# Supplementary Information

### Preprocessing of the resting-state dataset of 1000 subjects from the HCP

The HCP minimal preprocessing pipeline (HCP Functional Pipeline v2.0) was applied to resting-state fMRI images (Glasser et al., 2013). It includes gradient distortion correction, motion correction, EPI distortion correction, registration to the Montreal Neurological Institute (MNI) space, intensity normalization to a global mean of 10000, and masking out non-brain voxels. To remove non-neural spatiotemporal components and structured noise, all resting-state fMRI scans were further denoised through a process that paired independent component analysis (ICA) with the FIX (FMRIB's ICA-based X-noisifier). For a detailed description, please refer to S. M. Smith et al. (2013). Several procedures were further performed on the pre-processed fMRI scans using the GRETNA toolbox (Wang et al., 2015). Briefly, all resting-state fMRI scans were linearly detrended to minimize the effects of low-frequency drift. Then, several nuisance variables, including 6 head motion parameters, white matter, cerebrospinal fluid, and global signals, were regressed out. Finally, all images were temporally bandpass filtered (0.01-0.1 Hz) and smoothed spatially at 6 mm FWHM.

### Preprocessing of the resting-state dataset of 1000 subjects from the GSP

The rs-fMRI data of 1000 healthy subjects were obtained from the publicly available genome superstructure project (<http://neuroinformatics.harvard.edu/gsp/>) (Holmes et al., 2015; Yeo et al., 2011). The preprocessing procedure was similar to that of other studies from our lab (Xie et al., 2017). In brief, the first 4 volumes were discarded for magnetic field stabilization and the participants’ adaption to the scanning environment. The remaining volumes were then slice-timing corrected, realigned to correct head motion, and normalized to MNI space by DARTEL (Ashburner, 2007). Several procedures were further performed on the preprocessed fMRI scans using the GRETNA toolbox (Wang et al., 2015). The normalized rs-fMRI scans were spatially smoothed with a 6 mm FWHM Gaussian kernel and linearly detrended to minimize the effects of low-frequency drift. Then, several nuisance variables, including 6 head motion parameters, white matter, cerebrospinal fluid, and global signals, were regressed out. Finally, all images were temporally bandpass filtered (0.01-0.1 Hz).

## Supplementary Tables

Table S1. Selected TMS studies that disrupt facial emotion processing

|  |  |  |
| --- | --- | --- |
| **Study** | **Disruption** | **Sample Size** |
| (Pitcher, Garrido, Walsh, & Duchaine, 2008) | Reduced accuracy | 28 |
| (Mattavelli, Cattaneo, & Papagno, 2011) | Prolonged reaction time | 20 |
| (Rochas et al., 2013) | Reduced accuracy | 20 |
| (Pitcher, 2014) | Reduced accuracy | 14 |
| (Ferrari et al., 2016) | Reduced accuracy | 20 |
| (Sliwinska & Pitcher, 2018) | Reduced accuracy | 30 |
| (Sliwinska, Elson, & Pitcher, 2020) | Reduced accuracy | 22 |
| (Korb et al., 2015) | Prolonged reaction time | 30 |
| (Ferrari et al., 2016) | Prolonged reaction time | 12 |

Table S2. Peaks of clusters of activation network overlap map of each emotion category. The minimum cluster size is 100 mm3, corresponding to a minimum of 13 voxels.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Emotion** | **Voxels** | **Overlap** | **X** | **Y** | **Z** | **Region** |
| combined | 2485 | 169/230 | -48 | 14 | -14 | Temporal Pole |
| combined | 2390 | 168/230 | 52 | 16 | -16 | Temporal Pole / Frontal Orbital Cortex |
| combined | 1379 | 159/230 | 44 | -42 | -18 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| combined | 826 | 161/230 | -40 | -50 | -20 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| combined | 441 | 154/230 | 52 | -2 | 44 | Precentral Gyrus / Postcentral Gyrus |
| combined | 348 | 161/230 | -48 | -4 | 50 | Precentral Gyrus / Middle Frontal Gyrus |
| anger | 8650 | 34/ 39 | -48 | 14 | -14 | Temporal Pole |
| anger | 6601 | 36/ 39 | 48 | 18 | -18 | Temporal Pole / Frontal Orbital Cortex |
| anger | 959 | 28/ 39 | 48 | -6 | 48 | Precentral Gyrus / Postcentral Gyrus |
| anger | 493 | 28/ 39 | 0 | 4 | 64 | Superior Frontal Gyrus / Juxtapositional Lobule Cortex |
| anger | 334 | 28/ 39 | -42 | -40 | -16 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| anger | 312 | 26/ 39 | 44 | -40 | -24 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| anger | 189 | 24/ 39 | 48 | -56 | 0 | Middle Temporal Gyrus / Lateral Occipital Cortex |
| anger | 108 | 26/ 39 | 38 | -6 | 14 | Insular Cortex / Central Opercular Cortex |
| anger | 73 | 26/ 39 | -34 | -8 | 14 | Insular Cortex / Central Opercular Cortex |
| anger | 36 | 25/ 39 | -60 | -14 | 20 | Postcentral Gyrus / Parietal Operculum Cortex |
| anger | 28 | 23/ 39 | -56 | 30 | 6 | Middle Frontal Gyrus / Inferior Frontal Gyrus |
| anger | 17 | 24/ 39 | 6 | -4 | 58 | Precentral Gyrus / Juxtapositional Lobule Cortex |
| disgust | 18982 | 21/ 24 | -52 | 10 | -12 | Temporal Pole |
| disgust | 6803 | 21/ 24 | 52 | 16 | -16 | Temporal Pole / Frontal Orbital Cortex |
| disgust | 555 | 18/ 24 | -4 | 6 | 60 | Superior Frontal Gyrus / Juxtapositional Lobule Cortex |
| disgust | 142 | 15/ 24 | 26 | -94 | -10 | Occipital Pole / Occipital Fusiform Gyrus |
| disgust | 129 | 15/ 24 | -38 | -4 | 4 | Insular Cortex |
| disgust | 110 | 15/ 24 | 38 | 0 | 10 | Insular Cortex / Central Opercular Cortex |
| disgust | 79 | 15/ 24 | -28 | -50 | 56 | Superior Parietal Lobule / Postcentral Gyrus |
| disgust | 79 | 16/ 24 | 42 | 0 | -48 | Temporal Pole / Temporal Fusiform Cortex |
| disgust | 65 | 14/ 24 | -22 | -100 | -18 | Occipital Pole / Lateral Occipital Cortex |
| disgust | 58 | 15/ 24 | 66 | -14 | 22 | Supramarginal Gyrus / Postcentral Gyrus |
| disgust | 46 | 14/ 24 | -40 | -38 | 14 | Supramarginal Gyrus / Superior Temporal Gyrus |
| disgust | 20 | 14/ 24 | -34 | -26 | 2 | Planum Polare / Left Putamen |
| disgust | 17 | 14/ 24 | 12 | -30 | 68 | Precentral Gyrus / Postcentral Gyrus |
| disgust | 14 | 14/ 24 | -64 | -14 | 20 | Supramarginal Gyrus / Postcentral Gyrus |
| disgust | 14 | 14/ 24 | 28 | -34 | 72 | Superior Parietal Lobule / Precentral Gyrus |
| fear | 8499 | 62/ 78 | 46 | -42 | -22 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| fear | 7892 | 63/ 78 | -50 | 14 | -14 | Temporal Pole |
| fear | 1015 | 57/ 78 | 52 | -2 | 48 | Precentral Gyrus / Postcentral Gyrus |
| fear | 498 | 59/ 78 | -52 | -2 | 48 | Precentral Gyrus / Middle Frontal Gyrus |
| fear | 40 | 48/ 78 | 26 | -54 | 56 | Superior Parietal Lobule / Lateral Occipital Cortex |
| fear | 22 | 49/ 78 | -24 | -78 | 30 | Precuneous Cortex / Lateral Occipital Cortex |
| fear | 16 | 48/ 78 | 38 | -4 | 14 | Insular Cortex / Central Opercular Cortex |
| happiness | 244 | 28/ 44 | -52 | 0 | -16 | Temporal Pole / Superior Temporal Gyrus |
| happiness | 83 | 29/ 44 | -30 | 6 | -28 | Temporal Pole / Parahippocampal Gyrus |
| happiness | 52 | 27/ 44 | -42 | -14 | 40 | Precentral Gyrus / Postcentral Gyrus |
| happiness | 43 | 28/ 44 | 62 | 4 | -10 | Temporal Pole / Superior Temporal Gyrus |
| happiness | 40 | 28/ 44 | -32 | -10 | -20 | Parahippocampal Gyrus / Left Hippocampus |
| happiness | 39 | 29/ 44 | 32 | 8 | -24 | Temporal Pole / Right Amygdala |
| happiness | 37 | 26/ 44 | 46 | -16 | 40 | Precentral Gyrus / Postcentral Gyrus |
| happiness | 32 | 29/ 44 | 12 | -2 | -24 | Right Hippocampus / Right Amygdala |
| happiness | 26 | 27/ 44 | -38 | -36 | 18 | Supramarginal Gyrus / Superior Temporal Gyrus |
| happiness | 26 | 27/ 44 | 60 | -38 | 12 | Supramarginal Gyrus / Superior Temporal Gyrus |
| happiness | 24 | 27/ 44 | 44 | -12 | 18 | Parietal Operculum Cortex / Central Opercular Cortex |
| happiness | 24 | 26/ 44 | 44 | -52 | -20 | Temporal Occipital Fusiform Cortex / Inferior Temporal Gyrus |
| happiness | 23 | 27/ 44 | -46 | 18 | -22 | Temporal Pole / Frontal Orbital Cortex |
| happiness | 16 | 26/ 44 | 28 | -6 | -26 | Right Hippocampus / Right Amygdala |
| sadness | 6086 | 18/ 23 | 50 | 6 | -18 | Temporal Pole / Superior Temporal Gyrus |
| sadness | 3234 | 18/ 23 | -54 | 2 | -12 | Temporal Pole / Superior Temporal Gyrus |
| sadness | 560 | 17/ 23 | 46 | 0 | 44 | Precentral Gyrus / Middle Frontal Gyrus |
| sadness | 555 | 17/ 23 | 44 | -42 | -24 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| sadness | 433 | 15/ 23 | 8 | 10 | 48 | Superior Frontal Gyrus / Paracingulate Gyrus |
| sadness | 354 | 16/ 23 | -40 | -42 | -26 | Temporal Occipital Fusiform Cortex / Temporal Fusiform Cortex |
| sadness | 282 | 15/ 23 | -62 | -34 | 18 | Supramarginal Gyrus / Supramarginal Gyrus |
| sadness | 101 | 14/ 23 | -22 | -30 | 54 | Precentral Gyrus / Postcentral Gyrus |
| sadness | 99 | 14/ 23 | 40 | -24 | 48 | Precentral Gyrus / Postcentral Gyrus |
| sadness | 86 | 15/ 23 | 16 | -40 | 46 | Precuneous Cortex / Precentral Gyrus |
| sadness | 77 | 15/ 23 | 12 | -36 | 70 | Precentral Gyrus / Postcentral Gyrus |
| sadness | 77 | 15/ 23 | 44 | -18 | 34 | Supramarginal Gyrus / Precentral Gyrus |
| sadness | 57 | 15/ 23 | -40 | -22 | 34 | Precentral Gyrus / Postcentral Gyrus |
| sadness | 31 | 14/ 23 | -16 | -32 | 36 | Precuneous Cortex / Precentral Gyrus |
| sadness | 31 | 14/ 23 | -10 | -16 | 36 | Cingulate Gyrus / Cingulate Gyrus |
| sadness | 27 | 14/ 23 | -26 | -8 | 46 | Superior Frontal Gyrus / Precentral Gyrus |
| sadness | 27 | 15/ 23 | -40 | -6 | 46 | Precentral Gyrus / Middle Frontal Gyrus |
| sadness | 26 | 14/ 23 | 20 | -56 | 8 | Supracalcarine Cortex / Precuneous Cortex |
| sadness | 26 | 14/ 23 | -50 | 2 | 30 | Precentral Gyrus / Middle Frontal Gyrus |
| sadness | 17 | 14/ 23 | 42 | 18 | 4 | Insular Cortex / Inferior Frontal Gyrus |
| sadness | 16 | 15/ 23 | 8 | -48 | 56 | Precuneous Cortex / Precentral Gyrus |
| sadness | 15 | 15/ 23 | 8 | -22 | 60 | Precentral Gyrus / Juxtapositional Lobule Cortex |

Table S3. Peaks of clusters of activation network t map of each emotion category. The minimum cluster size is 100 mm3, corresponding to minimum of 13 voxels.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Emotion** | **Voxels** | **Max** | **X** | **Y** | **Z** | **Region** |
| combined | 20263 | 13.4 | 12 | 8 | -32 | Temporal Pole / Temporal Occipital Fusiform Cortex |
| combined | 18603 | 13.7 | -52 | 16 | -14 | Temporal Pole |
| combined | 399 | 8.45 | 36 | 16 | 24 | Precentral Gyrus / Middle Frontal Gyrus |
| combined | 347 | 7.53 | -4 | 4 | 64 | Superior Frontal Gyrus / Juxtapositional Lobule Cortex |
| combined | 233 | 6.51 | 34 | -4 | 16 | Insular Cortex / Central Opercular Cortex |
| combined | 125 | 6.29 | 26 | -52 | 52 | Supramarginal Gyrus / Superior Parietal Lobule |
| combined | 122 | 7.24 | -16 | -30 | -2 | Left Thalamus / Left Hippocampus |
| combined | 91 | 7.06 | -2 | 42 | -32 | Frontal Medial Cortex |
| combined | 71 | 6.09 | -10 | -18 | 44 | Precentral Gyrus / Juxtapositional Lobule Cortex |
| combined | 26 | 7.77 | 0 | 6 | 12 | Right Lateral Ventricle / Left Lateral Ventricle |
| anger | 8207 | 6.54 | -50 | 14 | -14 | Temporal Pole |
| anger | 7843 | 6.5 | 50 | 16 | -16 | Temporal Pole / Frontal Orbital Cortex |
| anger | 650 | 5.6 | -54 | -2 | 50 | Precentral Gyrus / Middle Frontal Gyrus |
| anger | 487 | 4.53 | -4 | 2 | 64 | Juxtapositional Lobule Cortex |
| anger | 403 | 4.36 | 50 | -4 | 40 | Precentral Gyrus / Postcentral Gyrus |
| anger | 234 | 5.83 | 24 | 8 | 30 | Right Lateral Ventricle / Right Caudate |
| disgust | 597 | 4.01 | -46 | -36 | -20 | Temporal Fusiform Cortex / Inferior Temporal Gyrus |
| disgust | 528 | 3.95 | 46 | -40 | 14 | Supramarginal Gyrus / Superior Temporal Gyrus |
| disgust | 471 | 4.39 | -18 | 0 | -42 | Temporal Pole / Temporal Fusiform Cortex |
| disgust | 404 | 3.99 | -50 | -46 | 12 | Supramarginal Gyrus / Superior Temporal Gyrus |
| disgust | 292 | 4.13 | -50 | 14 | -12 | Temporal Pole / Frontal Orbital Cortex |
| fear | 38697 | 7.69 | 16 | 10 | -30 | Temporal Pole / Frontal Orbital Cortex |
| fear | 2764 | 6.29 | 26 | 16 | 26 | Supramarginal Gyrus, posterior division / Supramarginal Gyrus, anterior division |
| fear | 1297 | 5.68 | -54 | 0 | 50 | Precentral Gyrus / Middle Frontal Gyrus |
| fear | 283 | 4.78 | 0 | 44 | -34 | Frontal Medial Cortex |
| fear | 279 | 4.31 | 26 | -52 | 50 | Supramarginal Gyrus / Superior Parietal Lobule |
| happiness | 385 | 3.68 | -52 | 18 | -16 | Temporal Pole |

## Supplementary figures

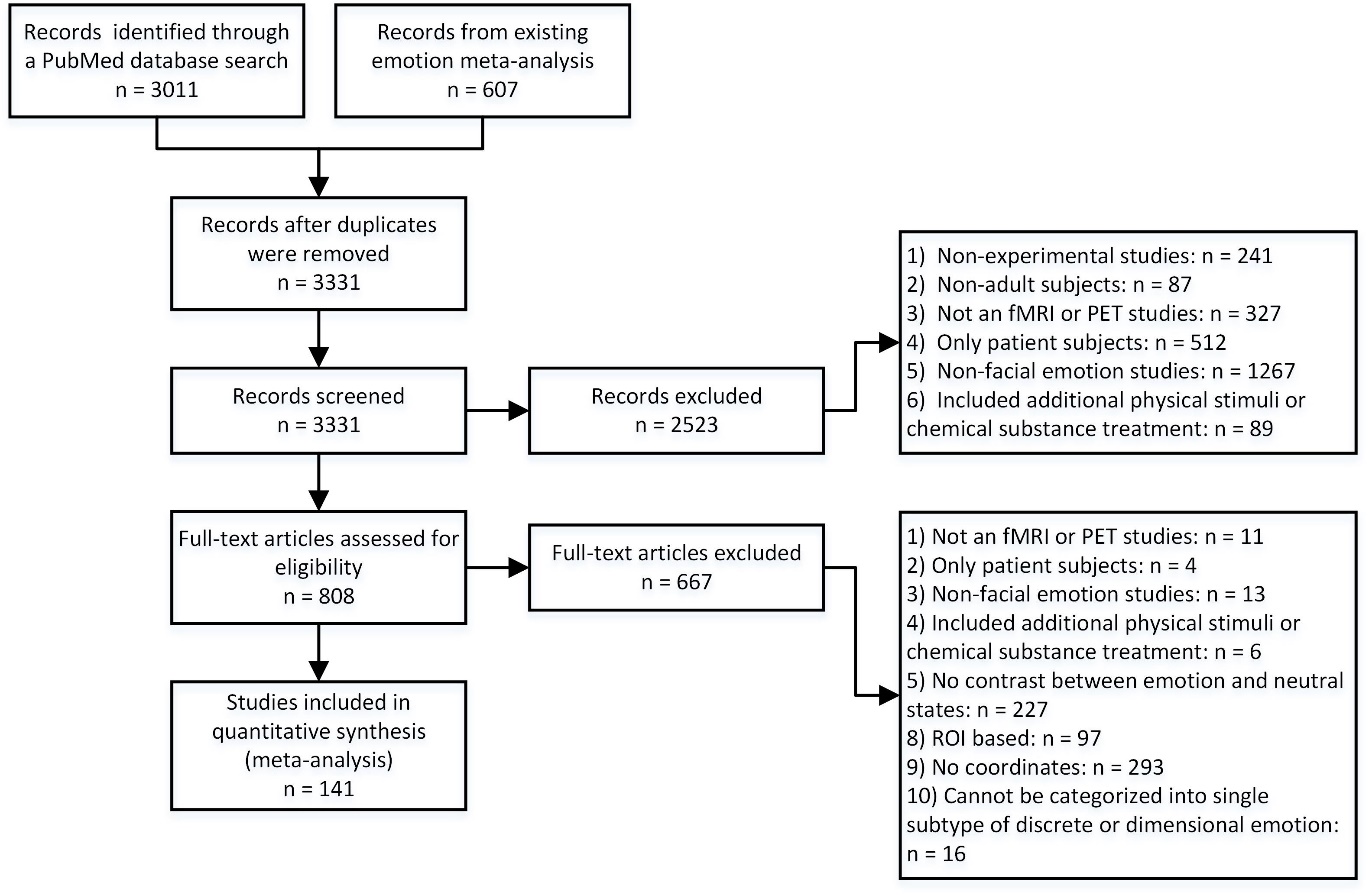


Figure S. PRISMA flowchart reporting the search strategy and the functional neuroimaging studies of facial emotion processing retrieved.

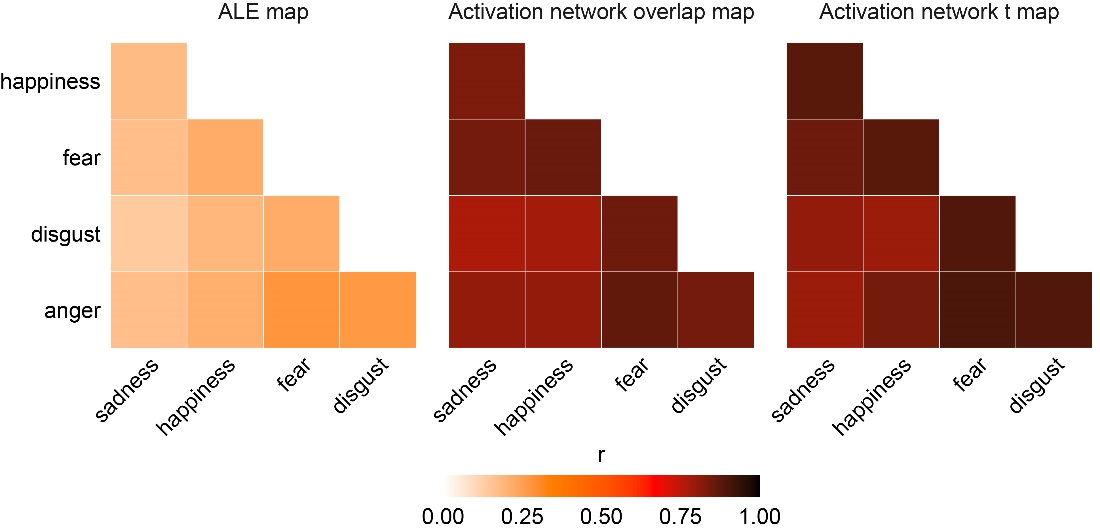


Figure S. The similarity of network patterns between each pair of basic emotions is far higher than that of activation patterns. Unthresholded maps from both ALE and ANM meta-analyses were used to compute the pairwise spatial correlation between pairs of basic emotions.

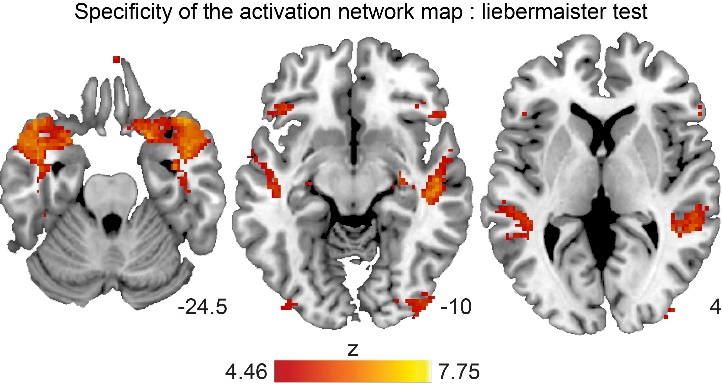


Figure S. The specificity of the facial emotion processing network using the Liebermaister test implemented in NiiStat. Activation network maps from facial emotion processing (n = 230) were statistically contrasted with activation network maps from non-emotional cognitive processing (n = 145) using binarized maps.

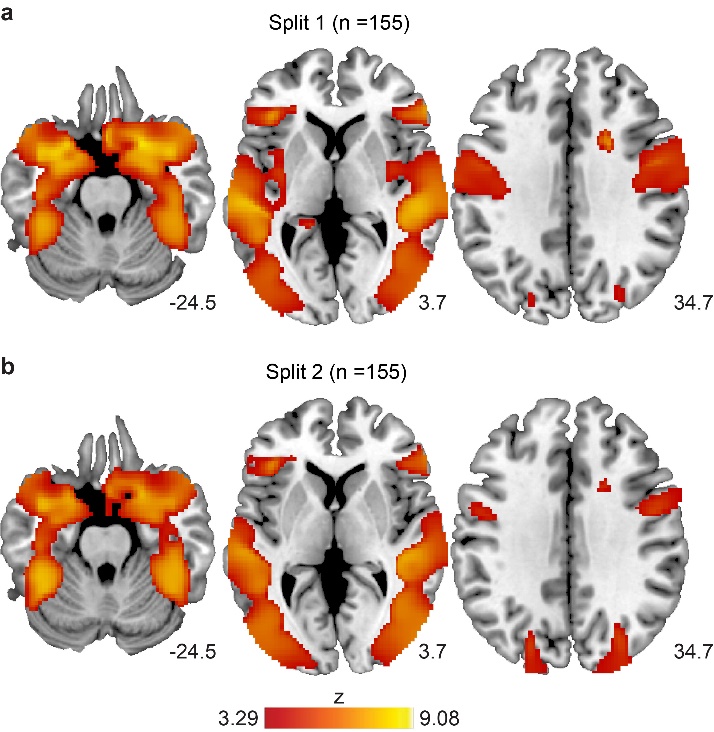


Figure S. The split-half replication test indicated high reliability of network localization of facial emotion processing. First, all experiments were split randomly into two equal subsets, and then sensitivity analysis was conducted separately using the one-sample t-test approach. The high similarity between the two resulting activation network t maps indicated the high reliability of the ANM results.

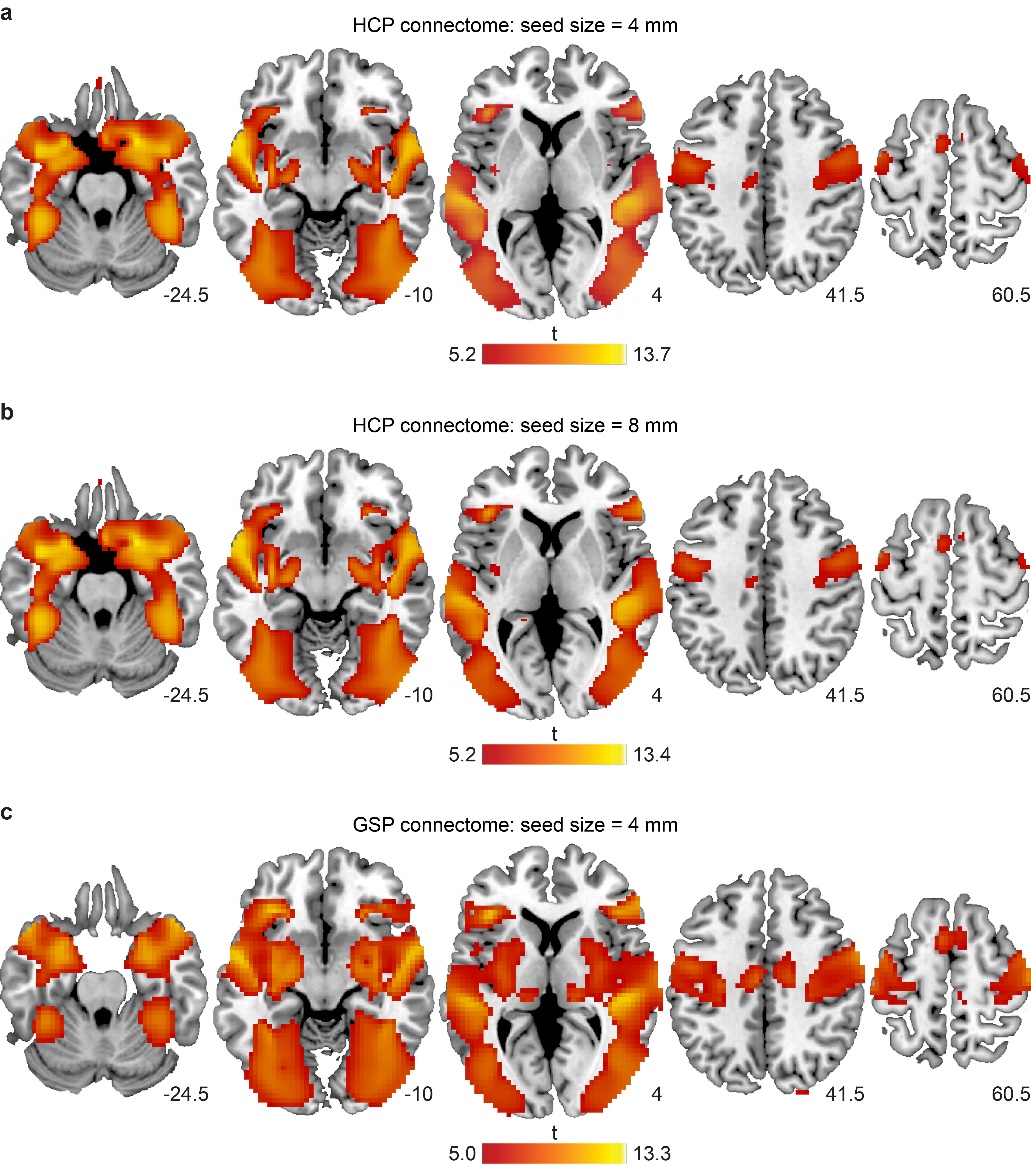


Figure S. Using a different seed size (8 mm) and human connectome database (GSP) identified a highly consistent functional connectivity map (activation network t map).

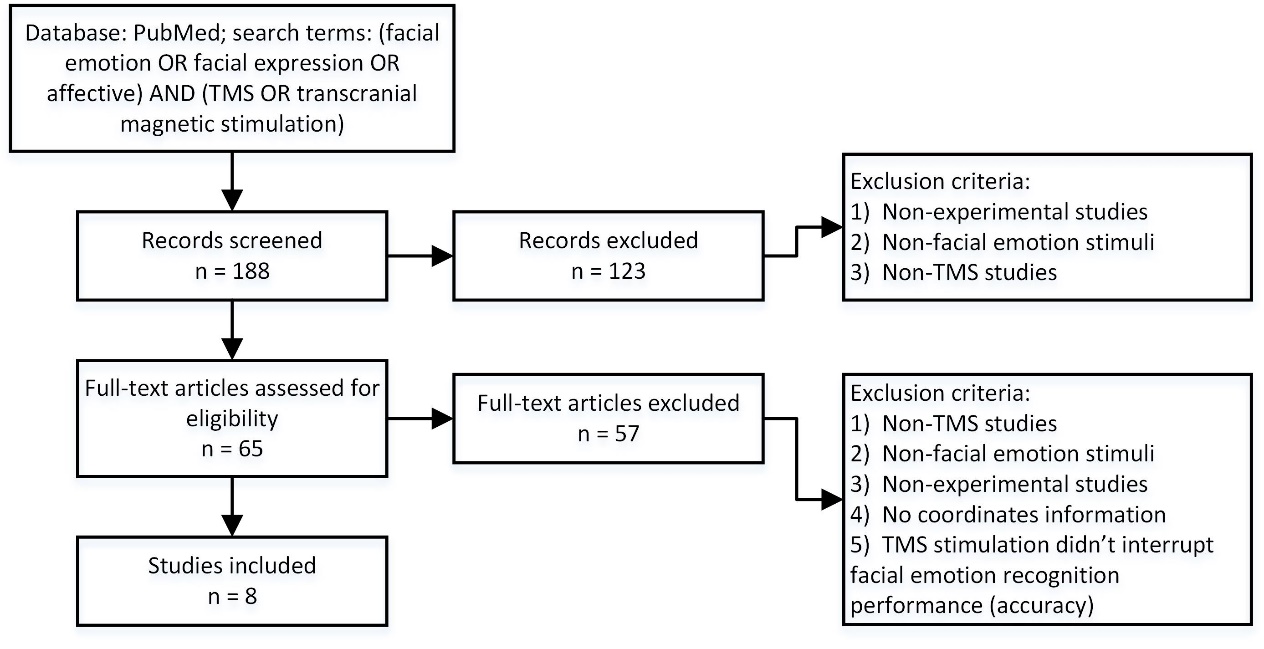


Figure S. PRISMA flowchart reporting the search strategy and the TMS studies retrieved.