Shared response modelling of somatosensory digit representations using 7-tesla fMRI

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Background

- High-field fMRI can capture fine-scaled functional topography in primary somatosensory cortices [1,2]
- Studying shared organizational principles requires alignment across participants, yet anatomical alignment cannot preserve topographies at fine spatial scale [3]
- Shared response modelling (SRM) [4] identifies shared latent variables that explain individual voxel time-series, independent of anatomical layout.
- Here, we apply SRM to explore the possibility to align individual participants' finger maps in a common representational space of somatosensory cortex

Methods

Data acquisition

- 12 participants were scanned in the 7T-MRI scanner in Magdeburg. Vibro-tactile periodic digit stimulation was applied using a Piezo-stimulator (Quearosys stimulator) in forward- and reversed-order (5.12 sec / digit, 10 repetitions)
- 1mm isotropic voxels, TR 2 sec, 256 volumes, 8:32 min

Preprocessing

- Spatial smoothing (2mm), temporal filtering (50 volumes high-pass, 2 volumes low-pass), mask contralateral hemisphere, GLM to identify associated voxels (F-Test over digit-regressors, cf. figure 1).

Shared response modelling

- Robust SRM [4]: Participants' functional data is decomposed into a set of 10 shared temporal factors and individual voxel-wise weights (cf. figure 2). We applied two modelling approaches:

1. Separate SRM for each of the two functional runs
2. Cross-validation scheme: SRM was estimated on training run and test run of held-out subject projected into model space, i.e. test data was neither used to estimate the SRM, nor subject-specific mapping

Figure 1. Individual ROI from one example participant. Voxels associated with digit stimulation were determined via subject-level GLM.

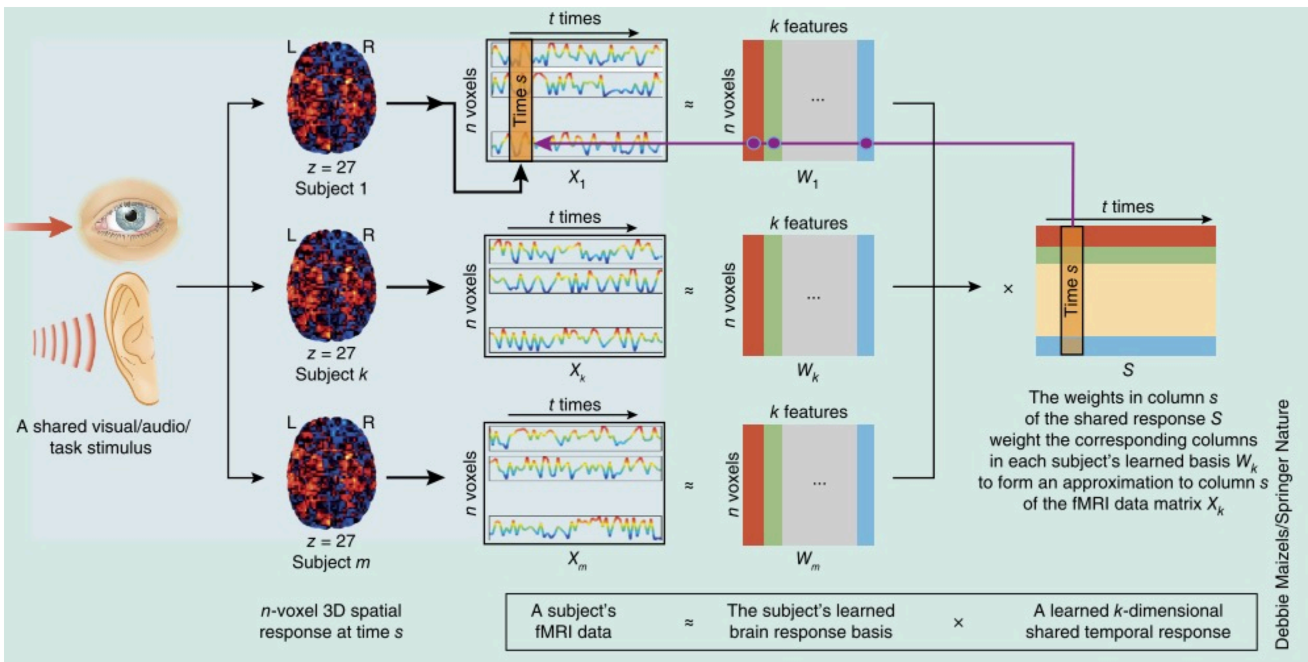

Figure 2. Illustration of SRM procedure (adapted from [5])

Results

Functional data in shared response space

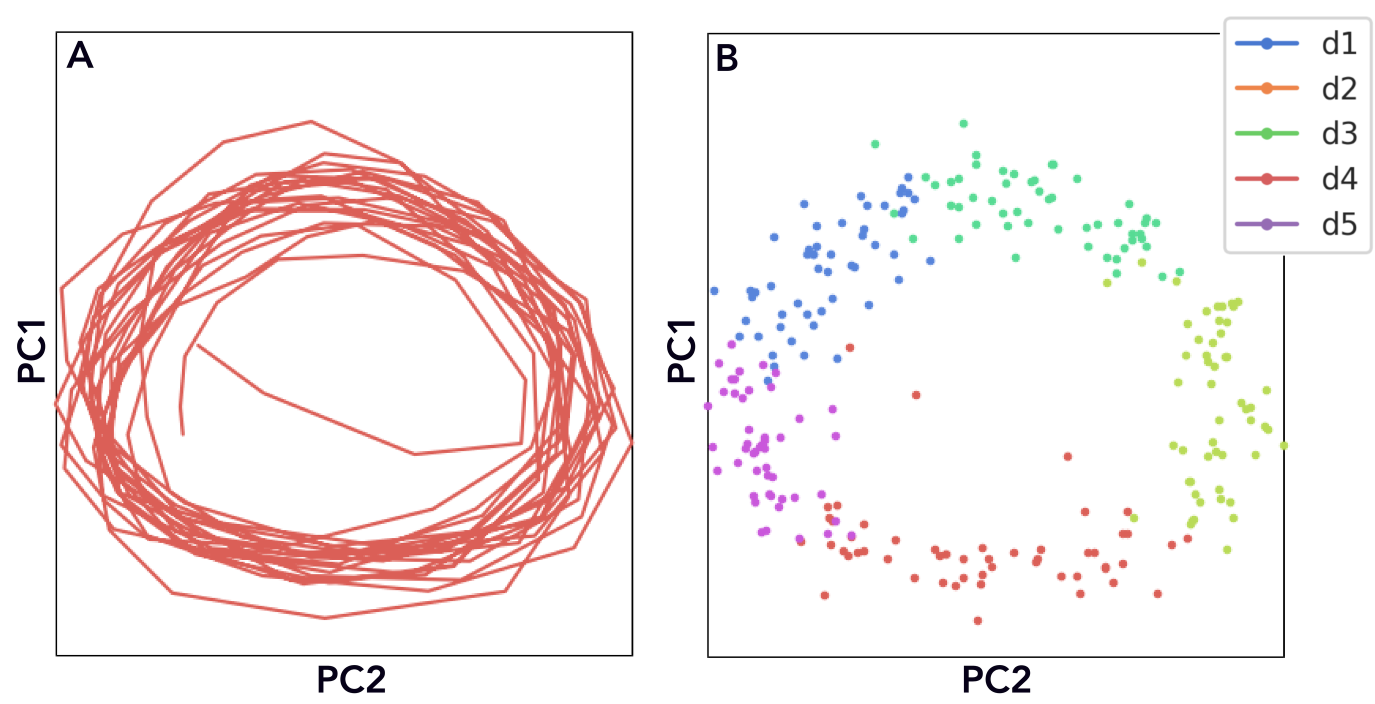

Figure 3. Functional data of one example subject as projected in shared somatosensory space. A: Trajectory throughout the run. B: Individual TRs. The ring-like trajectory reflects temporal transition between stimulation of five digits. SRM was estimated on one functional run, axes correspond to first two principle components (PC), color indicates stimulated digit.

Digit-wise similarity

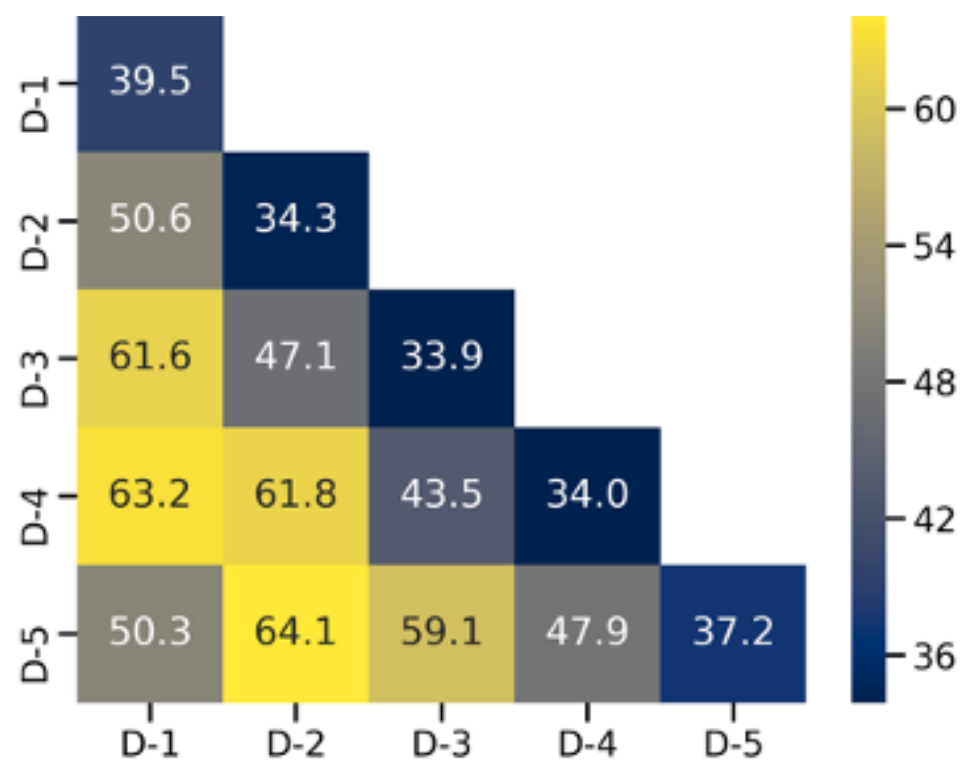

Figure 4. Average euclidean distance in shared space between samples associated with the five digits.

SRM cross-validation

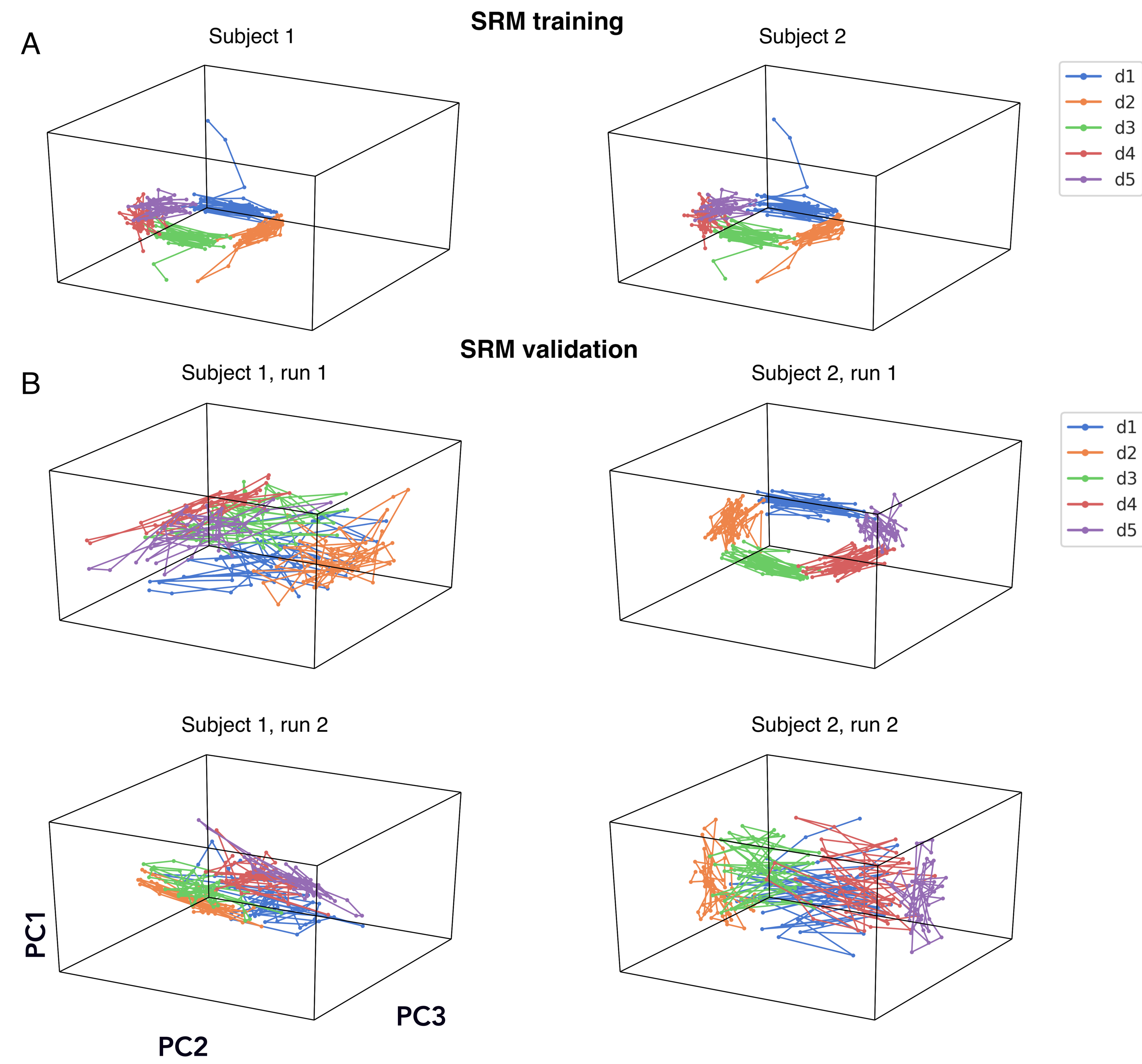

Figure 5. Example results from cross-validation. A: Averaged shared responses based on the training data. B: Held out participants projected into shared response space. Color indicates stimulated digit, axes correspond to first three principle components.

Discussion

- The ring-like trajectory reflects temporal transitions between five distinct sensory experiences
- Our results suggest:
  - SRM can capture a shared representational space of somatosensory cortex
  - SRM can align fine-scaled somatotopy across participants, opening up possibilities for future group analyses in ultra-high resolution MRI studies
- The clear-cut dimensionality of the stimulus (i.e. 5 distinct states) facilitates interpretability of locations in this shared space

References

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