Study Protocol

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

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Research Design and Method

163 adolescent girls with a high FEM (≥.75 SD above the mean on a screening[16]) completed these procedures in a single session: (1) baseline measures (demographics, puberty, mindsets, self-efficacy); (2) computer lesson (random assignment to group); (3) post-lesson mindsets, self-efficacy; (4) pre-Trier affect; (5) Trier; (6) post-Trier measures; (7) emotional challenge task (ECT), go-nogo, and resting state in the scanner. The selected tasks provide a multi-level, multi-method assessment of emotion processing, including self-reported negative affect (Trier, ECT; Hyp. Set 1c), naturally occurring *in vivo* ER in response to an ecologically valid stressor (Trier; Hyp. Set 1c), use of an explicit ER prompt (ECT; Hyp. Set 1c), neural correlates of reactivity and regulation (ECT, go-nogo; Hyp. Set 1a), neural recovery from emotional challenge (resting state; Hyp. Set 1a), and behavioral indexes of cognitive control (go-nogo; Hyp. Set 1b). At 2- and 4-month follow ups, girls completed via the Internet the mindset and self-efficacy measures and a self-report measure of ER in daily life.

Girls completed a 25-minute computer lesson with audio-recordings. The **GEM** manipulation, adapted by our research team from a well-validated mindset manipulation[65-68], involves 6 components: (1) <u>Introduction</u>: discussion of emotional experiences in teenagers; (2) <u>Explanation of neuroplasticity</u>, emphasizing the potential for changes in the brain and modification of emotions during adolescence; (3) <u>Scientific evidence</u> for the effect of ER training on mood improvement; (4) <u>Comprehension assessments</u>: brief factual quizzes and written summary of key points; (5) <u>Vignettes and written testimonials</u>: scenarios in which older youth describe challenging situations when they felt negative emotions and used growth mindsets to help regulate their emotions; and (6) <u>Self-persuasion exercise</u>: a. Girls read a hypothetical scenario about an emotional challenge and describe their likely thoughts and feelings; b. Girls imagine the same event happening to another (younger) teen and help them understand how they can change, integrating what they learned about malleability of the brain and emotion. The **CONT** condition involves a structurally similar session, with the same number and type of reading and writing activities, that focuses on general education about the brain[74].

Manipulation check. Before and after the lesson and at the follow-ups, girls completed a measure of mindsets about emotion, adapted from Tamir[16] to focus on teens (e.g., "The truth is, teens have very little control over their emotions."). The original measure has well-established psychometrics and is distinct from mindsets about other personal attributes[16]. Pilot data support the validity of the revised measure and support a single emotion mindset factor, $\chi^2(47) = 125.82$, CFI = .97, SRMR = .032.

Self-efficacy. Before and after the lesson and at the follow-ups, girls completed measures of **ER self-efficacy**[16].

Social stressor. Using an adapted version of the Trier Social Stressor Test[104-106], girls prepared a speech in which they convince a group of peers (who ostensibly will watch a video of the speech; in reality, there are no peers) that they should be selected for a fictional TV show about teens' ability to form friendships. Girls faced a computer screen displaying their image while preparing (1 min.) and presenting (3 min.) a speech. A female "evaluator" entered the room with a clipboard prior to the speech and fixed her gaze on the screen, avoiding eye contact. At intervals of 20 sec., she marked the clipboard. This task is well-validated for eliciting meaningful variability in adolescents' emotion reactivity and ER[104-106]. Before and after the Trier, girls rated several dimensions of state negative affect[52]. **Emotion reactivity** was reflected in a residualized score. After the Trier, girls rated their use of *in vivo* **ER strategies**: cognitive reappraisal (e.g., "I tried to think about the speech in a way that made me feel better."), positive thinking (e.g., "I imagined myself doing a great job on the speech."), rumination (e.g., "I kept thinking about how stressed I felt."), avoidance (e.g., "I tried <u>not</u> to think about how I felt."), and helplessness (e.g., "I felt there was nothing I could do to stop feeling stressed.")[54,57-59]. Girls then underwent scanner training.

Scan procedures. The scan consisted of **4 segments**: (1) neutral video; (2) emotional challenge task (**ECT**); (3) 8 min. resting state; and (4) emotional go-nogo task.

- **ECT**. Girls watched validated videos created for fMRI[107-108] depicting females making one of three types of statements with matching affective expression: negative (criticism; e.g., "You are a disappointment."), positive (praise; e.g., "You will be successful."), or neutral (e.g., "Pools have chlorine."). Before each video, girls received a prompt (2 sec.) instructing them to imagine how they would feel if the female were a friend speaking to them ("YOU"; **immerse**), or an actor practicing her lines ("ACTOR"; **reframe**). These cues make the statement either more (immerse) or less (reframe) personally relevant, with the reframe cue providing a proactive ER strategy. After the cue, there was a pause (2-7 sec.), presentation of the video (6 sec.), and another pause (3 sec.). After each trial, the participant rated how bad she felt on a 5-point scale. Comparing brain activation and negative affect during the criticism vs. neutral videos in the immerse trials provides an index of **emotion reactivity**[107-108]. Comparing brain activation and negative affect during the criticism videos in the reframe vs. immerse trials provides an index of **ER success**[107-108].

- **Resting state**. Girls fixated on a central cross. The resting state captured residual effects of ER efforts imposed during the immediately preceding ECT. Greater ability to flexibly engage and disengage ER in response to changing external challenges (imposed by negative, positive, and neutral videos) is expected to be reflected in the functional connectome for minutes beyond the ECT, as reflected in more within-network connectivity in cognitive control (CC) networks as well as more between-network connectivity with the AMY in girls who engage in proactive ER.
- **Emotional go-nogo**. Girls completed a CC task with emotion distractors[109] depicting negative (social rejection), positive (social acceptance), or neutral (scrambled) images[110]. Letters were presented sequentially at the center of the screen, with distractors in the background. The distractors were presented alone (350ms), prior to the letter (750ms), to make them difficult to ignore. Girls were instructed to ignore the images and respond as quickly as possible without sacrificing accuracy with a button press to every letter (go trials), except for Xs (no-go; 25% of trials). Girls acquire a prepotent tendency to press and must inhibit their responses during X trials. Research supports the validity of emotional go-nogo tasks[109-111]. Reaction time (RT) and accuracy scores provide an index of **ER**.

2- and 4-month follow-ups*.* Youth completed the mindset measure, self-efficacy measures, and a measure to assess ER (e.g., cognitive reappraisal, rumination) in daily life. Items were drawn from existing measures[112-117] or written for this measure. Pilot data in 158 adolescents support links between emotion mindsets and these self-reports of ER.

- The fMRI data were collected using a Siemens Prisma MRI 3 Tesla scanner. A standard 64-channel (phased array/transmit-receive) birdcage coil was used to collect imaging data. Sessions began with a Siemens Autoalign routine, with subsequent manual realignment when needed to ensure the dorsal portion of the participant's brain was within the acquisition volume. This was followed by an anatomical scan, a shimming routine to optimize signal-to-noise ratios, opposite-phase-encoded field maps, the social evaluation task, resting-state scan, and ended with the socioemotional go/no-go task. The high-resolution anatomical scan consisted of a 3D sagittal acquisition of T1-weighted magnetization-prepared rapid-acquisition gradient echo (MPRAGE) sequence (TR = 2300 ms; TE = 2.32 ms; TI = 950 ms; 8° flip angle; bandwidth = 200 Hz/Px; GRAPPA factor = 2; in-plane matrix = 256 × 256; FOV = 240 mm × 240 mm; slice thickness = 0.9 mm; 192 slices). Both tasks and the resting-state scan employed similar CCMR multiband T2*-weighted echoplanar imaging (EPI) protocols (TR = 1020 ms; TE = 30 ms; 52° flip angle; bandwidth = 2272 Hz/Px; MB factor = 3; GRAPPA factor = 2; matrix = 88 × 88; FOV = 220 mm × 220 mm; slice thickness = 2.25 mm; slice gap = 0.225 mm; 51 slices), varying in volumes collected for the SET-II (830 volumes), resting-state (480 volumes), and Emotional Go/No-Go (580 volumes) scans. The use of Center for Magnetic Resonance Research (CMRR) multiband sequences enables the acquisition of BOLD images with superior temporal resolution compared to traditional single band protocols while maintaining an acceptable signal-to-noise ratio (Feinberg et al., 2010; Xu et al., 2013).