Dynamic Color Perception: How Fast are the Munsell Hues?

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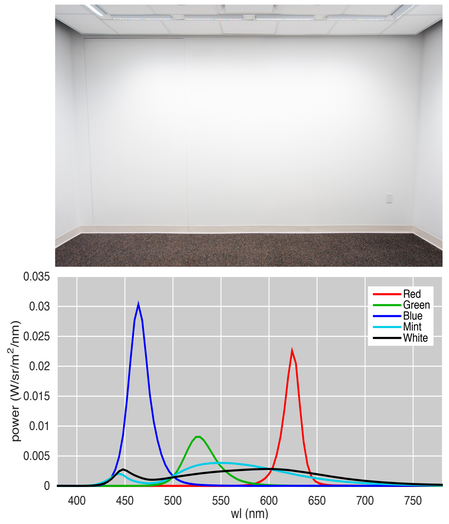
Summary

Can you describe the speed of a gradually-changing color transition in CIELAB ΔE_{ab}^* per second?

We conducted an experiment with LED illumination in which we compared the perceived speeds of dynamic color transitions in CIELAB *chroma* and *hue* directions, and between *hue* changes in centered at the five principle Munsell hues: 5R, 5Y, 5G, 5B, & 5P.

Dynamic Visual Adaptation Lab

The DVA Lab at RIT fills the observers' field of view with computer-controlled 5-channel LED lighting.



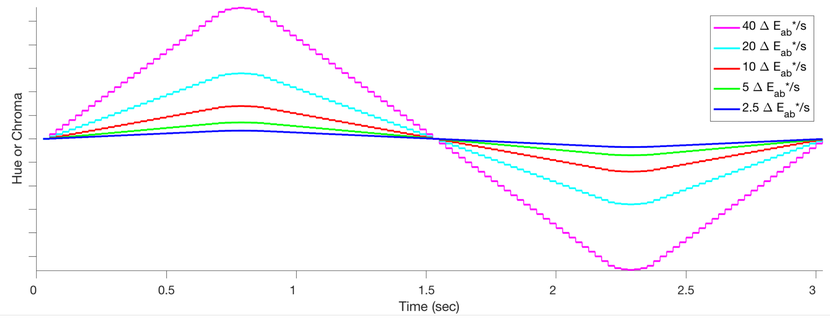
More information about the spectral and temporal capabilities of the DVA Lab can be found in:
M. J. Murdoch, Characterization and control of a multi-primary LED light lab, *Optics Express* 25(24), 2017.

Acknowledgements

Philips Lighting provided the Philips Color Kinetics SkyRibbon LED light fixtures used in the DVA Lab.
X. Kong's work was supported by the China Scholarship Council (201506950017) and Wuhan University of Technology (104971140150).

Dynamic Color Stimuli

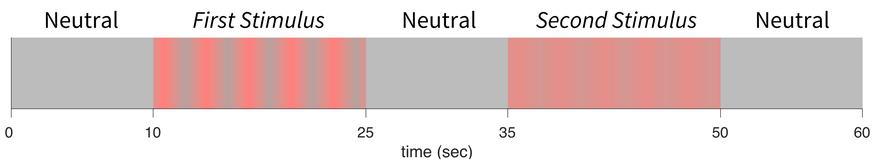
Periodic color transitions were generated, following softened triangle waves of varying slopes, as shown below. Slopes equivalent to speeds from 2.5 to 40 ΔE_{ab}^* per sec were used, in both *hue* and *chroma* directions, starting from five different base colors, the Munsell principle hues at L* 90 and C* 60, relative to a 4000K CCT adaptation white point.



Experimental Design

Method of Constant Stimuli was used to identify the point of subjective equality of speed. 2AFC sequential paired comparisons were presented, always including a reference of 10 ΔE_{ab}^* per sec. The observers' task was:

Which stimulus appears faster?



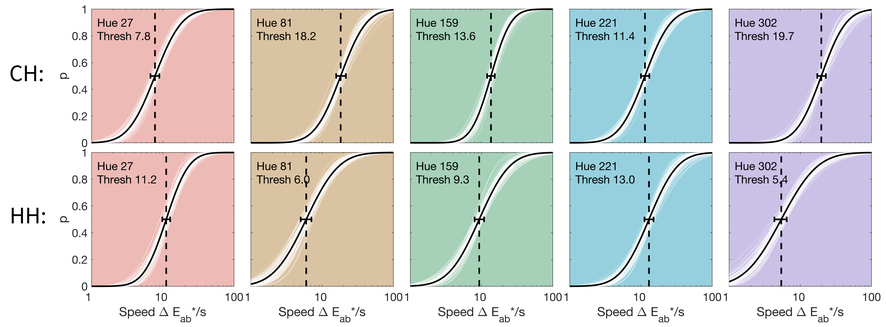
Sequential paired presentations:
- 10 sec neutral (4000K CCT white) before each stimulus
- 15 sec (5 cycles) of each stimulus
- Randomized speed presentation, blocked by base color

For each base color:
- CH comparisons: all *chroma* speeds versus the respective *hue* reference
- HH comparisons: all *hue* speeds versus the *red hue* reference
- Blocks of CH and HH presentations
- Middle three speeds repeated 2x (in second session)

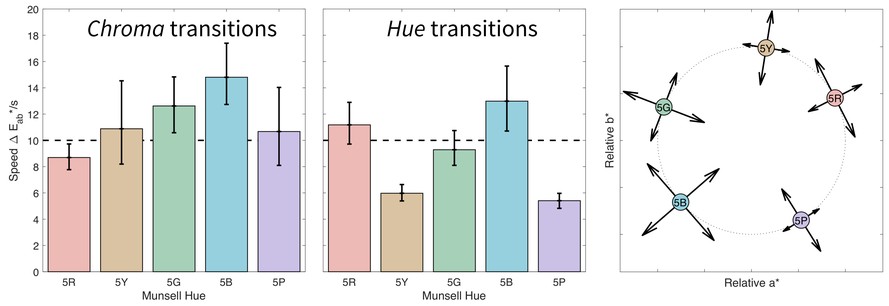
27 participants, normal color vision, 21-53 years, IRB approved experiment

Perceptual Results

Psychometric curves were computed to find points of subjective equality (thresholds where perceived speeds were equal) for all CH and HH comparisons. 95% confidence intervals computed using bootstrapping.



All of the results can be related to a reference *red hue* transition of 10 ΔE_{ab}^* per sec. In the bar chart below, values show the speed of transition that was perceived as equal to the reference. The hue circle shows relative directions.



Conclusions and Next Steps

- Perceived speed of periodic color transitions was studied, starting with the five principle Munsell hues
- Faster *hue* and *chroma* transitions in blue were equal to a reference transition of *red hue*
- Much slower *hue* transitions in purple and yellow were equal to *red hue*
- CIELAB was designed to describe spatial color differences, so no big surprise that it is not uniform for temporal color transitions
- Related ongoing work is studying sensitivity to flicker-rate stimuli
- Future work will seek a model for visual temporal sensitivity