Optimal Transport of Hallucinatory Colors

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1. Introduction

Background

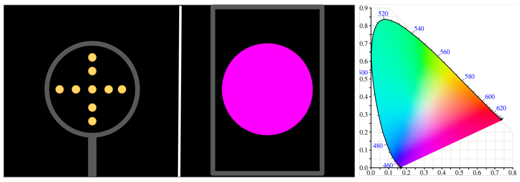
When stimulated with intense flickering white light under a ganzfeld setting, people often report seeing hallucinatory colors, geometric forms and patterns. Previous studies have characterized common form hallucinations, including ones consistent with the psychedelic-induced Klüver form constants[1], and proposed models for their occurrence[2,3,4,5]. However, there has been no recent systematic and detailed investigation of the mechanism or phenomenology of the colors perceived during flicker light stimulation. This project is based on a behavioral study which looked at the colors people saw when viewing an intense flicker at different frequencies, across two sessions. Given previous evidence for the role of frequency information in the perception of subjective colours[6,7,8], we aim to better characterise the relationship between flicker frequency and flicker-induced colours and to establish a proof of concept for future studies on the spectral code of subjective colors.

Research questions

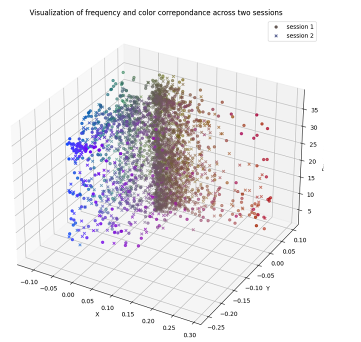
- What is the relationship between frequency and colors? Is there any frequency-color correspondence?
- If there is a correspondence, is it consistent within the same individual?
- Is it consistent across individuals?

Experimental paradigm

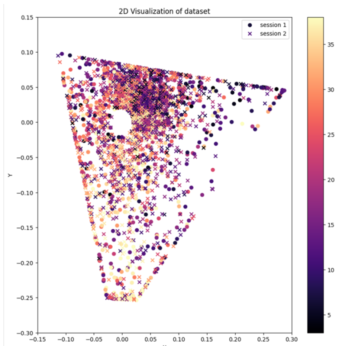
- Session 1: explore frequencies, match colors
- Session 2: fixed frequencies from session 1, forced color matches



2. Raw dataset visualization



3D visualization, where z-axis represents frequency



2D visualization, where the color of points corresponds to the frequency scale bar on the right side

4. Conclusion

- The correspondence between flicker frequency and hallucinatory colors is a many-to-many mapping
- Specific flicker frequencies elicited consistent colors within some individuals, confirmed by optimal transport results.
- There seems to be no consistent frequency-color correspondence across individuals, as shown by the GWOT results.

Acknowledgements

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References

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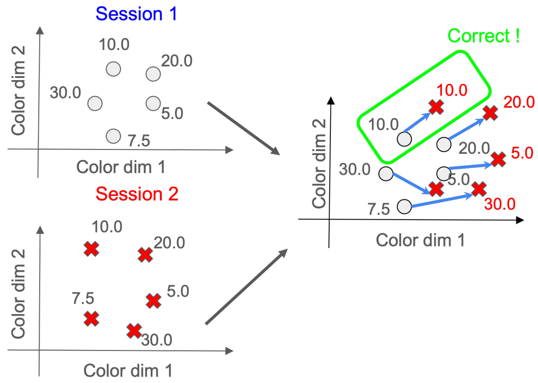
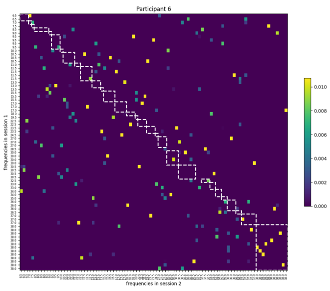
3. Methodology and results

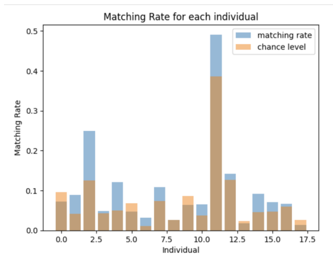
I. Optimal transport

Most efficient way of mass transport between two sets of data points within the same space (color matches of two sessions for the same participant)



Results

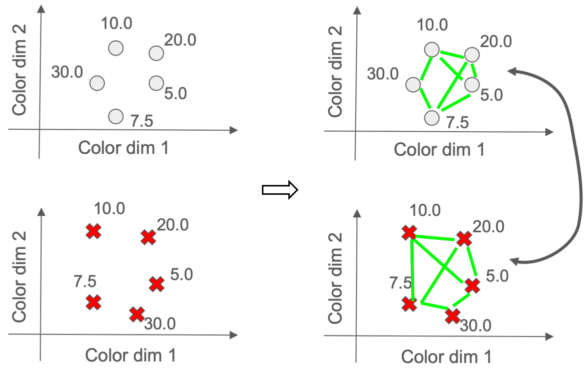




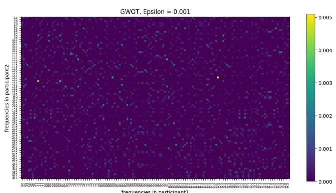
- If the matches across two sessions are consistent, colored points should fall into the white rectangles, and matching rates between session 1 and session 2 frequency labels should be higher than chance level.
- For most participants, the matching rate is higher than chance level.

II. Gromov-Wasserstein optimal transport[9] (GWOT)

Most efficient way of mass transport between two sets of data points in different spaces (color matches within the same session between different participants)



Results



- The frequency-color correspondence was generally not consistent between participant pairs (participant 1 & 2 in the graph).
- The matching rate between most pairs of participants was not significantly above chance.