SESSION VII
SOFTWARE SYSTEMS FOR
EXPERIMENTATION

CEDATS: A cognitive experimental design and testing system

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CEDATS (cognitive experimental design and testing system) is a set of programs that allows students and instructors to easily create unique experiments even though they may have no experience with computers or knowledge of any programming language. Designs including up to six independent variables may be created, and from 24 to 31 stimulus presentation parameters may be manipulated or controlled. Responses and response times are recorded and printed and/or stored on disk.

On-line computer systems for education in psychology may be divided into three basic categories: CAI, simulation, and on-line experimentation (Fischler, 1980). This paper is concerned with the third of these activities.

While the acquisition of microcomputers has proceeded at a rapid rate, the distribution of instructional software has been relatively slow.

Some educators have addressed this problem by designing "packages" of programs, along with instructor's and student's guides (cf. Bewley, 1974; Levy, 1979; Perera, 1981; Ellis, Note 1). These packages focus on particular themes, such as cognitive psychology, perception, learning, and so on. In general, these packages are well designed and easy to understand, and they are accompanied by background information on the problem, suggestions for data analysis, and so on.

The student's role may be to serve as an experimenter who locates subjects, introduces them to the computer, selects the appropriate program (experiment), and runs it. The computer presents the stimuli, records the responses, and displays or prints the results. The student/experimenter then combines the data with other subjects' data and (usually) writes up the results. Alternatively, the student may act as both a subject and an

experimenter. In these cases, the instructor provides instructions on how to run the experiment and perhaps a demonstration of the program. The student/experimenter/subject selects the assigned experiment and runs it, obtains the data, combines them with other members of the class, and prepares a report based on the results.

CEDATS (cognitive experimental design and testing system) is a system of programs designed to allow the novice computer user to set up and run experiments on the Apple II microcomputer.

CEDATS: OVERVIEW

CEDATS consists of nine programs (modules) including three "central" and six support programs and a variety of associated files and assembly routines. The system normally assumes that the user has two kinds of diskettes available. The first is the CEDATS SYSTEM MASTER, which contains all of the programs in the system; the second type includes diskettes ("experiments diskettes") that hold the files that contain the experiments to be run and the program that reads these files and runs the experiment according to instructions. The main programs and the data files they use are shown in Figure 1.

The SETUP module presents information and questions to the user about the kind of design he/she wants to construct. It accepts instructions to be given to subjects, designs consisting of up to six independent variables, their names, the number of levels of each, the number of replications for each condition, an appropriate ("correct") keyboard response, stimuli, and up to 31 parameters that describe the sequence of events to occur
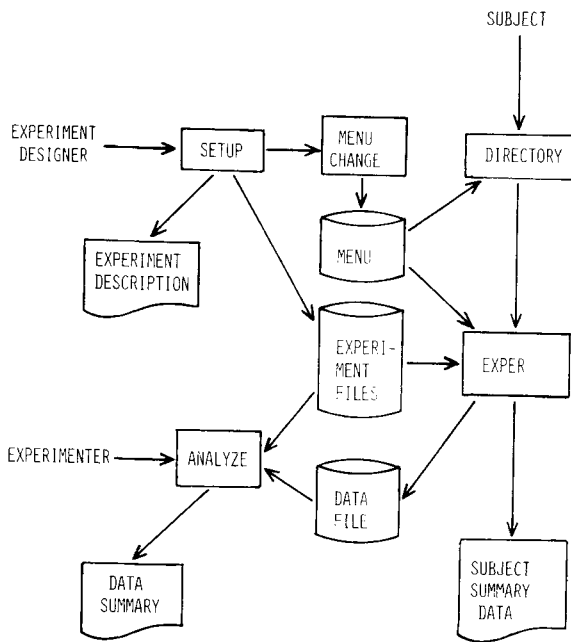
Figure 1. Data flow among the major programs of the CEDATS system.

in any given trial (e.g., whether a warning signal should be used, length of foreperiod, exposure time for stimuli, whether feedback should be given, intertrial interval, etc.).

This information is stored in disk files and read by the EXPER module, which presents the stimuli to subjects, records their responses and response times, and stores these data on disk.

The third module, ANALYZE, recovers the data and performs preliminary analyses and prints them out for entry into larger statistical packages (e.g., MINITAB, SPSS, etc.).

The support programs provide a variety of functions that make the system more accessible, such as program menus, experiment menus, and means by which to add and/or delete experiments to/from the menus, modify program parameters (e.g., forcing the EXPER program to always store the data collected on disk rather than giving the subject/student a choice about this, etc.), allow files to be copied, allow the creation of new "experiments diskettes" that contain all appropriate programs and files, and so on. One program (RECONFIGURE) automatically resets the "system configuration" (i.e., number of disk drives in the system, printer slot number, etc.) for each program in the system.

MAIN PROGRAMS

SETUP

SETUP accepts the entry of a complete experiment of up to six within-subjects independent variables, each of which may have up to nine levels. It is simple to

create between-subjects or mixed designs as well, although several runs of the program may be required. The only restriction is that the design must be completely balanced, with an equal number of stimuli in each condition.

The following materials must be prepared for entry into this program.

(1) Title and author of the experiment.

(2) Instructions to be presented to subjects. These are presented to the subjects in exactly the form in which they are entered. Up to 120 lines (six screen pages) can be entered.

(3) The experimental design, including the number of within-subjects independent variables, their names, the number of levels of each, and the names of the levels. Since the EXPER program assumes that each run of the program is for one subject, no between-subjects variables are identified. To set up a between-subjects design, separate files under different names need to be created for each level of the between-subjects variable. SETUP allows the user to save any of the files any number of times under any names he/she chooses, so this is relatively easy to do.

(4) The type of experiment to be designed. The program accepts any of three basic experiment types. In a "categorization" experiment, a stimulus is presented and the subject responds by pressing a single key. The reaction time (latency) and the response are recorded. In a "same-different" experiment, two stimuli are presented either simultaneously or in sequence. The subject normally responds by comparing the second stimulus with the first, indicating his/her response by pressing a key (e.g., "S" for same, "D" for different). Latency timing begins with the presentation of the second stimulus. The "study-test" experiment type involves presentation of a set of materials for study (e.g., one or more paragraphs), followed by a series of stimuli (e.g., questions). The subject responds to each stimulus; the response and reaction time are recorded.

(5) The stimuli to be presented for each condition in the design.

(6) An appropriate "correct" response for each condition. The response must be a single printable character.

(7) The "trial description," or list of parameters that describe the sequence of events that will occur in any given trial. These parameters differ depending on the type of experiment being run, but they generally include such things as whether a warning signal should be presented (a fixation point or a tone, or both), length of foreperiod, screen position of the stimuli, duration of first stimulus (for same-different experiments), interstimulus interval (for same-different experiments), maximum allowable response time, whether feedback should be provided on the correctness of the response and/or on the response time, length of intertrial interval, and so on. There is also a provision for the inclusion of one of several types of "distractor tasks" (for study-test and same-different experiments). These are tasks (e.g.,

letter search, tone judgments, simple arithmetic problems, counting backward by threes from a three-digit number, etc.) that can be introduced between the presentation of the study materials and test materials (if the experiment is a study-test type) or between the first and second stimuli (in a same-different type).

One of the most powerful features of the system is that it not only allows all of these parameters to be entered by the user but also allows any number of them to become independent variables. For example, it is easily possible to devise an experiment in which subjects receive feedback on half their responses, but not on the other half, or in which subjects are allowed to examine the stimuli for an unlimited amount of time in one condition, but for a restricted amount of time in another condition.

Any number of these may be varied either independently or simultaneously. With from 24 to 31 parameters of this sort available, an immense variety of designs become relatively easy to create.

(8) The randomization procedure to be used in the presentation of the stimuli. Three options are available: (a) completely sequential (no randomization), in which the stimuli are presented in the order they were entered, (b) completely randomized, in which the stimuli are randomized across all conditions in the design, and (c) randomized blocks, in which one variable (only) may be designated as a blocking factor and stimuli within the levels of this variable are randomized.

(9) A name or identifier for the files that SETUP will create for the experiment. The program creates four or more files, each of which may be duplicated under different names in order to allow the design of between-subjects experiments. It is assumed, in such cases, that at least one of the files will be different in some way. This name/identifier may also be added to the experiments MENU that can be automatically read by the EXPER program.

EXPER

The files created by SETUP are read by the EXPER program, which presents the stimuli and records the responses. EXPER is usually called from the DIRECTORY program, which is the first program on experiments diskettes. This is a "turnkey" system. That is, the user simply inserts the diskette into the disk drive and turns on the computer; the Apple II automatically loads and runs the program without further commands from the user.

DIRECTORY reads the MENU file and presents it to the user. In addition to listing the names of the experiments and getting the user's selection, the menu file also modifies the EXPER program before it is run so that it will automatically store the data on disk and/or print the data on a printer or give the EXPER user a choice about these options. The SETUP user must specify these when the experiment is added to the menu.

EXPER requests the subject to enter his/her name and some additional information before proceeding to the presentation of the instructions and stimuli.

EXPER's timing and input routines are written in machine language and are accurate to about .01 sec, although there is some variability here because the main program is in BASIC and the calls to the machine routines are often based on evaluation of conditional statements. The routines involving timing of presentation of study materials in "study-test" experiments require a Mountain Hardware Appleclock, although options are available for avoiding this by allowing the subject to examine the study materials for as long as he/she likes.

Assuming it was requested, the printed output from EXPER consists of the subject information collected at the beginning of the experiment and, if the user has an Appleclock in the system, the time the experiment was run and the elapsed time. This is followed by a list of the stimuli, the subject's response to each stimulus, a "1" or "0" indicating whether it was the correct or appropriate response, the response time, and the score on the "distractor task." Finally, a "summary by condition" is presented for all of the above information. All of these data, except the summary by condition, are also stored on diskette if the user has requested that option.

ANALYZE

The ANALYZE program is relatively short and unsophisticated; its purpose is less to provide an analysis of the data than to recover them from the diskette and present them in a form suitable for entry into more sophisticated programs (e.g., SPSS, MINITAB, etc.). Many programs are available to serve this purpose.

ANALYZE simply requests the name/identifier of the data files to be accessed, reads them, and prints out the results. The user has the option of requesting the complete set of raw data or a summary by condition, or both. The program automatically stops at the end of a data file and allows the user to insert another diskette if the data file is divided between diskettes.

ASSOCIATED PROGRAMS

In addition to the programs described above, additional support programs are included.

CREATE allows the user to create a new experiments diskette (each can be assigned a number that appears when the disk is booted).

DIRECTORY is automatically copied (by CREATE) onto all new experiments diskettes; it reads and presents the menu of experiments available on the diskette

asks for the user's selection, and then loads and runs the EXPER program. DIRECTORY also modifies certain parameters of the EXPER program so that EXPER will print and/or save the data on disk according to the specifications in the MENU file. If EXPER is run "from scratch," the user would normally enter this information at run time.

MENU CHANGE allows the user to add or delete experiments from the experiments menu on an experiments diskette and to modify the "print" and "disk save" options. This program may also be called from the SETUP program if the user wishes to add the experiment he/she has just created to the menu.

RECONFIGURE allows the user to change certain program parameters (e.g., printer slot number, number of disk drives, whether the system has a clock, upper-/lowercase character generator ROM, etc.) for all of the programs in the system so that they will run on the user's system without requiring a search through the programs to locate the lines in which these parameters are specified.

COPY allows the user to copy files from one disk to another.

TIMEFILE stores the time of the last run.

SOME SAMPLE PROGRAMS

My students and I have set up about 15 experiments with run times ranging from about 30 min to 2 h, depending on the number of modifications and parameter changes needed to obtain the desired results. Information on the specific studies, many replicating published research by others, is available from the author.

REFERENCE NOTE

1. Ellis, N. *Phonological coding in reading.* Unpublished computer programs and manuscript, University College of North Wales, Bangor, Gwynedd, 1981.

REFERENCES

BEWLEY, W. L. *Cognitive psychology: A computer-oriented laboratory manual.* Hanover, N.H: Project COMPUTE, 1974.

FISCHLER, I. An on-line laboratory in cognition and perception. *Behavior Research Methods & Instrumentation,* 1980, 12, 116-119.

LEVY, C. M. *Laboratory in cognition and perception.* Iowa City, Iowa: CONDUIT, 1979.

PERERA, T. B. A laboratory in experimental psychology using the TRS-80. *Behavior Research Methods & Instrumentation,* 1981, 13, 195-197.