ERN Characteristics on Partial versus Complete Errors

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Summary

• We modeled dipole solutions of the error-related negativities (ERNs) for complete and partial errors, using two stimulus-response compatibility tasks: the arrow task (AR) and arrow-orientation task (AO).
• The AO ERNs and the AR task complete error ERN produce a similar midline dorsal solution for the ERN at FCz. The AR partial error produced a more anterior solution.
• Thus type of error appears to interact with task in terms of dipole solution.

Introduction

Background: We reported at the 43rd SPR Annual Meeting that the ERN[1,2] elicited by partial errors have earlier peaks and smaller amplitudes than for complete errors, independent of type of the stimulus-response compatibility task.

Purpose: To determine, using a high density montage, whether partial error and complete error ERNs have similar topographies and generators.

Tasks:

AR task:
The participants were instructed to respond to the color of the arrow stimulus (red/green for upper/lower), but not to the pointing orientation, by briskly lifting the corresponding right or left middle finger. Color and orientation conflicted on half the trials. Upper (further) and lower (closer) response mapping onto colors was counterbalanced, as was hands.

AO task:
The participants were instructed to respond to the pointing direction of the white arrow stimulus (i.e., up or down), but not to the location (i.e., above or below fixation), by lifting the middle fingers.

Method

Participants:
Fifteen right-handed university students with normal vision. Informed consent was obtained.

Procedure:
We tested two SRC tasks, the arrow (AR) and the arrow-orientation (AO) task. According to the Kornblum's taxonomy[3], the AR task is Type 3 (i.e., Simon tasks[4])and the AO task is a Type 8 (e.g., a spatial Stroop task[5]). Each trial began with a central 500 ms fixation cross which was replaced by an imperative stimulus for 200 ms. Stimulus onset asynchrony was 1500 ms, including 800 ms duration of blank screen after the stimulus offset.

The order of the tasks was counterbalanced across the participants. Participants were requested to respond with both speed and accuracy. They were told that they did not have to correct an erroneous response when they committed errors, but instead to prepare for the next trial.

Electrophysiological Measurements:
• EEGs were derived from 256 scalp sites using the EGI system
• EOG Eye Regression and trial rejection for amplitudes ± 100 μV
• Response-locked ERPs (600 ms pre- to 900 post- response)
• EMG onset determined based on the criterion of a deflection of 4.0 *SDs* of the rectified EMG.
• Partial errors were defined as rectified EMG activity of the incorrect arm that did not lead to a switch closure, which was then followed by correct arm response within 300 ms.
• Generators of the ERNs were estimated by BESA.

Results

Electrophysiological results.

ERN:

• Figure 1 shows the ERN waveforms for complete and partial errors in the AR and the AO tasks, with timing differences as expected.

• ERN for the partial errors on AR showed a somewhat more frontal scalp distribution than for complete errors but all ERNs present a clear frontocentral negativity.

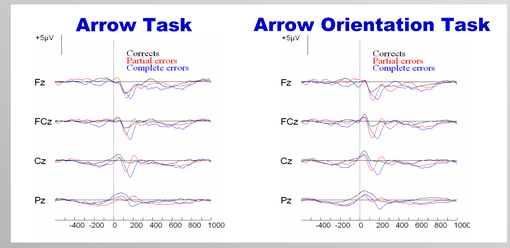

Figure 1. Waveforms for both error types and tasks. Baselines are 25 to 75 ms after EMG onset (not shown).

• Topomaps (Figure 2) and dipole solutions (Figure 3) were taken at the time when the ERN was maximum at FCz.
• Dipole solutions set with 3 pairs of symmetrical dipoles + 2 regional dipoles fixed at the eyes.
• All account for the ERN at FCz completely, with the highlighted dipole in the right hemisphere (and for AO partial error its symmetric partner in the LH) in the motor/premotor/SMA region accounting for the ERN.
• For the AO task, the partial and complete errors produced similar solutions (see Figure 3).
• For the AR task, the complete error produced a similar solution as for AO but the partial error had a more forward solution plus a posterior dipole producing a positivity caudal to the ERN.
• The partial error ERN tended to produce more bilateral solutions than complete errors which may be due to the bilateral responses on partial error trials.

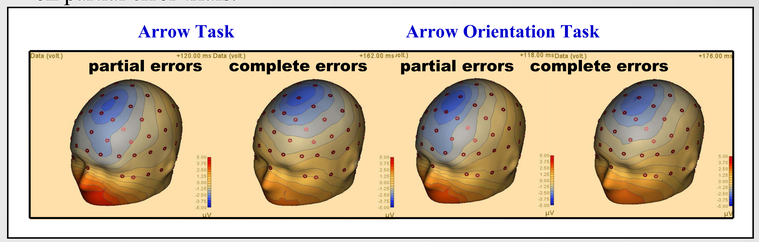

Figure 2. Topographical maps for both error types and tasks at the maximum ERN amplitude.

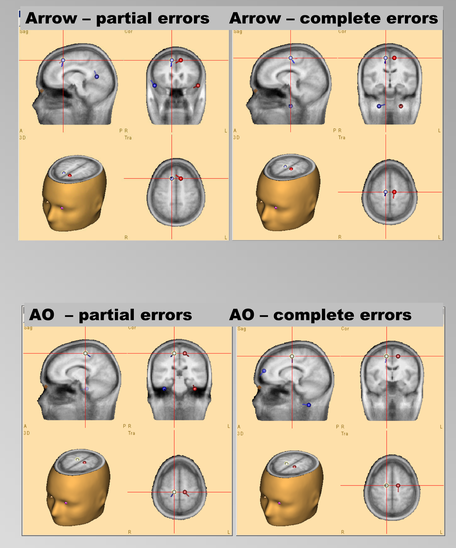

Figure 3. The source solutions contained three pairs of symmetric directional dipoles plus two regional dipoles fixed at the eyes. The dipole in the region of the right premotor/SMA region accounted for the ERN at FCz for 3 of the conditions. The partial errors in the AO had bilateral dipoles in this region.

Conclusions

• While ERNs for complete errors in the two tasks showed similar topography and similar dipole sources, the dipole source accounting for the partial error ERN appeared to be affected by the task, being more anterior for the AR task compared to the AO task. Considering that the partial errors by definition contain a second innervation, the easier AR task which has earlier corrective movements and earlier ERN would have a more complex set of activated fields.

• Comparing partial and complete errors, therefore, depends to some extent on the task. In the AO task, which has greater conflict on incompatible trials, the partial and complete error ERNs appear to have highly similar generators.

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