Spatial and Chromatic Properties of Negative Afterimages

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Introduction

Spatial, temporal and chromatic properties of retinal afterimages have serious influence on color perception. There is evidence that both photopigment bleaching and post-trichromatic processes contribute to afterimage effects[1]. However, measuring the aforementioned properties is a very delicate task, speaking of a dynamic effect, which is furthermore mostly superimposed on the inducing stimuli.

The present paper reports the first results of an experimental framework in which all three properties (spatial, temporal, and chromatic) can be investigated.

Method

Two experiments have been carried out regarding the spatial and chromatic properties of monochromatically induced negative afterimages. Monochromatic (or at least quasi-monochromatic) induction is a key concept because, beyond the obvious technical difficulties, it offers the possibility of investigating receptor-level mechanisms and action spectra.

The first experiment investigated the chromatic properties of negative afterimages with two methods. The first method was called “timed out matching” in which a monochromatic induction was followed by a limited-time interval-matching procedure. In this procedure, perceptual correlates (CIECAM02) were used to navigate to the matching color of an annular matching structure. The second method was a “blank rotation” method in which one of the multiple monochromatic inducers arranged on a circular path was cancelled – thus a “blank” inducer moved along a circular path – this way the afterimage was constantly present and could be matched with the aforementioned matching structure. In both cases, the task of the observer was to match the (CIECAM02) lightness, chroma and hue of the matching structure to the perceived sensation of the negative afterimage on white backgrounds. The apparatus consisted of a Xe arc lamp and a series of quasi-monochromatic metal interference filters of 10 nm bandwidth which provided the high-luminance monochromatic inducers; and a DLP projector which projected the matching structure. Three observers were included (one female, two males), between 23-26 years of age, all had good color vision tested by the F-M 100 Hue Test.

The second experiment investigated the spatial properties of monochromatically induced afterimages. Using the method of constant stimuli, the minimal contrast was determined at which exposing the retina with a Gabor-patch resulted in a perceivable negative afterimage, as a function of spatial frequency and conditioning wavelength. The task of the observer was to give positive or negative answer after the conditioning interval, if an afterimage had been seen. Observers were instructed to give a positive answer only in that case if a spatial structure of opposite phase had been seen. The apparatus consisted of a DLP projector filtered by quasi-monochromatic metal interference filters. The aforementioned two male observers were included.

Results and Discussion

Example results of the experiments are shown in Fig. 1. To the left, the result of the first method in the chromatic experiment is shown. Near the spectrum locus, the monochromatic inducers are shown, connected with the color coordinates of the samples matched with the afterimages. The closed black square shows the background white. In Fig. 1, to the right, an example of the spatial investigations is shown. Diamonds show the detection contrast sensitivity and squares show the afterimage contrast sensitivity (inverse of the minimal contrast that induced an afterimage), along with the 95 % confidence intervals. Detection contrast sensitivity was very roughly determined and thus it is depicted without confidence intervals.

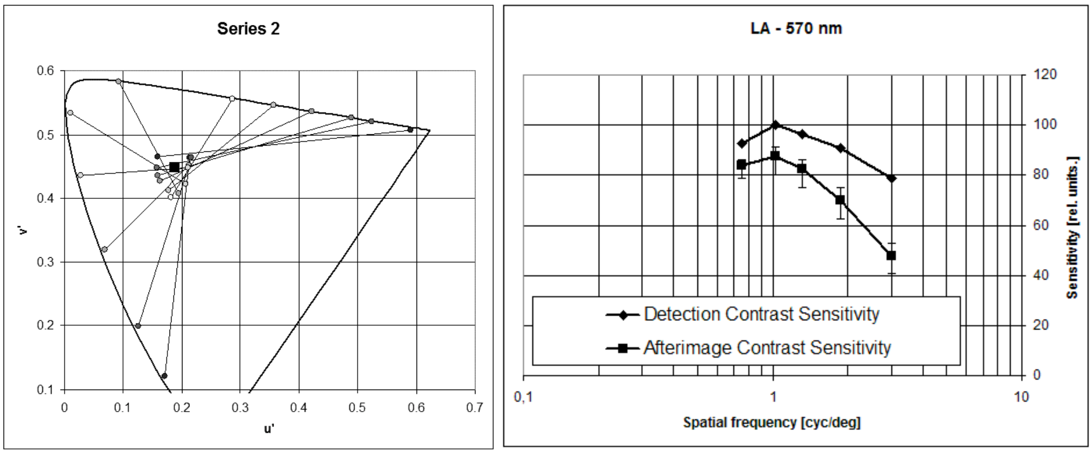

Fig. 1: Example Results of the Afterimage Experiments

These first results of our chromatic investigations show that the empirical statement of attributing an opposite hue to the afterimage can be confirmed, but it differs significantly from the 180 degree (CIECAM02) hue difference concept. In the second method (“blank rotation”), afterimages were matched with samples of higher chroma, compared to the first method (“timed out matching”). This finding may point toward a dynamic effect i.e. the time derivative of the amplitude of the inducer stimulus may be proportional to the chroma of the afterimage.

The results of the second experiment show that afterimage contrast sensitivity has a band-pass spatial frequency characteristics, with a peak frequency seemingly shifting towards higher spatial frequencies with the increase of the inducing wavelength, and, that the detection sensitivity and the afterimage sensitivity curves may join at lower spatial frequencies (possibly around 0.5 cyc/deg). Afterimage contrast sensitivity has a steeper breakdown in higher spatial frequency ranges than detection sensitivity. This may serve as an evidence for the larger receptive fields of the afterimage mechanism.

Conclusion

We described two experiments with an efficient apparatus to investigate the spatial and chromatic properties of negative afterimages. We intend to conduct further experiments on this complex dynamic phenomenon.

Reference

Anstis, S., Rogers, B., Henry, J. (1971). Interactions Between Simultaneous Contrast and Colored Afterimages. Vision Research. Vol. 18. 899-911.