Objectives

To determine the cortical organization of action features, we measured representational geometries during observation of transitive and intransitive gestures in two independent experiments, aiming to identify the set of brain regions tuned to dimensions of transitive actions and to test their ability to generalize to new stimuli and features.

Methods

During fMRI acquisition, fourteen subjects (4M, age: 37 $\pm$ 6 years) watched a set of 120 clips depicting hand-performed transitive actions varying in three categorical features: kinematic-based ('grasping-to-lift', 'pushing-away', 'putting-down'), animacy dimension of the object (animated, inanimate) and its category (animals, body parts, vegetables/fruits, artificial objects). Using a searchlight approach, we computed a Representational Dissimilarity Matrix (RDM; 1-r Pearson's coefficient) on the median activity patterns. We then calculated sensitivity index *d'* to assess discriminability of the neural representations of stimuli dimensions, and the associated *p-value* (permutation test, n=1000; Pareto approximation). Voxels showing high sensitivity for all dimensions ($q<0.01$, FDR corrected) were clustered by applying t-SNE on the RDMs.

A second independent fMRI dataset (n=25, 11M, age 26; $\pm$ 4 years) was used: subjects observed a continuous video depicting everyday artificial objects on a table and an actor performing transitive hand movements ('grasping-to-lift', 'reaching-to-touch') or intransitive ones, either meaningful (symbolic) or meaningless (nonsense). FMRI data was analysed using the pipeline described above and *d'* values for transitive and intransitive gestures were mapped onto the identified voxels.

Results

Using the first dataset, we identified a well-known set of regions involved in action observation, which retained a high sensitivity for action, animacy and object category dimensions. By mapping at the voxel level the relative contribution of these dimensions, we showed a dissociation between the action and the animacy/category dimensions. The ability to map both kinematic- and object-based features was encoded in RDMs at a higher spatial scale only, as in the precentral/postcentral and in posterior temporo-occipital areas.

Voxel tuning to observation of transitive action was replicated in the second dataset (~73% of voxels with significant *d'*, $p<0.05$). Lastly, we showed that the identified areas also encoded the meaning dimension of intransitive gestures.

Conclusions

Using representational similarity analysis, we found a dissociation between kinematic and object

characteristics at a voxel level, while a multiple dimension encoding was found when considering large patches of cortex. Moreover, the identified areas were not specific for transitive actions, as they carried discriminative information related to intransitive actions.

Representational geometries can be used to explore overlapping coding mechanisms, providing further support for the hierarchical organization of action.