Chapter 96

Applied Potential: Neuroergonomic Error Detection in Single Electrode Electroencephalography

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The present state of the art in fixed, laboratory EEGs are multichannel devices, which provide superior spatial coverage of functional regions of the brain, as well as rich variance–covariance data to support postprocessing approaches such as independent component analysis (ICA). In contrast, functional design of wearable electroencephalographic (EEG) equipment represents a balancing act in which each additional channel adds weight, artifact-inducing moving parts, computational requirements, and associated power consumption. Brain processes per se are often already well studied, and optimal electrode placement known and described.[1,2] As such, applied efforts should leverage this knowledge to employ the lowest number of electrodes allowing consistent detection of the pattern of interest. The ideal here would be one. Nevertheless, can single-electrode EEG, devoid of ICA postprocessing, perform well enough in the electrically noisy real world? Here, we build on previous work to address this question. Sawyer et al.[2] described, for the first time, the detection of the error-related negativity (ERN) evoked-response potential (ERP) in a visual search for complex stimuli. In this work, participants completed tasks during eight-channel EEG recording, which was then analyzed using ICA postprocessing.[3] These same data, restricted to the central scalp electrode (Cz), the electrode closest to the focus of the ERN signal, and without ICA postprocessing, was here reanalyzed. Visual inspection (see Fig. 96.1) and subsequent statistical analyses of these resultant time-locked ERP data clearly demonstrate that the ERN was detectable under both analytic approaches. Further, a large effect size was seen for both analyses, clearly showing that ERN ERP may be robustly detected in aggregate single-electrode encephalography data.

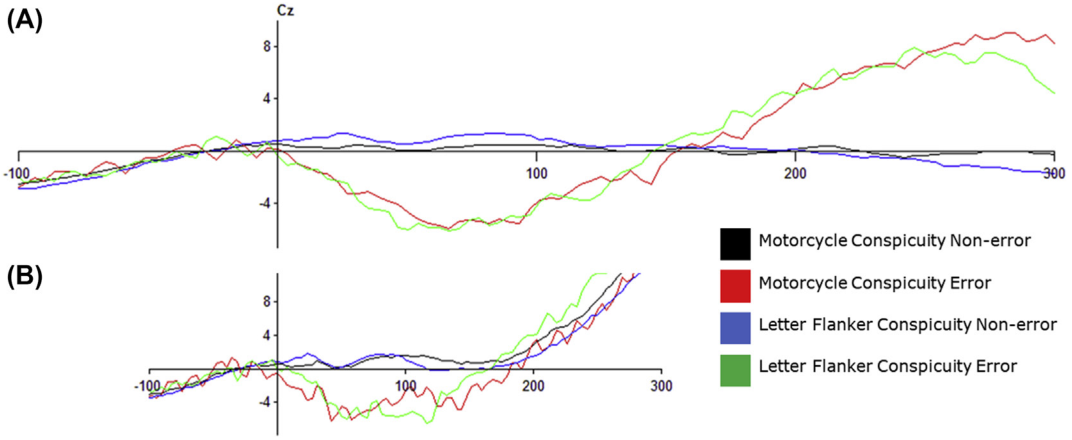

FIGURE 96.1 Waveform data for errors and nonerrors are shown across a simple letter flanker task and a complex motorcycle conspicuity task. Inspection of both (A) the ICA post-processed data and (B) raw single-electrode data reveals a pronounced negative deflection for error trials, as is typical for the ERN ERP. These data are plotted negative-down relative to a 50 ms baseline, whereas 100 ms of preresponse activity is shown for evaluative purposes.

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Successful elicitation and detection of this ERN in a visual search of complex images opens the door to applied neuroergonomics "in the field" (as in Fedota and Parasuraman, 2010),[1] enabling the investigation of the brain's error detection system in everyday life and work. Moreover, our present analytic approach can, and should, be applied to other brain processes. EEG features amenable to neuroergonomic analysis "in the wild" represent significant opportunities.

REFERENCES

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