Temporal signatures of multidimensional object properties in the human brain

Lina Teichmann[1], Martin N. Hebart[1,2,3], Chris I. Baker[1]

Our visual world consists of a huge variety of objects and yet we effortlessly identify, distinguish, interact, and reason about the things we see. This ability requires flexibility to integrate and focus on different object properties to enable diverse behavioral goals. What neural mechanisms support such a challenging task in the span of just a few hundred milliseconds? To address this question, we combined time-resolved MEG signals evoked by viewing thousands of objects with behavioral embeddings (Figure 1A). Specifically, we used millions of crowdsourced similarity judgments to model the neural representation of the object space and examined temporal profiles across behaviorally-relevant object dimensions. Overall, we found that the response to object properties in general starts to emerge at ~90 ms after stimulus onset and is initially driven by posterior sensors before it becomes more distributed at ~300 ms (Figure 1B). Looking at individual timecourses (Figure 1B rose plots & Figure 1C), we identified distinct temporal profiles for different dimensions. These profiles fall into two broad categories, with either a distinct and early peak (~150 ms) or a slow rise to a late peak (~300 ms). Further, the early effects are stable across participants, in contrast to later effects which show more variability across people. This highlights that early peaks may carry stimulus-specific and later peaks subject-specific object information. Given that the dimensions with early peaks seem to be primarily visual dimensions (e.g., white, colorful, cylindrical) and those with later peaks more conceptual (e.g., food-related, transportation-related), our results suggest that conceptual processing is more variable across people. Together, these data provide a comprehensive account of how the representation of object properties unfolds in the human brain.

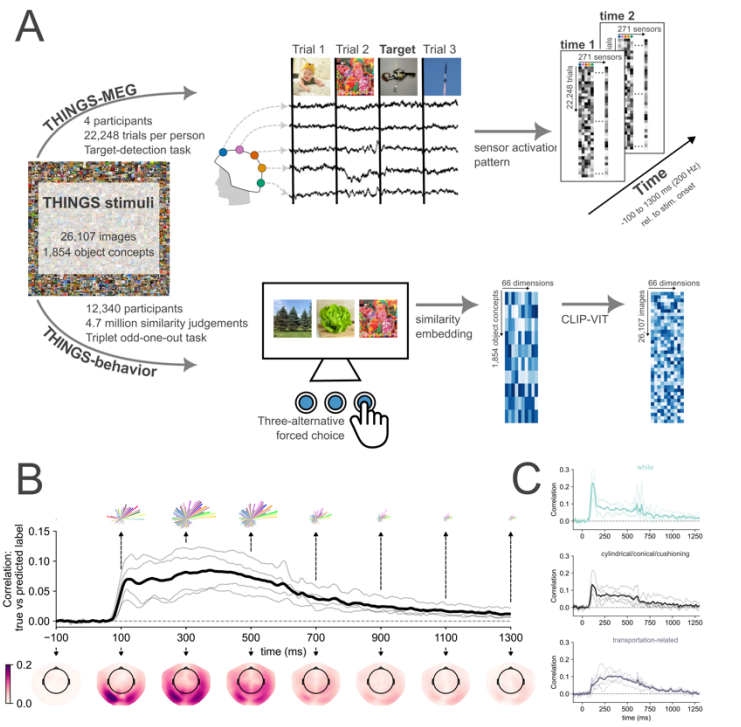

Figure 1. (A) Dataset description for MEG and behavioral data. (B) Time-resolved information across all object dimensions in the signal, with rose plots showing single dimension activations at certain timepoints. (C) Selected temporal profiles for three dimensions highlighting variability in temporal structure.

[1]Laboratory of Brain and Cognition, National Institute of Mental Health, National Institutes of Health, Bethesda MD, USA
[2]Vision and Computational Cognition Group, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
[3]Department of Medicine, Justus Liebig University, Giessen, Germany