SPECIAL SECTION COMPUTER-BASED TACHISTOSCOPES

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Introduction

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A series of eight papers is introduced on methods of using a computer system as a tachistoscope. Comparisons are based on the type of display and the type of software.

The bread-and-butter task of computers in experimental psychology laboratories is to serve as a flexible multichannel tachistoscope. Any minicomputer or microcomputer coupled with some kind of cathode-ray tube (CRT) display, and with some means of sensing and timing a subject's pushbutton response, can be programmed for the tachistoscope task. The program can be written in several ways. Our own computer-based laboratory at Johns Hopkins University has had three successive tachistoscope programs, with quite different characteristics.

It seemed to us that persons setting up new laboratories, as well as those now using computer tachistoscopes would profit from reading and comparing descriptions of a variety of different systems. Invitations were sent to a large number of laboratories, and eventually, papers were contributed by Aaronson and Grupsmith; Cunningham and Cooper; Mewhort; Palmer, MacLeod, and Loftus; Prinzmetal and Banks; Schwartz; and Taylor, Klitzke, and Massaro. These articles, which follow, describe a variety of different software systems. Because the systems are based on different hardware configurations, the software is not completely comparable, but the general approaches are typical of many other installations.

All of the systems are concerned with displays generated on CRTs. Some of the systems can also control slide projectors with shutters, and Nixie tubes. There are timing problems associated with slide selection on the projectors, but otherwise, these displays make no special demands on the software. Each needs its own special machine-language subroutine to control the actual signals sent to the device, but so does the CRT.

TYPES OF CRTs

Three kinds of CRT are in use. The most limited is the device that also functions as a computer terminal,

the so-called "glass Teletype." A terminal can typically display only ASCII characters, in from 12 to 24 lines of from 40 to 80 characters. Aaronson and Grupsmith, for example, use a display with 20 lines of 40 characters. The character size is fixed, as is the line configuration, which can be very constraining. On the other hand, the display "refresh" is automatic, so the display is bright and flicker free, with no effort from the computer. Some of these devices "scroll." That is, the information on one line moves up one line when a new line of information is entered. Careful use of scrolling can provide a simple timing mechanism.

At the other end of the spectrum, both in cost and complexity, are the graphics terminals. Prinzmetal and Banks describe a laboratory based on a DEC VT40 graphics terminal, and Cunningham and Cooper describe an efficient arrangement based on an IMLAC graphics display system. These devices include a separate microprocessor exclusively devoted to generating and maintaining the display. These displays can be told to plot points, characters, or straight-line segments between two points. A series of global commands must be provided to the microprocessor, which then takes over and generates the display. As with the simple terminals, the graphics system takes care of refreshing the display automatically, so that, within limits, the display is bright and flicker free. These devices are well adapted to creating dynamic pictorial displays, and thus have much more power than is needed for the typical tachistoscope project. But, when they are not doing their more elaborate thing, they can certainly serve as pedestrian tachistoscopes; they do so much themselves that they make minimal demands on the controlling computer system.

Most of the CRTs in use as tachistoscopes are point plotters. The computer furnishes the display equipment with the x/y coordinates of a point, and the point is displayed, as if on a Cartesian coordinate plot. To display a character, such as the letter A, a subset of

points in some array, typically a 7 by 5 array, is brightened. The computer must send the coordinates of each point in the A to the display equipment. Taylor et al. discuss in detail the problems of character generation on a point plotter.

One problem that must be faced by the user of a point plotter is the relation of refresh rate to display brightness. Typically, the point plotter plots each point on the display in turn, and then starts over, repainting each point, continuing until the display time has elapsed. Since the time to intensify each point is constant, the total light flux from the display is (approximately) constant, but a display with many points will seem dimmer than a display with few points, because the energy is distributed over more points. Thus, the word "HI" will appear brighter than the word "HELLO," because each point in "HI" is displayed at least twice as often. For the same reason, the number 171 will seem brighter than the number 568. One solution to the problem is to display null characters up to some fixed number, or to display several points in one corner of the screen that are then masked from the subject. Since brightness affects visibility, which in turn affects reaction time, this control is of critical importance in a tachistoscope. Some systems explicitly recognize this problem. Other systems take the view, "let the user beware."

TYPES OF SOFTWARE

There are three general approaches to providing system software to the user of a computer-based tachistoscope. Luckily, all three types are represented here.

The first type of system is well exemplified by Mewhort. Here, the user does not write a program, but instead prepares a file of input data in the proper format for a general-purpose tachistoscope program. Of course, the user then has the problem of either typing the data file by hand, or writing a program to prepare the data file, which is Mewhort's preferred mode of operation.

The second approach provides a special programming language, oriented to tachistoscopic experiments. The user writes a program in this language, hopefully not very different in appearance from a natural language description of the procedure. This program is either compiled or interpreted by the system software. Aaronson and Grupsmith describe SIMPLE, their version of an elementary easy-to-learn language. Palmer et al. provide a more elaborate all-encompassing language, PLE. SIMPLE normally requires a data file in addition; use of a data file in PLE is optional.

The third style, exemplified by Schwartz, is a package of subroutines that can be called by a program written in the standard programming language of the computer system. Schwartz describes a set of FORTRAN-callable subroutines. Similar routines are used by Prinzmetal and Banks and by Cunningham and Cooper.

The following collection, then, provides a broad sampling of approaches to the computer-based tachistoscopes. Green and Schwartz provide a summary and comparison as the last paper in the set. We wish to thank the editor, Joseph Sidowski, for encouraging our collection of this special section of *Behavior Research Methods & Instrumentation*.