TECHNICAL NOTE

A LIGHT-ACTIVATED SCHEDULING SYSTEM FOR COMPLEX VISUAL DISCRIMINATION TRAINING¹

Maez, Graham, McVean, and Farrer (1968) noted the difficulty in devising a system that will automatically schedule response contingencies when using a slide projector to present visual discrimination problems. Their solution was to modify mechanically an existing slide projector and to schedule each slide with a non-conductive strip of tape on one of its four edges, thus coding each stimulus. A logic circuit reads the category of stimulus being projected, and in combination with a certain response input designated as correct or incorrect, provides the appropriate reinforcement. Their system is limited to four response alternatives and only one correct response to each slide.

The present system provides for far greater flexibility in scheduling visual discrimination problems, without mechanical modification of an existing slide projector and without a complex logic circuit. Stimulus and response contingencies are scheduled by each slide using the available light from the projector with cadmium sulphide (CdS) photo-conductive cells used as scheduling relays. In this paper a 12-key system is described; however, the scheduling system is applicable to commercial one, two, and three-key experimental chambers.

In the present application, 12 response keys are arranged in a circle around a centrally located semi-transparent projection surface. Stimuli are projected on the rear of the keys by a Carousel projector (Kodak, model no. 650). A matrix was devised for slides to be used with this panel, which was photographically reduced to slide size (Fig. 1, upper frame). The slide illuminates both the rear of the response keys and the CdS cells, which are arranged on the rear of the response panel. The CdS cells were arranged to coincide with the topography of the slide matrix (Fig. 1, lower frame).

The CdS cells (Phillips [Norelco] model no. B873103) decrease in electrical resistance in the presence of light.

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Fig. 1. Upper Frame. The slide matrix consisting of stimulus elements arranged in a circular shape associated with the keys of the response panel. Scheduling elements are arranged vertically on either side of the stimulus elements. Element A schedules a timeout. (Elements B, C, and D serve CdS cells that have no function in the present application, but were included in the event that future applications might require additional scheduling capacity.) Lower Frame. Rear view of the response panel showing the rear projection surface of the keys and the CdS cells arranged to coincide with the scheduling elements on the slide matrix.

Thus, when light is permitted to pass through one of the scheduling elements in a slide, a particular CdS cell is illuminated and permits passage of current. Light directed towards the CdS cells cannot be seen through the response keys; conversely, light projected through the stimulus elements of the slide has no effect on the CdS cells, which operate only in a direct, unfiltered, light source.

The dark resistance of the CdS cells in use in the present application is greater than 10 megohms. At

an intensity of 1000 Lux (108 ft/c), resistance is about 75 to 300 ohms. The CdS cell has a minimum recovery rate of 200 Kohm/sec; the maximum peak voltage is 150 v. At 40°C the CdS cell dissipates 200 milliwatts.

This system has been used successfully in an experiment that made reinforcement or timeout contingent on the subject's choice of key. The CdS cells controlled standard commercial (Grason-Stadler) automatic apparatus (operating at 28 v). The present system eliminates the need for stepping switches, tape programmers, and major modifications of the slide projector. The only alteration in the projector is the use of a remote relay in the projection lamp circuit so that the lamp may be turned off without the use of a mechanical shutter. The remote switch on the projector, which moves the carousel to the next position, is modified so that it may be operated by relay.

Color stimuli slides, which are constructed by using several layers of equal density filters (Eastman-Kodak), have been used. Small color squares are taped in place over each stimulus element as required; for a black key or an unlit CdS cell, opaque tape is used over the appropriate element on the slide matrix. Shapes may be used as stimuli by drawing the desired form on an enlarged matrix and reducing the frame size photographically; it may also be convenient to produce color stimuli by a similar process. Color slides have been recently constructed by photographing an enlarged matrix with equal density color filters in place over the stimulus elements. The matrix was transilluminated and photographed and then reduced to the desired slide size. The position of the filters was varied as required for each slide.

The successful operation of this system depends on the alignment of the stimulus and scheduling elements

on the slide with respect to the keys and CdS cells on the response panel. Alignment is fairly easy to obtain when the topography of the matrix coincides with the features on the rear of the response panel; this can be accomplished with elementary drafting techniques. The platform holding the projector must be level, and the projector accurately centered for successful alignment (Fig. 2). The CdS cells in the present application do not seem to require an extraordinarily precise alignment procedure. They function adequately if the entire photosensitive surface is illuminated by direct, unfiltered light. The distance between CdS cells and projector lens used in the present application was 65 cm. This distance was determined by trial and error, and was the minimum distance (for maximum brightness) at which a matrix, with all elements open, accurately illuminated each stimulus and scheduling surface on the rear of the response panel. The projector lamp was a General-Electric 500-w, 120-v 200-hr projection lamp (type DAH). At 65 cm there was no overlap of projected circles of light.

The cost of scheduling the stimulus-response contingencies in the present system is limited to the cost of slide frames and a large number of matrixes (which may be conveniently reproduced from a 35-mm frame) and the CdS cells, which cost about \$1.00 each. The present system has been in use for several months without failure. The projector bulb life expectancy may be of some concern in view of its frequent firings, but it is routinely replaced after about 100 hr of use (for a 200-hr rated bulb); the CdS cells have been found to be completely reliable in all aspects. The system has been used in scheduling simultaneous discrimination problems, where subjects are trained in two prob-

Fig. 2. The Carousel projector in place relative to the rear of the response panel. The projector rests on an adjustable platform; its lens is inserted in a light shield to prevent extraneous light from entering the system.

lems each with unequal amounts of training (as in Biederman, 1968) using two of the 12 keys, in scheduling standard successive discrimination using one key, in a free-responding situation, and in a stimulus matching procedure using 12 keys.

The present system might have accomplished the same ends with fewer CdS cells (four is the logical minimum in a 12-key apparatus) and logic circuits similar to Maez *et al.* (1968), but the cost of adding logic circuitry far outweighs the cost of additional CdS cells.

It is interesting to consider using this system as an economical general device that may serve in scheduling complex contingencies in areas other than visual discrimination. A Carousel projector can be used in combination with a bank of CdS cells to schedule complex contingencies; this system, which is extremely economical and easy to construct, may replace costly tape programmers, random access projectors, and large

stepping switch-relay circuits. The system is limited only by the number of slides that a given carousel can hold (80), but a projector might be used to display a roll of film, one frame at a time, avoiding the limitation imposed by the capacity of the carousel.

REFERENCES

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