Statistical Analysis Plan

Official Title: Effect of Emotion Mindsets on Emotion Processing: A Multilevel Experimental Investigation

NCT Number: 03978871

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**Statistical Design and Power**

**Originally planned sample size: 150**

**Final sample size: 163 (due to scan problems in 13 participants)**

**Power**. Power for ANCOVAs and MANCOVAs was calculated with G*Power. Based on prior research, we expect a large effect size for the mindset manipulation and medium or medium-to-large effects on emotion processing (e.g., medium to large effects, including for Group x Time interactions, were found for biological stress responses). With *N* = 150, power to detect a medium or large manipulation effect (Group x Time interaction) is >.99. Power to detect a medium univariate or multivariate group effect is >.86. Power to detect a medium univariate or multivariate Group x Trial or Group x Time interaction is >.99. Power to detect a medium indirect effect using Monte Carlo simulations in Mplus is >.99.

**MRI data**. MRI data were preprocessed with fMRIPrep v21.0.0 (Esteban et al., 2018; Esteban et al., 2020; RRID:SCR_016216), a Nipype v1.6.1-based tool (Gorgolewski et al., 2011; Gorgolewski et al., 2018; RRID:SCR_002502). All preprocessing was implemented via an internal HPC image processing pipeline hosted by the Beckman Institute for Advanced Technology (v0.5.0 https://pipeline-hpc.readthedocs.io/).

A fieldmap of $B_0$-non-uniformity was estimated from two EPI reference images using the TOPUP method (Andersson, Skare, and Ashburner (2003); FSL 6.0.5.1:57b01774). T1-weighted (T1w) volumes were corrected for intensity non-uniformity using this fieldmap via N4BiasFieldCorrection v2.1.0 (Tustison et al., 2010) from ANTs v2.3.3 (Avants et al. 2008, RRID:SCR_004757). These were used as T1w references throughout the workflow—and skull-stripped using antsBrainExtraction.sh v2.3.3 (using the OASIS30ANTs template). Brain tissue segmentation of cerebrospinal fluid (CSF) and white-matter (WM) were performed on the brain-extracted T1w using the FAST routine from FSL (FSL 6.0.5.1:57b01774, RRID:SCR_002823, Zhang, Brady, and Smith 2001). Spatial normalization to the MNI152NLin6Asym template (Evans et al. (2012), RRID:SCR_002823; TemplateFlow ID: MNI152NLin6Asym) was performed through nonlinear registration with the antsRegistration tool (ANTs v2.3.3) using brain-extracted versions of both T1w volume and template.

For each BOLD run, a reference volume and its skull-stripped version were generated from a spatially aligned single-band reference image. Head-motion parameters with respect to this reference were then estimated using MCFLIRT (FSL 6.0.5.1:57b01774, Jenkinson et al. 2002). Slice-timing correction to 0.47s was performed using 3dTshift from AFNI (Cox and Hyde 1997, RRID:SCR_005927). The BOLD reference was then co-registered to the T1w reference using bbregister (FreeSurfer; Greve and Fischl, 2009) employing 6 degrees of freedom.

Additional confounding time-series were calculated for later nuisance regression based on the preprocessed BOLD. These included Powers et al. (2014) and Jenkinson et al. (2002) framewise displacements (FD), and global signals computed from application of CSF and WM masks. Volumes exhibiting greater than 5mm of framewise displacement were marked for scrubbing.

All resampling was performed with a single interpolation step by composing all the pertinent transformations (i.e., susceptibility distortion correction, head-motion realignment, and co-registrations to anatomical space). Gridded (volumetric) resamplings were performed using antsApplyTransforms (ANTs), configured with Lanczos interpolation to minimize smoothing effects. Results were visually inspected to verify successful preprocessing and identify images with significant signal dropout or other artifacts warranting exclusion from analysis. Preprocessed BOLD runs were subsequently smoothed using a 6mm FWHM Gaussian kernel implemented through SPM12 (Ashburner et al., 2014).

Linear contrasts for each planned comparison were created for each participant. BOLD signals were averaged across voxels within each ROI. We used Monte-Carlo simulations using the 3dClustSim tool in AFNI (Cox et al., 2016) to determine the minimum cluster size for the relevant contrasts at the whole-brain level (pvoxel-level < .005, pcluster-level < .05). CC ROIs were defined via reference to a functional atlas with adjunctive anatomical labelling (Schaeffer et al. (2018) 400 parcel, Yeo 7-network, FSLMNI152, 1mm resolution atlas). ROIs were constructed by aggregating spatially contiguous ROIs belonging to both the same anatomical region and same Yeo-7 network membership into single larger ROIs. This resulted in 27 ROIs assigned to the cingulo-opercular network (CON) and frontal-parietal network (FPN). Left and right AMY ROIs were defined via reference to the AAL1.V4 atlas (Tzourio-Mazoyer et al., 2002). **Neural reactivity** scores reflect activation in the AMY (activation

in the CON also will be explored given its potential role in both emotion reactivity and regulation). For resting state, **neural regulation** scores will be calculated by: (1) constructing connectivity matrices consisting of pair-wise Pearson's correlations across ROIs in the FPN and CON; and (2) creating aggregate scores by averaging correlations for each CC network of interest (FPN-AMY, CON-AMY), separately for each contrast of interest. For functional tasks, psychophysiological interaction analyses will be conducted.

**Planned Analyses**

**Manipulation check (Teen Emotion Mindset Measure)**: A Group (GEM, CONT) X Time (pre-manipulation, post-manipulation) ANCOVA will be conducted to test whether the mindset manipulation changes girls' mindsets about the malleability of emotion. It is expected that the GEM but not CONT group will show increases in their growth mindsets following the manipulation (Group X Time interaction). Similar analyses will be conducted for the 2- and 4-month follow-up mindset measures. The interaction here and in the following analyses will be decomposed by conducting paired comparisons within group. All analyses will adjust for relevant covariates.

**Hypothesis Set 1a (Brain activation):** Whole-brain and ROI analyses (MANCOVAs) will examine whether the GEM group relative to the CONT group shows (a) lower activation in the AMY contrasting the criticism vs. neutral videos in the immerse trials of the ECT, and the negative vs. neutral distractors in the go-nogo task (i.e., less **emotion reactivity**); and (b) stronger intrinsic and task-related connectivity between the AMY and the CC networks of interest (FPN and CON) contrasting the criticism videos in the reframe vs. immerse trials of the ECT, negative vs. neutral distractors in the go-nogo task, and during resting state (i.e., stronger **ER**).

**Hypothesis Set 1b (Behavioral modulation of emotion):** Analyses will examine whether a GEM predicts better behavioral modulation (attentional control) of emotion. A MANCOVA will be conducted to test whether the GEM relative to the CONT group is better able to ignore negative emotion (vs. neutral) distractors, resulting in faster RTs and better accuracy.

**Hypothesis Set 1c (state negative affect, Emotion Regulation Strategies, Emotional Self-Efficacy Scale):** To examine **emotion reactivity**, Group (GEM, CONT) X Time or Group X Trial ANCOVAs will be conducted to test whether the GEM relative to the CONT group reports less of an increase in negative affect (across the Trier) and less negative affect after the criticism vs. neutral videos in the immerse trials (ECT). To examine **ER success**, Group X Trial ANCOVAs will be conducted to test whether the GEM relative to the CONT group reports less negative affect after the criticism reframe vs. immerse trials (ECT). To examine **ER strategies**, a MANCOVA will be conducted to test whether the GEM relative to the CONT group reports using more proactive *in vivo* strategies during the Trier. To examine **long-term effects on ER strategies**, a similar MANCOVA will be conducted using the 2- and 4-month follow-up data on self-reported ER. To examine **self-efficacy**, a Group (GEM, CONT) X Time (pre-manipulation, post-manipulation) ANCOVA will be conducted to test whether the GEM relative to the CONT group shows bigger increases in self-efficacy.