If I can't stop myself, does it matter what I do next? An ERP study of the monitoring of primary stop errors and secondary choice errors

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Introduction

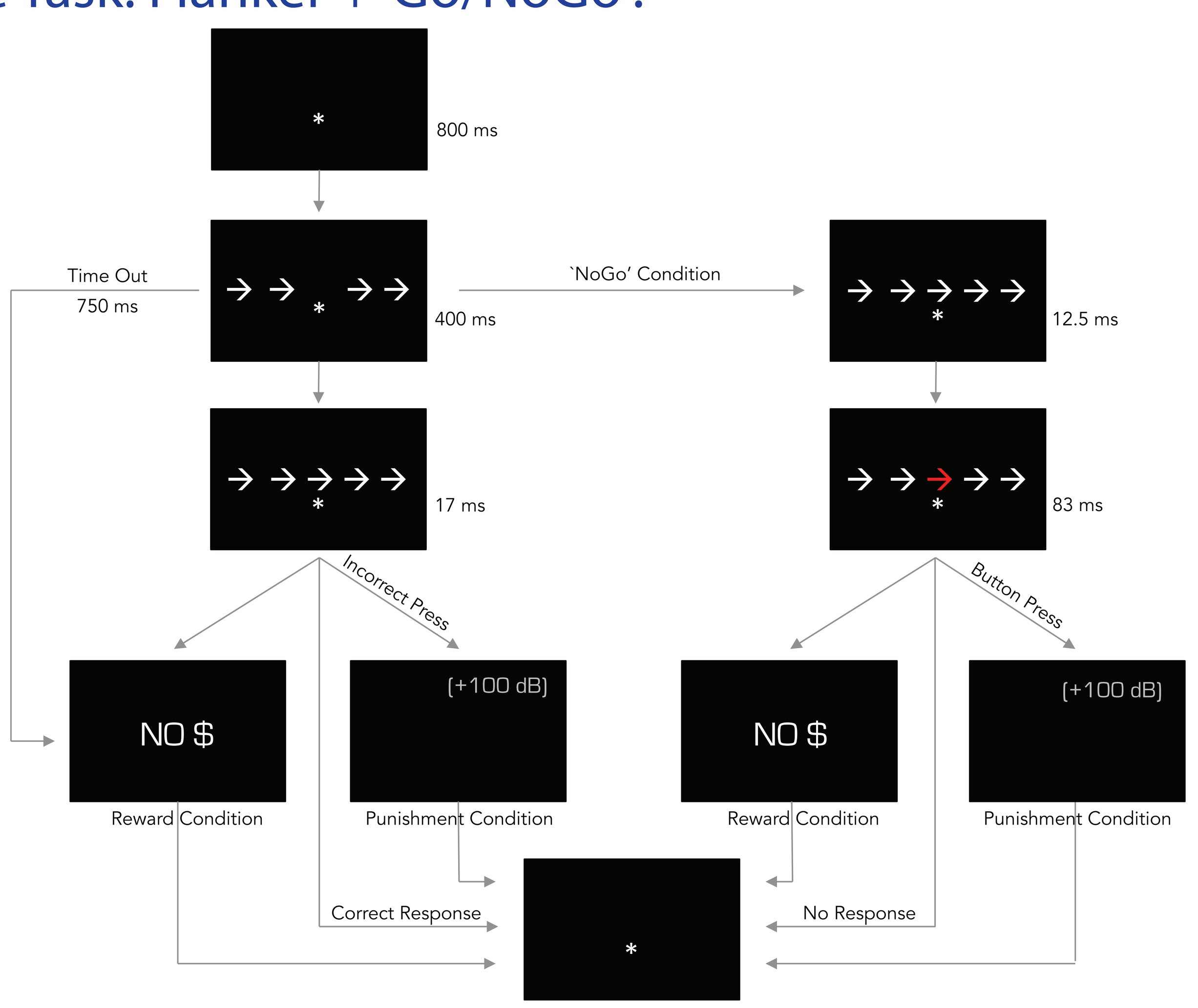
Adaptive behavior depends on our ability to monitor our ongoing performance in goal-directed tasks and make adjustments when errors are committed. Events surrounding the commission of errors have been well categorized on both a behavioral and physiological level. Most of these studies, however, employ classic action-monitoring paradigms that only allow for a binary response - correct or error, to each presented stimulus. In our daily lives we are not often presented with simple binary stimulus-response archetypes, but rather complex stimuli that may be evaluated on multiple dimensions and elicit responses that may be correct in terms of one set of criteria and incorrect in terms of another set, or incorrect on multiple dimensions. The value assigned to each of these errors may vary, but nonetheless they are associated with a single stimulus.

Methods

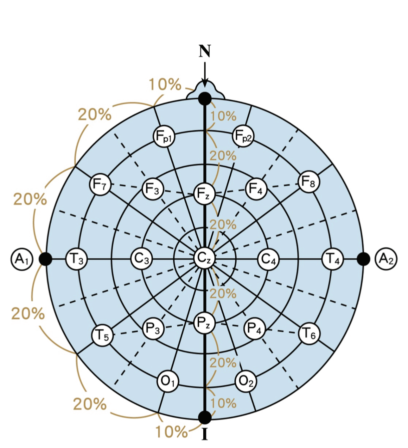
Participants:

Sixty-four undergraduate students from an introductory psychology class served as participants in this study, with 37 subjects having complete data for EEG analysis. 16 of these 37 original participants met final performance criterion and were included in the present study (minimum of 25 trials per condition).

The Task: Flanker + 'Go/NoGo':



EEG Recording and Data Preprocessing:



EEG was recorded from 24 scalp sites. Three electrodes, placed on the left and right inferior orbit and the naison were placed to monitor eye blinks and movements.

Data were sampled at 1000 Hz, amplified 20K times, bandpass filtered between 0.01 and 100 Hz, and impedances were kept below 5 kOhm. Blink artifacts were removed using independent component analysis in EEGLAB (Delorme and Makeig, 2004).

For all time-domain ERP analyses, continuous data were band-pass filtered between 0.1 and 15 Hz (wide-band) with a 385-point finite impulse response (FIR) filter.

For time-frequency decompositions, raw signals were first filtered between 3 and 13 Hz (narrow-band) using a 385-point FIR filter.

After filtering, all data were sorted into 3000 ms epochs.

Results

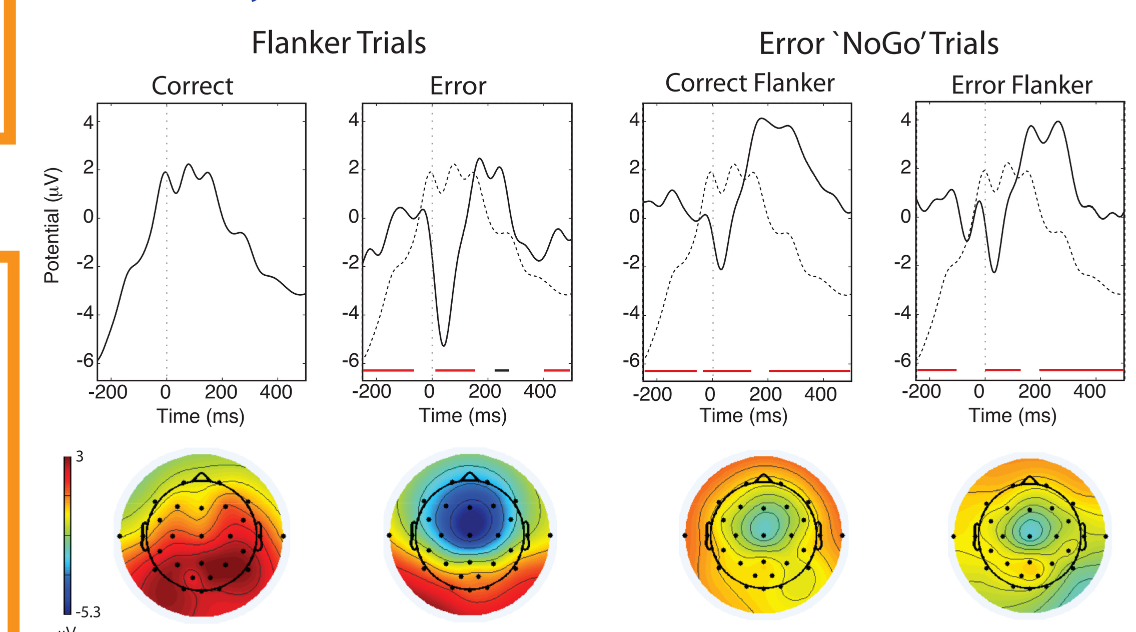
Error Trials

Behavioral Performance

Unmatched and matched trial type characteristics

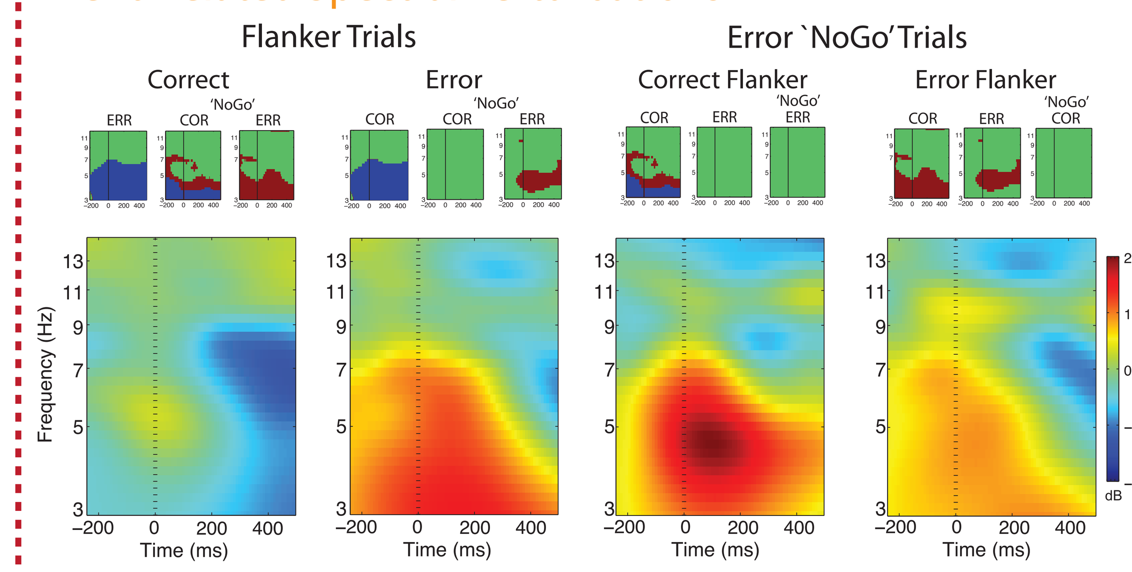
	Error Trials: Trials (± SE)	Error Trials: RT (± SE)	Post-Error Trials: Trials (± SE)	Post-Error Trials: RT (± SE)
Unmatched Values				
Flanker Error	140 (18)	576 (6)	58 (6)	
Flanker Correct	521 (21)	647 (6)	33 (2)	
'NoGo' + Flanker Correct	182 (9)	536 (9)	100 (5)	
'NoGo' + Flanker Error	60 (3)	566 (9)	33 (2)	
Matched Values				
Flanker Error	50 (2)	579 (9)	33 (2)	652 (4)
Flanker Correct	50 (2)	576 (8)	33 (2)	572 (7)
'NoGo' + Flanker Correct	50 (2)	570 (8)	33 (2)	656 (6)
'NoGo' + Flanker Error	50 (2)	568 (8)	33 (2)	654 (8)

ERP Analysis

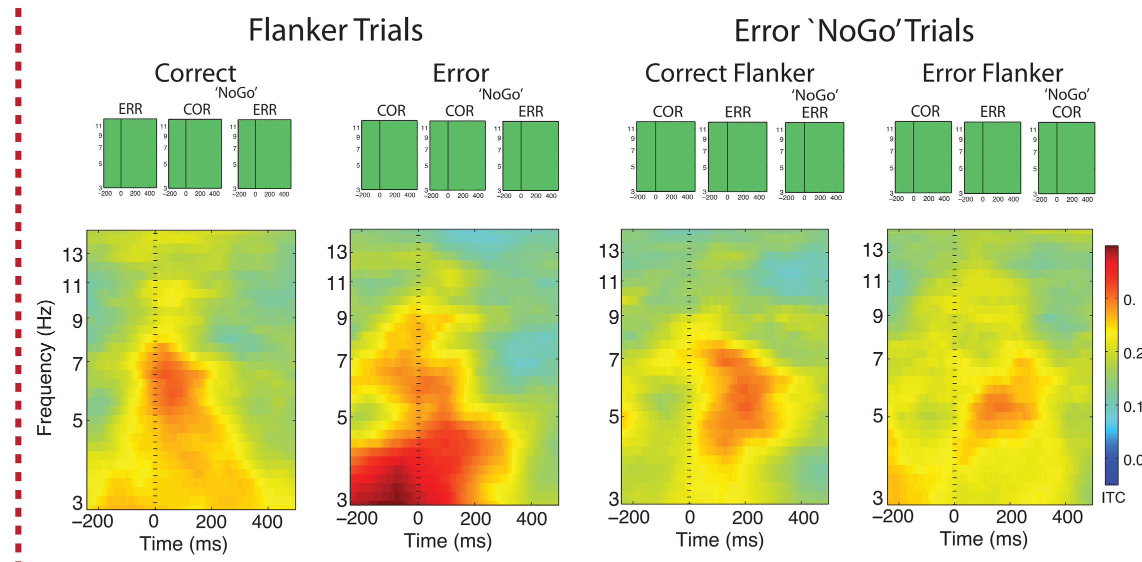


mPFC Theta Frequency Dynamics

Event-Related Spectral Perturbations

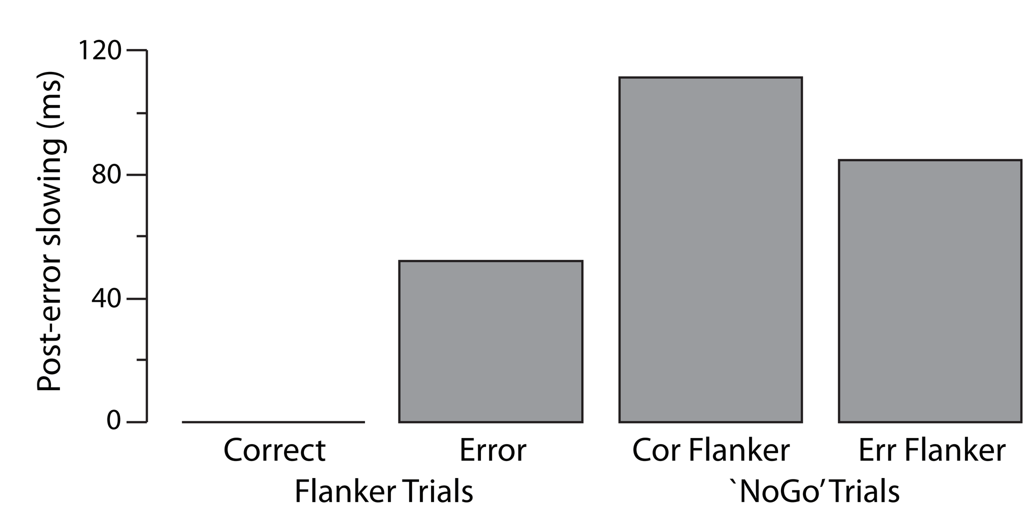


Inter-Trial Phase Coherence

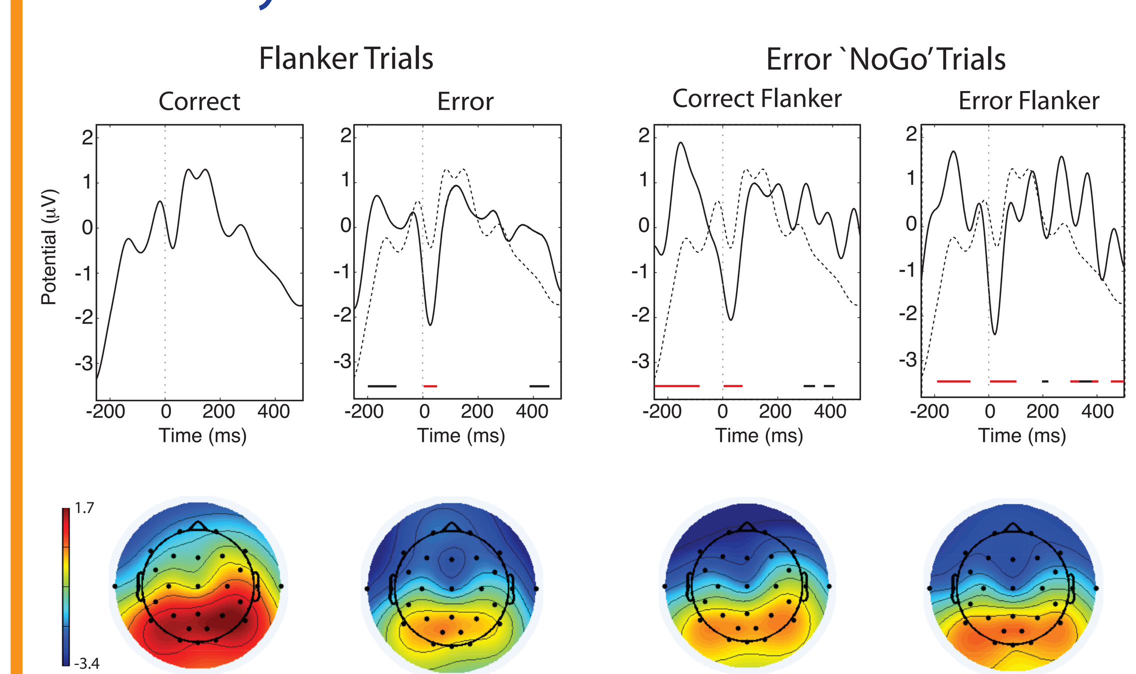


Correct Post-Error Trials

Post-Error Slowing

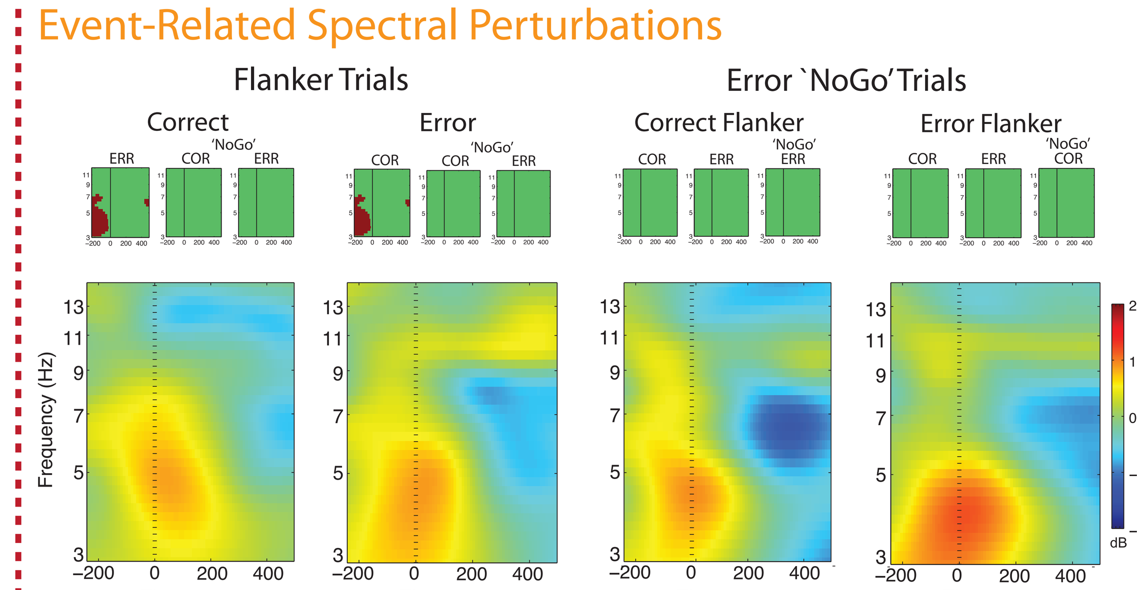


ERP Analysis

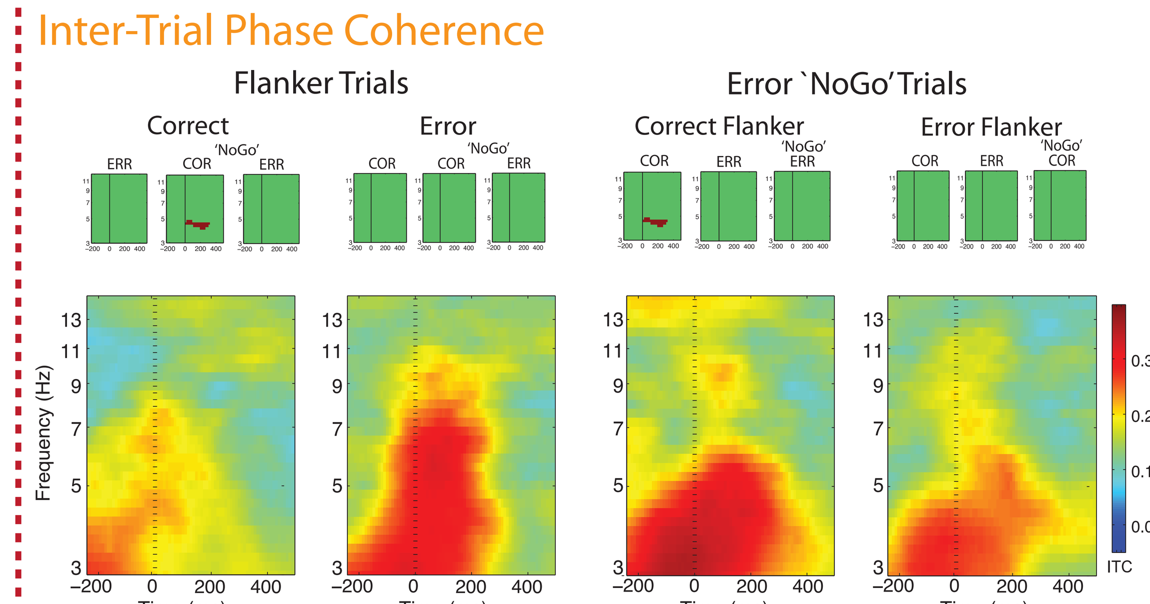


mPFC Theta Frequency Dynamics

Event-Related Spectral Perturbations



Inter-Trial Phase Coherence



Discussion

Error trials:

All types of errors elicited a response-locked ERN.

The largest negativity occurred following flanker errors.

Critically, there was no difference in the magnitude of this negativity between the 'NoGo' conditions: after failing to stop, this component was insensitive to whether the erroneous choice would have been correct on 'Go' trials.

A similar pattern was seen with the event-related theta power in these conditions.

The lack of difference between both ERN and time-frequency decompositions for 'NoGo' type errors reinforces the notion that salience largely contributes to immediate error processing, and that the ERN reflects a process needed for immediate tactical cognitive control rather than long-term strategic adjustments.

Post-error trials:

Correct trials following flanker error trials and both types of 'NoGo' error trials presented a negative response-locked voltage deflection compared to correct trials following correct trials.

There was no difference in the ERN between the three error-proceeding conditions. Additionally, there was no difference in response-locked theta power between the four conditions.

A significant increase in phase coherence was detected in correct trials following 'NoGo' + Flanker Correct errors compared to flanker correct conditions. In general, phase resetting allows for the selective amplification of afferent signals.

While it is clear that this phase resetting influences ongoing neural activity, it remains unclear the role of this resetting in regards to behavioral adaptation. This is a question for future analyses.

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