Electrophysiology of error processing: associations with depression, anxiety, fear of failure, and clinical perfectionism

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Introduction

- The ERN (error-related negativity) is a negative deflection in the electrograph seen within the first 100 ms after making an error.
- The Pe (error positivity) follows the ERN, peaking after 200 ms post-error.
- Both components are thought to be generated in part by the anterior cingulate cortex (ACC), a brain region involved in error detection and response conflict.
- One current debate about the ERN and Pe is whether they reflect performance monitoring or emotional response to errors.
- Consistent with the latter view, we predicted that ERN and Pe would correlate with depression, anxiety, fear of failure, and/or clinical perfectionism.
- We also looked for potential associations between ERN/Pe, self-compassion, and achievement goals.

Method

Participants

- 30 individuals who completed our survey of clinical perfectionism and associated measures came to the laboratory and completed a flanker task during EEG recording (4 dropped due to eye artifact, 1 dropped due to recording error, 1 dropped due to EEG outlier).
- Final sample: 24 (19 female; age 18-35)

Flanker task paradigm

- Participants seated 63 cm from the monitor
- 12 blocks of 48 trials each, each trial showing a string of 5 curly braces (stimulus duration = 200 ms each, but central brace did not appear until last 50 ms) with inter-trial interval = 2000 ms
- Participants pressed a key corresponding to direction of central curly brace
- Each string was either congruent }}}}} , {{{{{ or incongruent }}{}} , {{}{{
- Following each block, if accuracy >90%, response speed emphasized; if accuracy <75%, response accuracy emphasized

Electrophysiology

- 64-electrode GSN (Electrical Geodesics Inc.)
- 250 Hz sampling; 0.1 to 30 Hz bandpass filter
- Vertex reference; re-referenced to average
- **ERN**: mean amplitude calculated over a 20 ms window centered on peak amplitude 0-100 ms after response, using the electrode site with the largest negativity out of the following: (FC1, FCz, FC2, C1, C2, CZ, CP1, CP2, F1, FZ, F2)
- **Pe**: mean amplitude calculated separately at Pz, Cz, FCz, Fz, AFz, and the average of FP1 and FP2 (FPav) over a 125-325 ms window after response

Survey Measures

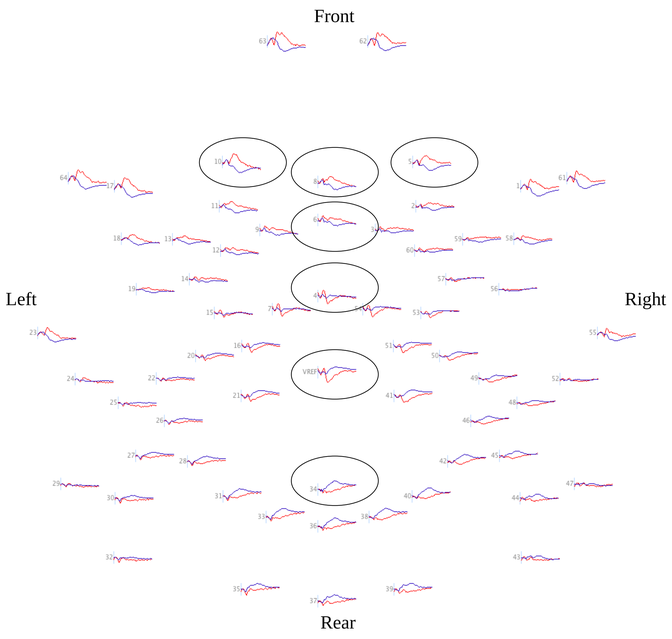
Clinical Perfectionism Questionnaire (CPQ), General Anxiety Disorder – 7 (GAD-7), Center for Epidemiological Studies Depression Scale Revised (CESD-R), The Performance Failure Appraisal Inventory (PFAI), Self Compassion Scale (SCS), College Test Anxiety Scale (CTAS), State Trait Inventory for Cognitive and Somatic Anxiety (STICSA), Achievement Goal Questionnaire (AGQ)

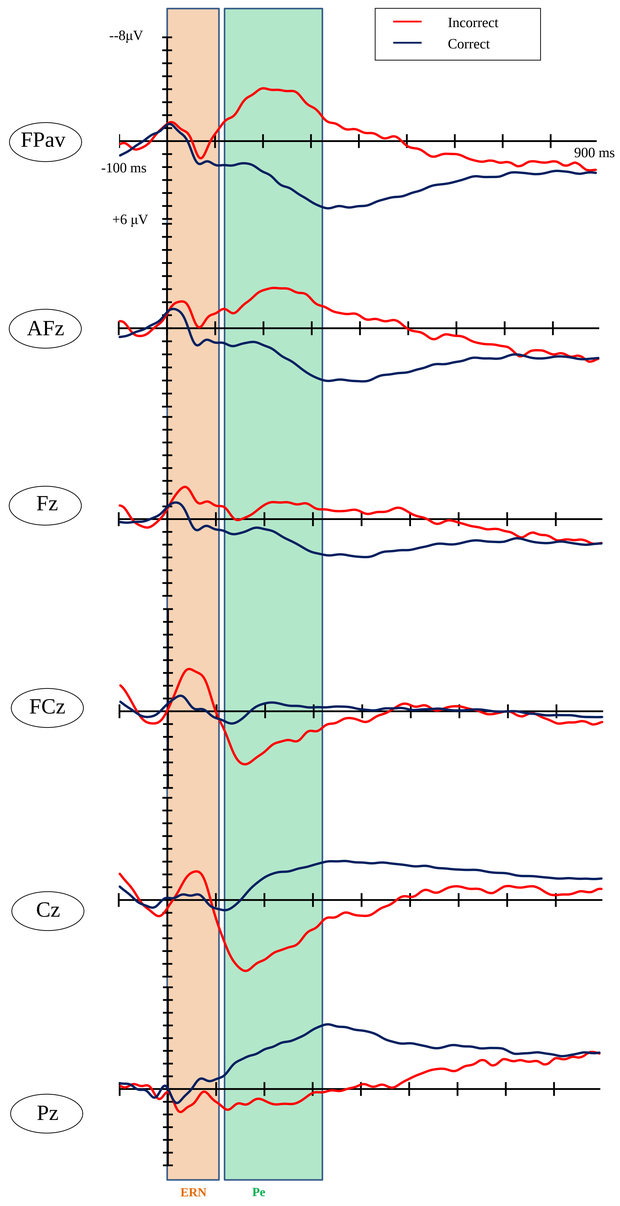
Results

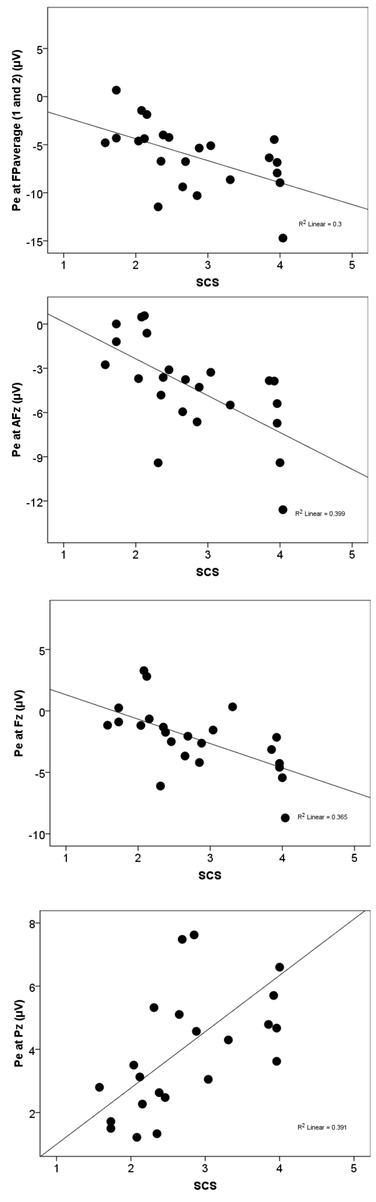
- ERN. Larger for incorrect responses (M = -5.43, SD = 2.01) than correct responses (M = -2.01, SD = 1.03, p < .001)
- Pe. 2 x 6 ANOVA: Response (incorrect vs. correct) x Electrode (FPav, Afz, Fz, FCz, Cz, Pz).
  - No main effect of response (F<1).
  - Interaction between Response and Electrode, F(1.52, 35.04) = 71.21, p < .001.
  - Planned comparisons show that differences between correct and incorrect responses are significant for all electrodes (p<.001).

Grand averaged waveforms at selected electrodes. ERN is observed during 0-100 ms window, Pe observed primarily during 125-325 ms window.

ERPs time-locked to **Incorrect** and **Correct** responses, grand averaged across all subjects. Enlarged waveforms for ERN and Pe (at Fpav, Afz, Fz, FCz, Cz, Pz) displayed to the right.







Scatter plots show average Pe amplitude at sites FPav (average of FP1 and FP2), AFz. Fz, and Pz, correlated with participant scores on the SCS. All correlations are significant with p = .007, .001, .002, and .001 respectively.

Discussion

- Findings replicate classic error-related negativity (ERN) effects as well as error positivity (Pe) effects at sites FCz, Cz, and Pz, indicating a larger brain response when making errors
- Larger *negativity* for incorrect responses (in the Pe time window) at anterior sites may reflect inversion of Pe (see our other poster, Beard *et al.*, #206)
- ERN amplitude was not correlated with any survey measures.
- Contrary to predictions, the ERN and Pe were not correlated with anxiety, depression, fear of failure, or clinical perfectionism. Instead Pe was correlated with self-compassion.
- Self-compassion (Neff, 2003) involves mindfulness and acceptance of mistakes which can be used to better oneself as opposed to reacting emotionally. This is consistent with the view that the Pe represents performance monitoring more than emotional response to errors.

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