A MULTIPLE STIMULUS PROGRAMMING SYSTEM¹

D. SUTTON AND G. S. BURT

ARIZONA STATE UNIVERSITY

Automatic presentation of several visual stimuli selected randomly from numerous alternatives can be accomplished effectively and economically by using a recycling 35 mm slide projector, (*e.g.*, Kodak Carousel or Sawyer's Rotomatic) visual readout devices, and interconnecting relay and photoconductive cell circuitry. The system described here performs much the same function as a solid-state controlled system but costs less, has broader switching capabilities, and is compatible with either solid-state or relay-controlled programming apparatus.

A schematic diagram of one element of the system is shown in Fig. 1. This circuit can be expanded to include numerous elements. Because many visual readout devices have independent lamps for each reticle pattern, a photoconductive cell and a relay are necessary for separate control of each lamp in the display unit.

The system operates as follows: 35 mm opaque slides punched with coding holes are projected against a matrix of independent photoconductive cells, each in series with a separate relay. The drop in resistance result-

ing from illumination of a photocell corresponding to the appropriate slide coding hole allows current to flow through the cell and the relay, which is thus activated. The relay contacts control the visual readout unit lamp.

A DPST relay² (see Fig. 1) provides a parallel circuit for additional programming information (*e.g.*, control of reinforcement). This feature makes the system more flexible, which, together with the indicated selector switch, permits the experimenter rapidly to select classes of stimuli for reinforcement.

Figure 2 is a schematic diagram of the completed system. Each photoconductive cell should be recessed into an individual compartment of an egg-carton light baffle 3 to 4 in. in depth. This minimizes light spread from illumination of adjacent units and reduces the effect of ambient light. If the system is to be operated in a brightly-lighted room, the face of the egg-carton structure should be covered with an opaque sheet in which $\frac{1}{2}$ in. holes are cut to correspond to the placement of each photoconductive cell. Failure to add this cover may result in spurious or maintained operation of a relay.

The matrix of photoconductive cells may be arranged in any configuration. A 4×6 array is used here, simply because two 12-lamp

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²Magnecraft X-17 relay. Allied Electronics, Chicago, Illinois.

readout devices are controlled by the projector and because it approximates the relative dimensions of a 35 mm slide. A photograph of the configuration provides a master slide indicating location of the photoconductive cells. Coding holes are punched in opaque slides using the master slide as a template. The coding slides are projected against the photoconductive cell matrix. Up to 100 stimulus combinations can be presented without repeating. The optics of the projector will dictate its separation distance from the matrix.

Operating the projection lamp at a reduced voltage prolongs its life. However, photoconductive cell resistance is greater under such conditions and more power is dissipated in the cell. It is advisable to conduct empirical checks on the illuminated resistance of the photocell if reduced projection lamp intensity is desired.

Any of several power supplies might be used for the photoconductive cell-relay circuit. The principal concern should be to select a relay with proper coil resistance. This can be done as follows³: given the available supply voltage (E), the rating of the photoconductive cell in watts (P), and the illuminated resistance of the photoconductive cell (R_1), the following formula applies in computing the resistance of the relay coil (R_2):

$$R_2 = E^2/0.5P - R_1.$$

The 0.5 is an arbitrary derating factor included to insure that the photoconductive cell is run well below maximum rating. The current (I) in the circuit then becomes $I = E/(R_1 + R_2)$. This value can be used to check whether the chosen relay will respond reliably. The pull-in current should be less than the current through the circuit.

Note that the photoconductive cell shown here (Sigma 5HC2)⁴ has a power limitation of 600 mw. Thus, high current relays would be unsatisfactory. This photoconductive cell was chosen because of its cost. Somewhat greater power can be handled by choosing a different photoconductive cell, although at increased cost.

The system shown uses Potter and Brumfield MH-1722-1 relays obtained through surplus sources. These relays can be operated

satisfactorily from a full-wave rectified unfiltered 60 v dc source.

Readout devices with a replaceable reticle were found to be most useful for presenting visual stimuli. A large number of stimuli for visual discrimination were required for the study, although relatively few were needed in any one session. Shelly Readout Devices (SRO 10)⁵ have been used successfully. These units can be dismantled and reassembled readily. Additional reticles can be made using almost any 35 mm camera with Kodalith or similar high contrast copy film.

The readout manufacturer provides a reticle layout sheet which can be used to locate patterns for photographic copying. The layout sheet insures that the patterns will be in proper relation to the projection lamps. Any stimulus pattern which can be drawn and photographed can be used. Reticles made this way can be produced for less than 10 cents each. Replacing the reticles in the readout device requires less than 5 min.

The system described has been used daily for eight months without failure. It is economical and compatible with a variety of behavioral programming equipment. The entire apparatus is easily adapted to automatic programming (Lubow and Stevens, 1964). Audible switching noise from the projector can be eliminated from the test environment by placing the projector and cell matrix in a separate room.

Different voltages may be switched simultaneously with this system, e.g., an intensity discrimination study. Absolute simultaneity of stimulus operation can be insured by using a relay in the programming equipment as a control over the circuit powering the readout lamps.

Aside from the cost of the projector (\$125) and the readout devices (\$37 each), the system is relatively inexpensive. The cost of the components indicated here is approximately \$110, including photoconductive cells, relays, and hardware.

⁵Cal-Glo Co., 11 Eucalyptus Drive, El Segundo, California.

REFERENCES

- Lubow, R. E. and Stevens, E. A technique for automatic, recycled, serial presentation of up to 80 unique visual stimuli. *J. exp. Anal. Behav.*, 1964, 7, 50.

³We thank Frederick Hegge for this formulation.

⁴Allied Electronics. Chicago, Illinois.