



**Bevil Conway**  
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As an aspiring brain scientist, my project was to discover the brain implementation of Opponent Colors Theory, the accepted explanation of color appearance. It took 20 yrs of trying (& failing) to find the corresponding neurophysiology, to realize the theory is wrong #color 1/8



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Color appearance and the end of Hering's Opponent-Colors Theory

OPINION by Bevil Conway, Saima Malik-Moraleda, & Edward Gibson,  
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**Trends in  
Cognitive Sciences**



Opinion

# Color appearance and the end of Hering's Opponent-Colors Theory

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Hering's Opponent-Colors Theory has been central to understanding color appearance for 150 years. It aims to explain the phenomenology of colors with two linked propositions. First, a psychological hypothesis stipulates that any color is described necessarily and sufficiently by the extent to which it appears reddish-versus-greenish, bluish-versus-yellowish, and blackish-versus-whitish. Second, a physiological hypothesis stipulates that these perceptual mechanisms are encoded by three innate brain mechanisms. We review the evidence and conclude that neither side of the linking proposition is accurate: the theory is wrong. We sketch out an alternative, Utility-Based Coding, by which the known retinal cone-opponent mechanisms represent optimal encoding of spectral information given competing selective pressure to extract high-acuity spatial information; and phenomenological color categories represent an adaptive, efficient, output of the brain governed by behavioral demands.

### Highlights

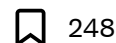
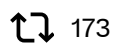
The essay reviews the psychological and physiological evidence for Opponent-Colors Theory and concludes the theory is wrong.

Behavioral work shows that the theory's three appearance mechanisms (red-versus-green, blue-versus-yellow, and black-versus-white) are not necessary to describe color.

Physiological work shows that neural color-encoding mechanisms are not characterized by tuning to the opponent colors of the theory. Contrary to Opponent-Colors Theory, the color-

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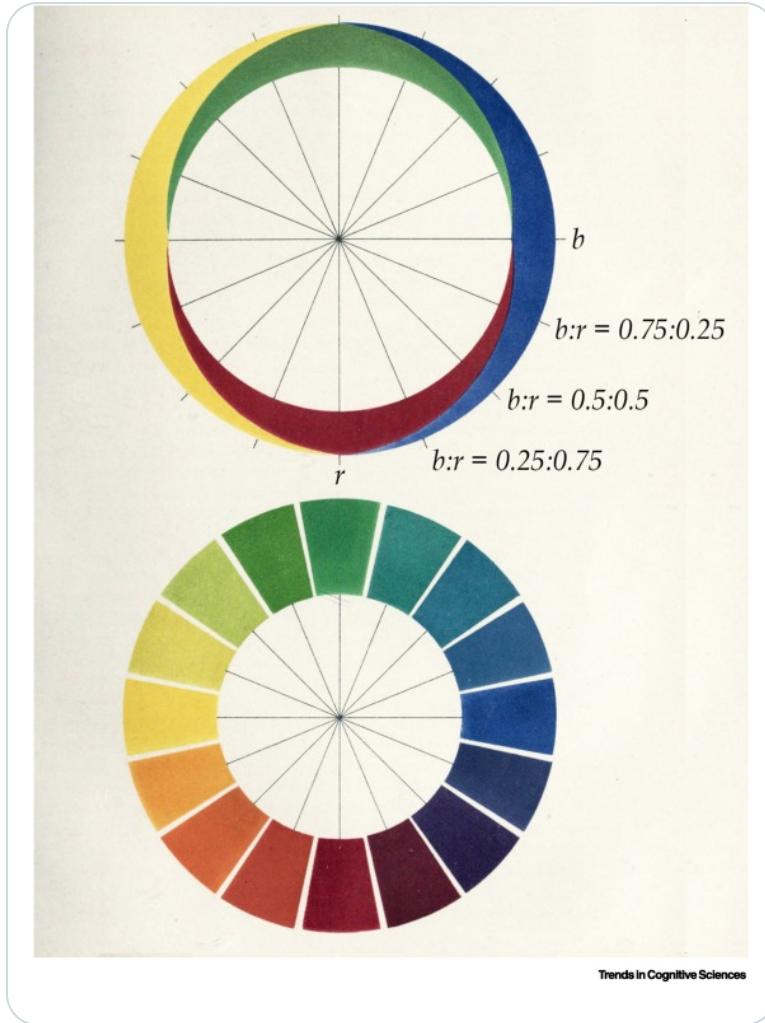




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What is OCT? It's the 19th c. idea that (1) color is necessarily and sufficiently described by red-vs-green, blue-vs-yellow, and black-vs-white; and (2) these perceptual mechanisms are implemented by three discrete innate physiological processes in the retina (or brain) 2/8



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But both the psychological & the physiological parts of the theory are now proven to be wrong! Jenny Bosten's group showed that colors can be perfectly well described with "elementary" colors purple, orange, lime, and teal (not R, G, B, Y) 3/8

[opg.optica.org/josaa/fulltext...](http://opg.optica.org/josaa/fulltext...)

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And copious physiological work shows that retinal opponent mechanisms do NOT correspond to the colors of Opponent Colors Theory. In fact, the visual system seems set up to overwrite any privilege of the colors associated with the color-opponent mechanisms in the visual system 4/8

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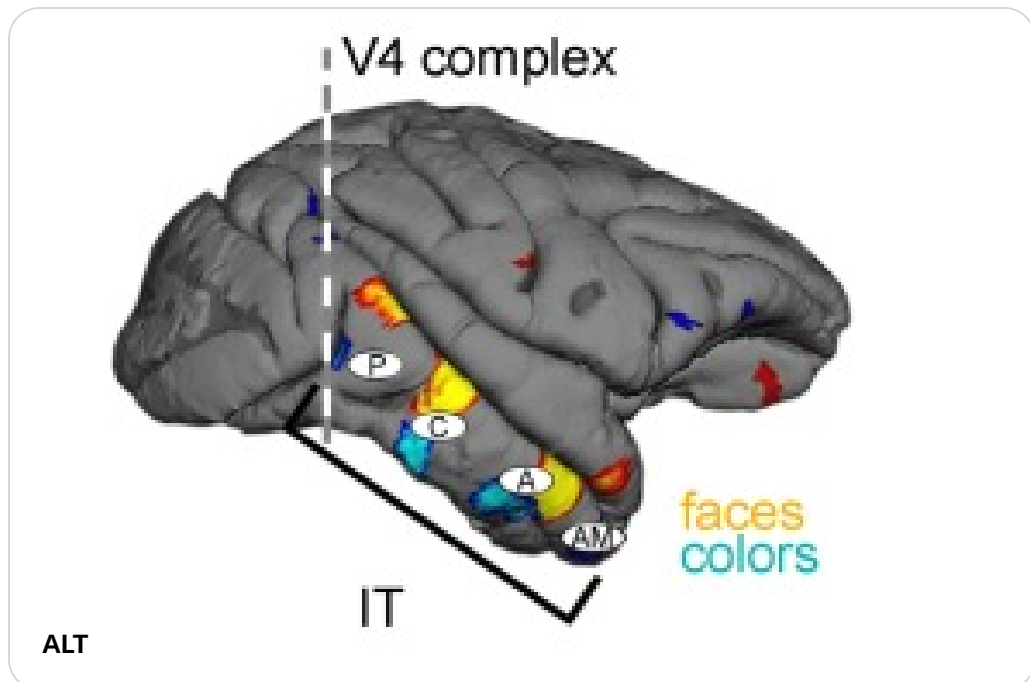
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There is surprisingly vast cerebral real estate implicated in color, about as much tissue as is involved in face perception. Color appearance is not accomplished with as simple a mechanism as called for by Opponent Colors Theory. 5/8



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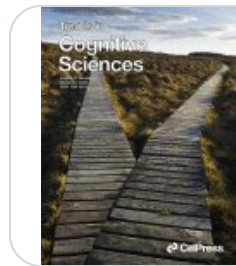




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It's one thing to show a theory is wrong, & quite another to toss it out for doing so requires a replacement. @LanguageMIT, @saima\_mm & I sketch out such a replacement, Utility-Based Coding (thx to @nogazaslavsky for suggesting the name) 6/8



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we are grateful to many people for feedback on this essay, including @anya\_hurlbert and many others not on twitter, five reviewers and a patient editor, and Will Tuten for the quote from Rushton in the acknowledgements... 7/8



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Ruston wrote, "The general emotional attitude in colour vision is similar to that often seen in politics and religion". But like Ruston, we assert that our 'own views, of course, are both moderate and reasonable – but so say all extremists. You must be the judge'. 8/8



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