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VALIDATING INDEPENDENT COMPONENT ANALYSIS OF NEUROPHYSIOLOGICAL DATA

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Abstract

Independent Component Analysis (ICA) is an analytical tool that can be used to reduce noise in non-gaussian data sets to extract normally distributed data. In lab we developed a new analysis protocol employing ICA for the purpose of analyzing Electroencephalography (EEG) data containing major muscle and eye artifacts. Using this pipeline, we are able to generate more precise Event-related Potentials (ERP). This method is particularly useful in regards to EEG since data can often contain movement-based artifacts as well as random noise that are irrelevant to waveforms. ICA uses an algorithm to reduce the amount of noise in the raw data set by organizing the source electrodes into components that are then presented in order of the amount of variance the component contributes. By removing components that account for the highest amount of variance in the data, ICA is able to reduce the number of movement-related artifacts and overall noise in the data set. This is useful during the analytical process because by reducing variance across the data set we are better able to isolate the EEG component in the data that is associated with the task when creating ERPs. By creating more precise ERP waveforms we are better able to isolate the relevant components of the waveform that are associated with a task increasing the accuracy of the analysis.

Introduction

Electroencephalography (EEG) is a procedure used to detect electrical brain activity by placing non-invasive electrodes on the scalp. Known for its temporal resolution, it is very good at detecting *when* something occurs in the brain by observing the change in the electrical signatures occurring under the scalp. These electrodes often detect eye movements and artifacts related to muscle movements as well which can result in noisy data. During analysis of this data, noisy trials must be thrown out due to their low resolution. Independent Component Analysis (ICA) is an analytical tool that can be used to reduce noise in non-gaussian data sets to extract normally distributed data (Congedo et al., 2010). ICA can be applied to EEG data in order to reduce the number of eye and muscle artifacts causing us to reject trials (Hallez et al., 2009). This becomes especially important when working with the wide range of populations on which EEG is difficult to use such as those suffering from neurological conditions like epilepsy (Weinstein et al., 2000) or infants. By not having to throw out as many trials during the analytical process we can save valuable data gathered from these challenging populations.

Methods

In lab we developed a new analysis protocol employing ICA for the purpose of analyzing EEG data containing major noise. An ICA algorithm is applied to the continuous portion of the data in which the trials of the experiment took place. ICA organizes the electrode data into components that are then displayed in order of contributing variance (fig. 2). Typically, the component responsible for the most variance in the data is removed, but specifically the component most associated with the eye and muscle artifacts is to be removed (fig. 3). After removal of components the data is segmented into epochs based on the trials. At this point trials are thrown out if they contain too much noise or too many artifacts (fig 4). After rejecting trials, all of the components are averaged into one figure called an Event-Related Potential (ERP). After conducting this analysis and generating ERPs (fig. 1) for all participants, grand average ERPs are created from averaging together all individual ERPs.

Results

Upon inspection of differences in individual ERPs we see small but noticeable changes in the ERP. This is displayed in Figure 1 by contrasting the segments contained in the circles. Though the change is not obvious to the naked eye, these slight differences in the individual ERPs result in much larger changes in the grand average ERPs. This is due to less noise in the continuous data allowing us to reject fewer trials and obtaining a larger sample of data to analyze. It can be assumed then that because fewer trials are being rejected during the analytical process the final product is a much more representative ERP waveform.

Conclusions

Independent Component Analysis is a useful tool when working with populations whose data is susceptible to interference for various reasons. If employed properly the immediate difference is not extremely substantial. However, by conducting ICA one can save more trials from being rejected and therefore obtain more representative Event-Related Potentials.

Reference

Congedo, M., John, R. E., De Ridder, D., & Prichep, L. (2010). Group independent component analysis of resting state EEG in large normative samples. *International Journal of Psychophysiology*, *78*(2), 89–99. https://doi.org/10.1016/j.ijpsycho.2010.06.003

Hallez, H., De Vos, M., Vanrumste, B., Van Hese, P., Assecondi, S., Van Laere, K., … Lemahieu, I. (2009). Removing muscle and eye artifacts using blind source separation techniques in ictal EEG source imaging. *Clinical Neurophysiology*, *120*(7), 1262–1272. https://doi.org/10.1016/j.clinph.2009.05.010

Weinstein, D., Zhukov, L., & Potts, G. (2000). *Localization of multiple deep epileptic sources in a realistic head model via independent component analysis*. University of Utah.

Appendix

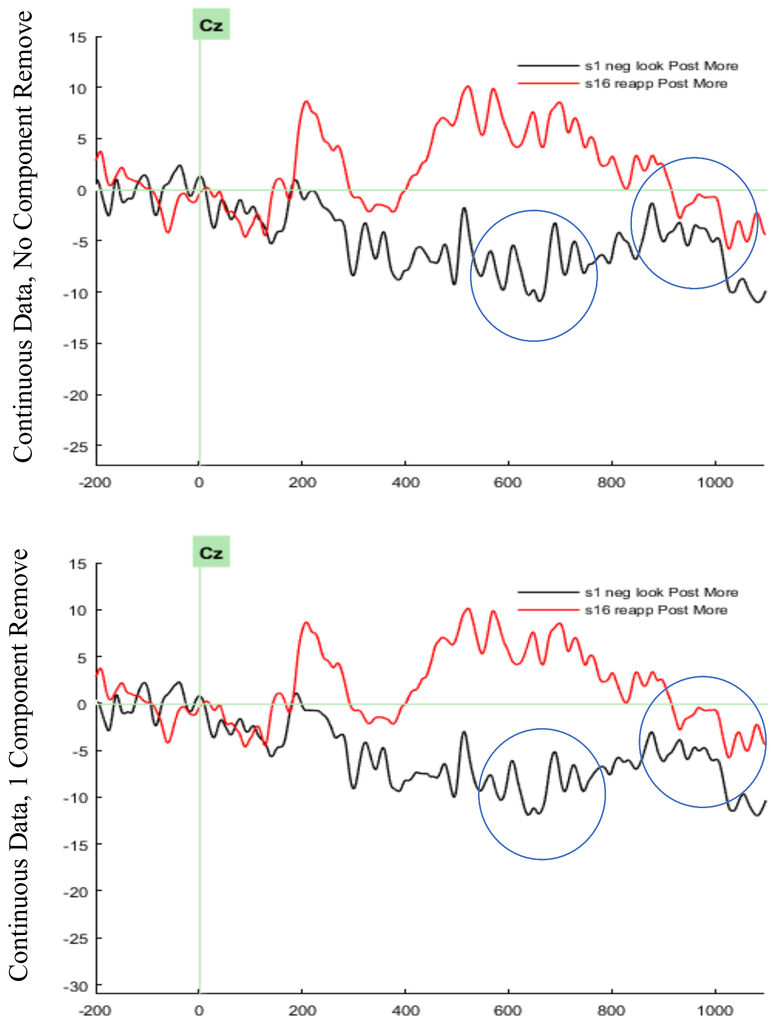

Figure 1: Changes in a single participant's Event-Related Potentials.

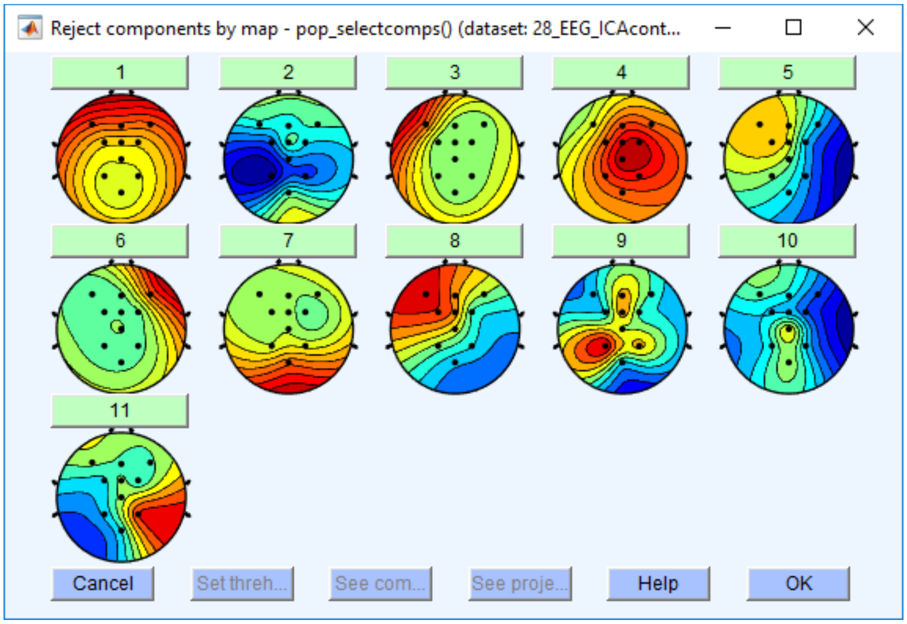

Figure 2: Components displayed in order of variance.

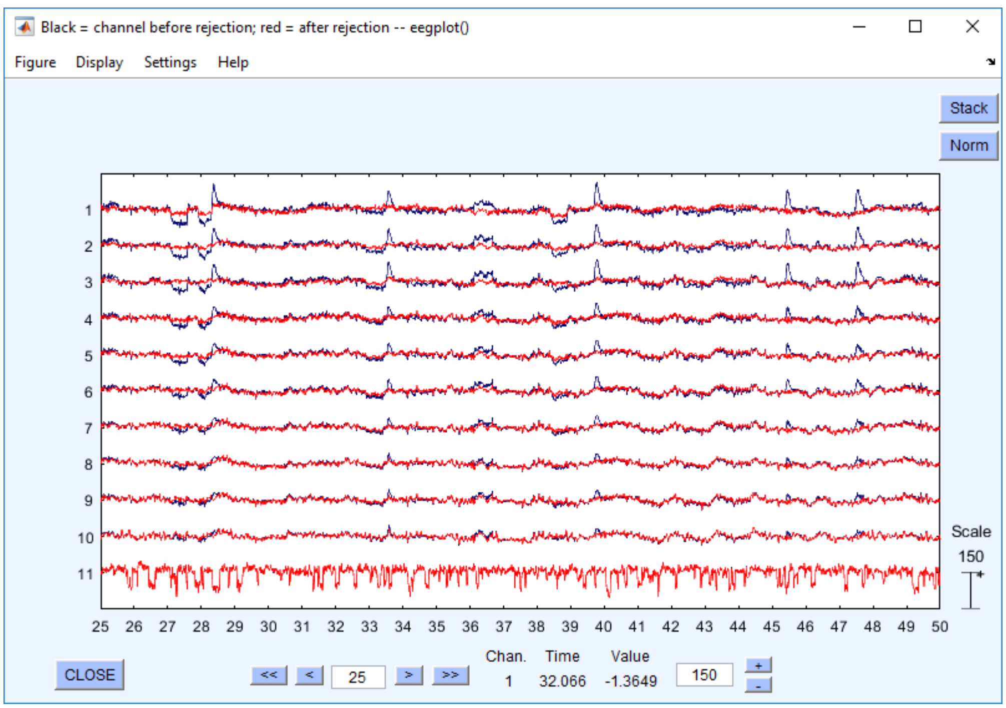

Figure 3: Comparing EEG data before (blue) and after (red) removing the component.

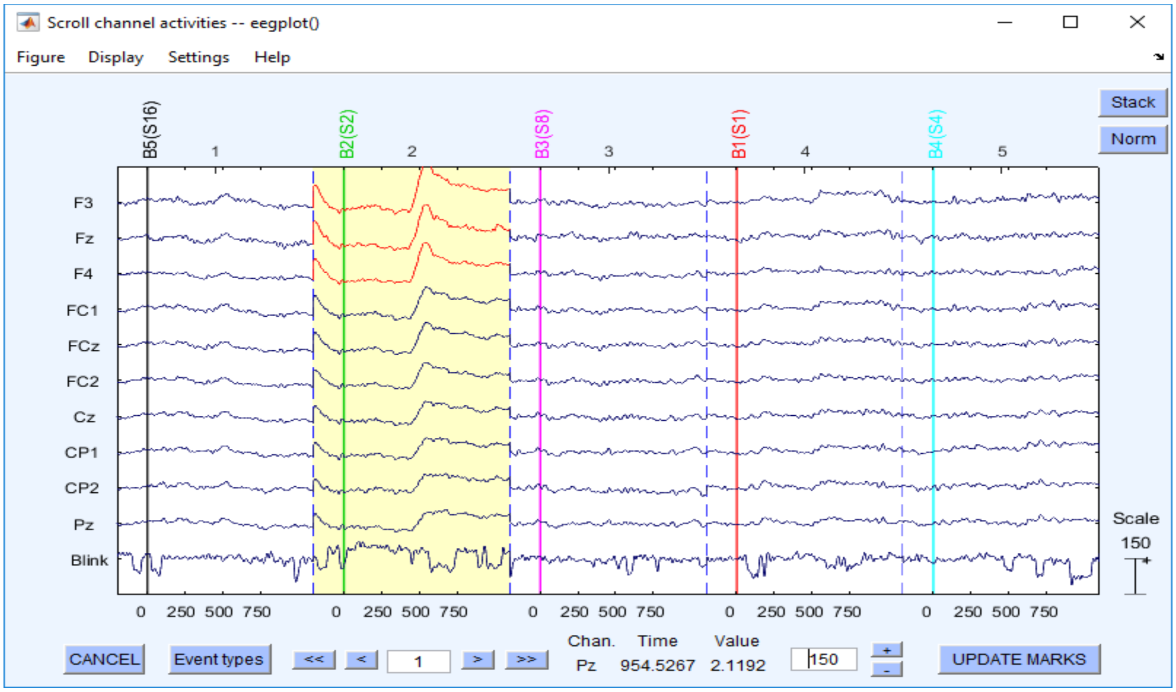

Figure 4: Rejection of trials containing artifacts.