COLOR PERIMETRY

john p. hemming

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Our present method of color perimetry is definitely not worth the effort envolved except in special circumstances. The most usefull colors are red and blue, noting chromatic endpoints in conditions such as tobacco amblyopia, minute foveal lesions, optic nerve disease, and suprachiasmal and infrachiasmal lesions. Patients with disease of the temporal, parietal and occipital lobes cause defects in acquired knowledge. These patients will have impaired ability to identify colors. It may be that substituting colored for white test objects is simply a way of reducing the strength of the stimulus.[1]

Color perimetry has been around for a long time although it is lacking in standardization and development. Research was published as far back as 1923 when Ferree and Rand wrote on the effect of the intensity of a stimulus on the size and shape of color fields. They ranked the colors as to the breadth of their illicited field.[2] Quantitative studies followed, comparing achromatic and color sensitivities.[3] Diagnostic value was recognized in neurosurgery by Alexander in 1956.[4] Applications are being published yearly by Verriest, Lakowski and many others. The basis for why color perimetry might be a meaningful diagnostic tool begins with the photoreceptors of the retina.

There are two sharply distinguished classes of photoreceptors.[5] Retinal regions are functionally

specialized by the distribution of rods and cones. Regions organized for detecting gross form and movement contain mostly rods. These areas collectivly are called the peripheral retina. The regions biased for inspecting detail are richer in cones. These regions make up the central retina. Colors are recognized in the central retinal cones. This central area tends to be free of major retinal blood vessels. The extent of the cone rich area is about one centimeter in diameter. The central fovea, containing only cones, occupies a region of only 54 minutes of arc. The fovea itself occupies five degrees of arc. Outside of the central fovea, the cone concentration falls from about 150,000 cones per square millimeter to some 4000 to 5000 cones per square millimeter across the entire retina. In perimetry, as the field size increases, the effective optical density of the cone visual pigments decreases exponentially.[6] Of the three types of cone pigments, the central fovea may be deficient of cones with a peak absorption in the blue.[5] In photopic conditions, the spectral sensitivity to short (blue) wavelengths increases from the fovea to ten degrees peripherally. Beyond ten degrees, there is no change in the sensitivity. This contradicts the Stiles two-color threshold for the red and green system. Their sensitivity continues to decrease in the periphery. The answer lies in the non-opponent system of short wavelength detection. If we did not bleach the rod system first, the detection

would be set up as a blue-yellow opponent system, following the Stiles threshold.[7] Apart from this, there is little information on the distribution of cone varieties in the retina. Excluding the central foveal 1/8 degree area of the retina, the trichromatic vision extends some 20 to 30 degrees. Outside of this area, although cones are still found, color sense is lost. Rods play a small part in color vision. Color coded cells in the visual system receive input from rods as well as cones. Color contrast isseen in images that stimulate only rods and red cone receptors. These are at mesopic levels outside the fovea. It is nudetermined what effect the rods have and how much of the retina is "tetrachromatic".[5]

The trichromatic theory of color vision was found in research by Maione[8] and others to exist in the periphery of the fundus as far as 80 degrees. This suggests that color perimetry should be useful beyond just a central tangent screen. Why then is there a history of poor application for color perimetry?[9] Physical definitions of colored stimuli and surrounds have been poor. Since the stimulus now differs from the background not only in brightness but in color, the chromatic element must be named. This leaves uncertainties in the psychophysical nature of each patient.

Color filters on perimeters have not been standardized, some giving a much broader spectral band.

In normal color fields, each color target gives two potential endpoints. The achromatic endpoint is when the patient first recognises the presence of a light. The chromatic endpoint is when the patient can name the color of the stimulus.[10] Under photopic conditions color perimetry can be directly equated to achromatic targets.[11] A central blue scotoma can be found. This may be due to a lack of blue photoreceptors or partially due to experimental design. If the blue cones have a different neural-retinal hookup, for a low luminance blue, a larger target is needed. This is an indication of summation occurring between the blue cones to illicit an excitatory responce. Carlow[10] found support for Traquair's theory of equal color isopters but only if the hue, saturation and intensity are all equated. There must be a definition of equal energy as well as equal brightness, saturation and hue when we are finding a normal color isopter. Again, more standardization is needed. In general blue and red have larger isopters than green and yellow.[9] Verriest and Israel equating brightness, found the red isopter the smallest.[10] With constant luminosity, the Committee on Colorimetry of the Optical Society of America found a decrease in isopter size from yellow or blue to red to green.

Wentworth, using equal energy stimuli, found the blue isopter different from the committee's by being a little smaller than that of red. In the periphery, he found a need to raise the stimulus energy for all wavelengths. In studies by Carlow,[10] the isopters were different from those found previously using equal luminosity and energy. He also found the achromatic threshold to be smaller than the rest with the red target. Carlow related the decreased red achromatic isopter to a decrease in the energy per quanta as the wavelength increases and to the peripheral retina being relatively protanopic. He related a decrease of the yellow chromatic isopter in equal luminosity to a desaturation effect due to background luminance. Yellow is closest to white physiologically, making it's desaturation greater on a psychophysical basis than other colors. The decrease of the red isopter for equal energy conditions was given to a greater energy requirement to stimulate the retina with longer wavelengths.

Lakowski, in 1977,[11] using a Goldman perimeter with high luminance chromatic targets, found the red threshold equal to an achromatic isopter. The green threshold was lower. He found a blue central scotoma. The threshold profiles did not deviate greatly from achromatic targets under maximum luminance conditions. Under the same photopic conditions, Lunel and Crone[12] found an increase in blue

sensitivity and a decrease in red when eccentricity across the retina increased. They attributed this blue phenomonon to characteristics of the blue peripheral cones or to a residual rod effect during photopic conditions. As one might expect, Maione[8] and others found decreased color sensitivity with increased age.

These "normal" isopter studies are inconsistent because of several factors. Everyone's technique for field study is different. There are differences of instrumentation, lighting, presentation, and filters. Subjects themselves vary greatly in ability to discriminate. Equating the colors to brightness or energy actually changes the stimuli for various testing conditions. With this in mind, results for the various applications for color perimetry to be used in a clinical setting may vary from scientific study. In general, it is usually believed that the blue isopter is the largest and has a central scotoma, followed by red and green.[1] Some recommendations for application and instrumentation set up can be made. Your perimeter must be standardized with your patients in your office conditions. For progression of disease or for acquired color deficiencies, color threshold should be used.[13] Different colored targets that are equally bright can be used for detection of subtle peripheral and central defects. Yellow is used in the central area, red in the midzone and blue in the periphery.[10] Lunel and Crone[9] feel exact

color perimetry needs the following:1)High photopic intensity; 2)Color definitions from monochromatic or interference filters;3)The stimulus should equal the surround in subjective brightness, keeping in mind these change at different retinal loci;4)Use static perimetry varying the color purity from 0 to 100 percent. Compare this figure to white(zero purity). The use for color perimetry extends not only for problems of the retina,but for systemic conditions that manifest anomalies of the visual system.

Anomalies of the macula should be good candidates for a color field study. The pigmentary retinopathies will show a decreased blue sensitivity. A generalized decrease in the color fields is seen in juvenile macular degeneration and progressive cone dystrophies.[14] For macular oedema, including central serous retinopathy, a blue target on a yellow background will give the greatest decrease in blue sensitivity.[13] Unfortunately, Maione[8] found no selective impairment in central serous retinopathies. This indicates if differences are found in experimental date, they will surely be found in clinical settings.

Changes in color vision will obviously be pronounced in a color field study. Using achromatic isopters,[15]there is a large decrease for blue in the aged. Red isopters may not correlate with the blue.With adaptation to blue, the isopter increases in normals but does not change in retrobulbar neuritis. This is attributed to a lack of contrast

perception. Blue can be used to analyze the ocular media. Green can be used instead of white for a general light sense. Color fields are good for finding decreased cone function. If there is symptomatic decreased visual acuity in bright surrounds, test the red and blue targets on a grey background under bright illumination.[16] These cases occur very infrequently. In congenital protanopia, the red threshold is poor, but is better than expected for blue. AS expected there is a decrease in the green fields for deuteranopia, and blue in tritanopia.[11]

Color fields are affected in lesions of the optic nerve and brain. Optic neuritis will yield decreased sensitivity to all isopters.[8] Verriest[14] found enhenced blue for optic nerve diseases. Red and green seem most sensitive in early diagnosis and permanant damage of involved areas of the optic nerve by relative central scotmas or sectoral defects.[17] In homonymous field defects, vascular brain lesions decrease the red and green fields. Lesions post-chiasmal have less an effect on color fields. Tumors usually do not affect the color fields of homonymous related lesions.[18]

The widespread use recently of ovulation inhibitors (the pill) has stimulated research in all areas for side effects. Toxicity may vary with the actual composition of the pill. The possibility of toxicity increases with prolonged use up to fifty percent for five years of administration.[20] An early sign of ocular toxicity is a defect in the blue visual field.[19] This may be an early indicator for sig-

nificant systemic side effects to follow.

Central visual field defects are exagerated with colored stimuli in some cases of amblyopia. IN strabismic amblyopia, a central scotoma is enhanced with blue or yellow light. The luminous efficiency of an amblyopic eye is slightly depressed for longer wavelengths.[21] With tobacco and alcohol amblyopia, the centrocecal scotoma for a red stimulus is exagerated.[22] It may become so large that it breaks through into the peripheral field and so broad vertically that it may simulate a bitemporal hemianopsia.[1]

Patients with early diabetic retinopathy without any other congenital anomalies may show a color field loss. Both eyes would have similar lesions although non-specific. In aproximately 45 percent of the cases there will be a red depression. There could be some decrease of the green of blue sensitivity.[23]

Some field chages may also be manifest with early Glaucoma, although Maione[8] found no selective impairment. As early as the diagnosis may be ocular hypertension a defect may be picked up with a blue or yellow light.[24] With an acute attack with or without optic atrophy a blue defect is illicited.[25] A similar defect may be picked up with open angle glaucoma.[24] Why are the defects so sensitive to blue? Damaged rod function in glaucoma affects the blue sensitivity. This helps access difference between the eyes.[26] The paracentral scotomas also have a greater

retrograde degeneration of the blue cell complexes.[27]

In summary, color perimetry can be useful. Standardization of technique, along with physical and psychophysical conditions must be made. For a given instrument, many normals should be run to standardize what the normal isopters are for the instrument and technique. These may not conform to the experimental averages found in Harrington.[1] Those numbers are not published here because they are unimportant when comparing to an individual instrument and technique. Color fields can aid diagnosis and progression of a number of ocular conditions to include macular diseases, nerve and brain lesions, color abnormalities, drug toxicity, glaucoma and a host of others not mentioned. It seems color perimetry has the most to offer in early diagnosis and progression of macular diseases, drug toxicity and glaucoma. Color perimetry can be more sensitive than combining achromatic static perimetry, visual acuity and color vision testing.[14]

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