SESSION III

CONTRIBUTED PAPERS:

PROCESS CONTROL (INTRODUCTORY)

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The slide projector as a computer-operated visual display*

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Advantages and method are presented for using the slide projector in a computer-operated visual display system.

The presentation of visual stimuli is a common procedure in psychological research (Aaronson & Brauth, 1972). For example, visual stimuli have been employed in our laboratory for experiments in perception, learning, memory, choice reaction time, and very short-term memory. Obviously, this is not an exhaustive list of potential uses. In the computer-controlled laboratory, the cathode ray terminal (CRT) or oscilloscope (CRO) may be used to meet this need (Sperling, 1971; Van Gelder, 1972; Wojnarowski, Bachman, & Pollack, 1971). In the smaller laboratory, however, the expense involved in obtaining, interfacing, and maintaining a CRO or CRT may be prohibitive. For these situations, a simple slide projector may provide a viable, inexpensive alternative.

When compared to the CRO, the slide projector has several advantages. To present a complex stimulus on a CRO, considerable computer memory may be required to store coordinates for individual components. In addition, a lengthy subroutine may be required to generate the components. If the stimulus is composed of many elements, the problem of display flicker arises. The standard, nonstorage CRO requires constant refreshing and a long-persistence phosphor for flicker-free display. This prohibits stimulus presentations of short duration. A storage oscilloscope display solves this problem, but the erasure process requires considerable time for recovery, limiting the ability to change stimuli quickly. CRTs may be purchased which avoid these problems by limiting the stimulus set to alphanumeric characters. A projector, on the other hand, can display stimuli limited only by the size of the screen and the Ss' ability to discriminate detail. Virtually anything that can be photographed can be presented with no flicker, and decay is determined solely by how fast the projector's shutter closes. Most psychologists

have had experience with slides and can generate appropriate stimuli easily. Furthermore, changing or supplementing the stimulus set requires no new programming and no additional memory storage.

Interfacing an inexpensive tachistoscope to the computer may also meet the E's requirements for a visual display. However, the projector is more flexible in that one can display many stimuli without E intervention, so that intertrial interval is precisely controlled. Furthermore, two projectors with superimposed images, paired in the proper timing sequence, can perfectly mimic a two-channel tachistoscope. The shutter on one projector is programmed to open as the shutter on the other projector closes. Thirdly, whereas a tachistoscope may be used to test one S at a time, a pair of projectors simulating a tachistoscope may present material to groups of Ss simultaneously.

With the addition of an external shutter, slide presentation durations and blank periods may be controlled to within less than 5 msec. Additionally, the shutter allows the E to present blank periods between stimulus slides without actually requiring blank slides.

HARDWARE REQUIREMENTS

Any small computer can be used to drive one or more slide projectors. Core requirements for even very sophisticated routines may be kept to less than 1,024 words of memory, and perfectly reasonable programs may require as little as 256 words.

A programmable input/output buffer with as little as 1 output bit and 2 input bits is necessary. The input buffer is used to accept responses from the S. Each projector requires 1 output bit for control. To accept operating parameters and to record responses and reaction times, a Teletype or similar device is required. Response buttons and the slide projector(s) complete the necessary equipment.

A Uniblitz shutter and controller is optional, but requires only 1 more bit of the output buffer, while providing much more precise control of stimulus durations.

PROJ1

The first version of the program, PROJ1, did no more than present slides divided into two categories: stimuli

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and probes. Each trial consisted of one stimulus followed by a series of test stimuli. Only one projector, without external shutter, was used.

The main program consisted of a set of questions to set parameters and a series of timing loops. The number of blocks (slide trays), the number of trials per block, and the number of probes per trial could be determined by the E. In addition, he also chose presentation duration for the stimulus, probe duration, stimulus-probe interval, interprobe interval, and intertrial interval.

Each trial began with the presentation of a stimulus slide, followed by a blank slide. Ss were allowed to respond during each probe presentation and part of the interprobe interval. The input buffer remained enabled either until a response was made or until 600 msec before the next slide change was to be initiated. In either case, the slide remained on until the probe duration was completed, and the next slide appeared after the interprobe interval. During the final 600 msec of the interprobe interval, the response and the reaction time were recorded on the Teletype. After all probes had been presented, the intertrial interval was timed and a new trial initiated.

The first application of PROJ1 was an experiment on the effect of organization on the storage of information for memory scan. Rather than memory lists composed of words or letters, as had been used in previous research, Ss were presented with facial features. Incomplete faces, composed of three of four features, and five-feature complete faces were generated. Three templates for each feature (ears, eyes, eyebrows, nose, and mouth) were constructed, and templates from each of several features were combined to construct memory lists. In all cases, the features were oriented as a face. A series of probes was also constructed, each probe containing one template (a single feature) in a facial orientation. Both memory list stimuli and probes were drawn on cards and photographed.

Since the laboratory was equipped with a CRO, programs could have been written to display the required faces, but the previously described problems prompted the use of slides. The CRO display program would have required at least 1K of core without storage buffers for the template coordinates. To create stimuli of sufficient clarity, resolution, and smoothness of lines required more memory than was available in a 4K PDP-8/e. Further, the CRO phosphor (P31) was insufficient to present this number of points without flicker. For this experiment, slides were the most reasonable solution.

A second experiment required a minor modification in PROJ1. Whereas the first experiment had used one stimulus slide, the second study required a series of stimuli followed by a series of probes. The list of parameters supplied by the E was expanded to include the number of stimulus slides per trial and the interstimulus interval; the timing loops in the main

program were modified accordingly.

The experimental configuration for PROJ1 had two basic problems. First, slide change time limited intervals between stimuli and probes to durations longer than 1,800 msec. The Kodak Carousel 800 projector required 900 msec to present each blank slide and an additional 900 msec to present the next stimulus. Secondly, recording data required an additional 600 msec of each interprobe interval.

PROJ2

PROJ2 added a Uniblitz shutter to the system. In essence, the shutter eliminated blank slides between stimulus and probe slides. Only one slide change took place between stimuli, reducing the minimum blank period to 900 msec. Slide change and Teletype operation were performed simultaneously.

PROJ2 was used in an experiment to test the Bower multicomponent memory model using hierarchically related words. Construction of stimuli was simple; words were typed directly onto the slides. Again, memory requirements of the program were considerably smaller than would have been needed to present these stimuli on a CRO. Moreover, this experiment was run 1 week after conception, since PROJ2 made new programming unnecessary.

The sequence of slides per trial was as follows: Eight stimulus words were presented to the S for 2 sec each. A 900-msec interstimulus interval elapsed between stimuli, allowing a slide change. One second after the last stimulus, the probe list began. Each probe consisted of two words, one from the stimulus set and one distractor. The S pressed one of two buttons to indicate which word had been previously presented. If no response occurred, a zero was recorded for both response and reaction time. After all probes were presented, a 3-sec intertrial interval was timed and a new trial began.

The intervals between slides were equal to the absolute minimum values allowed by PROJ2. Also, program limitations in the routine for recording data prevented exact timing of interprobe and intertrial intervals. A new version of the projector driver program was written to insure correct timing of all intervals and to further reduce parameter constraints.

PROJ3

PROJ3 placed the recording of data under control of the interrupt system. The data were stored in a buffer, and output was handled by a background routine. A second improvement was alternation between two slide projectors. Slides were presented from alternate projectors to further decrease the minimum time between slides. A given shutter remained closed for 900 msec during slide change, but this interval could now be filled by material from the second projector.

The second projector with external shutter allowed simultaneous presentation of two slides. This feature was used to implement a partial report procedure in the

study of very short-term visual memory. Procedural requirements in this research area have prompted further development of the projector display program.

PROJ4

Three further changes are currently being incorporated into the projector driving routine: masking capability, S-paced presentation rates, and optional feedback.

To add masking merely involves the addition of a few experimental parameters and adjustment of appropriate timing loops. Masks will be optional for stimuli, probes, or both. The E will also be given a choice between the same mask or different masks following each stimulus. If only one masking stimulus is employed, the external shutter controls actual presentation and no slide change is required. With this change, simulation of a two-channel tachistoscope is possible.

In a recent pilot study of digit comparisons, we were unable to present stimuli of sufficiently short duration on a CRO. The phosphor decay was slow enough to cause overlap in successive stimuli. A faster phosphor resulted in unacceptable flicker. It is expected that PROJ4 will solve this problem. The tachistoscope simulation is performed in the following manner. The prefield and postfield are the same masking stimulus, including fixation point. During each trial, both mask and presentation fields are continuously projected. External shutter movement determines the visual display. The distinction between stimuli and probes maintained in previous research with these projector routines is no longer important. If S may respond during or following the presentation of a slide, it must be considered a probe. Thus, the E may conduct research involving no probes or no stimuli.

Presentation of an S-paced probe is not difficult to insert. In the existing program, when a response is made, the data are recorded and control returns to the main program. The only required change is to initiate the next phase of presentation at this point.

Feedback may be computed by reading in a set of correct responses before each block of trials, to allow evaluation of the S's response. A device as simple as two light bulbs, one labeled "correct" and one "incorrect," may be used for reinforcement or feedback. Feedback

based on reaction times is similarly delivered. The E merely sets a criterion before each block, and any longer reaction time is declared "too long."

One example is a study involving binary choice with short intertrial intervals. Stimulus pairs are presented to Ss, and a "same" or "different" response is recorded. No stimulus slides or masks are required in this case. A trial consists of the probe presentation, a feedback interval, and the intertrial interval. By setting the probe duration sufficiently long and utilizing the S-paced option, the feedback interval will immediately follow the S's response. Since only one slide is presented per trial, a probe, no constraints must be imposed on stimulus duration in most cases. For this paradigm, the computer-controlled slide projector is superior to other display systems.

SUMMARY

The most inexpensive, widely available, and versatile device for display of visual material is the Carousel slide projector. It allows presentation of any stimuli that can be photographed. We present here a general, flexible program, PROJ4, to control one or more slide projectors. Any minicomputer with 1,024 words of memory or more can implement this approach. The current version of the program was written in PAL-III for a 4K PDP-8/e computer.

PROJ4 has been used to develop a general program of research in perception and memory. The E, in specifying his experimental parameters, has complete control of the number and duration of all stimuli and of interstimulus and intertrial intervals. This program has been used for research in paired-associate learning, memory search, choice reaction time, and very short-term memory. This approach is easily adapted to other areas of research.

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