Salience-Based Edge Selection in Flicker and Binocular Color Vision

Stuart Anstis and Grace Hong
Department of Psychology, University of California, San Diego

Alan Ho
Department of Psychology, Ambrose University, Calgary, Alberta, Canada

Abstract
A test cross that flickers between light yellow and dark blue at 5 to 8Hz looks apparently yellow on a dark gray surround and apparently blue on a light gray surround (flicker augmented contrast). The achromatic surround cannot be inducing the perceived colors. Instead, the visual system selects the more salient apparent color with the higher Michelson contrast. The same is true for dichoptic vision. When one eye views a steady, light yellow cross and the other eye views a congruent steady dark blue cross, the binocular combination of colors looks apparently yellow on a dark gray surround and apparently blue on a light gray surround. Thus, when competing stimuli are distributed over time (flicker) or space (dichoptic vision), the visual system overweights the stimulus with the higher contrast. To see objects clearly, we accept the best view of any object and downplay inferior alternatives.

Keywords
flicker, contrast, binocular, color

Date received: 31 March 2020; accepted: 3 May 2020

In simultaneous contrast (Heinemann, 1955), a gray test cross looks slightly darker when viewed against a white surround than against a black surround. We have previously reported a much stronger form of simultaneous contrast (Anstis & Ho, 1998): A cross that flickers between light yellow and dark blue at 5 to 8 Hz looks yellowish on a dark gray surround and...
bluish on a light gray surround. This is not caused by induction—an achromatic surround cannot induce colors (Anstis & Ho, 1998). Thus, when the cross alternates between a light and a dark hue, the visual system selects the more salient hue—the one with the higher Michelson contrast relative to the background (flicker-augmented contrast: Anstis, 2017; Anstis & Ho, 1998). In short, changing the surround luminance can completely change the appearance of a blue/yellow flickering cross.

We now extended our previous results by

1. *flickering* a dark blue/light yellow cross;
2. *binocular combination* of dichoptic crosses—one eye views a steady blue cross and the other eye views a congruent, steady yellow cross; and
3. *amalgamating* Conditions 1 and 2 by presenting a flickering blue/yellow cross to one eye and a yellow/blue cross, flickering in counterphase, to the other eye.

In all three conditions, the crosses were exposed on two different achromatic surrounds: a dark gray one, equiluminous with the dark blue cross, and light gray one, equiluminous with the light yellow cross. All three conditions can be demonstrated by viewing Movie 1 in three different ways:

1. *Flicker.* Run the movie. All crosses are flickering between identical blue and yellow. However, the upper crosses on the dark surround look light yellow, and the lower crosses on the light surround look dark blue (flicker augmented contrast).
2. *Dichoptic viewing.* Stop the movie and view the steady yellow crosses with one eye and the steady blue crosses with the other eye (cross your eyes to free fuse them). Result: The
upper, binocularly combined cross on the dark surround looks light yellow, and the lower cross on the light surround looks dark blue.

3. **Amalgamation of 1 and 2.** Run the movie so that it flickers as in 1. Free-fuse by crossing your eyes as in 2. The flicker is in opposite phase in the two eyes, but the observer is not aware of this. Instead, as before, the upper cross looks yellow and the lower cross looks blue. This impression is if anything more stable than in 2.

We measured the perceived colors in Conditions 1 and 2. The two colors were always given different Michelson contrasts, but to reduce binocular rivalry (Alais & Blake, 2004), we never showed a spatial increment to one eye and a spatial decrement to the other.

Observers moved a mouse to adjust a colored bar, seen by both eyes, so that it varied between (say) dark blue through gray to light yellow. They adjusted this bar to give a best color match to the flickering or binocularly combined crosses. Three different color pairs were used, namely, dark blue versus light yellow (shown here), dark magenta versus light green, and dark red versus light cyan. Stimuli were generated in Adobe Director on a Macbook laptop computer and calibrated with a Minolta Chromameter II. Figure 1 shows the results.

In Movie 2, the entire grid flickers uniformly between green and magenta. The upper flickering background is black while the grid is magenta and equiluminous gray while it is
green. So the magenta is higher in contrast than the green and the grid looks magenta. In the lower half, the opposite is true, so the grid looks green.

Not all dichoptic stimuli are like these. An orange and a lime disk, presented one to each eye, can combine into a single average yellow (Anstis & Rogers, 2012).

Comparable to our reports of monocular flicker versus binocular fusion, published reports describe two separate mechanisms that respond to (a) luminance versus contrast (Flynn & Shapiro, 2013), (b) monocular versus cyclopean brightness induction (Shevell et al., 1992), and (c) spatial integration at low color contrast versus edge responses at high color contrast (Shapley et al., 2019)

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: S. A. was supported by a grant from the University of California, San Diego Pathways to Retirement. A. H. was supported by a professional development fund from the Ambrose University in Calgary, Alberta, Canada.
References

Alais, D., & Blake, R. (Eds.). (2004). *Binocular rivalry*. MIT Press.

Anstis, S. (2017). Negative afterimages from flicker-augmented colors. *i-Perception, 8*(2), 1–3. https://doi.org/10.1177/2041669517699414

Anstis, S., & Ho, W. A. (1998). Nonlinear combination of luminance excursions during flicker, simultaneous contrast, afterimages and binocular fusion. *Vision Research, 38*, 523–539.

Anstis, S., & Rogers, B. (2012). Binocular fusion of luminance, color, motion and flicker–two eyes are worse than one. *Vision Research, 53*, 47–53. https://doi.org/10.1016/j.visres.2011.11.005

Flynn, O. J., & Shapiro, A. G. (2013). The separation of monocular and binocular contrast. *Vision Research, 18*, 19–28. https://doi.org/10.1016/j.visres.2013.10.006

Heinemann, E. G. (1955). Simultaneous brightness induction as a function of inducing- and test-field luminances. *Journal of Experimental Psychology, 50*(2), 89–96. https://doi.org/10.1037/h0040919

Shapley, R., Nunez, V., & Gordon, J. (2019). Cortical double-opponent cells and human color perception. *Current Opinion in Behavioral Sciences, 30*, 1. https://doi.org/10.1016/j.cobeha.2019.04.001

Shevell, S. K., Holliday, I., & Whittle, P. (1992). Two separate neural mechanisms of brightness induction. *Vision Research, 32*, 2331–2340. https://doi.org/10.1016/0042-6989(92)90096-2

How to cite this article

Anstis, S., Hong, G., & Ho, A. (2020). Salience-based edge selection in flicker and binocular color vision. *i-Perception, 11*(3), 1–5. https://doi.org/10.1177/2041669520929047