Plasticity of movement representations associated with long-term skill acquisition

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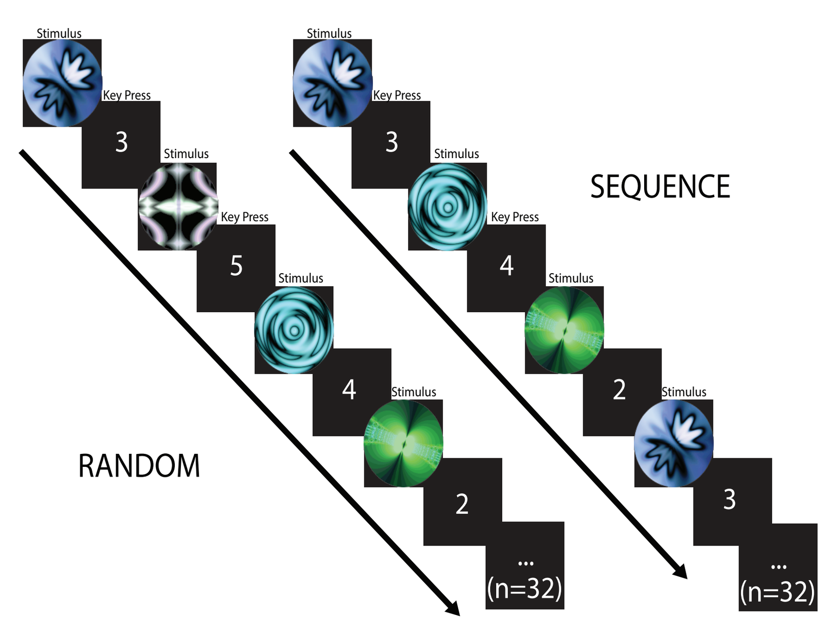
1. Background

Long term training on motor skills is thought to modify moveme-ment representations in motor cortex (Matsuzaka 2007, Nudo 1996).

We examined the plasticity of movement representations in human cortex by identifying
(1) what regions exhibit expansions or retractions following training.
(2) in what direction movement representations were modified in regions that exhibited plasticity.



Visual stimuli were presented in blocks of random and blocks of sequence (n=32).

Behavioral data was collected over 5 weeks of training (20,000 Random Trials, & 25,000 Sequence Trials).

Imaging data was collected pre and post training.

Movements were decoded pre and post training using MVPA.

2. Methods

Neurologically healthy adults (N = 6, 4 male, 25-36 y/o) trained 5x each week for 5 weeks on a 32-element sequence with structured frequency pairings between different fingers.

Acquisition/Preprocessing

-- Functional data acquired on a Siemens Verio 3T Scanner (32 channel head coil, TR:2000ms, TE:30.0ms, MBAF: 3, 66 slices, A>>P).
-- Realigned for motion correction, fieldmap undistorted, and slice time corrected.
-- Analyzed using a standard GLM with a regressor for each finger movement.
-- Anatomical data (T1 and T2*) processed using the HCP workbench for surface based ROI analysis.

Analysis

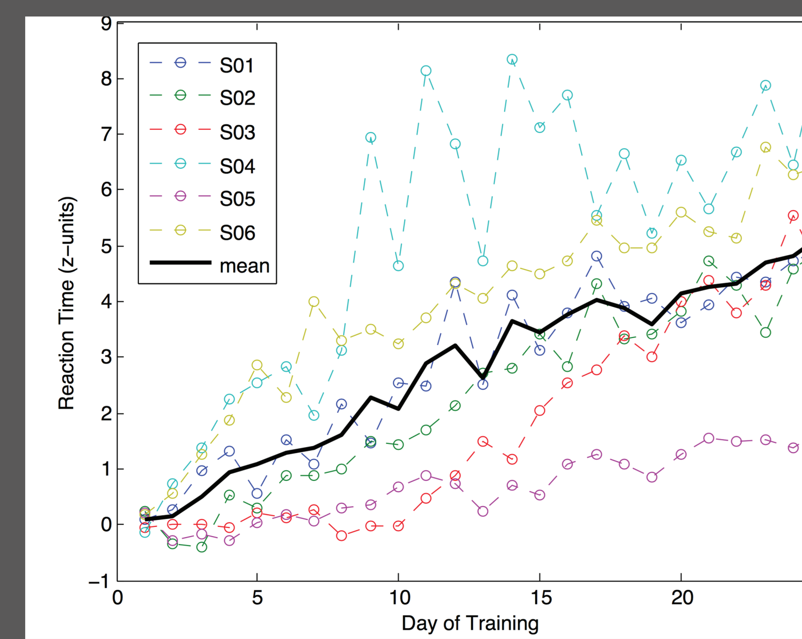
-- Conducted searchlight analysis to identify cortical regions that dicriminated between each finger, using H (average of cross-validated distances) as a summary statistic.

$$H = \sum_{i \neq j}^{K} \frac{d_{i,j}^2}{K(K-1)}$$

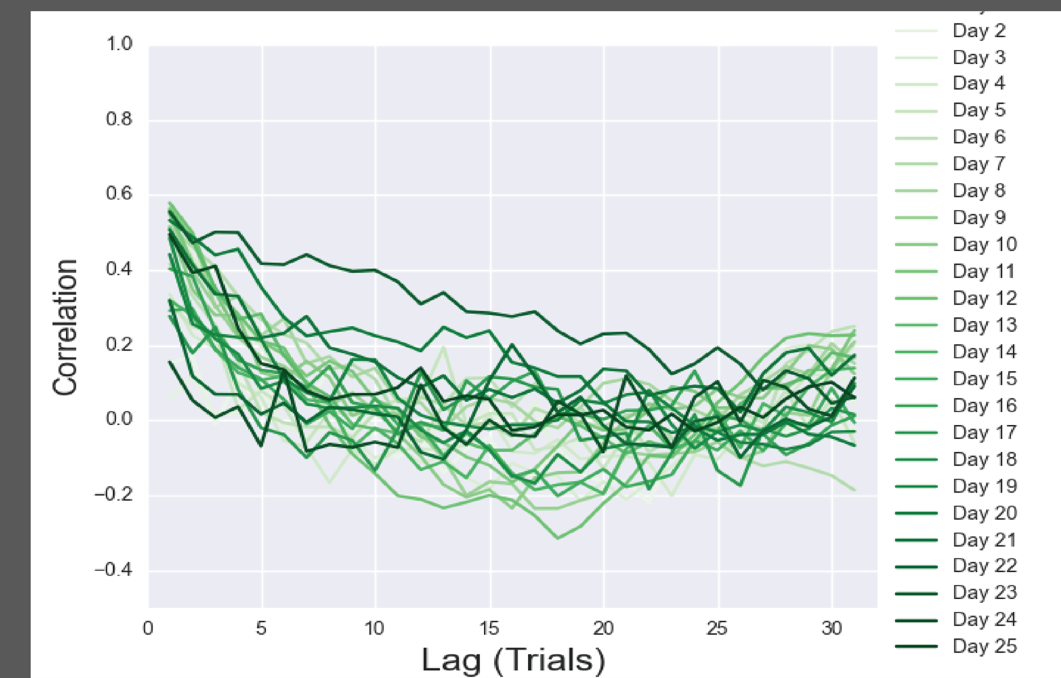
measured distance between movement representations

-- ROI analyses conducted using Freesurfer-defined Brodmann areas on each individual subject. Surfaces were reconstructed using the Human Connectome Project Pre-Processing Pipeline.
-- Classical multidimensional scaling was applied to each cross validated distance matrix for visualization.

3. Behavioral performance consistently improved throughout training

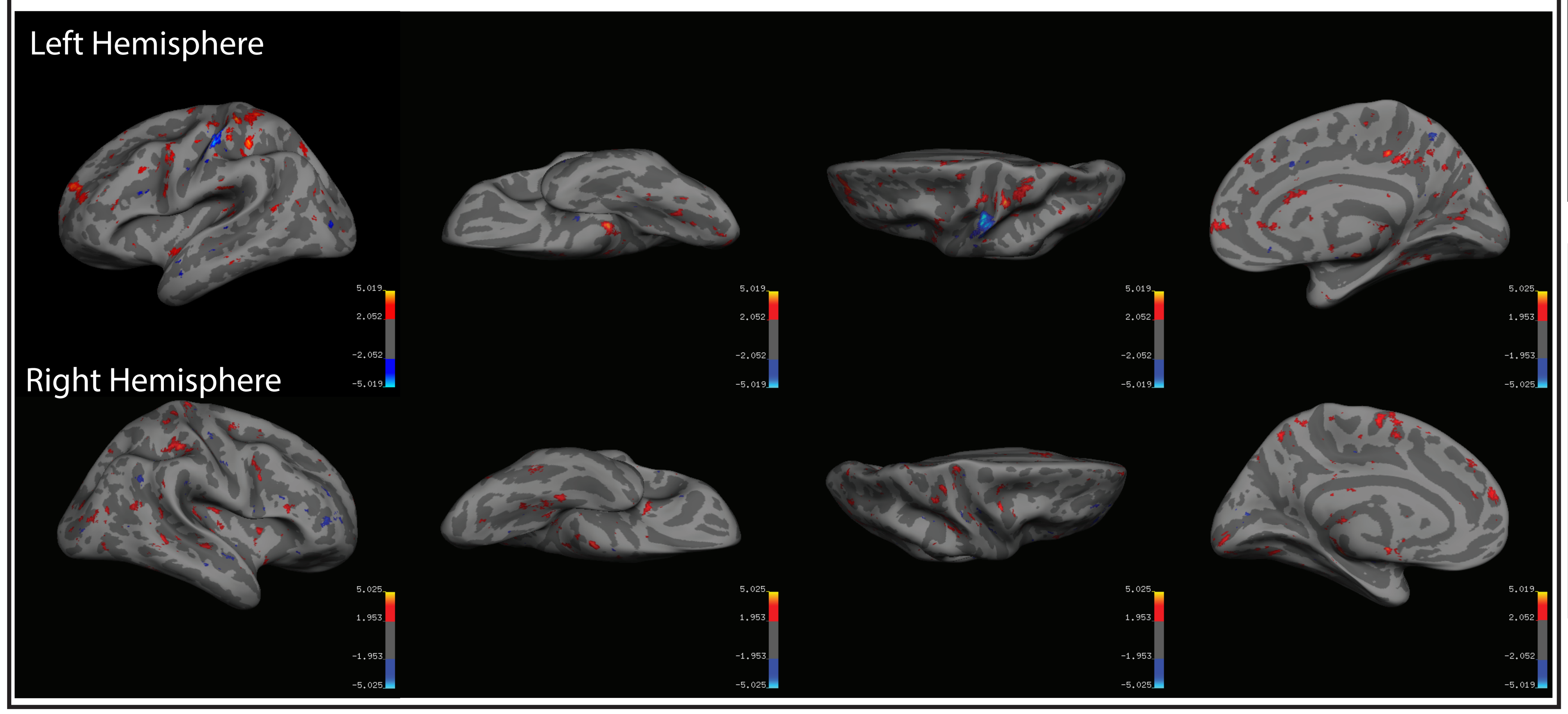


Z-scored reaction times comparing random vs. sequence blocks across all subjects

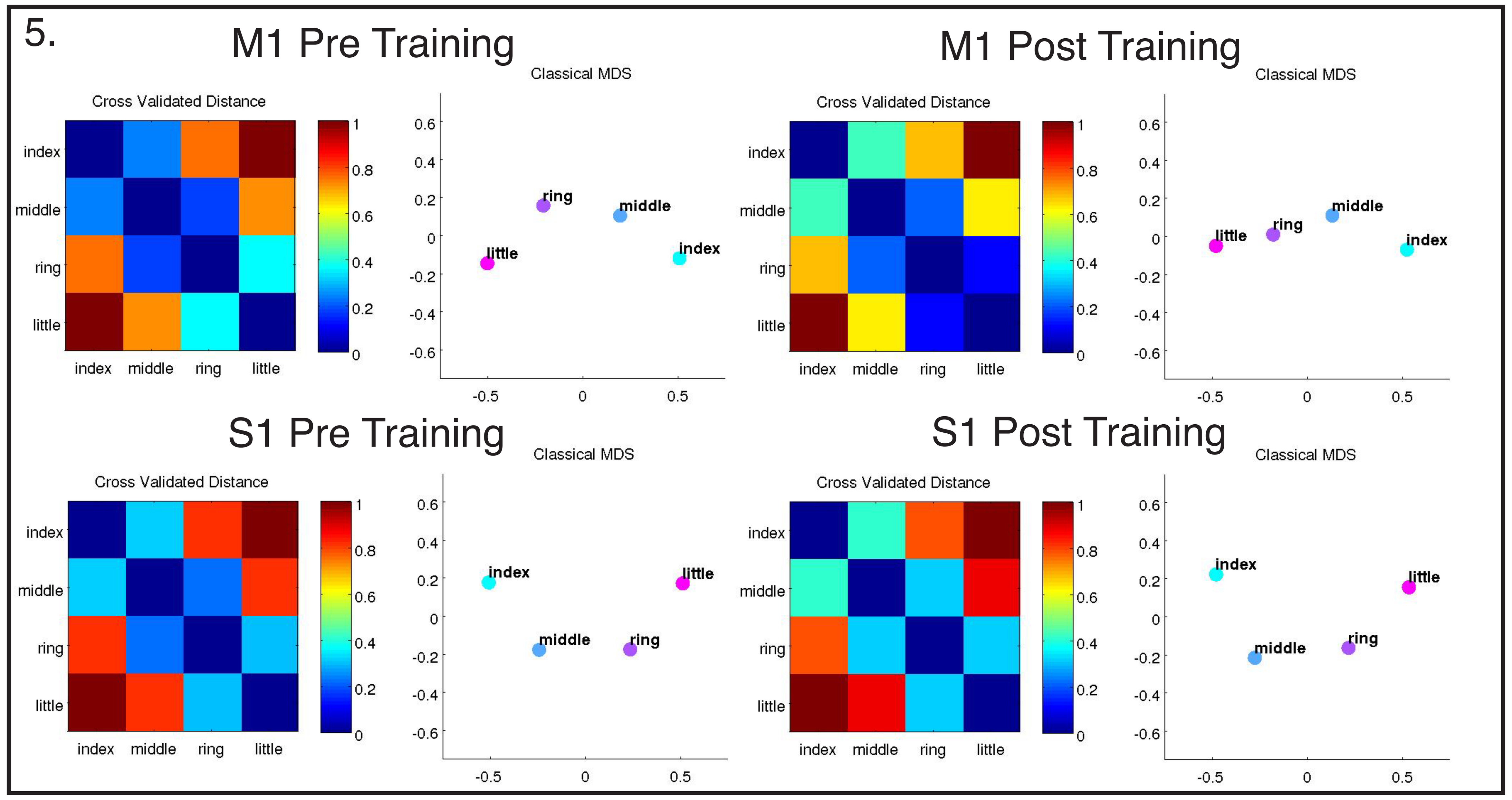


Example autocorrelation results (lag = 32) across 25 days of training.

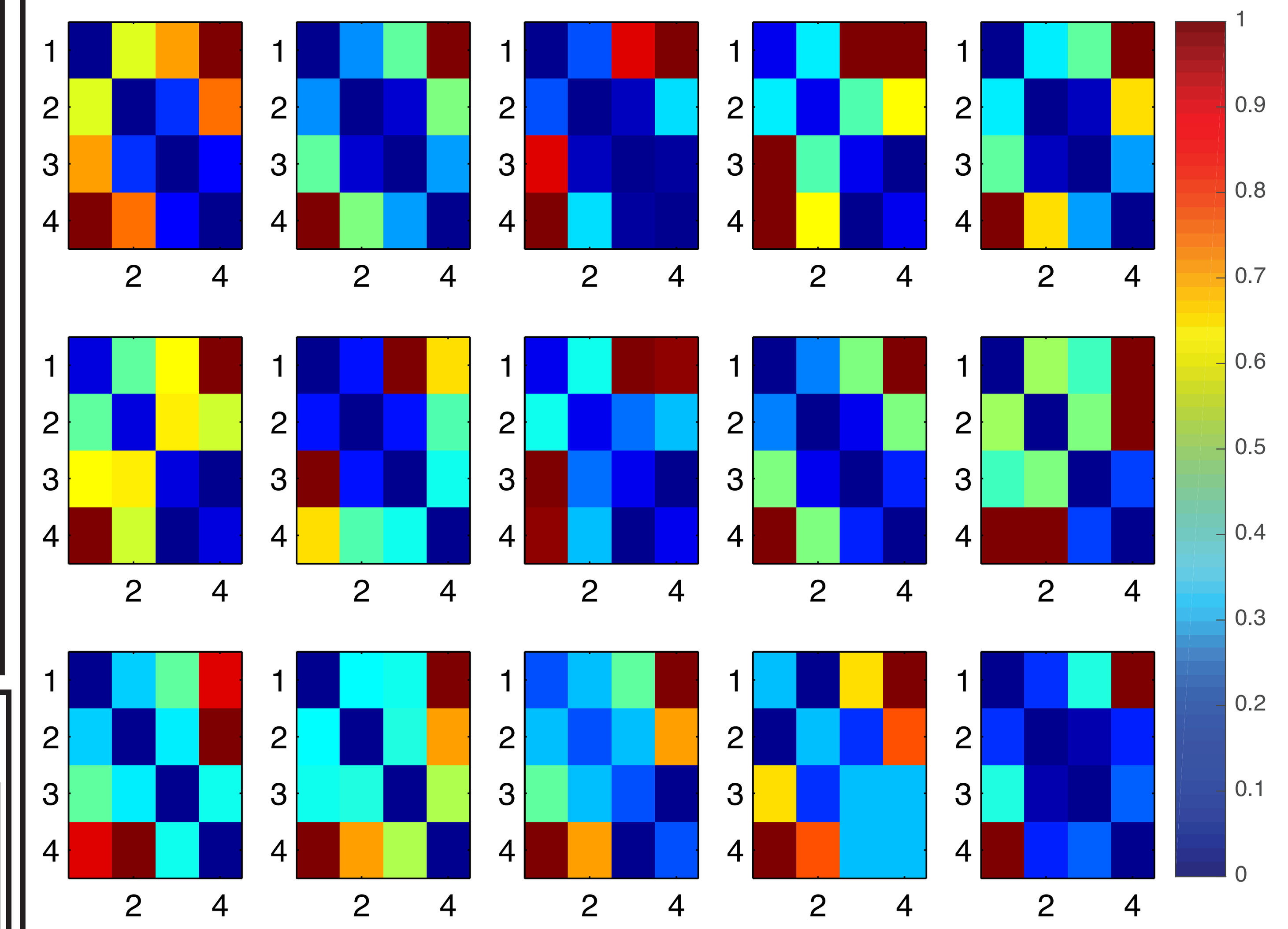
4. Cortical regions showing significant distance between representations



5.

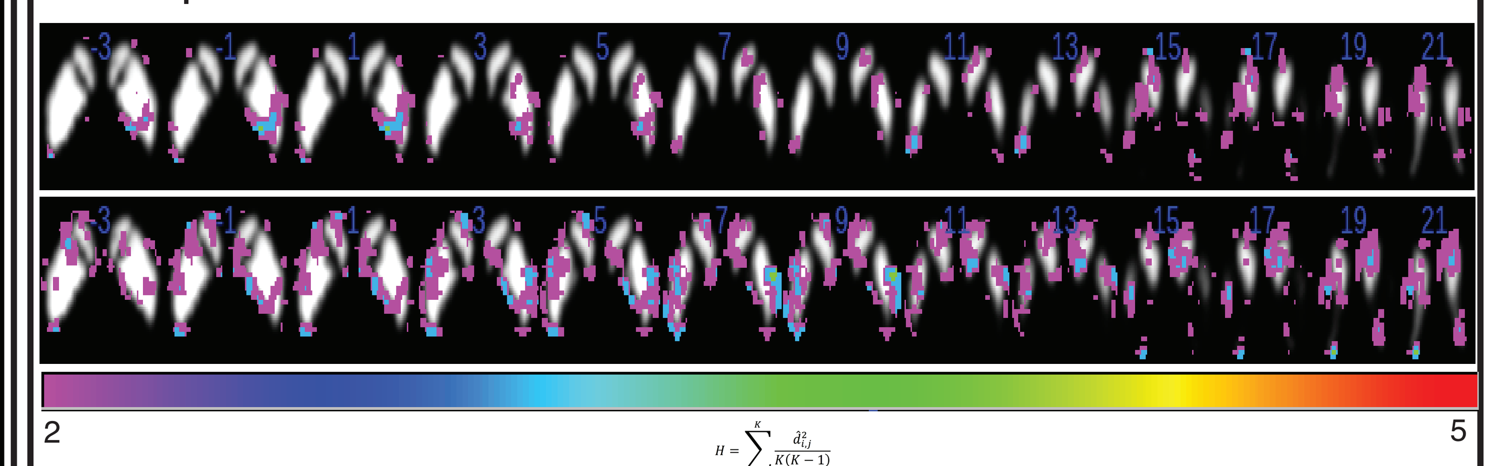


6. Cross validated distances are robust at single subject level



Representational dissimilarity matrices between each finger across all run pairs (6 choose 2) from an example subject (Index = 1, middle = 2, ring = 3, little =4)

7. Representational distances in the striatum



8. Summary

Long-term skill acquisition is associated with increased discriminability of movement representations in PPC and reduced discriminability of movement representations in M1, but not in S1.

Weaker increases in discriminability were observed in striatum.

Cross-validated distances between finger representations are robust at the single-subject level and may function as a useful marker of the plasticity of movement representations.

References

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