Beyond the Grand Average: A Novel Method for Identifying Single-Trial ERP Components in EEG Research

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30 Second Summary

- **By far the most widespread way of calculating ERP amplitude is based on "grand average" waveforms pooled across many trials and subjects (Luck, 2014)**
- **While this method is suitable for many applications, it is not ideal for single-trial or intra-individual ERP analyses**
- **Here, a method is proposed which identifies ERPs on a single-trial basis and thus is not reliant on data averaged across subjects or trials**
- **Based on the data presented here identifying single-trial ERPs provides estimates which are more reliable with fewer trials, measure single-trial ERPs better, and can identify novel intra-individual variations in ERPs**

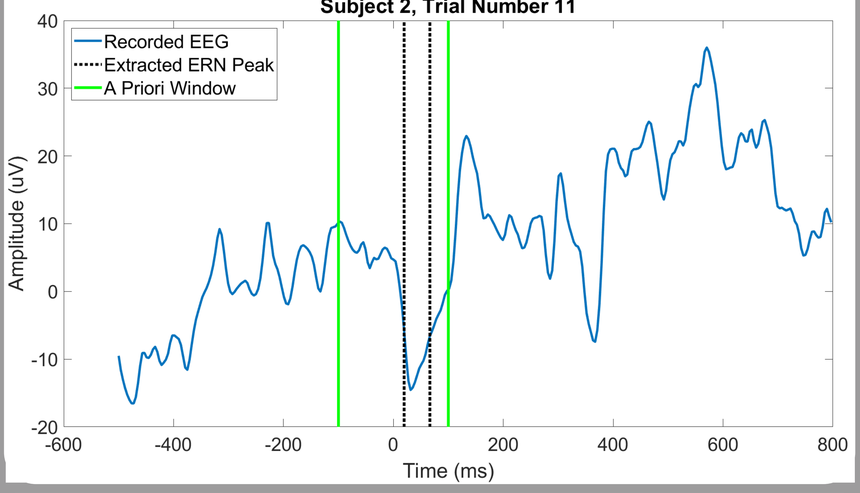
Methods

1. The data presented here are response-locked ERPs from a flanker task (N = 70, 720 trials). Each flanker was preceded by either an image of a face or a scrambled image. Response-locked ERPs were analyzed from incorrect (error-related negativity; **ERN**) and correct (correct-related negativity; **CRN**) trials. Eye movement correction was performed using the method outlined by Kraus (2020).

2. The method proposed here uses a sliding function within an a priori time window (-100 to 100ms) to identify an ERN peak on each trial. It attempts to identify a trough (or peak) surrounded by at least 20ms of consecutive positive-going (or negative-going) data points on either side. If no peak is present, the algorithm then identifies the local minima (or maxima) within the a priori window. Grand average ERP amplitudes were calculated from a 0-100ms time window post response.

3. Once the peak is identified, the AUC is calculated for the waveform to center the single-trial ERN peak. If the AUC results in a window which does not include the original peak, the trial is centered on the original peak. If the value identified via AUC is outside of the a priori window, then the mean ERN latency for that subject is used.

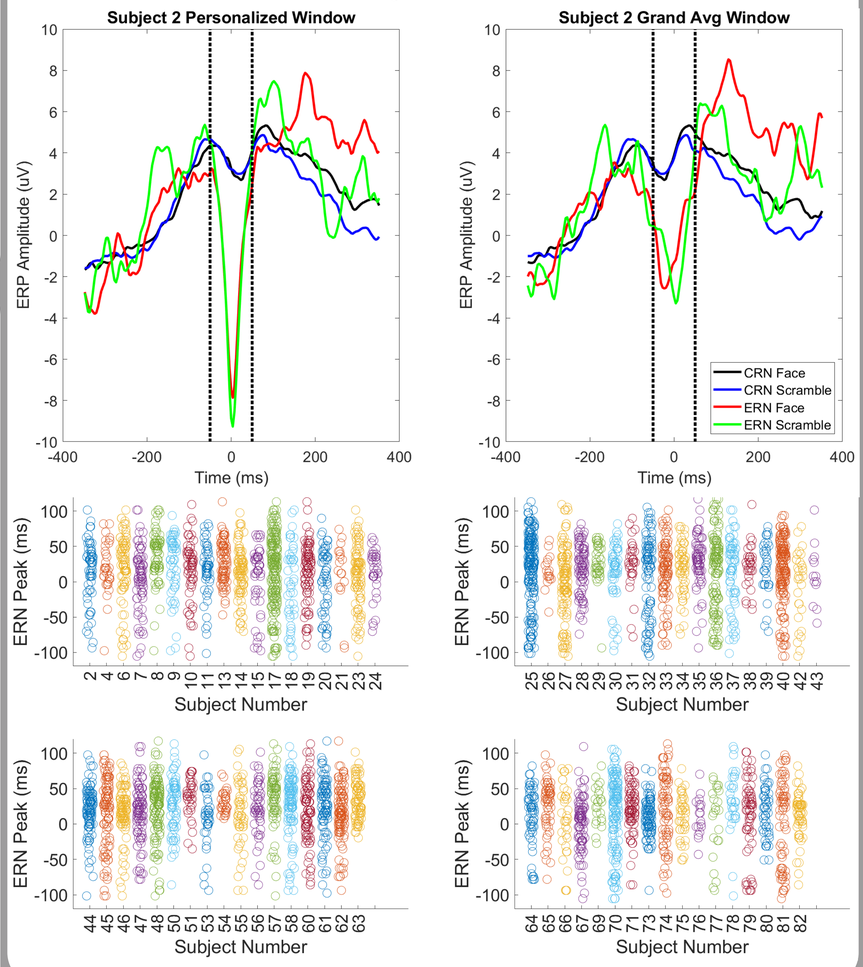
4. CRN latency was calculated from the mean ERN latency for each subject.



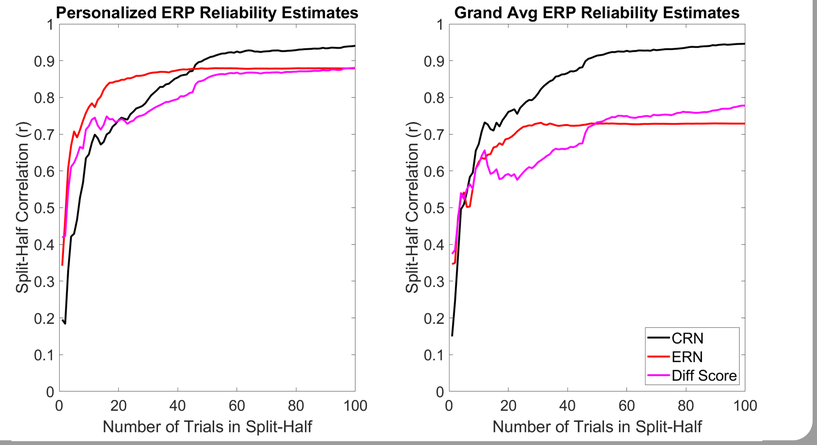
Conclusions

- **Single-trial ERPs can be reliably identified at the single-trial level**
- **ERP amplitude at the single-trial level differs from single-trial estimates obtained from grand average ERPs**
- **This method provides an innovative approach to analyzing single-trial ERP data in EEG research**

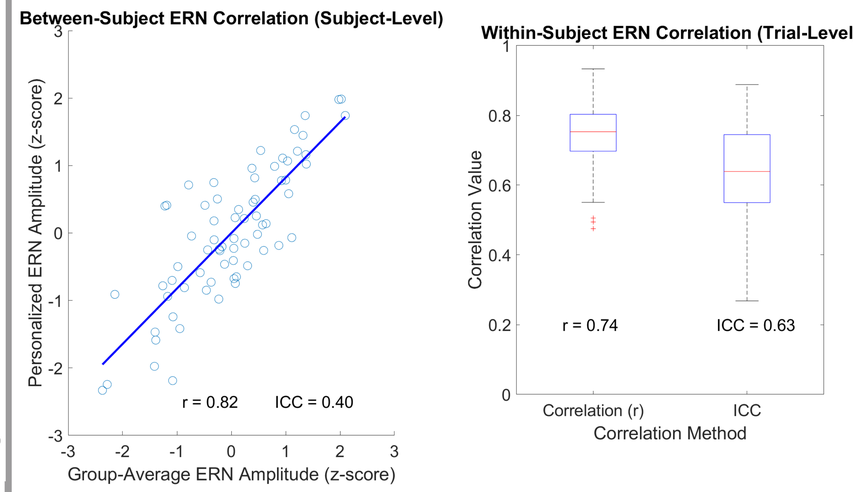
1. ERNs can be identified at the single-trial level, and differ in latency across individuals



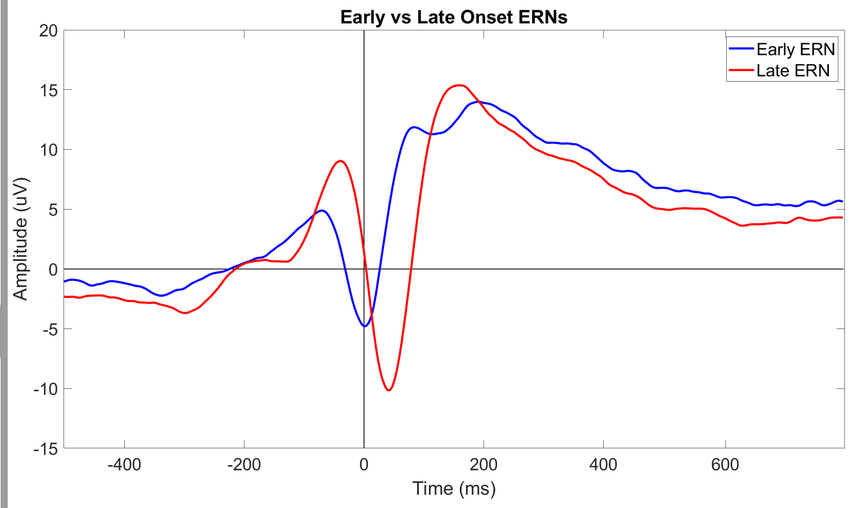
2. ERPs are more reliable with less trials using personalized versus grand average approach



3. Approximately half of the variance in amplitude of single-trial ERNs is not captured by the grand average



4. Single-trial ERNs show intra-individual variation that is masked using a grand average-based approach



References

1. Kraus, B. (2020). An Automated Method For Correcting Ocular Artifacts In EEG. Poster presented at the Cognitive Neuroscience Society annual conference, Virtual Conference.

2. Luck, S. J. (2014). An introduction to the event-related potential technique. MIT press.

Acknowledgements

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