Hyperclassification reveals shared representation of physical and vicarious perception of touch and pain across two brains

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Introduction

- Both physical and vicarious pain may activate sensory and affective components of the "pain matrix" [1], allowing simulating other's somatovisceral states.
- It remains unresolved how accurately the somatosensory and affective information is shared across individuals experiencing stimulation physical and those simulating it vicariously.
- We introduce a novel two-person 'hyperclassification' approach and reveal shared neural signatures underlying painful experience and vicarious pain.

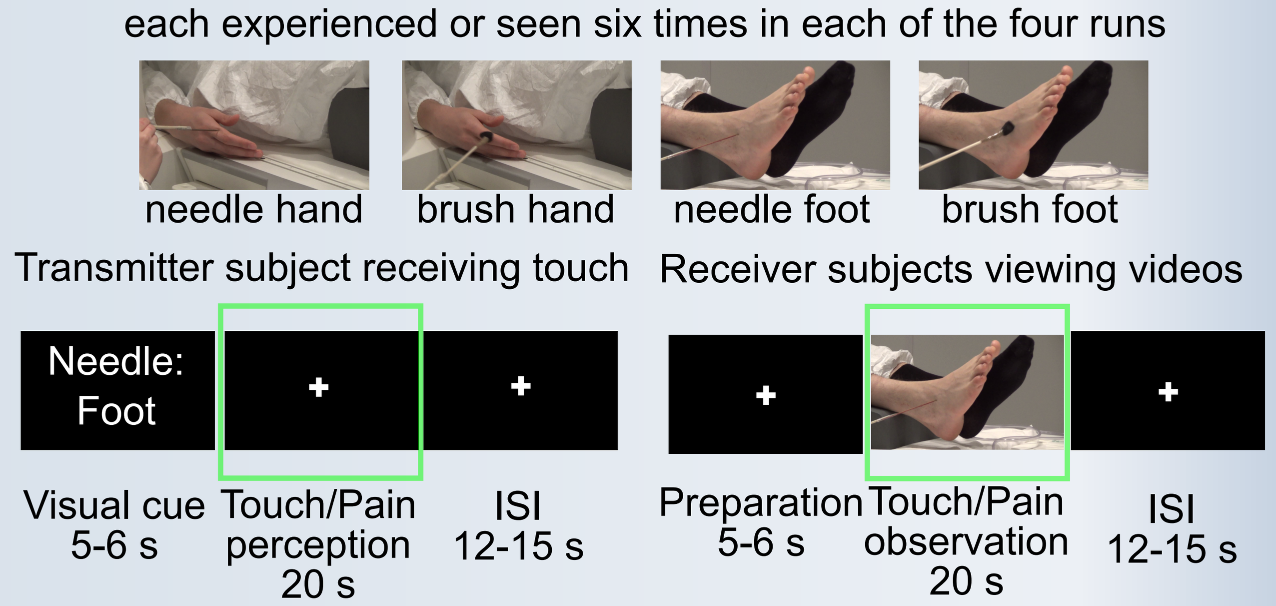
Methods

Imaging: 3T Siemens Magnetom Skyra, EPI sequence, TR 2.5 s, 346 scans in one run.

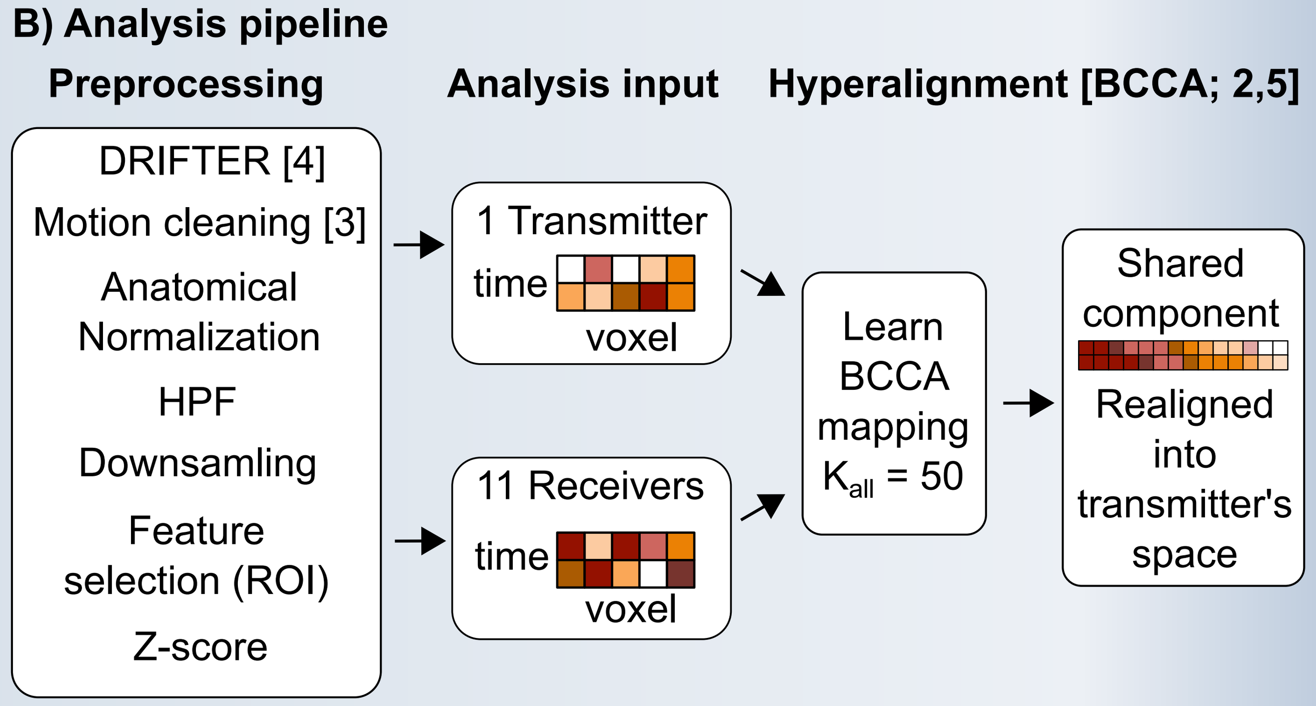
Regions of interest: 1) Derived from subject-wise localizer scans 2) meta-analytic "pain" ROI from NeuroSynth [6] 3) task-irrelevant validation ROI: frontal pole.

1. Experimental design and analysis pipeline.

A) Experimental design



B) Analysis pipeline



Results

2. Hyperalignment allows successful classification of pain and touch across transmitting and receiving brains.

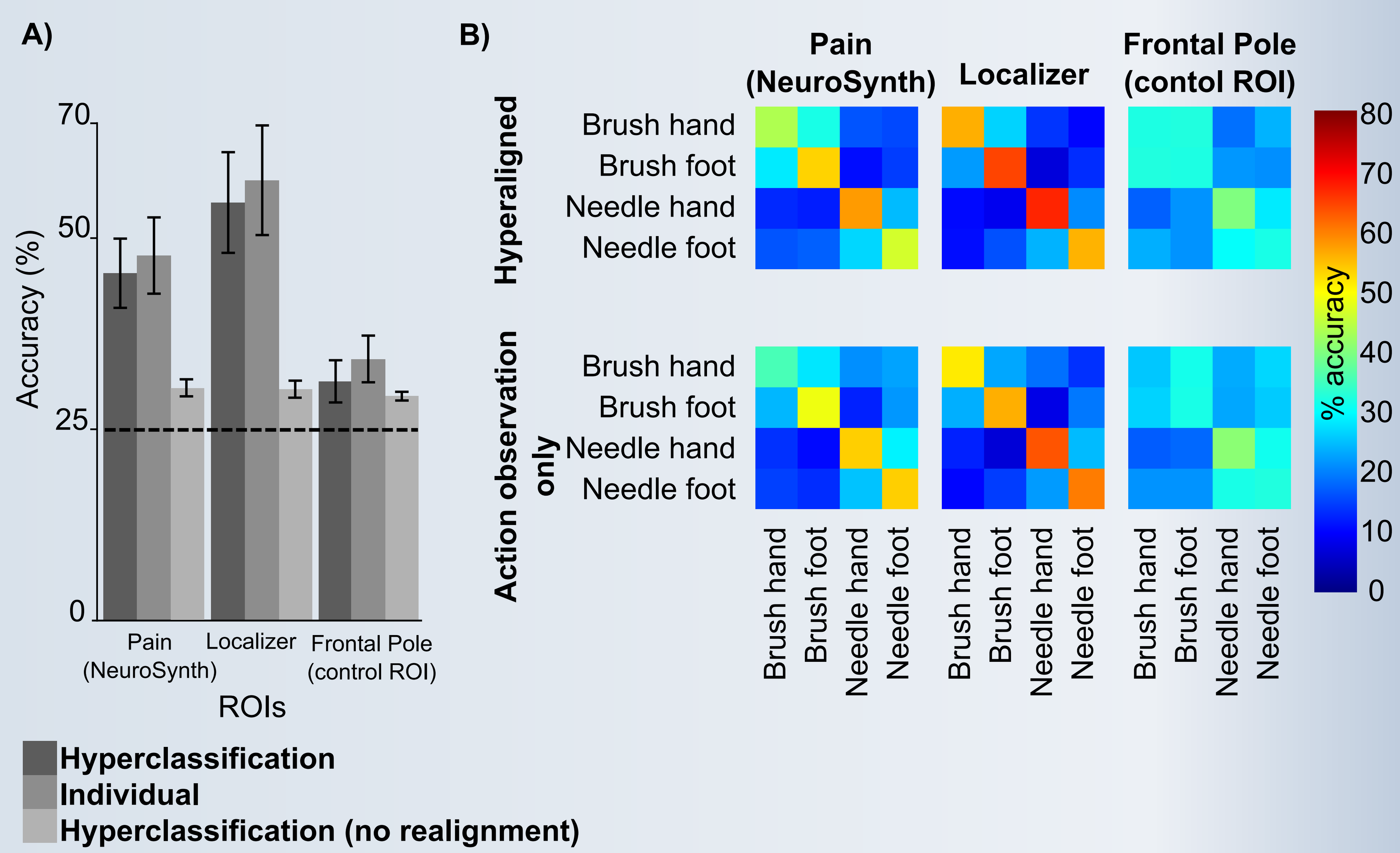


Figure 2. A) Mean and SEM of classifier accuracy for various ROIs. Dashed line represents chance level (25%). B) Confusion matrixes for each touch category.

3. Cortical representation of vicarious pain versus touch.

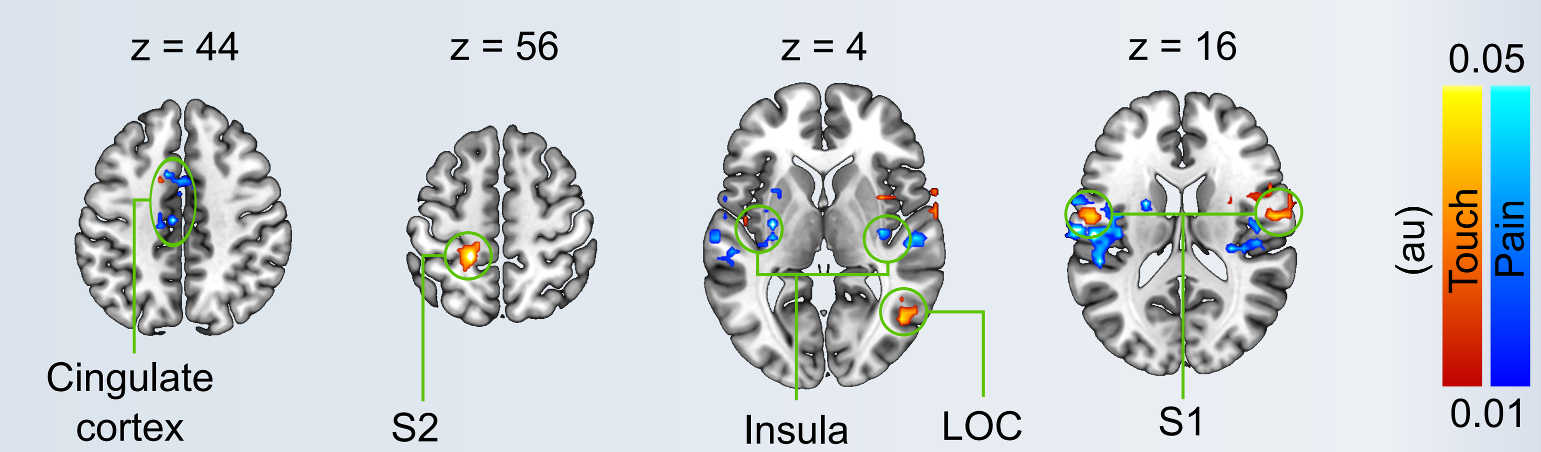


Figure 3. Classifier importance maps for binary vicarious touch-pain classification. Voxels colored with hot colors contributed to classification of observed category as touch, cold-colored as pain. 5% strongest voxels are shown, cluster-corrected.

4. Hyperalignment improves classification between sensory and vicarious pain and touch.

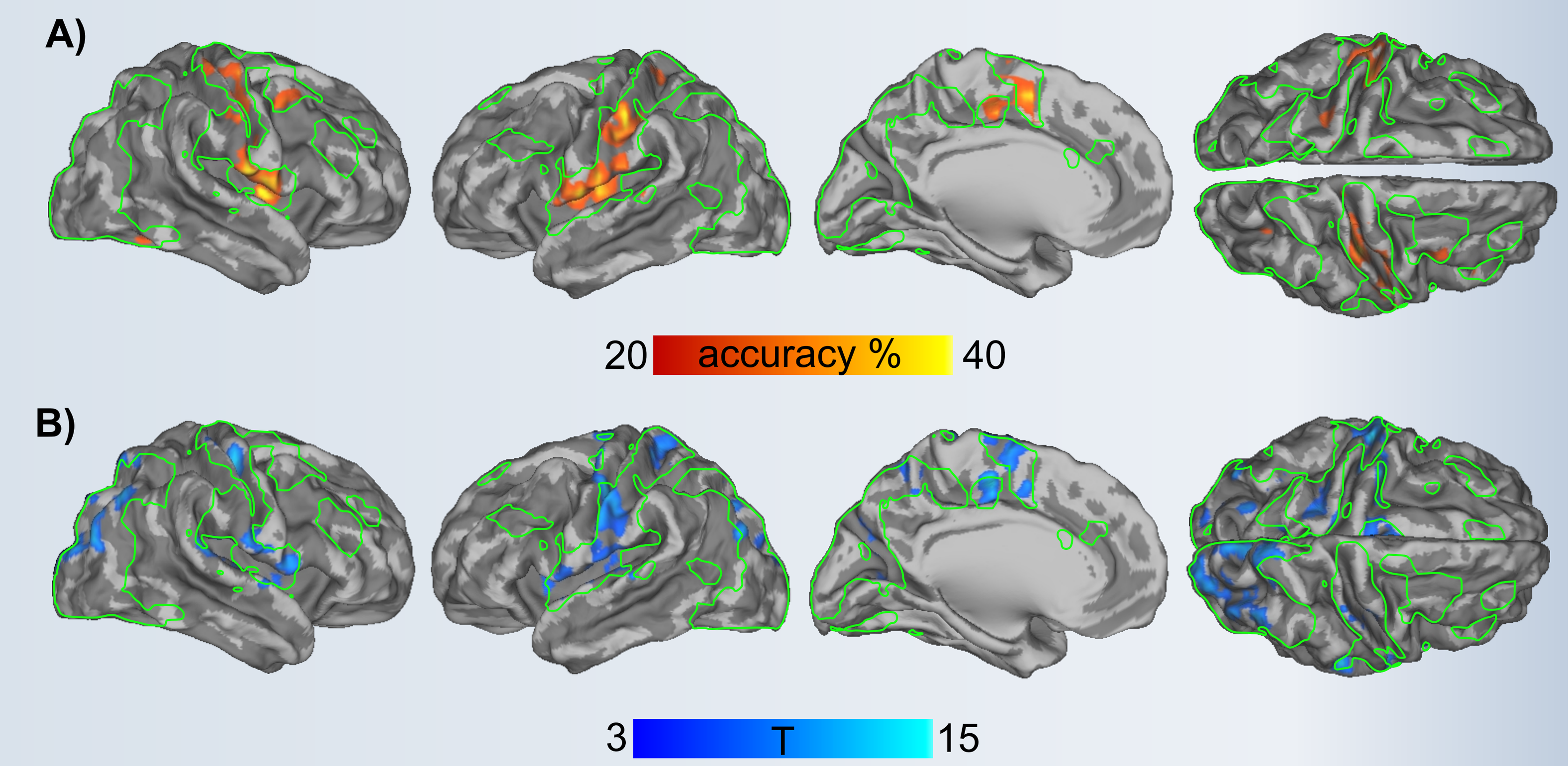


Figure 4. A) Increase in hyperclassification accuracy (kNN searchlight) after functional realignment, p < 0.05 FDR-corrected. B) Increase in transmitter-receiver correlation after functional realignment. White outline represents voxels included in localizer ROI.

Conclusions

- Brain responses to seeing pain and touch can be predicted from another individuals' brain responses experiencing the corresponding tactile and nociceptive stimuli.
- Vicarious and sensory pain share specific neural signatures.
- Vicarious pain was successfully differentiated from vicarious touch with somatosensory cortices contributing to touch hyperclassification and cingulate and insular cortices to pain hyperclassification.
- Functional hyperalignment model is robust to noise and performs accurately only when shared signal between transmitters and receivers exists.

References

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