Durham University
Department of Psychology

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The role of sparse perceptual representations in visual consciousness

Background

Although we feel we perceive rich detail across our visual field, research shows that outside the focus of attention only a limited subset of information is consciously accessible. This has sparked the "richness vs sparseness" debate: are perceptual experiences genuinely detailed, with attention and memory limiting report, or does the brain encode unattended information sparsely using ensemble representations - summary statistics such as mean and variability?

Recent studies indicate that the human visual system sparsely encodes variability across multiple features (colour, orientation, spacing). However, little is known about how these sparse representations interact and to what extent they determine the contents of our visual consciousness.

Aims and Methods

This project will investigate how sparse ensemble representations contribute to conscious visual perception through one or more key objectives:

1. Test whether variability in one visual feature (colour, orientation, spacing) influences perception of others.
2. Examine whether encoding of ensemble statistics requires attention and/or conscious processing.
3. Manipulate perceived variability via adaptation to assess its impact on the precision of mean feature estimates.

All experiments will be conducted using Durham Psychology's psychophysics facilities, including ViSaGe displays and response devices.

Relevance

The project bridges cognitive neuroscience, psychophysics, and consciousness research, providing novel insights into how sparse visual representations support subjective experience. This will inform us about the sensory representations that actually comprise the majority of our conscious experience, which is a necessary step when evaluating the neural correlates of consciousness. It also has the potential to advance our understanding of the adaptive mechanisms underlying visual perception, which may have applications in fields requiring high perceptual precision, such as radiology or security screening.

Training

The candidate will gain advanced training in psychophysical methods and analysis, Bayesian modelling, and experimental design, alongside theoretical grounding in perception, consciousness, and ensemble coding.

Suitable for

PhD and MSc by Research students.

References and Further Read

1. Haun, A. M., & Tononi, G. (2025). The unfathomable richness of seeing. *Trends in cognitive sciences*.
2. Whitney, D., & Yamanashi Leib, A. (2018). Ensemble perception. *Annual review of psychology*, *69*, 105-129.
3. Norman, L. J., Heywood, C. A., & Kentridge, R. W. (2015). Direct encoding of orientation variance in the visual system. *Journal of Vision, 15(4),* 3.