Decoding categorical representations of human actions from brain activity associated with viewing point-light movies

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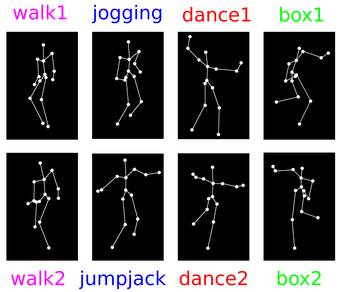
INTRODUCTION

In this study, we investigate the categorical representation of human actions by analyzing the neural similarity structure associated with viewing point-light videos of eight distinct human actions that comprise 4 superordinate categories. We describe a data-driven approach, the "bootstrap similarity searchlight" method, to discover and decode the representational structure embedded in the distributed multivariate fMRI signal.

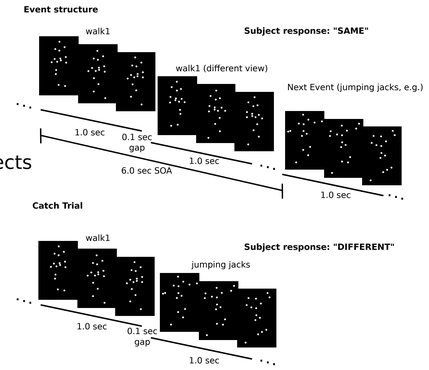
STIMULI

8 distinct actions

4 superordinate categories

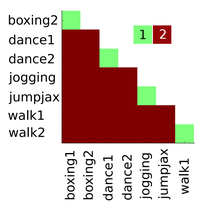


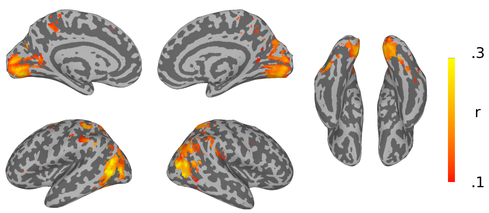
TASK



N = 12 Subjects

TARGET CATEGORICAL STRUCTURE

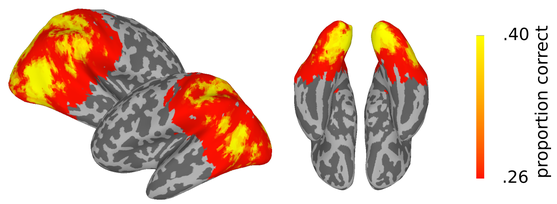




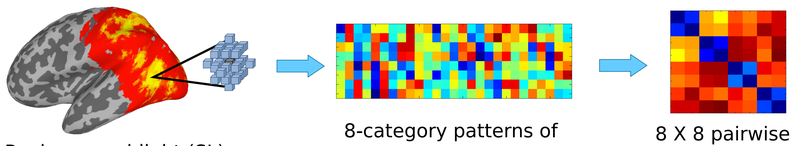
Similarity searchlight analysis maps the local correlation in neural similarity space with a target similarity structure Connolly et al., 2012

Data-driven approach to discover representational structure using a bootstrap similarity-searchlight

STEP 1: Identify informative voxels using pattern classification searchlight (Kriegeskorte et al. 2006)



STEP 2: For each subject, compute a dissimilarity matrix for each voxel using local activity patterns at each searchlight

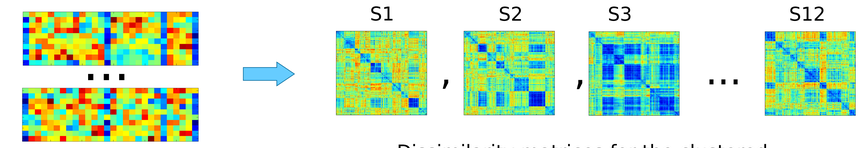


Roving searchlight (SL) (3 voxel radius)

8-category patterns of beta-weights for each SL

8 X 8 pairwise dissimilarity matrix for each SL

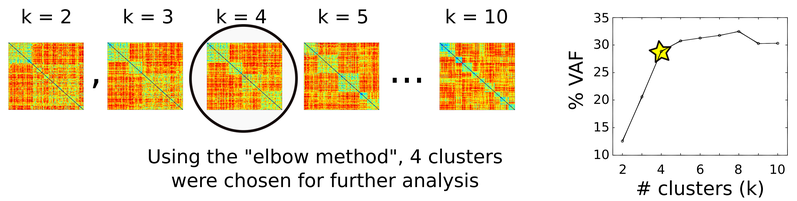
STEP 3: For each subject, cluster the set of searchlight dissimilarity matrices into 10 clusters, saving 10 cluster centroids for input into group analysis



~6000 vectorized SL dissimilarity matrices

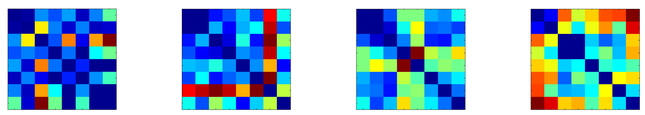
Dissimilarity matrices for the clustered SL dissimilarities ordered by cluster assignment

STEP 4: Cluster the set of 120 cluster centroids using 2 to 10 clusters and determine the "true" number of clusters by analyzing the variance accounted for by each solution



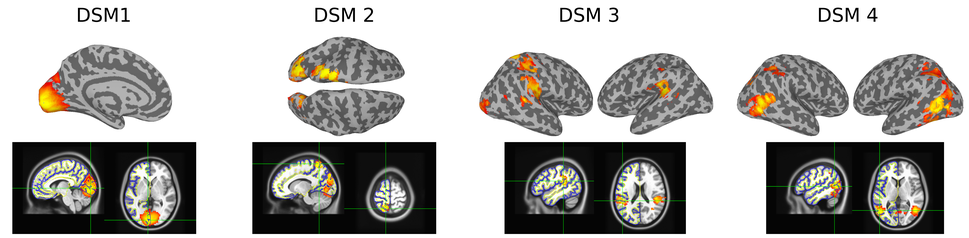
Using the "elbow method", 4 clusters were chosen for further analysis

STEP 5: Use the centroids identified in step 4 as new targets for similarity searchlights



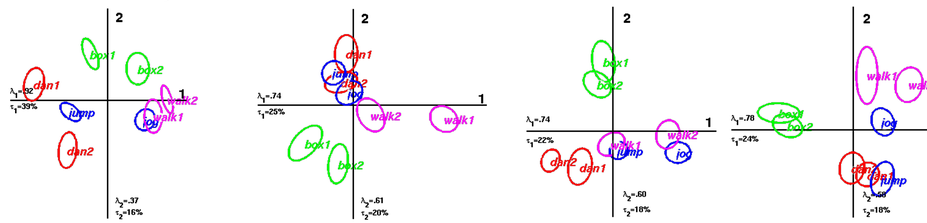
4 Target dissimilarity matrices (DSMs)

Anatomical regions associated with each target similarity structure



Group T-statistic maps for similarity searchlights. These maps were used to make ROI masks.

Structural analysis:

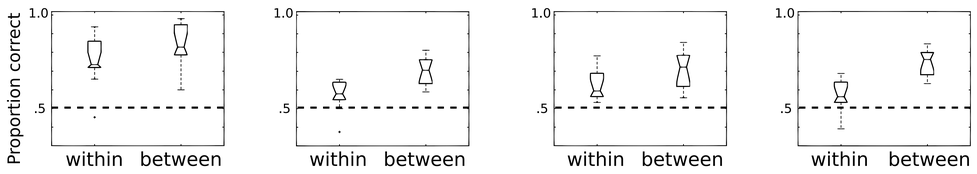


Multidimensional scaling solutions for dissimilarities recalculated individually for each subject within each ROI. Ellipses represent 95% confidence intervals tht reflect individual variability. Solutions were calculated using DISTATIS (Abdi et al., 2012).

Correlations with target category structure:

r = .29 r = .24 r = .26 r = .53

Pairwise classification:



Pairwise support vector machine classification for each ROI as a function of within and between superordinate category comparisons. Categorical structure is reflected by greater between category accuracies than within.

CONCLUSIONS

Four distinct representational spaces were found providing evidence for a four part distributed network for representing human actions

The first part of this network is the early visual region in the medial occipital pole with a similarity assumed to reflect low-level visual properties

The posterior middle temporal region, thought to contain human MT and the extrastriate body area was associated with the most categorical representational structure

References

Abdi, Williams, Valentin, Bennani-Dosse (2012) STATIS and DISTATIS: optimum multitable principle component analysis and three way metric multidimensional scaling. WIREs Computational Statistics, 4, 124-165

Connolly, Guntupalli, Gors, Hanke, Halchenko, Wu, Abdi, Haxby (2012) Representation of biological classes in the human brain. Journal of Neuroscience, 32, 2608–2618

Kriegeskorte, Goebel, Bandettini (2006) Information-based functional brain mapping. PNAS USA 103, 3863-3868