TECHNICAL NOTE

COLOR MIXING WITH KODAK WRATTEN FILTERS

The Industrial Electronics Engineers (I.E.E.) display cell (model E 4580 #164) contains, among other things, five different Kodak Wratten Filters (numbers 65, 74, 99, 73, and 72 B). When illuminated by a standard tungsten illuminant (illuminant A, with a color temperature of 2848K) these filters have dominant wavelengths of 501, 538, 555, 576, and 606 nm respectively. This paper describes a procedure by which pairs of these filters can be combined to produce a third stimulus with a peak wavelength approximately midway between the pair. Because the light source in the I.E.E. cell is not identical with illuminant A, it is not possible to specify exactly the spectral composition of light from these filters either individually or in pairs. But, as an approximation, the values given here are based on illuminant A, and it must be understood that the use of another tungsten light source would produce somewhat different values. With these limitations, the spectral peak for combining filters 65 and 74 was found to be 517 nm. This value was obtained by the standard methods for combining wavelengths with the 1931 C.I.E. chromaticity curve.¹ According to this procedure, the combinations of the peak wavelengths of the individual filters were read. Although this curve is based on human psychophysical data, the similarity of the pigeon color vision to that of the human (Blough, 1957) permits this technique, at least as an approximation.

Within these limitations on the actual values, the results of combining pairs of individual filters produces the following peak values: 65 and 74 yield 517 nm; 74 and 99 yield 549 nm; 99 and 73 yield 559 nm; and 73 and 72 B yield 587 nm. The determination of these peak wavelengths takes into account any differences in the per cent luminance transmittance characteristics of the filters.

¹Cell colorimetric specifications are based on 1931 standard CIE colorimetric and luminosity data.

Pigeons given a standard generalization test involving these wavelength stimuli, *i.e.*, the five produced by the filters and the four produced by combining the pairs, responded as if the stimuli lay along an ordinal scale. For example, pigeons tested for generalization to the nine wavelengths, following single-stimulus training to 555 nm, produced generalization gradients with a single peak at the 555-nm stimulus. Discrimination training between stimuli with peaks at 555 nm (S+) and either at 549 or 559 nm (S-) resulted in a "peak-shift" in a post-discrimination generalization test involving the nine wavelengths. The pigeons did not seem to be affected by intensity differences among the stimuli but, rather, seemed to respond on the basis of wavelength.

Thus, combining the Wratten Filters in the manner described is an effective way of increasing the number of wavelength stimuli available from the I.E.E., display cells, model E4580 #164. Using the filters and their combinations for generalization testing seems to produce data comparable to that obtained from generalization testing with wavelength stimuli produced by other sources. However, since it is difficult to identify precisely the wavelength stimuli when the filters and their combinations are used, or the effects of wide-band stimulation, we do not recommend their use when other narrower-band sources of wavelength stimuli are available. But, in the absence of such light sources, the filters and their combinations may be used to provide an approximation of the shape of the generalization gradient that would be produced by wavelength stimuli from a narrow-band light source.

REFERENCES

- Blough, D. S. Spectral sensitivity in the pigeon. *Journal of the Optical Society of America*, 1957, 47, 827-833.

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