Quantifying Psychedelic Visual Phenomena: An AI-Driven Computational Framework for Analyzing Form Constants and Representational Competencies

Cynthia-Maria Kanaan (ckana065@uottawa.ca), Nadia Mohamed (nmoha102@uottawa.ca), Rishika Achyuthan (rachy100@uottawa.ca), Hannah Demidovich (hdemi023@uottawa.ca), Jean-Philippe Thivierge (jean-philippe.thivierge@uottawa.ca)
University of Ottawa

Abstract

Psychedelic experiences are widely reported to induce vivid visual phenomena characterized by recurring geometric patterns, known as form constants (Bressloff et al., 2002). These hallucinations have been shown to provide therapeutic benefits (Aynsworth et al., 2017; Gattuso et al., 2022; Leptourgos et al., 2020) and offer insights into the neural mechanisms of altered perception, through their ability to disrupt normal states of consciousness (Carhart-Harris et al., 2016; Greco et al., 2025; Suzuki et al., 2017). However, the processes underlying these effects are not yet fully understood as existing approaches lack a standardized, quantitative framework to characterize and study them (Castelhano et al., 2021; Gattuso et al., 2022). This study addresses these limitations by introducing a proof-of-principle methodology that leverages generative artificial intelligence (AI) to extract, quantify, and classify perceptual features commonly associated with experiences of visual hallucinations.

A generative pre-trained transformer was developed to generate image-to-text descriptions focusing on underlying form constants and their mathematical properties, while avoiding surface-level content. The custom model was employed to analyze 40 psychedelic artworks inspired by subjective experiences (i.e., containing hallucinatory patterns), and 40 non-psychedelic images collected from online sources. Textual outputs were converted into semantic embeddings using a transformer-based encoder in the R language. Hierarchical clustering and cosine similarity analyses revealed strong within-group and low between-group similarity for both categories (Figure 3). Principal component analysis (Figure 4) further confirmed the AI's ability to capture distinctive themes characteristic of psychedelic imagery, demonstrating how the proposed computational method can systematically analyse subjective visual phenomena.

This study contributes to bridging the gap between subjective psychedelic experiences and objective quantitative analysis, offering a novel tool for understanding neurological and perceptual mechanisms underlying altered states of consciousness. It lays groundwork for future research into how artificial systems may simulate and process high-dimensional sensory data, advancing cross-system representational competencies.

Keywords: form constants; visual hallucinations; psychedelics; generative artificial intelligence (AI); image classification; systematic comparisons; representational strategies; computational methods; quantitative frameworks.

Figures

Figure 1: Example of a psychedelic artwork image.

Figure 2: Example of a non-psychedelic image.

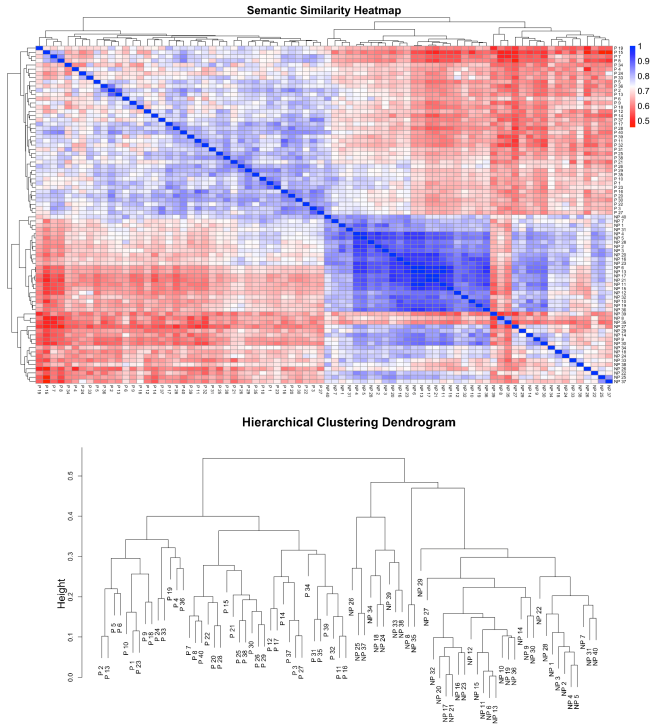

Figure 3: Semantic similarity matrix and hierarchical clustering dendrogram of transformer embeddings. The heatmap (top) displays cosine similarity between psychedelic and non-psychedelic images, with blue indicating high similarity and red indicating low similarity. The dendrogram (bottom) reveals image clusters based on shared features.

Figure 4: Principal component analysis of transformer embeddings showing the distribution of psychedelic (P, turquoise) and non-psychedelic (NP, red) images.

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