SESSION VIII

THE DESKTOP EXPERIMENTAL LABORATORY: ELIMINATING PROGRAMMING IN PROFESSIONAL AND UNDERGRADUATE RESEARCH

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MacLab: A Macintosh system for psychology labs

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MacLab, a program that turns the Apple Macintosh into a psychology laboratory tool, is described. MacLab combines intelligent editors, a millisecond timer, MacPaint pictures, and the ease of use of the Macintosh user interface to create a system with which experimental psychologists can quickly create and run powerful experiments with no need of any knowledge of programming.

The program discussed in this paper, MacLab, addresses the need to eliminate programming for creating and running psychology experiments. Learning how to write programs that accomplish sophisticated tasks can be so difficult that an experimenter may settle for a simple version of an experiment. Although simple can be elegant, the search for a certain psychological effect may at first involve experiments with a rather large number of variables. These first exploratory experiments should be easy to implement so that many of them, and many variations of them, can be run. If a separate program has to be written for each of the variations of each experiment, the programming task can become large enough to warrant the services of a full-time programmer. Communication problems between the psychologist and the programmer can waste much time as two people work together to create experiments that, with MacLab, a non-programmer psychologist can quickly create.

The power of the Apple Macintosh computer, for which MacLab is written, is so great that programming for it is more difficult than programming for other personal computers. The power of this computer, however, is often needed, and its particular capability to create and display images has already made it an indispensable tool in many

laboratories across the world. MacLab simplifies the use of the Macintosh for experimental psychology by creating a controlled environment for designing and running experiments that involve visual stimuli. This environment is "controlled" in that, at any point during the development of an experiment, the writer of the experiment is faced with a relatively small, well-defined set of choices. The situation of having a blank sheet of paper on which a program has to be written, with the multitude of choices involved, never occurs. There is no notion of syntax errors, because the writer is never given the choice to do something that does not make sense in relation to the rest of the experiment being written. On the surface, creating a controlled environment is all done with the use of standard interfaces that the Macintosh offers. Thus, someone who has used the Macintosh for other purposes, such as data analysis, word processing, or even games, will already be accustomed to how MacLab interacts with its user.

WHY MACLAB?

MacLab was first written for Steve Kosslyn's imagery laboratory at Harvard. There was a need for a system that would allow experimenters to quickly prototype and develop experiments that used the picture display power of the Macintosh combined with millisecond accuracy in response measurement. The program also had to be easy to use, so it could be easily mastered by the new people that join the lab every year. Being one of these students who needed to do a series of experiments, and having been involved with experiments before the days of the Macintosh, I felt I had a good feel for what was needed; being

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reasonably proficient at programming on the Macintosh, I set to the task of creating the first version of MacLab.

As it became apparent that MacLab was extremely useful (almost every student in the lab has used it for some experiment), more Macintoshes were acquired, and a great deal of effort was made to satisfy all reasonable requests of what capabilities should be incorporated into MacLab, keeping in mind that all these capabilities had to present to the user a consistent interface that would remain easy to learn. Other labs in the department started using the system, as well as labs at other universities that had heard about MacLab. Some have found little need for a tachistoscope after using MacLab, thus saving a large amount of money in equipment purchases. Others were eager to use MacLab because of the short development time needed for a MacLab experiment. Shortly before I graduated, there was talk of using MacLab to let students in introductory methods in psychology courses create their own experiments on the Macintosh, quickly and with no need of programming knowledge. With MacLab, the difficult part of creating an experiment became the theory behind the experiment, not the creation of the experiment itself.

The remaining task is to let more people know about the availability of MacLab, and that is part of the purpose of this paper.

WRITING AN EXPERIMENT

Trials and Events

A MacLab experiment, as defined by the user, consists of a series of trials, each made up of events. Events are the smallest unit of the experiment. For each event, the computer displays a picture on the screen, leaves it on the screen for a specified amount of time or until the subject's response, and records what has happened during the event.

Pictures in MacPaint format are read from disk. The vast majority of picture making programs for the Macintosh use MacPaint format, so finding one that can be used to make stimuli for MacLab should not be a problem. These pictures are read in groups as large as the computer's memory permits. Each picture requires about 22K of memory. A 1-MB computer can hold about 33 pictures simultaneously (the rest of the memory is needed for MacLab and the Macintosh operating system). This means that any combination of 33 different pictures can be displayed in succession without access to disk. MacLab can display up to 30 pictures every second, a limit imposed by the Macintosh's speed in transferring data into its screen display memory area and its rate of redrawing the screen.

Response Measurement

MacLab's accuracy is due to its use of a millisecond timer in measuring subjects' responses. The amount of time that a picture is displayed can be controlled by the experimenter when the experiment is written or by the subject. Each event, or display of a picture, is terminated

by a specified-length timeout, by a subject's response on the computer's keyboard, or through the use of the mouse. Keyboard termination can be either by pressing a single key, where the time measurement is done with millisecond accuracy, or by typing in a whole phrase or paragraph. In the latter case, $\frac{1}{60}$ of a second accuracy is used in measuring the time from the picture display to a press of the return key. When using a mouse, the time between the display of the picture and the press of the mouse button is measured.

For each event, certain information can be saved to disk. The experimenter may save any combination of the name of the file that was displayed, the amount of time that it was displayed, the key pressed or text that was typed in to terminate the event, and the location of the mouse when the event was terminated. These items are saved in memory and periodically saved to disk in a standard text file that can be examined and edited by any word processor. Each event can generate a line of output, and each trial may have a name that is also inserted in this output file to make it more readable.

RUNNING AN EXPERIMENT

Once an experiment is defined as a set of trials, the study may be run in several ways. The simplest way is to tell MacLab to run the experiment as is. In this case, the experiment file is loaded, and MacLab asks for a file name to which any subject output should be saved (the experimenter can tell MacLab that no output file is desired). Finally, the trials are run in the order they appear in the experiment file.

Trial Orders

Many experiments consist of a series of trials that are presented to different subjects in different orders for purposes of counterbalancing. For this reason, MacLab allows the experimenter to define a trial order file. This is simply a file that consists of numbers, which refer to trial numbers of an associated experiment file. When an experiment file is run in conjunction with a trial order file, the trials in that experiment are presented to the subject in the order specified by the trial order file. Any arrangement of numbers can be used; a particular trial number may be specified any number of times, or never, in which case it will not be presented.

Scripts

A scripting facility is provided so that many experiment files, with associated trial order files and output files, can be run serially. To accomplish this, a script file has to be created. To create the script file, MacLab asks the experimenter which experiment files are to be run in conjunction with which trial order files, and into what output files the subjects' responses should be put. From this information, MacLab then creates the script file on its own. This file, like all other MacLab files, is a text file, so it can be created with a regular word processor. Once

Figure 1. The main editor of MacLab is shown here. Five trials are visible. The first one presents a picture named "Welcome" and waits for a mouse buttonpress. Each of the rest has five events: (1) display a "get ready" picture and wait for the subject to press the space bar, (2) display a picture for the subject to memorize and wait for the space bar to be pressed, (3) display a mask for 1,000 msec, (4) display the test stimulus for 175 msec, and (5) show a blank screen and wait for the subject's response, accepting either the "z" key or the "/" key, and saving the response time and the key pressed.

a script file exists, it is the only thing that needs to be specified in order for MacLab to go through a series of experiment files with no further help from the experimenter. Furthermore, double-clicking on a MacLab script file from the Finder will start up MacLab and run that script file automatically. Selecting a group of script files from the Finder and running them will execute the script files in the order they were picked in the Finder, without any interruptions.

MACLAB'S INTERACTION WITH THE EXPERIMENTER

The majority of the input that MacLab needs from the experimenter is requested through intelligent editors (see Figure 1). When an experiment file is being worked on, for example, the experimenter interacts with an editor that knows about the format of trials and events. Thus, the experimenter need not try to conform to this format, because the editor takes care of all syntax.

When a trial or an event needs to be added or changed, a Macintosh dialog window (see Figure 2) is presented, which simply asks the experimenter to check off the boxes that correspond to the actions that are to be performed by the trial or event under consideration. When the name of a file is needed, a button will bring up a minifinder to display the files present on a disk. Values that are entered are checked and automatically converted to proper syntax. Text is truncated to properly fit the fields it is put into. All of this work is done to ensure that when an experiment is run, the system will not suddenly find some

kind of error in the file being read and interrupt the experiment in progress with an error message.

Miscellaneous Features

Other features are provided to make it easier to manipulate items in the text editors: copying groups of trials, and at the same time renumbering the new trials according to their new positions in the experiment file; adding ordered sequences of numbers in trial order files; and setting the location (disk and folder) of picture files for an entire experiment, so that these do not have to be in the same folder or disk as MacLab or the experiment file that uses the pictures. Printing of the different types of files

Figure 2. This window is brought up whenever an event is added or edited. The event being edited here is the one that is highlighted in the previous figure. The name of the file to display is "Blank," the termination condition is a keypress, valid keys being "z" or "/", and the items to save are the response time and the key pressed by the subject.

is also supported. Printing an experiment file from MacLab formats that experiment file, highlighting trial names and putting headers on each page with information about the file. When output files are printed, the names of the experiment and trial order files that were used are also given.

Although many of these features are small, together they provide a single system that can handle the needs of a large number of users. Many of these features were added to

MacLab because of a user's specific requirement. This commitment to implementing users' wishes continues, as MacLab becomes more powerful with each release.

AVAILABILITY

MacLab is available from the author at DC Software, P.O. Box 9161, Stanford, CA 94305-0246. The cost is \$200; a demo system is available for \$10.