Neurocognitive Assessment of Regulatory Flexibility

Laura J. Egan[1], Sarah Babkirk[2,1], Jean Quintero[1], Olga Gulyayeva[1], George A. Bonanno[3], & Tracy A. Dennis[1,2]

[1]Hunter College, The City University of New York, [2]The Graduate Center, The City University of New York, [3]Teachers College, Columbia University

- Emotion regulation (ER) strategies are often classified as adaptive versus maladaptive.
  - However, adaptive ER may be best characterized by flexibility independent of specific strategies (Bonanno & Burton, 2013).
  - Such flexibility may depend on the ability to respond sensitively to context and the ability to draw on a repertoire of regulatory strategies, yet few methods exist for assessing ER flexibility.
- Measures of sensitivity to emotional context should examine both facilitation of approach *and* inhibitory control
  - Behavioral measures of these processes can be derived from a Go/No-Go task: reaction times to Go trials (i.e., facilitation of approach) and false alarm rates to No-Go trials (i.e. inhibitory control). Previous research suggests that emotion modulates these processes: approach is facilitated when happy faces are the Go stimulus and inhibitory control is disrupted when emotional faces are the No-Go stimuli (Tottenham, Hare, & Casey, 2011)
  - Event-related potentials (ERPs) may provide further insight into these processes: N170 amplitudes reflect relatively early attentional selection and discrimination (Batty & Taylor, 2003) and N2 amplitudes reflect later cognitive control (van Veen & Carter, 2002).
- Measures of flexibility should examine the full range of regulation: downregulation *and* upregulation
  - Several studies document the utility of ERPs (specifically, the late positive potential or LPP) in tracking the ability to regulate emotional reactions to complex images (Foti & Hajcak, 2008; Hajcak, Dunning, & Foti, 2009; Hajcak & Nieuwenhuis, 2006).

GOALS

- Identify normative behavioral and ERP responses that may capture the flexibility of emotion regulation in terms of:
  - **Sensitivity to emotional context**, including facilitation of approach and inhibitory control
  - **Regulatory flexibility**, including the ability to decrease and increase emotional responses
- Examine links between biobehavioral measures of emotional context sensitivity and regulatory flexibility in relation to self-reported adaptive and maladaptive ER.

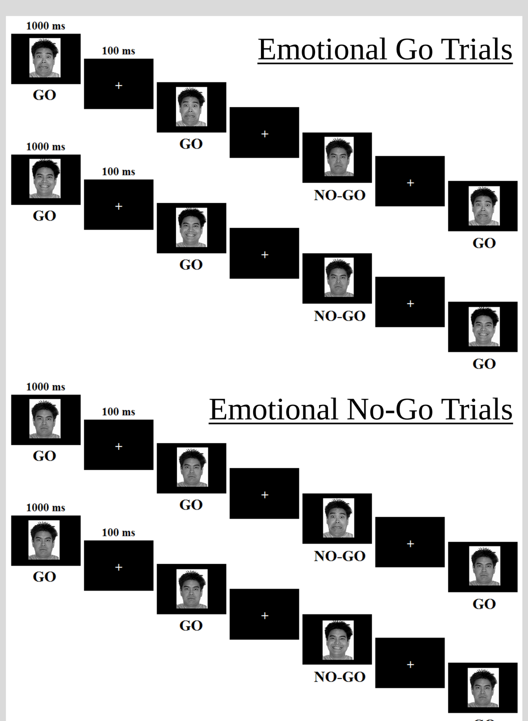
METHOD

Participants

- Participants were 74 adults aged 18-47 (M = 20.73, SD = 4.56). There were 18 males (24.3%) and 56 females (75.7%).

EEG Recording and Data Reduction

- EEG activity was recorded during the tasks via BioSemi 64 Ag/AgCl scalp electrodes, sampled at 512 Hz. Eye movements were monitored by electro-oculogram (EOG).
- Using Brain Vision Analyzer, data were re-referenced offline to the average of the entire scalp (N170, N2) or the average of the mastoid electrodes (LPP) and filtered with a low-cutoff frequency of .1 Hz and a high-cutoff frequency of 30 Hz.
- Following ocular correction (Gratton, Coles, & Donchin, 1983), artifacts were identified using the following criteria and removed from analyses: voltage steps greater than 50 µV, changes within a given segment greater than 300 µV, and activity lower than .5 µV per 100 ms. In addition to this semi-automatic identification of artifacts, trials were also visually inspected for any further artifacts.

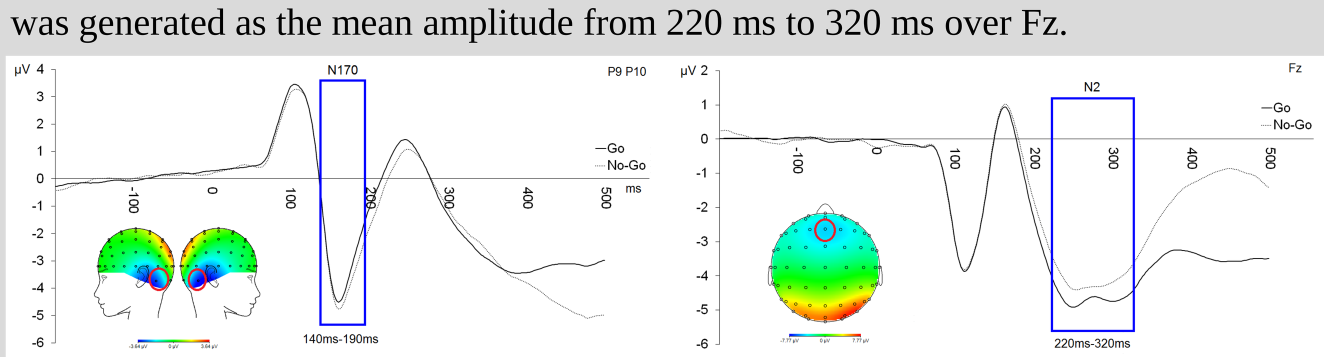


Emotional Go/No-Go Task

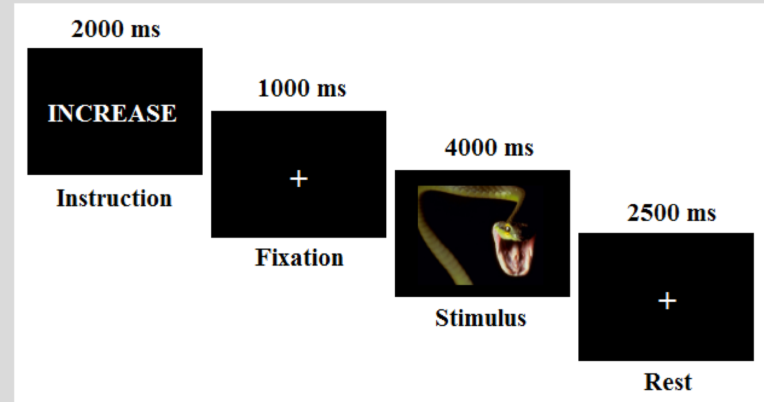
- Emotional faces (fearful, happy, neutral) from the NimStim set (Tottenham et al., 2009) were presented as either the Go or No-Go stimulus. Each block consisted of 50 trials: 35 Go trials (70%) and 15 No-Go trials (30%). Participants were instructed to respond to the Go stimulus by pressing the spacebar and to refrain from responding to No-Go stimulus.
  - Data reduction: reaction time for correct responses for Go trials (facilitation of approach) and false alarm rates for No-Go trials (inhibitory control)

ERP Data Reduction: N170 and N2

- Face-locked data were segmented into epochs from 200 ms before stimulus presentation to 2000 ms after stimulus onset, with a 200 ms baseline correction separately for the go and no-go faces.
  - N170 was generated as the mean amplitude from 140 ms to 190 ms over P9 and P10 and N2 was generated as the mean amplitude from 220 ms to 320 ms over Fz.



Directed Emotion Regulation Task



- Images from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) were presented during a directed emotion regulation task. Participants were asked to either increase, decrease, or maintain their emotional response to pleasant, unpleasant, and neutral images (maintain only for neutral images). There were 25 trials in each block.

ERP Data Reduction: LPP

- Image-locked data were segmented into epochs from 200 ms before stimulus presentation to 4000 ms after stimulus onset, with a 200 ms baseline correction separately for each block.
  - The early LPP was generated as the mean amplitude from 400 ms to 1200 ms and the late LPP was generated as the mean amplitude from 1200 ms to 4000 ms, both over P5/P7/PO7 and P6/P8/PO8.

Self-Reported Measures

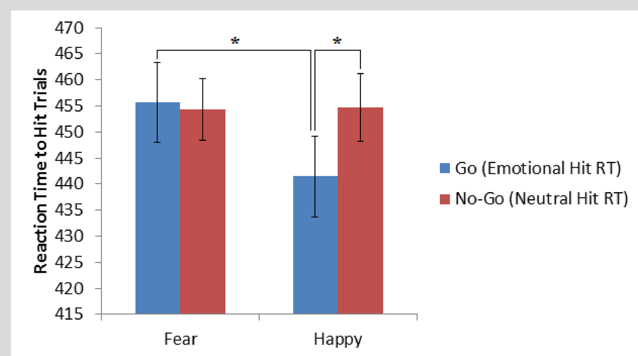
- Participants completed a series of questionnaires:
  - Flexible Expressive Regulation Ability Scale (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004): measures the ability to modulate emotional expressions and experiences to positive and negative information
  - Cognitive Emotion Regulation Questionnaire (Garnefski & Kraaij, 2007): ability to use a variety of subscales (self-blame, other blame, acceptance, rumination, positive refocusing, planning, reappraisal, putting things into perspective, catastrophizing)
  - Coping Flexibility Scale (Kato, 2012): measures the ability to discontinue ineffective strategies (evaluation) and implement alternative strategies (adaptive)
  - Satisfaction with Life Scale (Diener, Emmons, Larsen, & Griffin, 1985): measures judgments of satisfaction with one's life

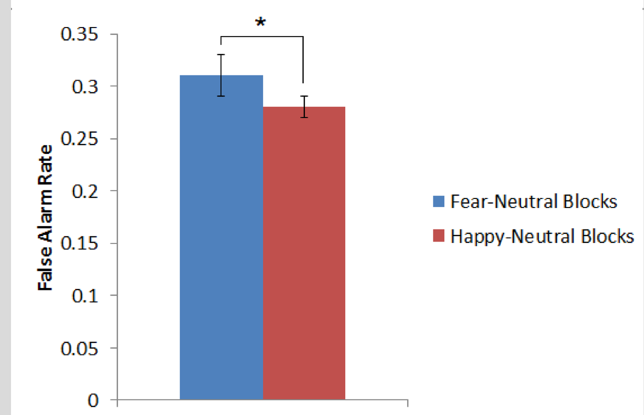
RESULTS

SENSITIVITY TO EMOTIONAL CONTEXT

Emotional Go/No-Go Task

- A 2(Emotion: fear, happy) x 2(Stimulus: go, no-go) repeated measures ANOVA was conducted for each behavioral measure. **Positive emotional stimuli (happy faces) facilitated approach (go) and inhibitory (no-go) responses:**
  - Reaction times were faster when happy faces were the go versus no-go stimulus (p = .004) and faster when the go stimulus was a happy versus fear face (p = .006) [Emotion x Stimulus: $F(1, 73)$ = 5.30, p = .02, partial η^2 =.07].
  - False alarm rates were lower in the happy (M = .28, SE = 0.01) versus fear blocks (M = 0.31, SE = 0.02) regardless of whether the emotional face was the go or no-go stimulus [Emotion: $F(1, 73)$ = 3.33, p = .07, partial η^2 = .04].



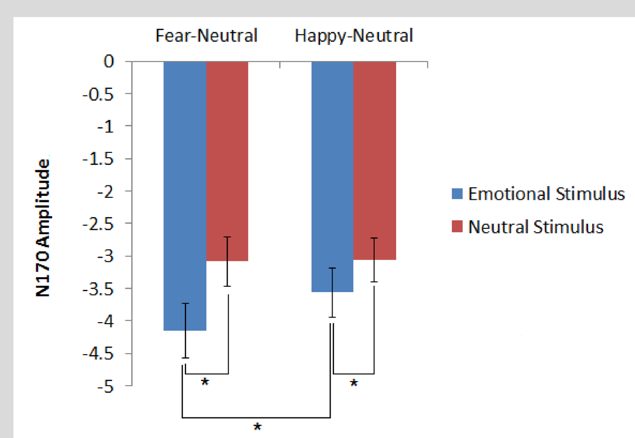


ERPs: N170 and N2

- A 2: (Block: fear-neutral, happy-neutral) x 2(Valence: emotional, neutral) x 2(Stimulus: go, no-go) repeated measures ANOVA was conducted for each ERP.

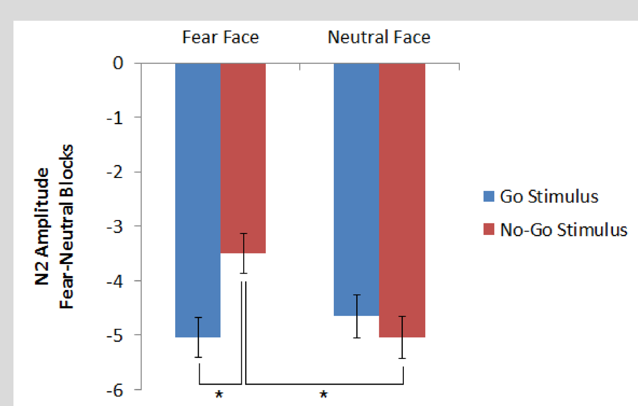
N170

- N170 amplitudes were larger to No-Go versus Go faces, regardless of facial emotion [Stimulus: $F(1, 68)$ = 5.35, p = .02, partial η^2 =.07].
- N170 amplitudes were larger to the emotional versus neutral faces within both blocks (ps < .01) and larger for the fearful versus happy faces between blocks (p = .02) [Block x Valence: $F(1, 68)$ = 3.61, p = .06, partial η^2 =.05].



N2

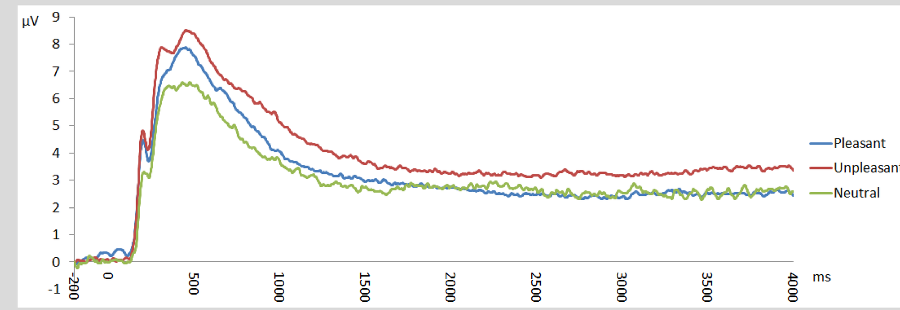
- Different patterns emerged in the fear-neutral and happy-neutral blocks
  - For the fear-neutral blocks, amplitudes were *smaller* for the No-Go versus Go stimulus for fearful faces only (p < .001). Additionally, amplitudes were larger for No-Go neutral versus No-Go fearful faces (p < .001) [Block x Valence x Stimulus: $F(1, 68)$ = 3.41, p = .07, partial η^2 =.05]
  - However, for the happy-neutral blocks, amplitudes were larger for the neutral versus happy faces regardless of stimulus type (p < .001) and larger for Go versus No-Go faces regardless of emotion (p < .001)



REGULATORY FLEXIBILITY

Directed Emotion Regulation

- A 2: (Block: fear-neutral, happy-neutral) x 2(Valence: emotional, neutral) x 2(Stimulus: go, no-go) repeated measures ANOVA was conducted for each ERP.
  - As expected, LPP amplitudes were larger to pleasant and unpleasant versus neutral images [Valence: $F(2, 144)$ = 3.85, p = .02, partial η^2 = .05]



- However, the effect of emotion regulation instruction on LPP amplitudes did not reach significance.

Correlations with Self-Report of Emotion Regulation

- To provide preliminary converging evidence for the utility of behavioral and neurocognitive measures of emotional context sensitivity and regulatory flexibility, we examined their associations with self-report measures of emotion regulation and dysregulation.

Facilitation of Approach (Go Trials)

- Enhanced neurocognitive responses to emotional go stimuli, but faster behavioral responses to neutral go stimuli were associated with more adaptive emotion regulation outcomes. Specifically:
  - Faster hit rates for neutral go stimuli were associated with greater self-reported reappraisal capacity, for both fear (r = -.32, p = .006) and happy (r = -.25, p = .03) no-go stimuli.
  - Greater N170 amplitudes to fear go (r = .29, p = .01) and happy go (r = .25, p = .03) trials were associated with reduced catastrophizing.
  - Greater N2 amplitudes to fear go trials were associated greater evaluative coping (r = -.23, p = .05).

Inhibitory Control (No-Go Trials)

- When happy was the go stimulus, greater false alarm rates to neutral faces was associated with greater self-reported expressive flexibility and emotional experience regulation:
  - increased emotional expression to negative (r = .23, p = .05).
  - increased emotional experiences to negative (r = .28, p = .02).
  - decreased emotional experiences to negative (r = .27, p = .02).
  - modulated emotional experiences overall (r = .27, p = .02).
- Greater N170 amplitudes to no-go trials were associated with more adaptive emotion regulation:
  - Greater N170s to fear no-go trials was associated with reduced rumination (r = .24, p = .05) and greater adaptive coping (r = -.24, p = .04); greater N170s to happy no-go trials were associated with reduced catastrophizing (r = .26, p = .02).
- Greater N2 amplitudes to no-go trials were associated with more adaptive emotion regulation outcomes:
  - Greater N2 amplitudes to fear no-go trials was associated with greater satisfaction with life (r = -.26, p = .03); and greater N2 amplitudes to happy no-go were associated greater evaluative coping (r = -.29, p = .01).

Directed Emotion Regulation

- Greater ability to increase negative regulatory responses (larger LPP amplitudes to unpleasant images following the increase versus maintain instruction) was correlated with greater catastrophizing (r = .27, p = .02).

DISCUSSION

- We identified several behavioral and ERP responses that may capture the flexibility of emotion regulation in terms of sensitivity to emotional context and regulatory flexibility.
- For emotional context sensitivity, more adaptive emotion regulation outcomes were associated with: enhanced neurocognitive responses [both early attention discrimination (N170) and cognitive control (N2)], to positive and negative emotional go stimuli, and faster behavioral responses to neutral go stimuli.
- For regulatory flexibility, greater ability to increase negative regulatory responses (larger LPP amplitudes to unpleasant images following the increase versus maintain instruction) was correlated with greater emotion *dysregulation* (catastrophizing).
- Taken together, findings set the stage for future biobehavioral research examining typical and atypical emotion regulation responses that emphasize the flexibility of responding rather than the discrete types of strategies used.

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