Disentangling visual and semantic object representations in time and space using MEG and fMRI decoding

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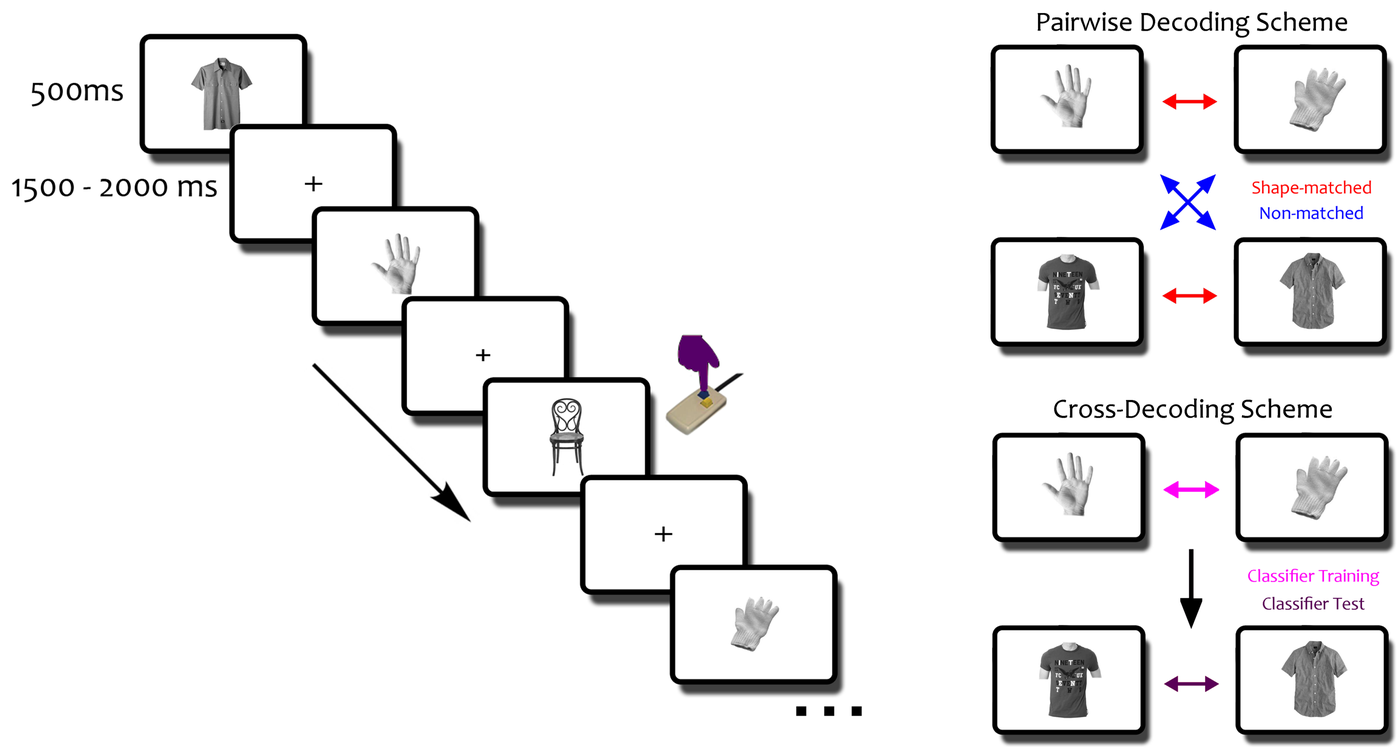
Introduction

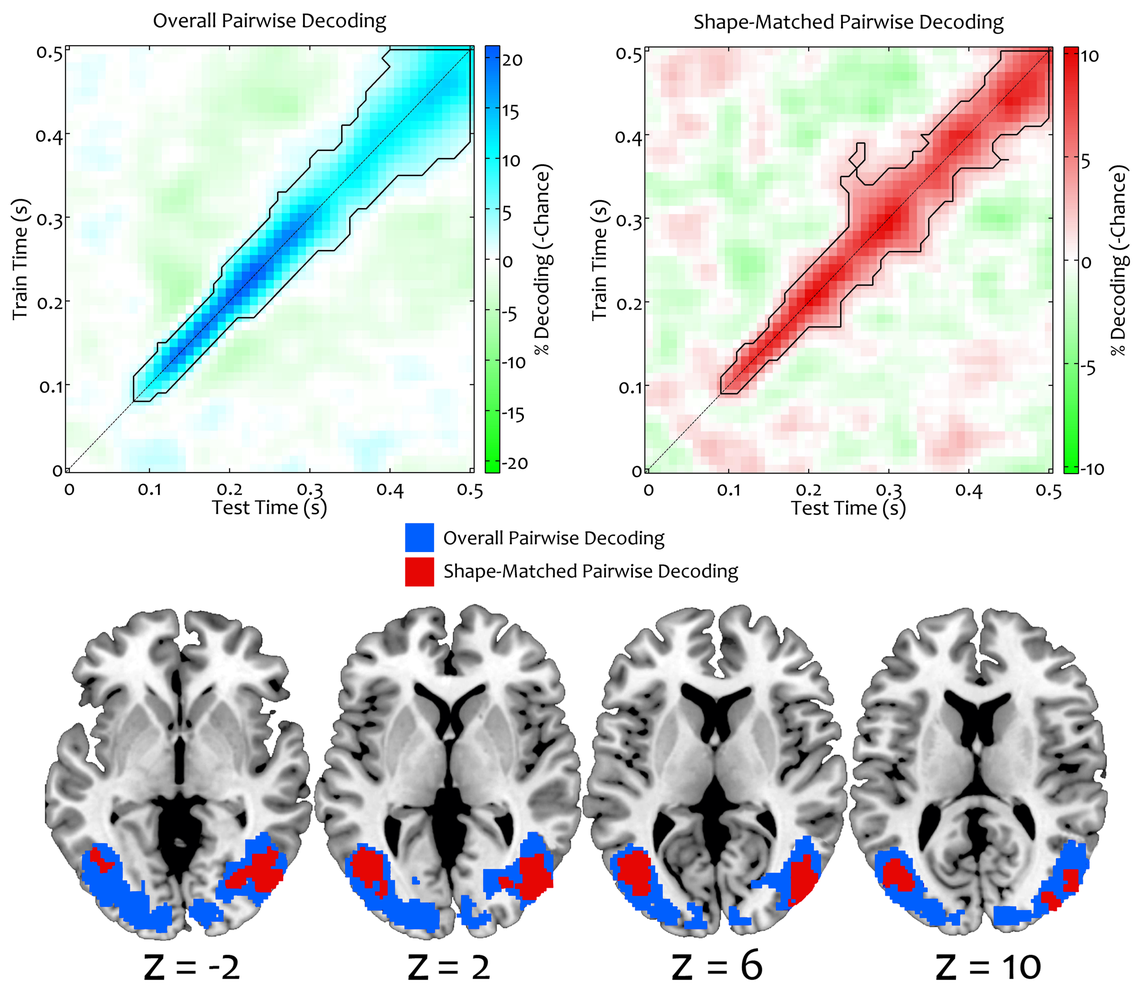
Previous neuroimaging research has identified specific spatio-temporal signatures of visual category processing. For example, the processing of the human body recruits distinct brain mechanisms that are uniquely traceable in space and time[1]. It is unclear whether these representations are primarily driven by visual stimulus features[2], or if these representations are to some degree semantic, and thus detached from visual properties[3]. Here, to characterize the nature of body representations in space and time, we used multivariate decoding on both MEG and fMRI data. Participants viewed human body parts (hands and torsos) and visually highly similar pieces of clothing (gloves and shirts). These stimuli allowed us to test how separable the two categories remained when matching for shape. Additionally, we tested whether such shape-independent body representations generalize across different body parts (i.e. hands and torsos).

Stimuli & Paradigm



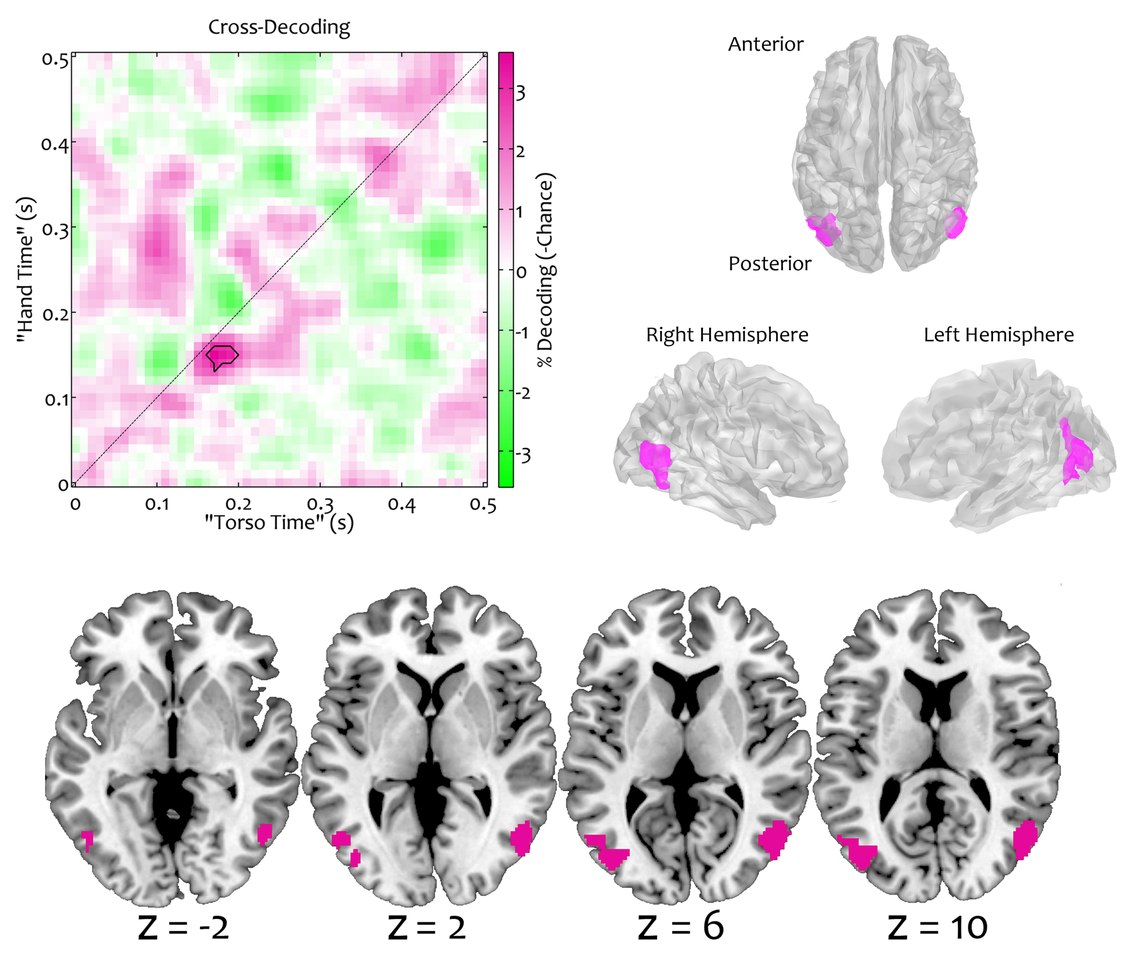
The experimental design was identical for the MEG and fMRI studies. Decoding analyses for the MEG data were based on single-trial response patterns across sensors, while for the fMRI data we used a whole-brain searchlight approach with moving voxel neighborhoods.

Pairwise Decoding Analysis



We found robust decoding across all pairwise comparisons (i.e. hand vs. glove, hand vs. shirt, torso vs. glove, torso vs. shirt), starting from 70ms (significance indicated by the connected area) and spatially extending over large parts of visual cortex, including early visual areas. When we restricted our analysis to shape-matched comparisons (i.e. hand vs. glove, torso vs. shirt), we found considerably lower decoding performance both for the MEG and fMRI data, with a later onset (90ms) of decoding, and a shift towards more lateral and anterior regions.

Cross-Decoding Analysis



For the cross-classification analysis, classifiers were trained on hands vs. gloves and tested on torsos vs. shirts (and vice versa). This analysis revealed a very localized spatio-temporal signature of a body representation that generalize across different body parts: Our MEG data show that response patterns between 150 and 200 ms allow for successful discrimination of human bodies and clothes (significance indicated by the connected area). Additionally, our fMRI analysis shows that these category representations were highly localized in lateral occipital cortex.

Conclusions

In sum, our findings suggest that visual category representations (here: the human body) are not explicable by shape features. Matching for shape reduces decoding accuracy in early visual processing, but preserves later category-specific processing. Additionally, in our visual cross-decoding analysis, we found specific spatio-temporal signatures of body representations that are not only independent of shape features, but also generalize across body parts.

References

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