INSTRUMENTATION & TECHNIQUES

Using an Apple II to control a two-field projection tachistoscope

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A suite of programs is described that enables an Apple II+ microcomputer to control slide projectors and shutters as a two-field projection tachistoscope. This system is portable and allows more precise exposure timings and more complex visual stimuli to be used than are possible with earlier systems.

Minicomputer-controlled tachistoscope systems have been available for some time (see Green & Shwartz, 1978, for a review), but their use often requires considerable programming skill and they are limited to locations with access to computer terminals. To overcome these problems, Norris (1984) developed a minicomputer-based system that makes few demands on programming skills and can be readily transferred to a suitable microcomputer. However, the Norris system is not without limitations. The most serious of these relates to the presentation of stimuli on the CRT monitor. The nature of the raster-scan mechanism that generates images is such that exposure times are unreliable unless a system for synchronizing stimulus and frame-scan onset is included (Broyles, Prill, Marks, Salthouse, & Spencer, 1982; Lincoln & Lane, 1980). Even with such synchronization, exposure times can be incremented only in steps of 16.67 msec (USA) or 20 msec (Europe). Stimulus and raster-scan onset can be synchronized by the system described by Norris (1984) and by a system designed for the Apple IIe described by Diener and Smee (1984). The latter authors point out, however, that hardware modifications are needed if their system is to be used on Apple II or II+ machines.

In addition to the limitation on exposure time incrementation, CRT displays are constrained by the relatively poor sophistication of the graphics systems found on many microcomputer systems. This is especially important when investigating processing of complex pictorial stimuli for which a high degree of graphical sophistication is often needed.

Both of these problems are overcome by the present system, which uses a microcomputer to control slide projectors fitted with shutters. The system also enables more

precise matching of the luminous intensities of the fixation and stimulus fields than is possible on a CRT, and it can keep records of data files.

THE APPLE II TACHISTOSCOPE SYSTEM

Two main considerations guided the development of the system: (1) it should be easy to use by individuals not familiar with computers, and (2) the amount of effort (mental and physical) required of the experimenter should be kept to an absolute minimum.

The system consists of a suite of programs that allows the investigator to define an Experiment Description File that contains all the information necessary to control the projectors and shutters and to keep, for each subject, separate records of the sequence of stimuli presented and responses made. In addition, the formal structure of the programs allows them to be used in any situation where an experimenter wants subjects to respond to predetermined sequences of timed stimuli.

Hardware

The system requires an Apple II+ or Europlus computer with 48K RAM and one disk drive running DOS 3.3 (16-sector disks) and Applesoft in ROM. A real-time clock card is not required; all timings are achieved by machine language idling loops. Two Kodak S-AV 1000 carousel slide projectors and two COMPUR model 141 electronic shutters are controlled through the Apple's game I/O connector. The annunciator outputs AN0 to AN3 are assigned as follows:

- AN0: Shutter 1 (logic 1/on = open, logic 2/off = closed).
- AN1: Shutter 2 (logic 1/on = open, logic 2/off = closed).
- AN2: Projector 1 advance mechanism.
- AN3: Projector 2 advance mechanism.

Pin outputs of the game I/O are given on page 100 of the *Apple II Reference Manual* (Apple Computer, Inc., 1979), and the memory locations referencing the annun-

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ciator outputs are given on page 24, Table 9. When an annunciator is "off," the voltage on its pin on the game I/O is about 0 V; when it is "on," the voltage is near 5 V. The outputs from AN0 and AN1 are used to control both channels of a two-channel shutter driver that requires a threshold of 2.5 V to generate the 24-V 3 A required by the shutters. These allow minimum exposure times of 8 msec, with opening and closing times of 1.5 msec. The output from AN2 and AN3 activates a transistor-buffered relay system connected to the slide advance mechanism of the two projectors. Because the annunciator outputs can drive only a single TTL load, this arrangement requires the construction of a small interface unit with associated leads that plug into the game I/O.

Software

The system consists of a suite of nine programs, described below.

HELLO. This is the greeting program that is automatically run when the computer is switched on. It displays a message that shows the date on which the system was last used and invites the user to enter the current date, which is then stored on disk for reference by other programs in the system.

MENU. This program is automatically run at the end of each of the other programs in the suite. It lists all the available programs and tells the user how to select and run the desired one. A single carriage return will cause the MENU to erase all programs in memory and return the computer to BASIC.

DEFINE STIMULUS NAMES. This program allows the user to set up a file containing the names of the symbols (objects, pictures, etc.) used in the experiment. Up to nine stimulus names are allowed and are assigned to the numbers 1 through 9 on the keyboard.

TEACH EXPERIMENT. This program allows the user to create a set of files that contain the sequence of projector slide advances and opening and closing of shutters required to perform an experiment, as well as a list of the experimental stimuli in order of presentation. The Experiment Description File contains the information on the steps required to operate the projectors and shutters, and the two Carousel Description Files contain information on the sequences of stimuli in the slide magazines.

To make things easy for the user, there is a **STANDARD EXPERIMENT** option that assumes a single-fixation stimulus on projector 1 and a sequence of tachistoscopically presented stimuli (T-stimuli) on projector 2. The system asks the experimenter for the fixation stimulus number (as defined in **DEFINE STIMULUS NAMES** above), the number of presentations, and the field and stimulus number for each of the T-stimuli.

By not opting for the standard experiment, the experimenter has much more control over the sequence of events that can be performed. For example, the fixation stimulus could be changed midway through the experiment. When the **STANDARD EXPERIMENT** option is not chosen, each event in the sequence of operations needed to present a slide must be specified.

CHECK. This program allows the experimenter to check that all the electrical connections between the Apple and the peripheral equipment have been correctly made and that the projectors and shutters are operating properly.

EXPERIMENT. Selecting this option from the menu allows the experimenter to run an experiment with a subject. When called up, it requests an Experiment Description File name, which is supplied by the experimenter. It then asks for details about the subject, experimenter's name, mode of response, and exposure time for T-stimuli (0–255 msec). When these details have been supplied, a message reminds the experimenter to ensure that the projectors and shutters have been correctly set up. When this is done and **RETURN** is pressed, the program closes both shutters and begins executing the event sequence according to the Experiment Description File. When the T-stimulus is presented, the subject's response is requested by the program. Provision is made for failure to respond: the stimulus is re-presented once and, if it fails again, is re-presented at the end of the experimental sequence. Whenever a T-stimulus is about to be presented, the experiment can be aborted by typing **A** followed by **RETURN**. This will cause the program to write the results obtained thus far to an Experiment Output File. An experiment aborted in this way can be restarted from where it was stopped by running the **RESUME EXPERIMENT** program described later.

At the end of the event sequence, the program searches the response record for presentations that were failed twice. If one is found, a message is displayed that gives details of the required repositioning of the slide magazines. When all the final presentations have been completed, the program writes the experimental results to a file, the name of which incorporates the subject's name, the Experiment Description File name, and the date. When the writing is complete, the system returns to the menu.

RESUME EXPERIMENT. This program is used to continue an experiment that has been aborted during the **EXPERIMENT** program. During the running of this program, it is possible to abort again if necessary.

ANALYZE EXPERIMENT. This program performs simple statistical analyses on the contents of an Experiment Output file. At present, the analysis consists of four screen displays. Pressing **RETURN** on Page 4 returns the system to **MENU**.

Disk Space

The suite of programs described above occupies 200 sectors on the disk, leaving 360 for files. A 50-presentation experiment will use seven sectors for the Experiment Description and Carousel Description files, and each time the experiment is run, the output file will be 3–4 sectors long.

Although the system as it stands is quite flexible, modifications can be made to any of the programs to render them more suitable to the particular requirements of individual researchers. Structural features of the Apple limit this system to the control of two fields, but revisions of the program are currently under way to enable it to run on other

machines, in particular, the Acorn BBC "B", which would allow control of up to four fields.

The system allows an Apple II microcomputer to be used to run two-field projection tachistoscope experiments with a high degree of flexibility. It also allows the storage and analysis of the experimental data. The system has the advantage of being readily usable by someone with little or no knowledge of computers and computing and requires a minimum of decision making during the actual running of an experiment, thus allowing the experimenter to pay more attention to the subject. This last feature makes the system particularly valuable for use with children, mentally handicapped people, and others who might show a low level of cooperation.

AVAILABILITY

Copies of the software may be obtained by sending to the author a formatted 5.25-in. disk and \$2 to cover postage and packing.

REFERENCES

- Apple Computer, Inc. (1979). *APPLE II Reference Manual*. Cupertino, CA: Author.
- BROYLES, J. W., PRILL, K. A., MARKS, M. H., SALTHOUSE, T. A., & SPENCER, K. L. (1982). An empirical approach to the timing limitations of the raster-scan CRT. *Bulletin of the Psychonomic Society*, **20**, 287-289.
- DIENER, D., & SMEE, W. P. (1984). Apple tachistoscope. *Behavior Research Methods, Instruments, & Computers*, **16**, 540-544.
- GREEN, B. F., & SHWARTZ, S. P. (1978). Comparative evaluation of computer-based tachistoscopes. *Behavior Research Methods & Instrumentation*, **10**, 789-795.
- LINCOLN, C. E., & LANE, D. M. (1980). Reaction time measurement errors resulting from the use of CRT displays. *Behavior Research Methods & Instrumentation*, **12**, 55-57.
- NORRIS, D. (1984). A computer-based programmable tachistoscope for nonprogrammers. *Behavior Research Methods, Instruments, & Computers*, **16**, 25-27.

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