

3.7 Making the latent category structure of fMRI data explicit with Formal Concept Analysis

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Understanding how semantic information is represented in the brain has been an important research focus of Neuroscience in the past few years. The work I presented in this talk is aimed at extracting concepts and their relationships from brain activity, and to correlate these concept with behavioral measures. We showed previously (Endres et al 2010) that Formal Concept Analysis (FCA) can reveal interpretable semantic information (e. g. specialization hierarchies, or feature-based representations) from electrophysiological data. Unlike other analysis methods (e. g. hierarchical clustering), FCA does not impose inappropriate structure on the data. FCA is a mathematical formulation of the explicit coding hypothesis (Foldiak, 2009) Furthermore we (Endres et al 2012) investigated whether similar findings can be obtained from fMRI BOLD responses recorded from human subjects. While the BOLD response provides only an indirect measure of neural activity on a much coarser spatio-temporal scale than electrophysiological recordings, it has the advantage that it can be recorded from humans, which can be questioned about their perceptions during the experiment. Furthermore, the BOLD signal can be recorded from the whole brain simultaneously. In our experiment, a single human subject was scanned while viewing 72 grayscale pictures of animate and inanimate objects in a target detection task. These pictures comprise the formal objects for FCA. We computed formal attributes by learning a hierarchical Bayesian classifier, which maps BOLD responses onto binary features, and these features onto object labels. The connectivity matrix between the binary features and the object labels can then serve as the formal context. In a high-level visual cortical area (IT), we found a clear dissociation between animate and inanimate objects with the inanimate category subdivided between animals and plants when we increased the number of attributes extracted from the fMRI signal. The inanimate objects were hierarchically organized into furniture and other common items, including vehicles. We also used FCA to display organizational differences between high-level and low-level visual processing areas. For a quantitative validation of that observation, we show that the attribute structure computed from the IT fMRI signal is highly predictive of subjective similarity ratings, but we found no such relationship to responses from early visual cortex. Collaborators: Peter Foldiak, Uta Priss, Ruth Adam, Uta Noppeney

References

- 1 D. Endres, P. Földiak and U. Priss (2010) An Application of Formal Concept Analysis to Semantic Neural Decoding, *Annals of Mathematics and Artificial Intelligence*, 57(3-4), pp. 233-248.
- 2 D. Endres, R. Adam, M. A. Giese and U. Noppeney (2012) Understanding the Semantic Structure of Human fMRI Brain Recordings With Formal Concept Analysis., In *ICFCA 2012, 10th Inte’l Con. on Formal Concept Analysis*, LNCS 7278, Springer, 96-111.
- 3 P. Földiak (2009) Neural Coding: Non-Local but Explicit and Conceptual, *Current Biology*, 19(19):R904-R906, 2009.
- 4 B. Ganter and R. Wille (1999). *Formal concept analysis: Mathematical foundations*, Springer.