

# Looking for potential indicators of human tetrachromacy

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Cases of human tetrachromacy are those in which two variants of either the L or M cone, differing in spectral sensitivity, are present in the subject's retina. Due to the sex-linked inheritance of the L and M photopigments, this condition occurs in women only. Given the frequency of certain photopigment allele variants and their corresponding sensitivity profiles, red tetrachromacy appears to be more frequent than green tetrachromacy (Jameson et al., forthcoming). Another suggested difference is between weak vs. strong tetrachromacy depending on whether the responses of the two variants of the L (or M) photopigment are differentially processed by the nervous system (Jordan and Mollon, 1993; Nagy et al., 1981).

We are currently testing a combination of three different methods for its capacity to separate potential tetrachromatic subjects from trichromats. The methods are the following.

(1) Discrimination of wavelengths over 700 nm. Looking into an aperture, subjects are shown a circular field the left and right halves of which comprise two such wavelengths (we used 700, 720, 730, 740, and 750 nm interference filters). The task was to achieve a match by adjusting the intensities of the two sides, or indicating refusal. Subjects did 12 different trials two of which involved identical wavelengths on the two sides to control for false alarms.

(2) Spectrum delineation. This task was originally devised and used by Jameson et al (2000). Subjects saw a picture of the spectrum, in our case brought about by a projection of a linear interference filter on a sheet of tracing paper. Their task was to mark with a pencil the borders of all the different color bands seen within the spectrum.

(3) The FM hue test was administered three times for each subject with about 40 minutes passing between subsequent testings.

(4) The Welhagen-Broschmann isochromatic plates were also given to the subjects to check for color deficiency. Only subjects who performed normally on this test were included in the study.

## **Expectations.**

(1) Our main question is whether there is any systematic difference in discrimination pattern between a subgroup of women heterozygous for color deficiency (those heterozygotes who, according to other measures, have better-than-average color vision), and trichromats with no indication of heterozygosity.

(2) Jameson et al (2000) found that as a group, women heterozygous for color deficiency delineated a significantly greater number of bands than females and male controls.

(3) There have been hints in the literature (Jordan and Mollon, 1993; Jameson et al., 2000) that some heterozygous women who have better-than-average color vision show a worse-than-average performance on the FM test (and in some cases on isochromatic plates as well). We hypothesized that (i) genuine color deficiency or poor color discrimination results in errors that, although tend to occur in the same critical ranges in subsequent testings, will be largely random regarding the particular ordering of caps. However, (ii) if some heterozygous subjects exhibit more correlated erroneous orderings in subsequent testings, that may indicate that they see a slightly non-standard order among the FM colors.

## **Results.**

So far we have examined a control group (18 university students, 13 females, 5 males). Data collection and analysis of carriers of color deficiency is currently in progress.

### LW discrimination:

Subjects made discriminations in a rather consistent way. For our subjects examined so far, 740 nm differed in hue from most or all other wavelengths used. All other wavelengths could be matched with one another by adjusting intensities. Individual differences are found in terms of how many other wavelengths 740 nm was discriminated from. We made the same observation in an earlier pilot study using a similar method (Jakab and Wenzel, 2004). For an explanation of these findings we appeal to the phenomenon of Brindley's isochromes (Wyszecki and Stiles, 2000, p.424), and the possibility that M cones have a small secondary sensitivity peak beyond 700 nm. However, the exact pattern that we found cannot be understood based on these phenomena alone.

### Spectrum delineation:

(i) Number of bands delineated by the subjects was independent from FM performance; somewhat surprisingly, we did not find a negative correlation between total error score and number of bands delineated. (ii) The range of values is wider than Jameson et al. (2000) found. Number of bands indicated by our subjects varied between 5 and 22 (5 and 16 for Jameson et al., 2000). (iii) The number of bands delineated repeatedly by the same subject is fairly stable. (Each subject repeated delineation six times, the first three of them light adapted, the second three dark adapted.) However, the borders of individual bands vary substantially (presumably due to changes in adaptation). Naming the color bands at the time of drawing their borders did not influence performance (compared with a no-naming condition). Nor did light versus dark adaptation have a significant effect on the number of bands delineated.

Repeated FM tests: In our group examined so far we did find that erroneous orderings in subsequent FM tests are uncorrelated. We are currently collecting and analyzing data of heterozygotes for comparison.

## **References**

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