AN INEXPENSIVE AUTOMATICALLY-PROGRAMMED MONOCHROMATOR¹

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Many recent studies of stimulus control have made use of a stimulus-presenting system which transilluminates a response key with narrow-band monochromatic light. This is usually done by passing white light through either a monochromator or a single-valued interference filter. The monochromator is more versatile than a set of individual filters because it allows the experimenter to select from a continuous set of stimuli and is easier to program automatically for instantaneous changes of wavelength. Quality commercial monochromators are not practical for most purposes because of their relatively high price (greater than \$1000 before automatic programming) and also because their light intensity is generally too weak. The monochromator described below has eliminated both of these problems. Any one of a set of 15 high-intensity, narrow-band monochromatic stimuli can be instantaneously projected onto a translucent response key. The parts for this device cost approximately \$400. In almost two years of continuous operation it has not malfunctioned.

Figure 1 shows a schematic diagram of the monochromator. White light is passed through a continuous interference filter (1) which is supported by a metal frame (2). The filter (Schott type Veril S-200) costs \$178. The manufacturer's specification showed that the wavelength of the light transmitted at a given point is a linear function of distance along the filter. This function has been confirmed by a calibration made with the aid of a Bausch and Lomb spectrometer. The specifications also state that the average half-width of light transmitted by the filter is approximately 12 m μ and that the average transmission is approximately 30% (range: 26-33.5%).

The bottom side of the filter frame consists of a row of teeth which is engaged with a gear (4) that can be turned by either a two-way 28 v dc stepping motor (3) (Nortronics part #514910-3; available as new surplus from Herbach and Raderman for \$10.95) or by a knob (5). A pointer (6), that is rigidly attached to the frame of the filter, indicates the distance between the end of the filter and the point at which a narrow light beam passes through the filter.

White light is provided by a 25 w Sylvania Xenon Arc Lamp (10) which contains a point source (7)². This lamp is also available in other wattages ranging from 10-300 w. Sylvania's specifications state that a 25-w lamp has a life expectancy of 600 hr. Experience has shown that a bulb used continuously 10 hr a day, seven days per week, begins to dim noticeably after approximately 400 hr. The manufacturer's specifications also showed that the energy output of the lamp was essentially constant across the visible spectrum. At each wattage the lamp is available with an optically flat glass surface through which the light is directed. Another optional feature that is useful where accurate positioning is required is a precision-made brass base which has both a tapped hole for a set screw (8) and a flattened edge (not shown). Ventilating holes (9) in the tube surrounding the lamp were sufficient to prevent overheating.

A point of light is focused onto the back surface of the interference filter by a convex lens (11). Two razor blades, 3 mm apart, adjacent to the opposite surface of the filter, provide a slit (not shown) through which the light emerges from the filter. This slit insures that the half-width of the transmitted light is

¹This work was supported by USPHS Grant HD-00930 and NSF Grant GB-1629.

²A G.E. ribbon filament microscope illuminator bulb, suggested by Donald Blough (personal communication), might prove to be a brighter and less expensive source of light.

Fig. 1. Schematic diagram of automatically-programmed monochromator.

no greater than $15 \text{ m}\mu$. The light is next collimated by a second convex lens (12) and passed through a filter box (13), in which neutral density filters and an aperture stop may be inserted, and finally through an electrically operated shutter (14) onto the back surface of a translucent pigeon key.

The task of presenting monochromatic stimuli that were equally bright according to Blough's (1957) photopic visibility function for the pigeon was accomplished by juxtaposing a variable neutral-density filter with the interference filter inside the frame (2) of the interference filter. The variable neutral-density filter was a custom-made Kodak gelatin step-filter (cost, approximately \$130) within which the density value could be changed every 5 mm. Since the gear ratio used dictated that the distance between each stimulus was at least 5 mm, it was possible to produce monochromatic stimuli of homogeneous density despite discontinuous changes in density

within the neutral-density filter. Any problems that stem from these abrupt changes in density could be easily eliminated with a monochromator that used a circular continuous interference filter (e.g., Barr and Stroud, 6" diameter model, cost \$185) in conjunction with an independently programmed circular neutral-density wedge (e.g., Kodak 0.0-2.0 log unit, 6" diameter model, cost \$190). This design, which is similar to the linear device described above, has the additional advantage of compactness. Either model can be built by a competent shopman in approximately one week. Estimates for the construction of either type monochromator may be obtained from Mr. R. Brenner, Department of Psychology, Columbia University, New York, N.Y. 10027.

REFERENCE

- Blough, D. S. Spectral sensitivity in the pigeon. *J. opt. soc. Amer.*, 1957, 47, 827-833.