

Brain functional connectivity predicts emotional awareness

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Introduction

The aim of this study was to use brain functional connectivity at rest to predict emotional awareness. Emotional awareness is part of interoceptive awareness and refers to the awareness of certain bodily sensations associated with emotions. Deficiencies in emotional awareness may lead to psychopathology, such as alexithymia. The literature on the cerebral underpinnings of emotional awareness is rather limited. Whereas some studies point to a role of the (anterior) insula¹, other studies report evidence of the involvement of the posterior superior temporal sulcus^{2,3}.

Methods

Participants.

A total of 86 normal healthy control subjects participated in the study. Average age of the participants was 43.6 ± 6.6 years (47F, 39M).

Psychological testing.

Participants completed the Multi-dimensional Assessment of Interoceptive Awareness (MAIA) which consists of 32 questions probing different aspects of interoceptive awareness. The scale provides both an overall measure of interoceptive awareness, as well as subscores of eight components, including emotional awareness⁴.

MRI scanning.

We used a 3T Philips Achieva with a 32-channel phased array head coil. The MRI session included one anatomical sequence (T1-weighted) and one eyes-closed rsfMRI scan (RS). T1-weighted images are obtained with a gradient-echo sequence with an inversion prepulse acquired in the sagittal plane with TR=9.1ms, TE=4.6ms, flip angle=8°, 150 slices, slice thickness=1mm, in-plane resolution reconstructed in 0.75x0.75 mm². RS MRI T2*-weighted sequence was collected with echo-planar imaging: in-plane resolution=3.438*4.348, TE=30 msec, TR=2000ms, FA=90°, 35 slices (ascending), slice thickness=3.44mm. The whole brain slices were scanned 200 times per run.

rs-fMRI Preprocessing.

This consisted of linear trend removal to exclude scanner-related signal drift, a temporal high-pass filter to remove frequencies below 0.005 Hz and correction for head movements using a rigid body algorithm for rotating and translating each functional volume in 3D space. Data were also corrected for time differences in the acquisition of the slices. Regression analyses were performed to remove artefacts due to residual motion and changes in ventricles. Data were smoothed in the spatial domain (Gaussian filter, FWHM=5mm). Anatomical and functional volumes were spatially normalised in MNI space. We used BrainVoyager and a customized Matlab code to calculate cross-correlations between the average time-course signals, extracted from 280 regions^{5,6}. Using connectome-based predictive modeling (CPM), we tested for predictive models of brain-emotional awareness relationship from connectivity data using cross-validation⁷. This implies four consecutive steps: 1) feature selection, 2) feature summarization, 3) model building, and 4) assessment of prediction significance. This produces a generalizable model with as input brain connectivity data and that generates predictions of behavioral measures in novel subjects, accounting for a large amount of the variance in these measures.

Results

Connectome-based predictive modeling revealed that emotional awareness could be predicted from the RS data. The correlation between the predicted and actual emotional awareness was 0.258 ($p=0.016$) (Fig.1). The prediction significance of this correlation, based on 2,000 permutations, resulted in a p value of 0.01. The two highest degree nodes were right and left parahippocampus. The connections with the highest correlation value with emotional awareness were from left STS to bilateral thalamus, right subgenual cingulate and CrusI, cerebellum (Fig.2).

Conclusions

The current data point to a role of the parahippocampus and the left posterior superior temporal sulcus in emotional awareness. These data also provide new insights in the cerebral correlates of interoceptive awareness as measured by the MAIA⁸.

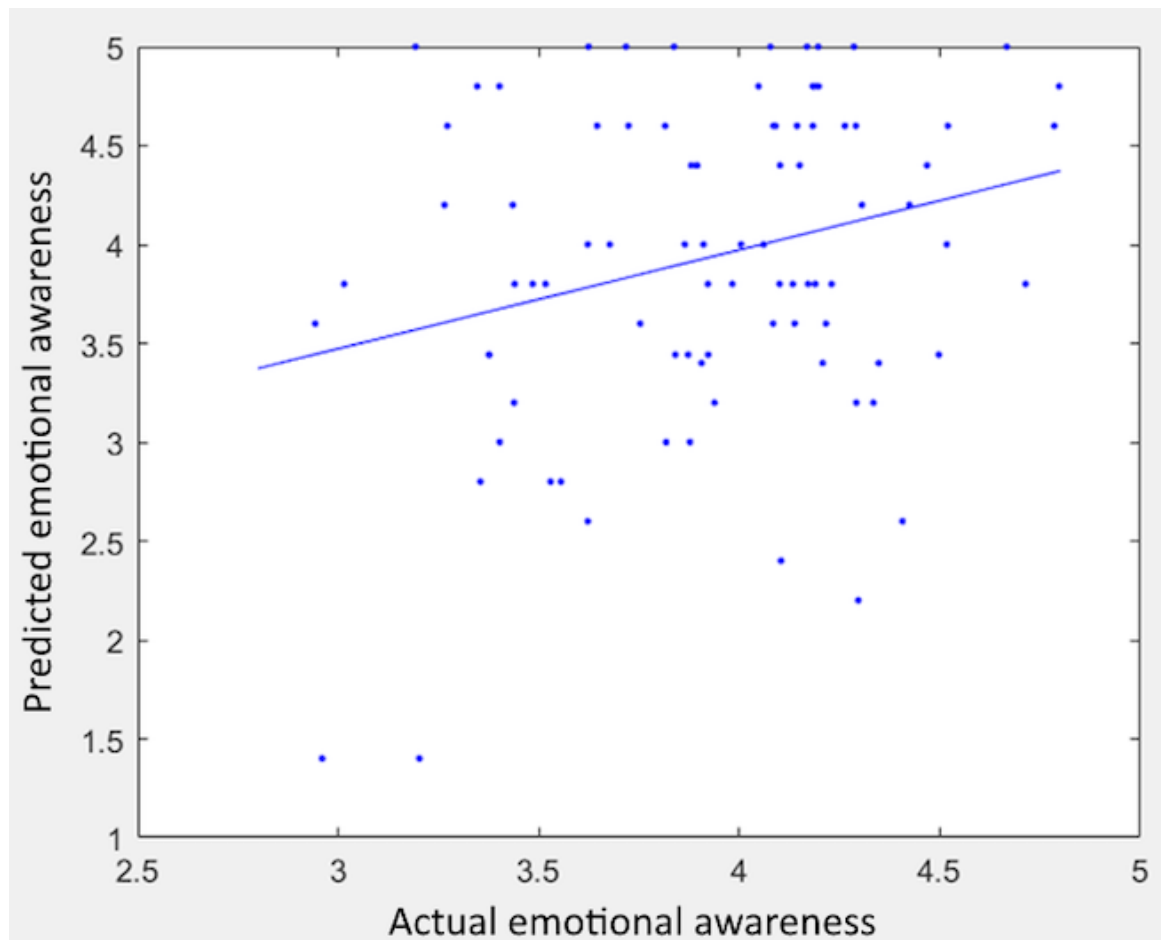


Figure 1: Correlation between actual and predicted emotional awareness based on CPM.

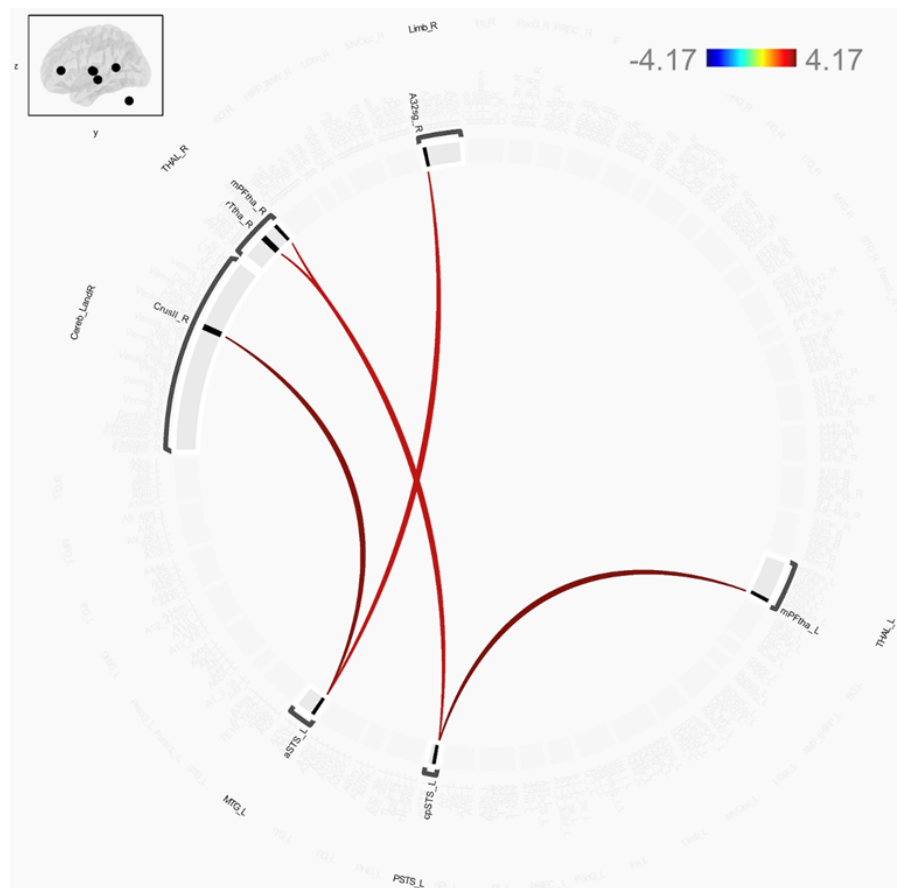


Figure 2: Highest significant connections best correlating with emotional awareness.

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