

A Representational Similarity Analysis of the Dynamics of Object Processing Using Single-Trial EEG Classification

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Related Publication

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EEG datasets available for download from SDR: <http://pur1.stanford.edu/bq914sc3730>

Main Findings

- ▶ Visual object categories and exemplars can be decoded from single-trial EEG.
- ▶ Classification using data from all time samples and electrodes: Category-level (6 class) 40.68% ($p < 10^{-14}$); exemplar-level (72 class) 14.46% ($p < 10^{-14}$); within-category (12 class) faces 18.30% ($p = 0.002$), objects 28.87% ($p < 10^{-7}$).
- ▶ Human Face category is most distinct; Inanimate categories cluster together.
- ▶ Both spatial and temporal codes exist for object category representation.
- ▶ Low-level image features may drive classification for the present stimulus set.

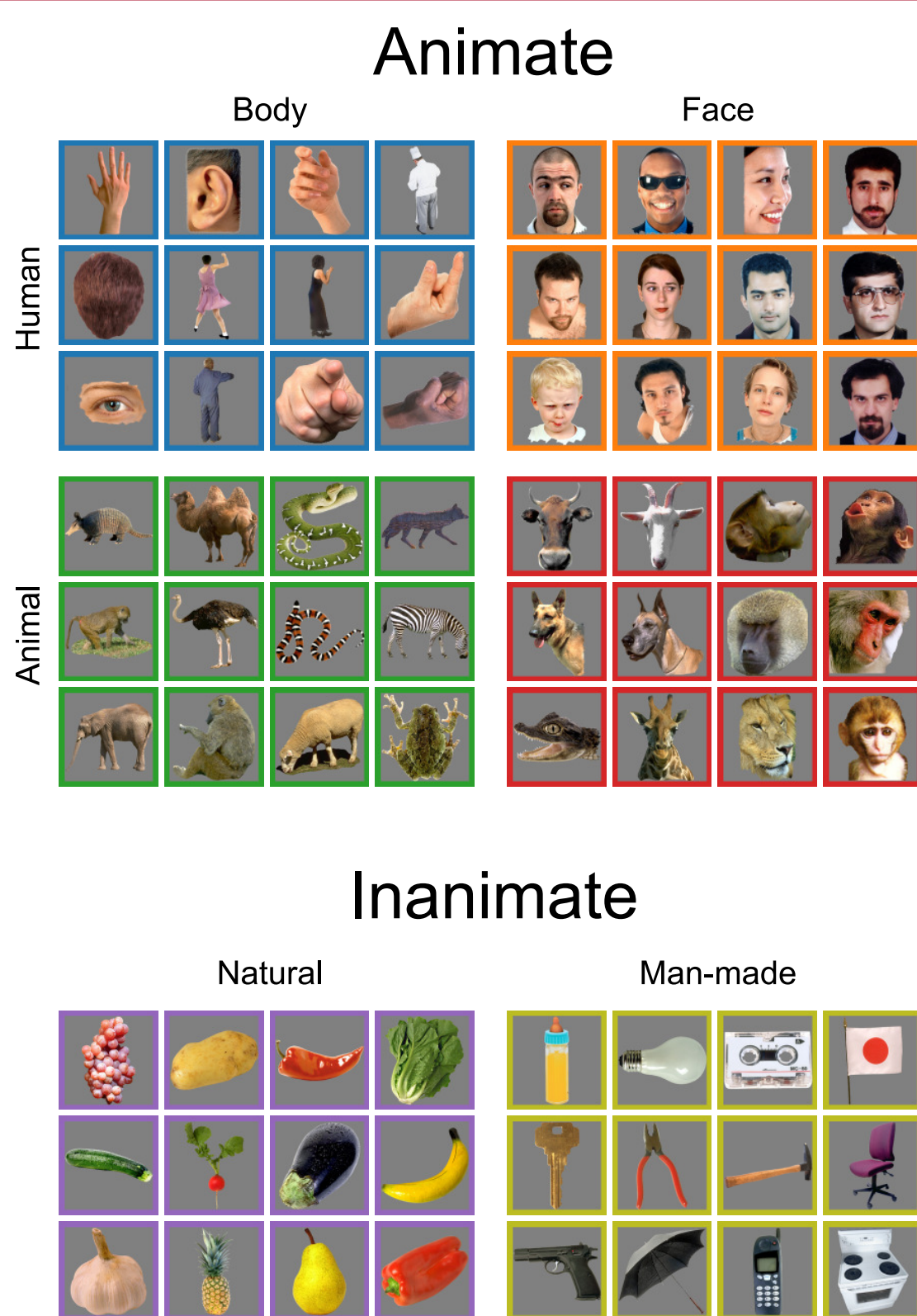
Background

- ▶ Representational Similarity Analysis (RSA): Pairwise distances between response patterns used to characterize and compare representations across modalities.
- ▶ Past studies have used a shared image set to explore object category processing in single-cell, fMRI, and MEG responses using response latencies, pairwise correlations, and single-trial classification.
- ▶ The present study utilizes the same image set and derives pairwise distances from multi-category confusion matrices from single-trial EEG classification.

Methods

Stimuli and experimental paradigm

- ▶ Stimuli: 72 images derived from previously used 92-image set.
 - ▶ Six object categories.
 - ▶ Twelve exemplars per category.
- ▶ Ten participants viewed each image 72 times (no colored borders shown).
- ▶ Images shown onscreen for 500ms followed by 750ms blank screen.
- ▶ 5,184 total trials per participant.
- ▶ 128-channel EEG, EGI GES 300.
- ▶ Preprocessing: Filtering, downsampling, eye artifact removal (ICA), average reference.
- ▶ Epoching: 0–496ms post-stimulus response.



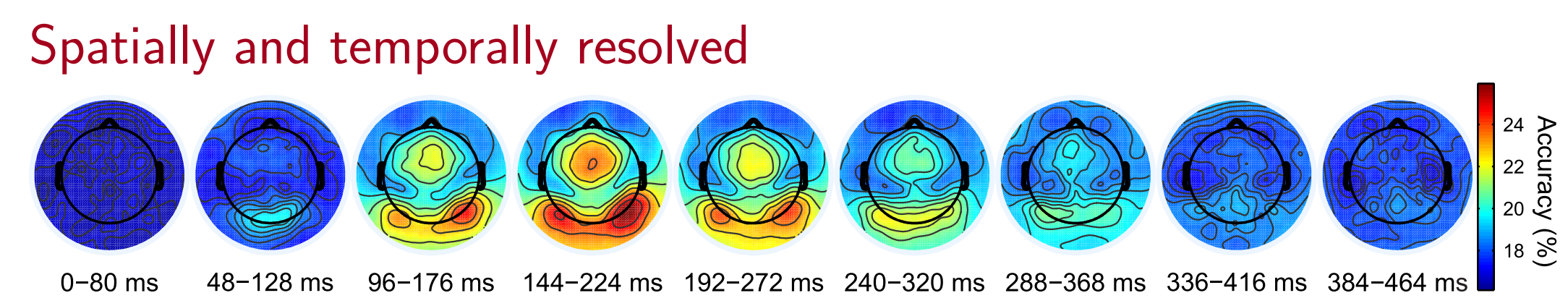
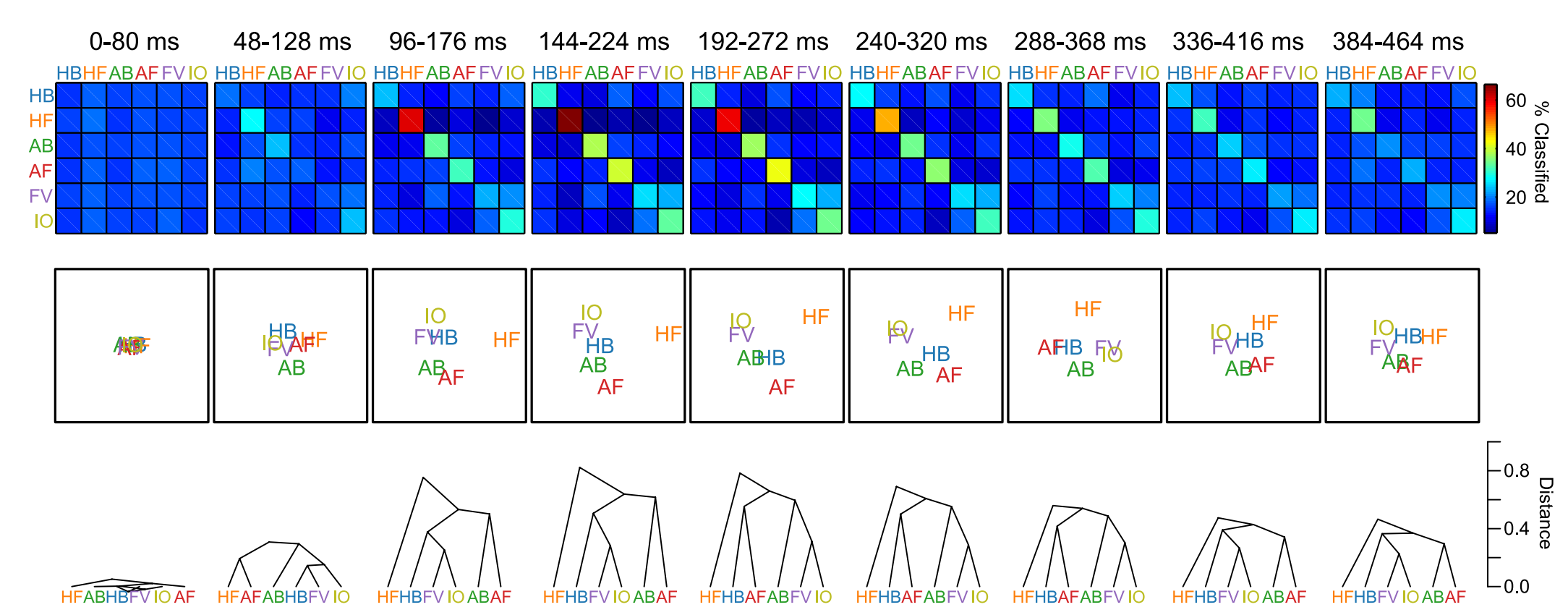
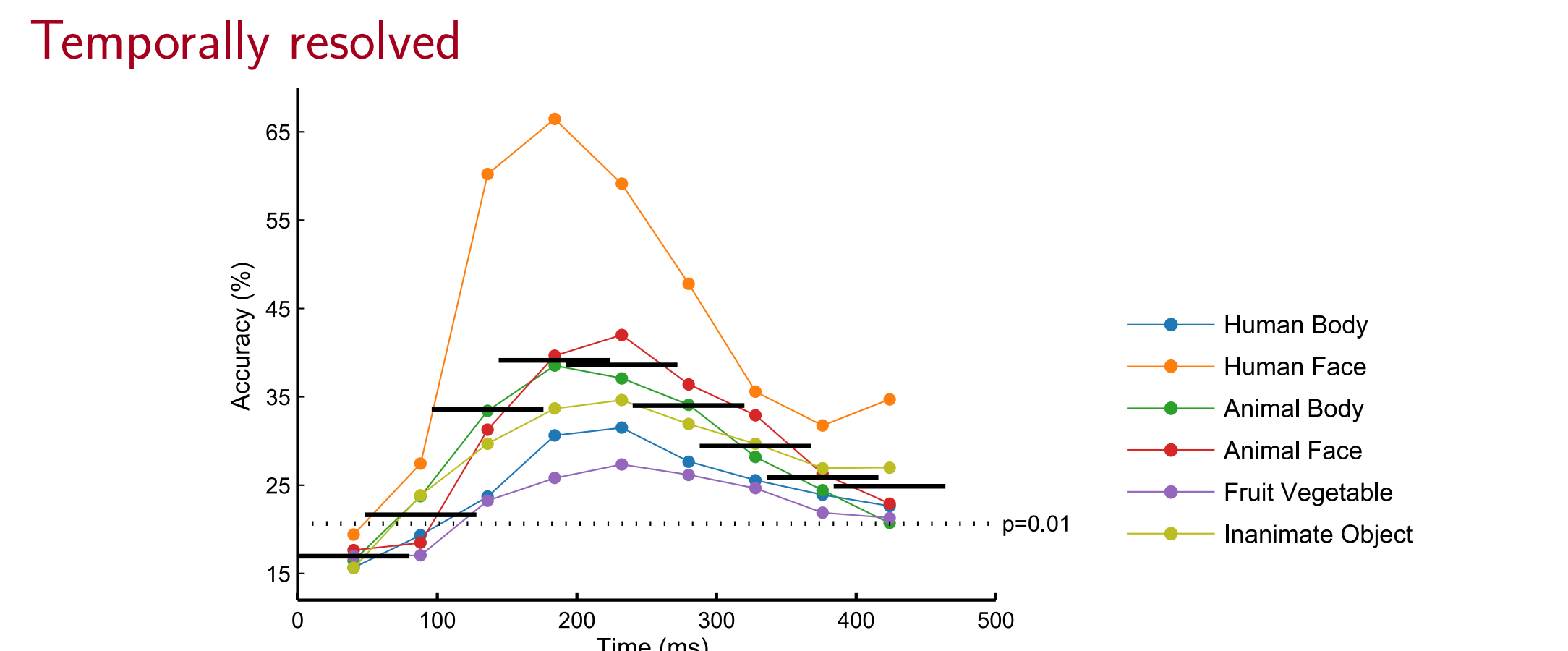
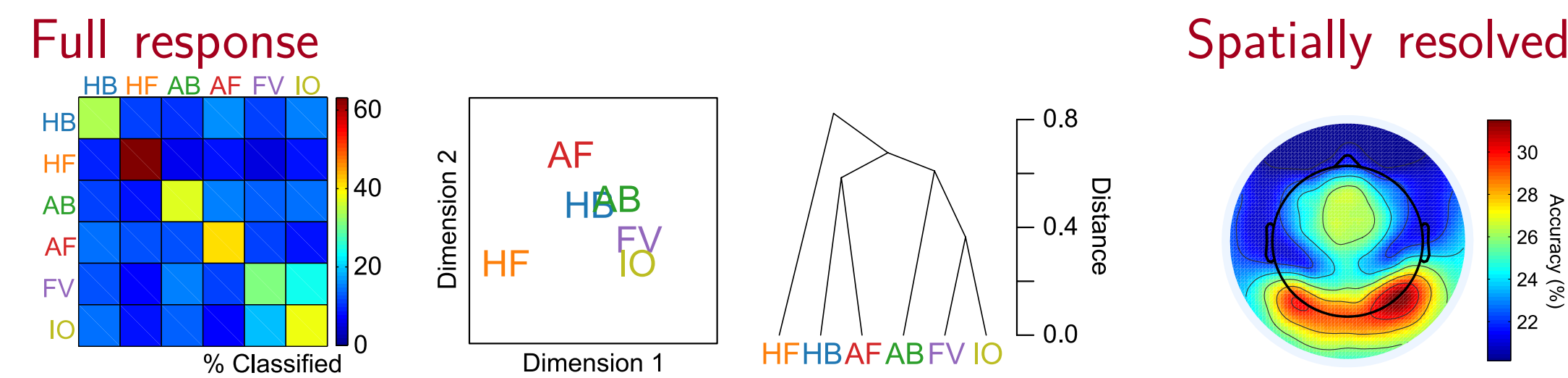
Single-trial classification

- ▶ Classification: LDA with PCA and ten-fold cross validation.
- ▶ Number of PCs optimized using nested ten-fold cross validation in each training-test iteration.
- ▶ Trials labeled by either image category or image exemplar.
- ▶ Classifications performed using full response, plus spatial and/or temporal subsets.
- ▶ Classifications performed within-participant; results averaged across participants.

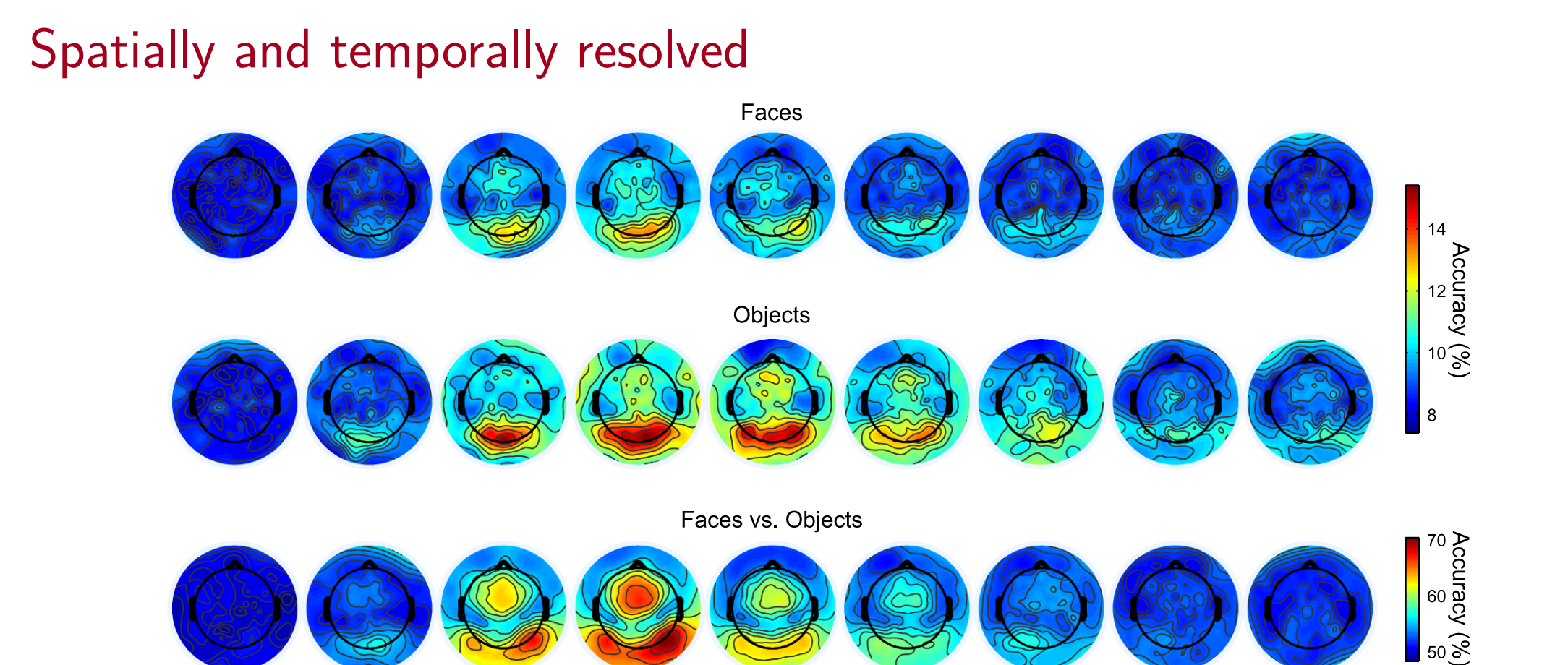
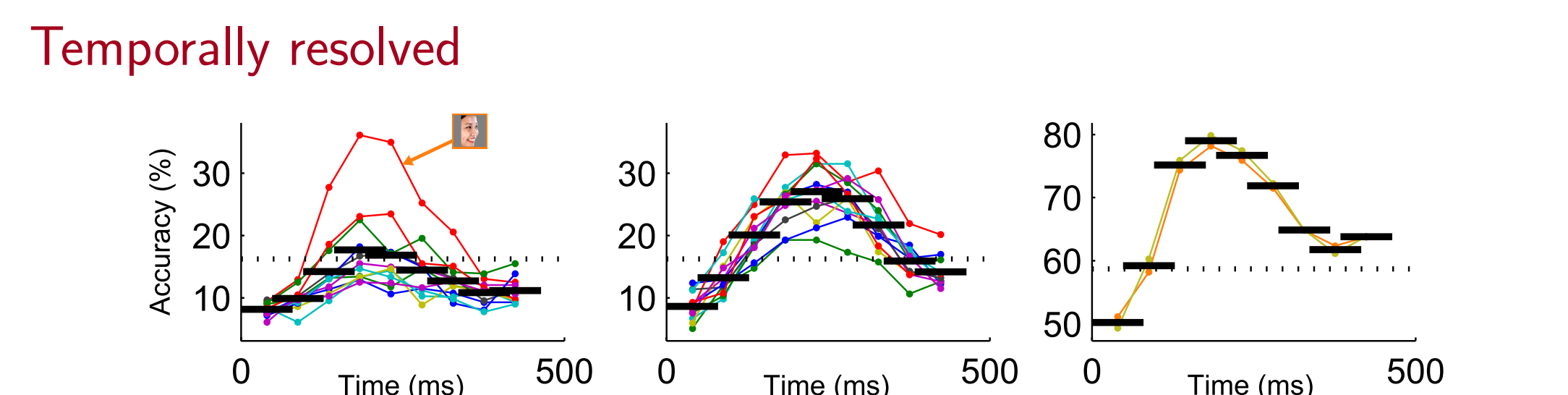
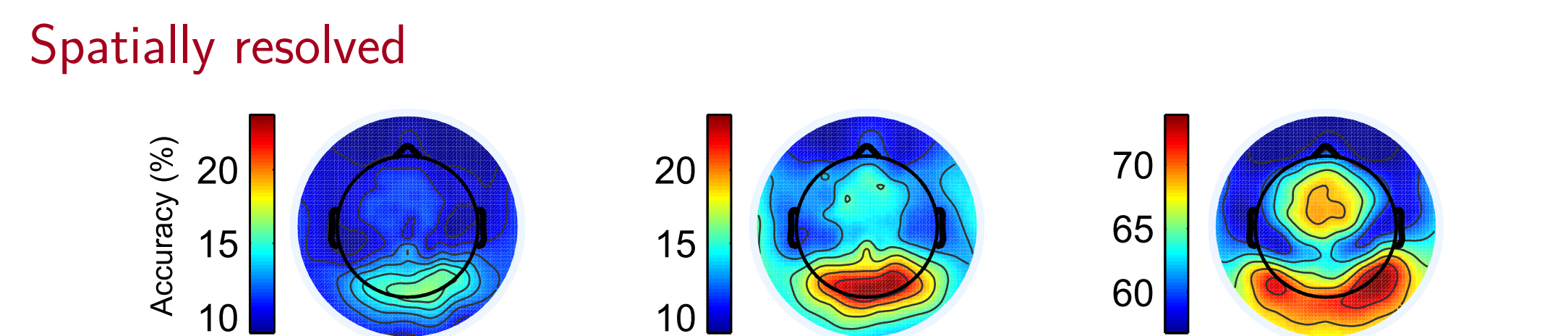
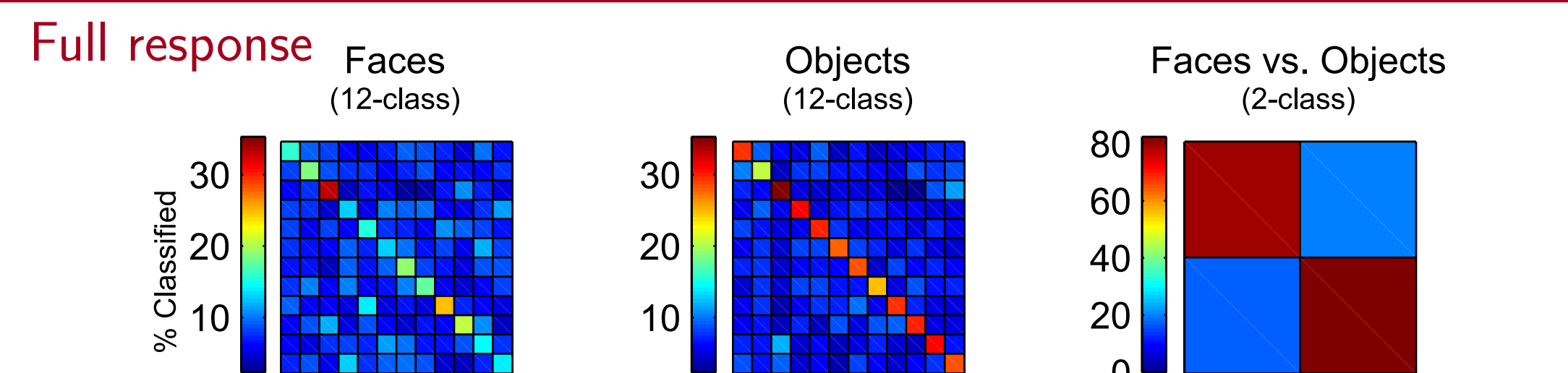
Clustering and visualization

- ▶ Pairwise distances derived from multi-category classification confusion matrices.
- ▶ Classical MDS converts pairwise distances to coordinates in orthogonal dimensions.
- ▶ Hierarchical structure visualized as dendrograms, using UPGMA for linkage.

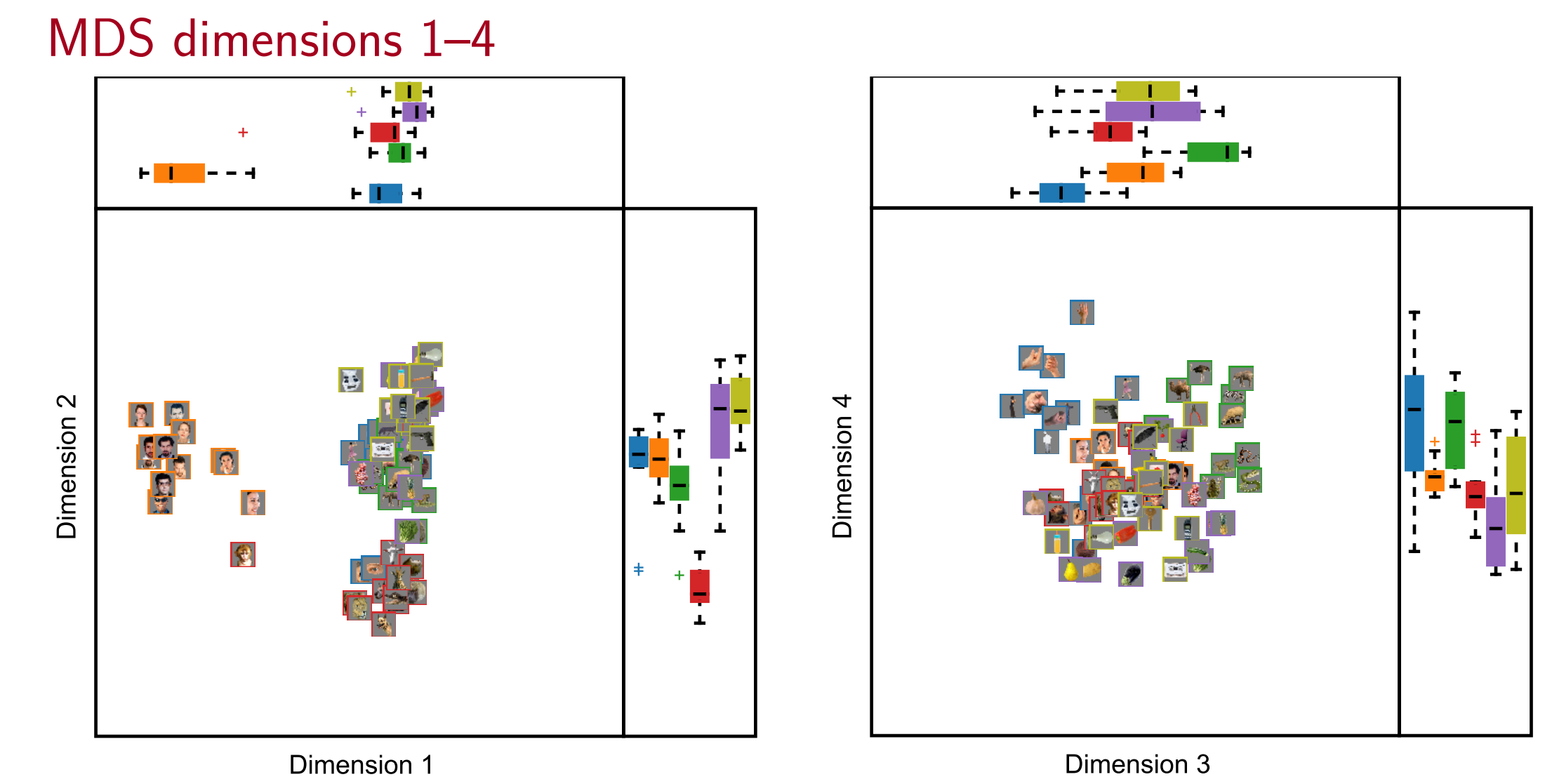
Category-Level Classifications (6 class)



Within-Category Classifications (12 class)



Exemplar-Level Classifications (72 class)



Dendrogram and reordered confusion matrix

