Resting state functional connectivity predicts changes in interoceptive awareness following mindfulness training

Maryam Falahpour[1], Lori Haase[2], Martin P. Paulus[2], and Thomas T. Liu[1]

[1]*Center for Functional MRI, University of California San Diego, La Jolla, CA, United States,* [2]*Department of Psychiatry, University of California San Diego, La Jolla, CA, United States*

Purpose: Mindfulness is a complex construct consisting of regulated attention, knowledge that events are momentary, and absence of emotion or cognitive appraisal of events. In addition to the literature documenting the effectiveness of mindfulness training at reducing stress-related sequelae related to chronic mental health [1] and medical disorders [2], there has been mounting evidence to suggest that mindfulness training may be an important characteristic of resilience [3]. The primary aim of the present study was to investigate whether baseline measures of functional connectivity obtained before training can predict changes in a subject's self-assessment of interoceptive awareness.

Methods: Seven athletes were recruited from the USA BMX (Bicycle Motocross) cycling team. They underwent an intensive 8-week mindfulness training program called mindful Performance Enhancement, Awareness and Knowledge (mPEAK), which was intended to help participants develop skills of attention, awareness, concentration, coping, and communication. Participants completed several self-report assessments including Multidimensional Assessment of Interoceptive Awareness (MAIA) and Toronto Alexithymia Scale (TAS) and underwent two fMRI scans: 1) pre-training, which occurred 3 days prior to the mPEAK program, and 2) post-training, which occurred approximately one week following the mPEAK program. In this abstract, we focus on the fMRI data from the pre-training scans. During each scan 10 minutes of fMRI resting state data with eyes open (with fixation) were acquired with the following parameters: echo planar imaging with 300 volumes, 40 slices, 3.75x3.75x3mm^3 voxel size, 64x64 matrix size, TR=2s, TE=30ms. ***Self-assessment measures:*** Pre and post training self-assessment measures were compared using paired t-tests. Subscales that showed a significant difference between the pre and post sessions were used for further analysis. ***MRI Data analysis:*** AFNI, FSL and MATLAB were used to analyze the data. Functional data were corrected for time-shift, motion, and field inhomogenities, then transferred to standard space, and resampled to 3mm^3 isotropic voxels. Nuisance regressors removed from the resting data using AFNI 3dDeconvolve included: 1) linear and quadratic trends, 2) six motion parameters and their first derivatives, and 3) mean WM and CSF signals and their first derivatives. Each functional volume was spatially smoothed to 6mm FWHM and low pass filtered with a cut-off frequency of 0.1 Hz. ***Functional connectivity (FC):*** The seed ROI chosen for FC was a 6 mm-radius sphere in the posterior cingulate cortex (PCC) with the coordinates described in Van Dijk et al. [4]. Connectivity maps were generated by computing the correlation between the average time series in the PCC and all other voxels in the brain. Correlation maps were subsequently normalized to z-scores using the Fisher-Z transformation. ***Comparing with self-assessment measures:*** To examine the relation between pre-training FC and self-assessment scores, we correlated z-score maps (on a per-voxel basis) with the changes (Post-Pre) in the self-assessment scores.

Table 1	t-stats (Post-Pre)
MAIA Self-regulation	t=3.8, p=0.0088
MAIA Trusting	t=3.8, p=0.0083
TAS Identifying feelings	t=-2.6, p=0.036

Results and Discussion: Two subscales of MAIA and one subscale of TAS showed significant changes after training (see Table 1). Figure 1 displays the region for which pre-training FC with a seed in PCC was significantly correlated with changes (Post-Pre) in "MAIA trusting" (p = 0.05, corrected for multiple comparisons with AFNI AlphaSim). This region contained 195 voxels and primarily included right insula and right claustrum. The left panel of Figure 2 shows the increase in "MAIA trusting" score after training (t(6)=3.8, p=0.008). For a qualitative view of the relation between the change in scores and baseline FC, we calculated the average pre-training FC with the PCC in the identified region and plotted this average FC against the changes in MAIA trusting (Post-Pre) (Figure 2 right panel; r=0.95, p=0.0008). Figure 3 displays the region for which pre-training FC with a seed in PCC showed a significant negative correlation with changes (Post-Pre) in "MAIA Self-Regulation". This region contained 163 voxels and contained portions of the left lentiform nucleus, left claustrum, left insula and left thalamus. The left panel of figure 4 shows the increase in "MAIA self-regulation" score after training (t(6)=3.8, p=0.008). The right panel shows a significant negative correlation between the magnitude of changes in MAIA self-regulation and the average pre-training FC with PCC in the identified region. We did not find a significant relation between the FC with seed in PCC and changes in "TAS identifying feeling" score. Together with the important role of the insula in emotion and interoception, these results support the notion that a subject's baseline level of functional connectivity between the PCC and the identified regions (which include the insula) can serve to predict the effect of mindfulness training on their self-assessment of interoceptive awareness.

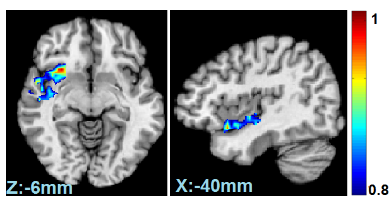

Figure 1. Correlation between pre-training FC with a seed in PCC and changes in "MAIA trusting" (p<0.05, corrected)

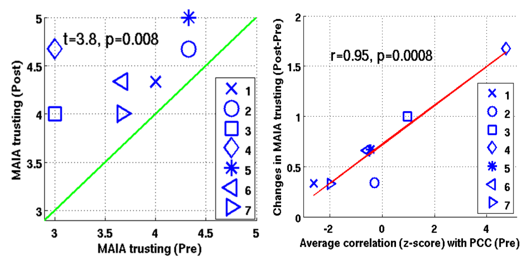

Figure 2. Left: pre and post training "MAIA trusting" scores. Right: relation between the changes in MAIA trusting vs. the average connectivity in the identified region in Figure 1.

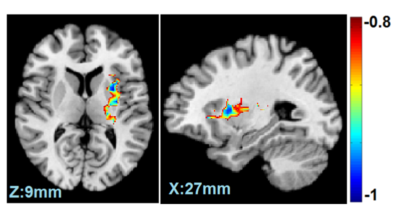

Figure 3. Correlation between pre-training FC with a seed in PCC and changes in "MAIA Self-Regulation" (p<0.05, corrected)

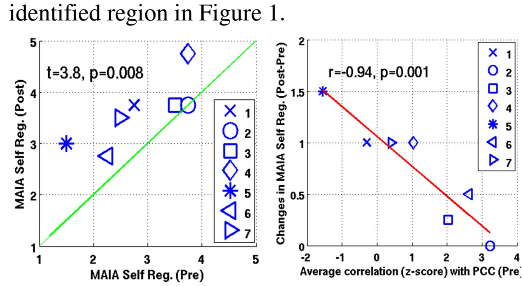

Figure 4. Left: pre and post training "MAIA Self-Regulation" scores. Right: relation between the changes in MAIA Self-Regulation vs. the average connectivity in the identified region in Figure 3.

References: [1] Hofmann et al. 2010, J Consult Clin Psychol, 78(2):169-183 [2] Kabat-Zinn et al 1985, J Behav Med, 8(2):163-190. [3] Haase, et al (under review) [4] Van Dijk et al, 2010 Neurophysiol. 103, 297–321.