfactory. The assessment methods were doubtful measures of the characteristics they were designed to assess and the instructional procedures seemed to have little demonstrated effect on performance in scientific examples outside of the very narrow context in which the learning occurred. The clear demonstration of transfer of the general principles of scientific methods of analysis as the result of specific instructional arrangements remain a challenging goal for instructional research.

Computer As Instructional Focus.

The evaluation of the effect of computer-assisted instruction showed an interesting minor result. An analysis was made of the open-ended responses of students on the evaluation form in which positive and negative comments were made about a number of features of the seminars. In those seminars where computer assistance or a traditional instructor were used, the majority of the comments were about the computer or the instructor. In the other seminars, responses covered a range of issues with no consistent focus. It appears that both computer and humans, when they are the instructional focus, dominate the reaction of students. In this way at least computers and humans share an effect.

Individual Differences.

The analyses of individual differences was not included in the design of this project. However, the data collected includes considerable information about previous educational experience and preferences for instructional styles. Analysis of this data may provide leads as to whether there are meaningful interactions of individual learning styles and mode of instruction.

Laboratory Experience.

There is a design problem in this project which should be recognized and discussed. If the use of the PAVCO program to instruct students in the design of experiments was the focus of the study, then it seems reasonable that one of the control groups should have been one in which actual laboratory experience was the mode of instruction. As indicated in an earlier section, classical eyelid conditioning is too expensive and time consuming to be easily adapted to laboratory usages in an introductory course and so no attempt was made to provide a suitable laboratory group control. However, probably some other kind of laboratory experience could have been substituted. As it stands, an unanswered question is whether or not actual laboratory experience provides special learning experiences where general skills of scientific investigation are learned in a way for which no simulation can substitute. This is a meaningful question. An investigation could attempt to determine the effectiveness of laboratory experience in the conduct of experiments, regardless of specific content, in increasing the frequency and quality of general scientific behaviors such as hypothesis formation, design of experiments and analysis of results. There are those who argue with conviction that there is no substitute for the actual laboratory experience in the training of the scientist. There are of course, many specialized technical and methodological skills which can be practised best in laboratories. However, whether or not those general approaches to discovering, clarifying and solving problems which are the basis for scientific methodology can only be learned in actual laboratory practices remains a question with inconclusive answers. This project provides no contribution to the resolution of the issue. However, simulations of the kind under investigation here provide a means for exploring the laboratory experience to determine what characteristics of learning are replicable or not replicable in other instructional formats.

Calendar-Based Effects.

There is an interesting trend that occurs in the comparison of the seminar evaluations of each semester. The general decrease in positive evaluation from the Fall Semester to the Spring Semester has already been noted but seems to deserve additional comment. The observations and comments of staff of the project indicate that the computer-assisted groups of the second semester were better organized, more consistent and clearer in focus and goals than those of the first semester. Also the staff was more experienced and confident. From the instructor's point of view, the seminars of the second semester came closer to meeting the design criteria, and the content and skills post-test results bear this out. Yet, the student evaluations clearly favored the computer-assisted groups of the first semester. One obvious hypothesis is that the "Hawthorne Effect" influenced the evaluations of the Fall Semester groups. A second possibility is the difference in educational contexts between a fall semester with its atmosphere of beginning and a spring semester with its atmosphere of conclusion. Also, since the majority of students in the seminar groups were freshmen, it may be that the enthusiasm of the Fall Semester computer-assisted groups reflected the special outlook of students beginning a new educational experience. While these suggested hy: theses cannot be tested with the data of this project, it does seem worthwhile to give more attention in instructional research to the calendar-based sequences that influence role and expectations.

Teaching-Research Teams.

This instructional evaluation project was accomplished by two faculty members and five students operating as a team. Among the several teaching-research team configurations that are possible in projects such as this, three merit brief description and comment. First, a "faculty dominated team" is possible in which the design and detailed operating procedures are provided by the faculty and the student assistants complete tasks assigned to them. This arrangement is common in research and instruction and although having some time efficiency and other advantages was not used here.

Second, a "collaborative team" can be assembled, where there is a division of labor and considerable sharing of roles. In this project, the faculty members were responsible for the research design, general project administration, selection and construction of assessment instruments, and data analysis, but joined the student members in developing specific instructional arrangements. The student members, with some faculty assistance, devised their own instructional materials suited to the general project objectives, the constraints of the course format, the specific mastery goals regarding subject matter, and their individual teaching styles. This involved the multi-draft preparation of general instructions, orientation to the computer terminal operations, teaching materials on classical conditioning, background and instructions on experimental design, data preparation and analysis and selection of supplementary reading. Since several formats and instructional conditions were required by the research design, this proved to be exceptionally challenging. The student members shared the several instructional roles which emerged, each at various times acting as lecturer, discussion-leader, research design consultant, subject-area resource, computer advisor, and data analysis consultant. The instructional competence and related skills of the student members grew impressively during the year. Both student and faculty team members expressed great satisfaction with this aspect of the project.

It should be noted that while shared responsibility was characteristic, some specialization developed. The three team members who were more technically proficient with programming tended to do more with computer-related development of the project. While the other two members became acquainted with BASIC and related computer skills, they did not advance as far in this area as they had intended. A stable division of labor also occurred in preparing final drafts of teaching materials in which the two most skilled writers dominated. While it is sensible to take advantage of differential talent, management of a team of this type should emphasize shared responsibility and new skill learning for its members.

A third possible configuration is one in which team members not only implement the teaching-research objectives of the project but also 1) write new instructional programs and 2) design learning contexts within which to deploy the newly written programs. It was hoped that the PAVCO team would emerge from a Type 2 to a Type 3 team. It did so only in a very limited way. Team members discussed alternative contexts individually and at staff meetings and did some preliminary planning. Three members began work on other experimental simulation programs but none were developed sufficiently to be operational by the termination of this project. Certainly it is difficult for undergraduates (or anyone) to develop instructional materials, evolve an effective teaching style, implement four or five seminars and also be expected to write and deliver new instructional programs. But we think that this would be the preferable team configuration -- emphasizing "development" along with "delivery" on the part of the student members with faculty responsible for general design, guidance, and evaluation. The "development team" takes advantage of student investment and ingenuity in programming as well as social skills involved in teaching. It requires of the student not only mastery of the subject matter initially taught, but detailed knowledge of the domain being newly simulated and the complex formalisms necessary to simulate. This team arrangement can meet both the objectives of team Types 1 and 2 as well as educate its members more fully and produce additional instructional simulations for later use.

Computer Attitudes.

Responses on the evaluation instrument indicate that in the several CAI modes, the computer was the dominant instructional characteristic. Affect responses regarding the course materials and the staff were generally highly positive but the computer was the prominent positive characteristic. No subject having access to the computer reported negative affect, although several expressed disappointment and impatience with the occasions during which it was not operating effectively. This pattern is in line with the generally positive orientations toward computers suggested by the Social Attitudes Toward Computers used in pre-and post-testing and with attitudinal data research summarized elsewhere (Hess, 1970; Levien, 1972).

It appears not to be the case that there is any student culture bias against the instructional use of computers. Levien concludes, "Their attitudes are more likely to be shaped by their perception of the quality of each specific application" (Levien, 1972, p. 541). At least in this project, students reported very positive responses and indicated interest in further computer-assisted instruction.

Continued development experience with the PAVCO simulation in this project has demonstrated to the satisfaction of the investigators that the use of simulations of this kind in instruction is worth further development. The PAVCO program will be continued on a batch-processing basis as a regular component of the introductory course. An advanced form will be developed to use in a course in Methods in Psychology. Other simulations are being adapted to supplement the PAVCO program. The refinement of the program as a result of this project will be studied and analyzed and no doubt revised further.

Demonstrations.

In addition to the instructional applications of PAVCO, a number of demonstrations were held. Brief descriptions of the program, the evaluation research design, and of other features of the project were prepared and distributed. Two scheduled sessions in the final weeks of operation drew faculty, administrators and students from the physical and social sciences at Macalester College. Most of those attending took the opportunity to run an experiment. On several occasions throughout the year campus visitors (e.g. visitors from other universities and colleges and foundation representatives) also had the PAVCO program demonstrated and the project discussed. The main objective of these demonstrations was to interest others in the instructional use of computer simulations. We are gratified that these demonstrations led to renewed work in the Physics Department, the beginning of a highly promising project in the Economics Department, and continued interest in the Psychology Department. A college-wide committee is currently developing a program for instructional use of the computer and the PAVCO project has provided important information and evaluations for the committee's deliberation.

Encouragement of Instructional Uses.

The experience and suggestions of this project relate to other applications of simulated experiments such as the Experimental Simulation Program in the Psychology Department of the University of Michigan coordinated by Dr. Dana B. Main (Main, 1971) or the programs developed by Dr. Richard R. Johnson (Johnson, 1971) at Earlham College. Such simulations are used as an aid in instructing undergraduates in specific subject matter areas but also introduce many issues and procedures of a scientific discipline. This dual objective renders them somewhat more complex than other simulated experiments and other computer-assisted instruction systems where demonstration of a phenomenon or effect is the only goal. The dual objectives also raise challenging "instructional nesting" questions. It would be highly desirable if developers and users could be in closer communication, could collaborate more directly, and be part of a more effective dissemination network than now exists. It appears that at this point in time, the mix of hardware-software technology, the state of development of simulated experiments, the level of interest in this class of instructional innovation, and the new emphasis on more accountable educational resource allocations makes enhanced communication highly desirable.

CONCLUSIONS

The analysis of the results of the project permits the following conclusions:

1. The learning of factual content about classical conditioning is not superior in any of the instructional modes which were tested. The groups that received no special instruction but were exposed to the relevant textbook materials performed almost as well as groups which had special two-week seminars dealing with the subject. It appears, that in this project, factual content can be acquired equally well in a variety of instructional modes.

2. Learning of skills associated with the appropriate labeling of experimental variables and controls and identification of graphic representations of relationships is facilitated by computer-assisted instruction using experimental simulations. However, the ability to generalize knowledge about classical conditioning or to apply experimental principles to problems in new contexts is not facilitated by any of the instructional procedures. Information is dealt with adequately in the same general context in which it is learned but very few students display competence in generalizing principles and techniques of hypothesis formation and testing.

3. No significant changes in attitudes toward science or toward computers were related in any systematic way to modes of instruction.

4. Students tended to evaluate their experiences with computer-assisted instruction as favorably as instructor-assisted instruction and indicated a significant interest in continuing the experience.

5. Cost analysis indicated that a group of twelve students could conduct twenty computer simulated experiences each for the same cost of a traditional instructor led lecture-discussion group.

To summarize the results from a different perspective, it is possible to compare the benefits and shortcomings of the different instructional modes which were tested. Traditional instructional methods fare well in comparison with the other modes which were tested. Computer-assisted instruction does as well as or slightly better than traditional instruction on the assessment measures. Students generally have strong positive regard for their experience with computer-assistance. Instruction using computer produced results without individual interaction with the computer terminal produces adequate instructional results but is not viewed as a rewarding educational experience by most students who were instructed in this way. Use of this mode of instruction should include attempts to improve the affective context of learning. While results do not establish any clear superiority of instruction using computer simulation of actual experiments, they do support the conclusion that it is a promising alternative or supplement to other styles of instruction and tends to be an involving and favorably received experience for students.

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APPENDIX

TABLE 1A

Frequencies on Evaluation Items*

(Five point scales with 1 most positive and 5 most negative)

1. Were the objectives of this seminar clear?

Fall	+	1	2	3	4	5-
Group	I	3	4	2	0	0
	II	3	5	1	0	0
	III	5	2	2	0	0
	IV	1	2	4	8	0
	V	1	2	3	3	0

Spring

Group	I	1	6	3	0	0
	II	4	3	0	0	0
	III	3	6	1	0	0
	IV	3	0	2	2	0

2. Was the general project information clear?

Fall	+	1	2	3	4	5-
Group	I	3	3	4	0	0
	II	6	2	1	0	0
	III	5	3	1	0	0
	IV	4	3	4	4	0
	V	1	3	3	2	0

Spring

Group	I	5	4	0	1	0
	II	4	3	0	0	0
	III	4	4	2	0	0
	IV	2	2	2	1	0

*See E Form in Appendix

TABLE 1A (continued)

4. Was the amount of work required appropriate to the credit received?

Fall	+	1	2	3	4	5-
Group	I	0	9	0	1	0
	II	0	9	0	1	0
	III	0	6	3	0	0
	IV	0	2	9	4	0
	V	1	3	4	0	1
Spring						
Group	I	1	8	1	0	0
	II	3	3	1	0	0
	III	0	6	3	1	0
	IV	1	3	2	0	1

5. Was the assigned reading useful?

Fall	+	1	2	3	4	5-
Group	I	7	0	1	1	0
	II	7	1	1	0	0
	III	6	2	1	0	0
	IV	9	3	3	0	0
	V	1	5	2	1	0
Spring						
Group	I	2	2	4	2	0
	II	2	0	1	4	0
	III	1	6	2	1	0
	IV	2	1	4	0	0

7. Were the computer instructions clear?

Fall	+	1	2	3	4	5-
Group	I	8	2	0	0	0
	II	6	3	0	0	0
	III	8	1	0	0	0
	IV	na	na	na	na	na
	V	2	2	5	0	0
Spring						
Group	I	9	0	1	0	0
	II	6	1	0	0	0
	III	na	na	na	na	na
	IV	4	1	2	0	0

NA = NOT APPLICABLE

TABLE 1A (continued)

8. Was the instructional staff helpful to you?

Fall	+ 1	2	3	4	5-
Group I	8	2	0	0	0
II	9	0	0	0	0
III	7	2	0	0	0
IV	8	1	2	1	0
V	4	4	1	0	0
Spring					
Group I	9	0	0	1	0
II	6	1	0	0	0
III	5	3	2	0	0
IV	5	0	2	0	0

9. Considering all of the characteristics mentioned in preceeding items and any other aspects of the seminar, how would you rate this seminar?

Fall	Exc	Very Good	Good	Fair	Poor	Very Bad
Group I	0	5	2	2	1	0
II	1	4	4	0	0	0
III	0	3	4	2	0	0
IV	0	1	7	3	3	1
V	0	1	4	2	1	1
Spring						
Group I	0	1	4	5	0	0
II	0	2	3	1	1	0
III	1	2	3	4	0	0
IV	0	0	1	5	1	0

TABLE 1A (continued)

12. After taking this seminar, I feel the topic of classical conditioning is:

Fall		positive	descriptive	negative
Group	I	5	3	1
	II	6	2	1
	III	4	4	0
	IV	7	5	3
	V	6	1	2
Spring				
Group	I	7	0	3
	II	6	0	1
	III	5	3	1
	IV	5	1	1

13. The best thing about this seminar was:

Fall		computer	instructor	other
Group	I	7	0	3
	II	6	2	1
	III	8	0	1
	IV	na	6	5
	V	na	0	9
Spring				
Group	I	6	0	4
	II	5	0	1
	III	na	2	5
	IV	3	2	2

TABLE 1A (continued)

16. Would you do something like this seminar again?

Fall	Yes	No	"depends"
Group I	9	1	
II	7	0	2
III	8	1	
IV	7	6	1
V	3	5	1

Spring

Group I	5	5
II	4	3
III	7	3
IV	2	5

NAME ____________________
GROUP ____________________

QUESTIONNAIRE

Indicate the degree of your agreement with each of the following statements by choosing one number from the appropriate scale.

USE SCALE A FOR ITEMS PREFACED WITH AN A;	USE SCALE B FOR ITEMS PREFACED WITH A B
5 = strongly agree	1 = strongly agree
4 = moderately agree	2 = moderately agree
3 = neither agree nor disagree	3 = neither agree nor disagree
2 = moderately disagree	4 = moderately disagree
1 = strongly disagree	5 = strongly disagree

___1. (A) I believe that the scientific way of thinking is a most important tool for acquiring knowledge.

___2. (B) Science has a system of thought that is rigid and unproductive.

___3. (B) The scientific method is very limited in its scope of applicability.

___4. (A) It would be a good idea if more people m appreciated the value of science.

___5. (A) I believe wholeheartedly in the value of the scientific approach.

___6. (B) "Facts" suppossedly "established" by scientific method are mo more valid than mere opinion.

___7. (A) The scientific method is the surest way we have of arriving at knowledge.

___8. (B) The scientific method is based on false assumptions.

___9. (A) Science provides a means whereby man can solve his problems instead of becoming a victim of them.

___10. (B) The scientific method often leads to absurdities. I have more confidence in common sense and my own experiences.

___11. (B) Science is all right in the laboratory, but any application of it to life is bound to fail.

___12. (A) The methods of science are the best means by which to arrive at an understanding of human behavior.

___13. (B) I feel that science will never be able to offer very much to the solution of social problems.

___14. (A) Man should apply the scientific method in the solution of social problems.

___15. (B) It is practically impossible to aplly the scientific method outside of the natural sciences.

___16. (A) The application of scientific methods to the field of human behavior has resulted in many valuable discoveries.

__17. (B) The scientific has only limited applicability to the study of human behaviour: common sense and intuition are much more valuable in this field.

__18. (A) Scientific investigation can be just as fruitful in the social sciences as in the natural sciences.

__19. (B) I doubt that science would be helpful in solving any of our social problems.

__20. (A) It is sometimes possible to use the scientific method in the study of human behaviour.

__21. (B) Science is more destructive than constructive.

__22. (A) It would be wise to support science to a greater extent than we do now.

__23. (B) One thing I object to about science is the way it is destroying human values.

__24. (A) Every effort should be made to discover and encou age people who have an aptitude for science.

__25. (B) If all the scientific discoveries of the last ten years had not take place, the world would be better off.

__26. (B) Science spends too much time on worthless investigations..

__27. (A) The rapid development of science should be encouraged.

__28. (B) Growing opposition to science should be regarded as a healthy sign.

__29. (B) I do not approve of science as it is being practiced in the world today.

__30. (A) The world should spend more money on scientific investigations than it does now.

__31. (A) Children shpuld be taught the value of science in everyday life.

__32. (A) Almost everyone should learn a little about the nature of scientific methods.

__33. (B) There is too much emphasis on science in our present curricula.

__34. (B) I see little or no value in requiring college students to take at least one course in a science.

__35. (A) It would be aggood thing if more people understood the scientific approach to problems.'

__36. (B) I do not believe that the study of scientific methods is useful to anyone except those expecting to become a scientist by professon.

(B) I am not a bit interested in learning about scientific methods.

38. (A) The study of scientific methods is an essential part of a college education.

39. (B) I would consider a course on scientific methods a tedious waste of time.

40. (A) Knowledge of scientific methods should be more widespread.

NAME ____________________

GROUP ____________________

SOCIAL ATTITUDES AND THE COMPUTER

Following are assertions frequently made about computers. Would you please indicate by your agreement or disagreement with each statement by circling the letter in the left margin?

Agree	Disagree		
A	D	1.	There's something exciting and fascinating about electronic computers.
A	D	2.	Computers are kind of strange and frightening.
A	D	3.	They are so amazing that they stagger your imagination.
A	D	4.	They sort of make you feel that machiens can be smarter than people.
A	D	5.	They are very important to our man-in-space program.
A		6.	They can be used for evil purposes if they fall into the wrong hands.
A		7.	They will help bring about a better way of life for the average man.
A	D	8.	With these machines, the individual person will not count for very much anymore.
A	D	9.	They can think like a human being thinks.
A	D	10.	These machines will free men to do more interesting and imaginative types of work.
A	D	11.	They are becoming necessary to the efficient operation of large business companies.
A	D	12.	They can make serious mistakes because they fail to take the human factor into account.
A	D	13.	Someday in the future, these machines may be running our lives for us.
A	D	14.	They make it possible to speed up scientific progress and achievements.
A	D	15.	There is no limit to what these machines can do.
A	D	16.	They work at lightning speed.
A	D	17.	These machines help to create unemployment.
A	D	18.	They are extremely accurate and exact.
A	D	19.	These machines can make important decisions better than people.
A	D	20.	They are going too far with these machines.

PRETEST

NAME ____________________

GROUP ____________________

Circle your choice of responses in the following multiple choice items:

1. Four of the most basic phenomena, isolated and named by Pavlov, were

   a. conditioning, generalization, discrimination, extinction.
   b. behavior, conditioning, responses, extinction.
   c. behavior, higher orders, conditioning, reconditioning.
   d. behavior discrimination, generalization, extinction, responses.
   e. behavior, conditioning, reconditioning, extinction.

2. In classical conditioning the originally neutral stimulus is later called the ________ stimulus; the initial response is called the ________.

   a. conditioned; unconditioned.
   b. unconditioned; conditioned.
   c. unconditioned; unconditioned.
   d. conditioned; conditioned.

3. An independent variable

   a. is not dependent on the manipulations of the experimenter.
   b. is manipulated by the experimenter to ascertain its effect on the dependent variable.
   c. cannot be controlled experimentally.
   d. is not measurable.

4. The strongest conditioning is established when the

   a. conditioned stimulus follows the unconditioned stimulus by about half a second.
   b. conditioned and unconditioned stimuli are presented simultaneously.
   c. conditioned stimulus precedes the unconditioned stimulus by about half a second.
   d. time intervals between the conditioned and unconditioned stimuli are varied from trial to trial.

5. Pavlov's dogs salivated to the presence of the meat because

   a. they had learned that this was paired with the bell.
   b. they had learned to do this prior to the experiment.
   c. it was a natural response.
   d. they had learned to salivate to other foods.

6. Salivating when food is placed in the mouth is an example of

   a. a conditioned response.
   b. an unconditioned response.
   c. discrimination.
   d. response generalization.

7. The association between the bell and the food in conditioning

   a. is usually learned in one trial.
   b. constantly increases as the number of pairings increases.
   c. does not increase very much after a certain number of trials.
   d. decreases if too many trials are given.

8. Professor X conditioned cats to blink to the sound of a buzzer, and subsequently extinguished this behavior. If he leaves the cats alone for a period of time, and then tests them again, they will probably show

   a. spontaneous recovery.
   b. stimulus generalization.
   c. response generalization.
   d. discrimination.

9. If an experimenter decides, after the initial learning has taken place, to present the bell alone, the result would be

   a. generalization.
   b. discrimination.
   c. extinction.
   d. spontaneous recovery.

10. A metronome that has been paired with food comes to evoke salivation. The metronome is then paired with a buzzer, which also comes to evoke salivation. This is an illustration of

   a. stimulus generalization.
   b. the generalization of extinction.
   c. higher-order conditioning.
   d. instrumental conditioning.

11. For each of the following statements indicate whether it is (T) or false (F).

   ____ In Pavlov's experiments salivation was an independent variable.
   ____ Discrimination learning is a form of stimulus generalization.
   ____ In the classical conditioning of the eyeblink response, the unconditioned stimulus is usually a drop of mild salt solution applied to the eye.
   ____ A major technique for achieving control in an experimental design is to hold potential independent variables constant.
   ____ Experimental studies support the hypothesis that strength of a habit is a positive function of amount of reinforced practice.

12. Write "Yes" before any of the following that you would classify as unconditioned responses; write "No" before the others.

   ______ salivation to sounds from a laboratory kitchen
   ______ salivation to a weak acid solution in the mouth
   ______ foreleg withdrawal to painful stimulation such as shock
   ______ foreleg withdrawal to a buzzer.

13. Give an example of classical conditioning that has been applied to some area of human behavior.

POST-TEST

NAME____________________

GROUP____________________

1. Pavlov's dogs learned to salivate to the bell because

   a. the meat powder and the bell were presented together.
   b. the meat powder was presented before the bell.
   c. the bell was presented alone.
   d. the meat powder was presented after the bell.

2. Four of the most basic phenomena, isolated and named by Pavlov, were

   a. conditioning, generalization, discrimination, extinction.
   b. behavior, conditioning, responses, extinction.
   c. behavior, higher orders, conditioning, reconditioning.
   d. behavior discrimination, generalization, extinction, responses.
   e. behavior, conditioning, reconditioning, extinction.

3. Salivating to a bell prior to the presentation of food is an example of a(n)

   a. unconditioned response.
   b. conditioned response.
   c. unconditioned stimulus.
   d. conditioned stimulus.

4. In classical conditioning, the originally neutral stimulus is later called the __________ stimulus; the initial response is called the __________.

   a. conditioned; unconditioned
   b. unconditioned; conditioned
   c. unconditioned; unconditioned
   d. conditioned; conditioned

5. An object that normally elicits a certain form of behavior is called a

   a. conditioned stimulus.
   b. unconditioned stimulus.
   c. conditioned response.
   d. unconditioned response.

6. An independent variable

   a. is not dependent on the manipulations of the experimenter.
   b. is manipulated by the experimenter to ascertain its effect on the dependent variable.
   c. cannot be controlled experimentally.
   d. is not measurable.

7. The "interstimulus interval" refers to the amount of time between

   a. learning trials.
   b. extinction trials.
   c. presentations of the bell and the food.
   d. experimental sessions.

8. The strongest conditioning is established when the

   a. conditioned stimulus follows the unconditioned stimulus by about half a second.
   b. conditioned and unconditioned stimuli are presented simultaneously.
   c. conditioned stimulus precedes the unconditioned stimulus by about half a second.
   d. time intervals between the conditioned and unconditioned stimuli are varied from trial to trial.

9. Which of the following is <u>not</u> true of Pavlov's conditioning experiments?

   a. The dog had to be able to distinguish the bell from other stimuli.
   b. The bell had to be presented before the meat.
   c. The subject had to learn to associate the bell with the meat.
   d. Salivating to the presence of the meat in his mouth had to be learned.

10. Pavlov's dogs salivated to the presence of the meat because

   a. they had learned that this was paired with the bell.
   b. they had learned to do this prior to the experiment.
   c. it was a natural response.
   d. they had learned to salivate to other foods.

11. When an experimenter attempts to return behavior to its preconditioning level, he is attempting to

   a. extinguish the conditioned response.
   b. teach discrimination learning.
   c. teach generalization.
   d. elicit spontaneous recovery.

12. Salivating when food is placed in the mouth is an example of

   a. a conditioned response.
   b. an unconditioned response.
   c. discrimination.
   d. response generalization.

13. A dog, taught to salivate to the sound of a whistle, is now going through many trials in which the whistle is not followed by food reward. The dog will probably

   a. salivate even more than previously to the sound of the whistle.
   b. begin to salivate to other sounds he hears in the environment.
   c. maintain his former level of salivation.
   d. stop salivating to the sound of the whistle.

14. The association between the bell and the food in conditioning

   a. is usually learned in one trial.
   b. constantly increases as the number of pairings increases.
   c. does not increase very much after a certain number of trials.
   d. decreases if too many trials are given.

15. If a dog is taught to salivate to a red light, and then salivates to a blue light the phenomenon is called

    a. spontaneous recovery.
    b. discrimination.
    c. extinction.
    d. generalization.

16. Professor X conditioned cats to blink to the sound of a buzzer, and subsequently extinguished this behavior. If he leaves the cats alone for a period of time, and then tests them again, they will probably show

    a. spontaneous recovery.
    b. stimulus generalization.
    c. response generalization.
    d. discrimination.

17. A child is shown a picture of a witch every time he is given a piece of candy to eat, this being repeated many times. Whenever candy is chewed, saliva is secreted. The candy is best seen as a

    a. US.
    b. URS.
    c. CRS.
    d. CR.
    e. CS.

18. If an experimenter decides, after the initial learning has taken place, to present the bell alone, the result would be

    a. generalization.
    b. discrimination.
    c. extinction.
    d. spontaneous recovery.

19. If a child is burned while playing with matches, and subsequently is afraid to go near the kitchen stove, this is an example of

    a. classical conditioning.
    b. stimulus generalization.
    c. response generalization.
    d. spontaneous recovery.

20. A metronome that has been paired with food comes to evoke salivation. The metronome is then paired with a buzzer, which also comes to evoke salivation. This is an illustration of

    a. stimulus generalization.
    b. the generalization of extinction.
    c. higher-order conditioning.
    d. instrumental conditioning.

21. When a dog learns to salivate only to a bell, and not to a buzzer, the process that has taken place is called

    a. extinction.
    b. conditioning.
    c. discrimination.
    d. generalization.

22. After salivating to the sound of a buzzer has been learned, using the buzzer to establish salivation to a light is an example of

    a. stimulus generalization.
    b. response generalization.
    c. classical conditioning.
    d. higher-order conditioning.

23. Which of the following statements is true?

    a. Extinction occurs more rapidly with higher-order conditioning than with ordinary conditioning.
    b. Higher-order responses are more resistant to extinction than are other responses.
    c. Higher-order responses extinguish at about the same rate as conditioned responses.
    d. T he relationship between higher-order conditioning and learning is not known.

24. As far as the role of the CS in classical conditioning is concerned, it

    a. has very similar mearning for the organism as the US before conditioning is achieved.
    b. is no longer believed to be an important part of classical conditioning.
    c. is, usually, very similar to the US physically.
    d. has to be paired with a CR in order to elicit a US.
    e. is originally neutral for the organism.

25. A typical experiment varies

    a. one independent variable.
    b. one dependent variable.
    c. as many independent variables as possible.
    d. at least two dependent variables.

26. For each of the following statements indicate whether it is true (T) or false (F).

_____ In Pavlov's experiments salivation was an independent variable.
_____ The phenomenon of responding to similar stimuli in the same way is called stimulus generalization.
_____ Discrimination learning is a form of stimulus generalization.
_____ In learning a discrimination the organism must make about half correct responses and half incorrect responses.
_____ In the classical conditioning of the eye-blink response, the unconditioned stimulus is usually a drop of mild salt solution applied to the eye.
_____ Major contributions to learning theory (extending Pavlov's findings) have been made by Clark L. Hull.
_____ A major technique for achieving control in an experimental design is to hold potential independent variables constant.

______ In an experiment the kind of behavior under investigation is called the independent variable.
______ Experimental studies support the hypothesis that strength of a habit is a positive function of amount of reinforced practice.
______ The shorter the time interval between trials in acquiring a conditioned response the faster the response is learned.

27. Write "Yes" before any of the following that you would classify as unconditioned responses; write "No" before the others.

______ salivation to sounds from a laboratory kitchen
______ salivation to a weak acid solution in the mouth
______ foreleg withdrawal to painful stimulation such as shock
______ foreleg withdrawal to a buzzer

28. If the statements below are characteristics of an unconditioned stimulus, write "Yes", otherwise write "No".

______ it elicits a conditioned response
______ it emits an unconditioned response
______ it is a result of training
______ it elicits an unconditioned response
______ it elicits a response without training

29. Give an example of classical conditioning that has been applied to some area of human behavior (other than specific laboratory investigations of classical conditioning)-

30. You want to determine if a dog is color-blind or has color vision. Describe how you might apply the principles of classical conditioning to answer the question conclusively. Diagram the procedure labeling the unconditioned and conditioned stimuli and responses that you use.

31. Classical conditioning procedures have been used in a form of behavior modification called conditioned aversion (an extreme example was enacted in "A Clockwork Orange"). The goal of the training is to condition a strong unpleasant reaction to stimuli which have formerly been attractive but which in some personal, social or legal sense evoke undesirable responses. Setting aside ethical or aesthetic considerations for the sake of this question, describe an example of the use of conditioned aversion (make one up if you wish). Indicate the US, CS, UR and Cr.

(please use other side of paper)

NAME ____________________

GROUP ____________________

A number of studies of social behavior in college students have indicated that first-born children (male and female) are more susceptible to social pressure and are less independent than are later born children. Assuming these findings are reliable, how many _different_ possible explanations can you propose to account for the relationship? List as many possibilities as you can think of below and indicate how you could get evidence to test _one_ of your suggestions.

NAME ______________________

GROUP ______________________

In a recently published study based on a survey of 17 North American clinics, problems of reading, arithmetic and speech impediments were 12% greater for persons born in March, April and May than for people born in other months. Where major mental illness is concerned the rate is even higher. Assuming these findings are reliable, how many _different_ possible explanations can you propose to account for the relationship between month of birth and susceptibility to psychological problems? List as many possibilities as you can think of below and indicate how you could get evidence to test ONE of your suggestions.

NAME

GROUP

Many years ago a study was published which tested a theory about learning. It can be described generally as follows:

Sixty normal male undergraduates were allocated at random to one of two groups. One group was rigorously deprived of any food, drink and tbacco throughout a day. The other group was allowed to eat, drink and smoke in their usual manner. Both groups contained approximately equal proportions of smokers. At the end of the day all subjects were conditioned, using the frequency of conditioned eyeblink responses to a tone stimulus as a measure of conditioning. The results indicated that the mean number of conditioned eyeblinks obtained from the deprived group was 50% of total presentations of the tone on the fifteenth trial. The undeprived group result was 60%. Both groups were extinguished and both reached a level of less than 10% responding after ten trials.

1. Write a title for this study that states the relationship that was investigated.

2. Name the independent variable(s) under investigation. (If you can't identify the independent variable write "Don't know")

3. Name the dependent variable(s) under investigation. (If you can't identify the dependent variable write "Don't know")

4. What experimental controls are indicated in the description of procedures? (If you can't identify controls write "Don't know")

5. Identify the conditioned stimulus and the conditioned response in the experiment.

Conditioned Stimulus =

Conditioned Response =

6. Considering the description of the study, what theoretical relationship do you think was being tested? Try to state the purpose of the study in the form of an experimental hypothesis. Do the results seem to support the hypothesis?

Posttest

NAME ______________________________

GROUP ______________________________

Below are some idealized curves that represent some important phenomena in classical conditioning. For each curve indicate (1) the phenomenon which is represented (2) the most likely measure on the vertical axis and (3) the most likely measure on the horizontal axis. Choose your responses for (1) from Column A and your responses for (2) and (3) from Column B. (No egg roll.)

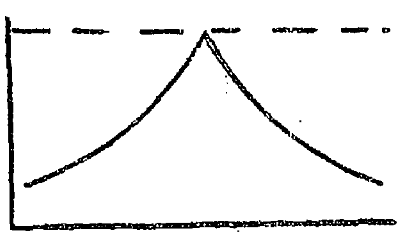
Column A

1. Acquisition
2. Extinction
3. Primary Generalization
4. Spontaneous Recovery
5. Differential Conditioning (Discrimination)
6. Secondary Generalization
7. Higher Order Conditioning
8. Backward Conditioning

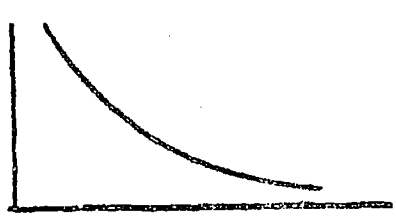
Column B

1. Response Strength
2. Trials
3. Interstimulus Interval
4. Intertrial Interval
5. Stimulus Similarity
6. Number of Subjects
7. Amount of Reinforcement

1. ______________________________
2. ______________________________
3. ______________________________

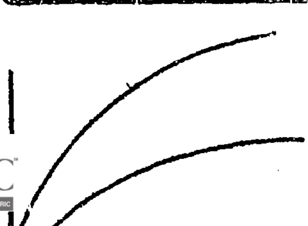


1. ______________________________
2. ______________________________
3. ______________________________



1. ______________________________
2. ______________________________
3. ______________________________

1. ______________________________
2. ______________________________
3. ______________________________



1. ______________________________
2. ______________________________
3. ______________________________

E-FORM

In using the following scales please indicate your responses by placing an X in the space which best represents your feeling.

1. Were the objectives of this seminar clear?

CLEAR | | | | UNCLEAR

comment or example:

2. Was the general project information clear?

CLEAR | | | | UNCLEAR

COMMENT OR EXAMPLE:

3. How much total time (in hours) did you spend on this seminar (include class time, planning time, consultation with staff, etc.)

________hours

4. Was the amount of work required appropriate for the credit received?

TOO MUCH WORK | | APPROPRIATE | | TOO LITTLE

5. Was the assigned reading useful?

USEFUL | | | | NOT USEFUL

comment or example:

6. Did you read materials related to the topic other than those assigned? Please specify:

7. Were the instructions regarding thecomputer clear? (Disregard if not applicable to your seminar.)

CLEAR | | | | UNCLEAR

comment or example:

8. Was the instructional staff helpful to you?

HELPFUL ——|——|——|——| NOT HELPFUL

comment or example:

9. Considering all of the characteristics mentioned in the preceeding items and any other aspects of the seminar that are important to you, how would you rate this seminar? (please circle the appropriate response)

EXCELLENT VERY GOOD GOOD FAIR POOR VERY BAD

10. (For group I only) Did the small group interaction contribute to your learning in this seminar?

VERY MUCH ——|——|——|——| VERY LITTLE

Please complete the following sentences so as to express the way you feel.

11. The best course format for me to learn is:

12. After taking this seminar I feel that the topic of "classical conditioni[ng"] is:

13. The best thing about this seminar was:

14. The worst thing about this seminar was:

15. If I could change this seminar I would:

16. Would you do something like this seminar again?
Yes______ No________
comment:

17. If you could would you like to continue with this seminar for the next cy[cle?]
Yes_____ No_____
comment:

Please add any additional comments: