NIC Technical Document # 7 2004-05-27
Gwen Frishkoff

Summary of ICA results for 34-channel Simulated Blink Data (DS#5): With and without band-pass filter (.5–20hz)

Introduction

The current report describes evidence for two blink-related components, which differ in temporal frequency: we suggest that the quick, or "phasic," component corresponds to the artificially generated blinks, whereas a second blink-related component has a slower timecourse, which may be related to the amplifer recovery time, or "time constant" that was associated with physiologically generated blinks in the original data. This discovery motivates the future use of information about the spectral characteristics of latent components, as a tool to aid in the identification and classification of latent components.

Methods

We describe a subset of our results from a series of experiments, in which Independent Components Analysis (ICA) was applied to a "synthetic" EEG dataset in order to separate blink-related activity from non-blink activity. The goal of these experiments was to compare the efficacy of two ICA algorithms — Infomax and FastICA — across a range of contexts, in which we varied parameters of both the datat (blink activity) and algorithms (e.g., using different contrast functions and different correlation thresholds for identification of blinks). A summary of results from these experiments is provided in our recent paper, Glass, Frishkoff, Frank, Davey, Malony, & Tucker (in press). A more comprehensive report is in progress.

Seven Datasets were included in our original study. Dataset #5, the focus of this report, consists of 59,409 samples (237, 636 ms) of "synthetic" EEG data. These data were created by superposing an artificially generated blink stream onto a series of real, blink-free, 34-channel EEG data (procedure illustrated in Figure 2). See NIC Technical Report 2004–02 for complete details on construction of Dataset #5, including a description of the artificially generated blink stream.

What we refer to here as the "original" dataset was sampled at 250hz, using a .1hz highpass and 100hz lowpass filter. With NetAmps (series 200), the highpass filter corresponds to a 1-second time constant: this implies that a signal takes approximately 1-second to go to half-power. A 30hz digital lowpass filter was applied to the data offline. Before adding the artificially generated blinks, the actual (phsiologically generated) blinks were identified and removed from the data by an expert EEG analyst. The resulting "blink-free" segments were concatenated to form a continuous time series, to which the artificial blinks were subsequently added.

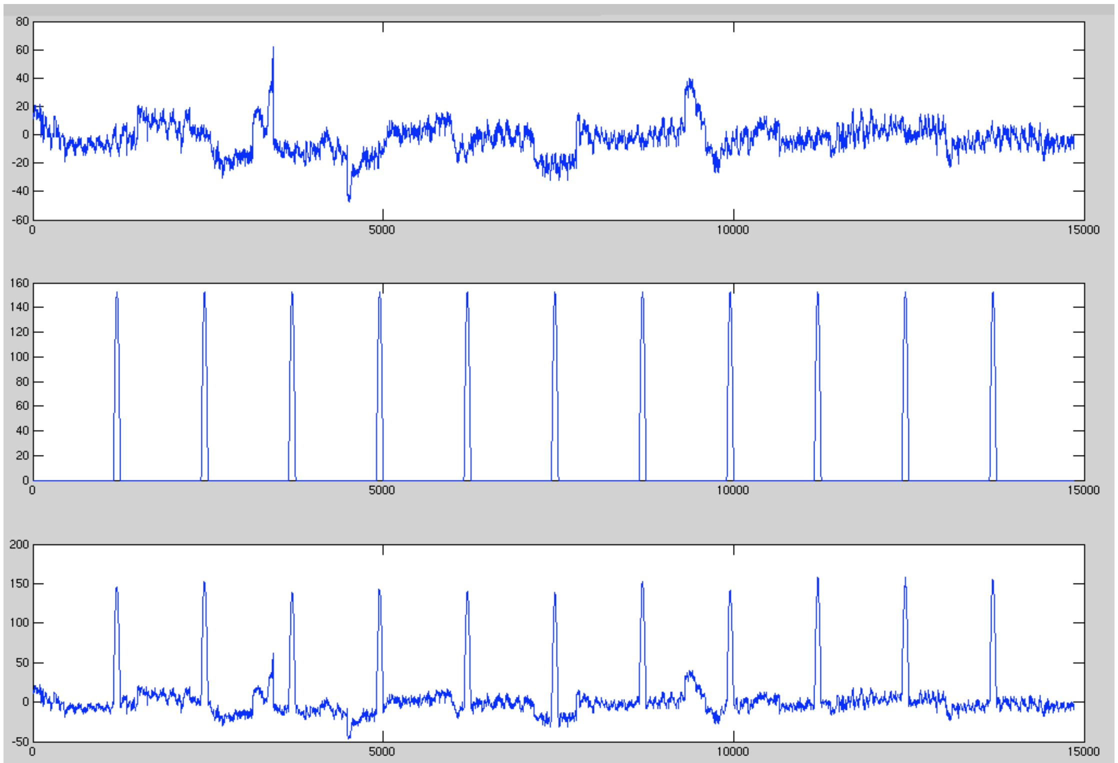


Figure 1. Construction of Dataset #5. From Top to Bottom: (1) Clean, Blink-Free, Data; (2) Blink Stream; (3) Clean, Blink-Free, Data + Blink Template * Blink Stream

ICA results for original data

The original data were subjected to a series of ICA runs: one ICA run was executed using the Infomax algorithm, and three runs were executed using FastICA. As described in our previous report (Glass, et al., in press), Infomax has proven quite stable: results do not vary greatly from run to run. FastICA, by comparison, gives variable results from run to run. Thereore, it is important to consider multiple runs of FastICA, when comparing the two algorithms.

Figure 2 shows the 34 independent components (activations) that were generated in the application of Infomax to Dataset #5. The activations were segmented with reference to the peak of each artificial blink (1,500ms before and 1,500ms after the peak); we then averaged across these segments. This procedure accentuates the blink-related timecourse of each independent component, in the same way that event-related averages in brainwave analysis amplify components of the data that are related to a event that occurs on each trial (e.g., the onset of a stimulus or response).

To identify which of the 34 independent components are blink-related, we compared the topographic (spatial) projection of each component with the blink "template" that was used to generate the artificial blink stream (see NIC-TR2004–003 for description of the blink template). Independent components had to match two criteria to be identified as blink-related: (1) polarity must invert over and below the eyes, and (2) the source projection must "match" the blink template (a range of correlation thesholds was examined). Using a correlation threshold of .75, two ICA components were defined as blink-related on the Infomax run. These components are marked in red in Figure 2: note that IC#1 has a timecourse that precisely matches that of the blink strem, whereas IC#10, has a slower timecourse, and is not so clearly time-locked to the artificial blinks.

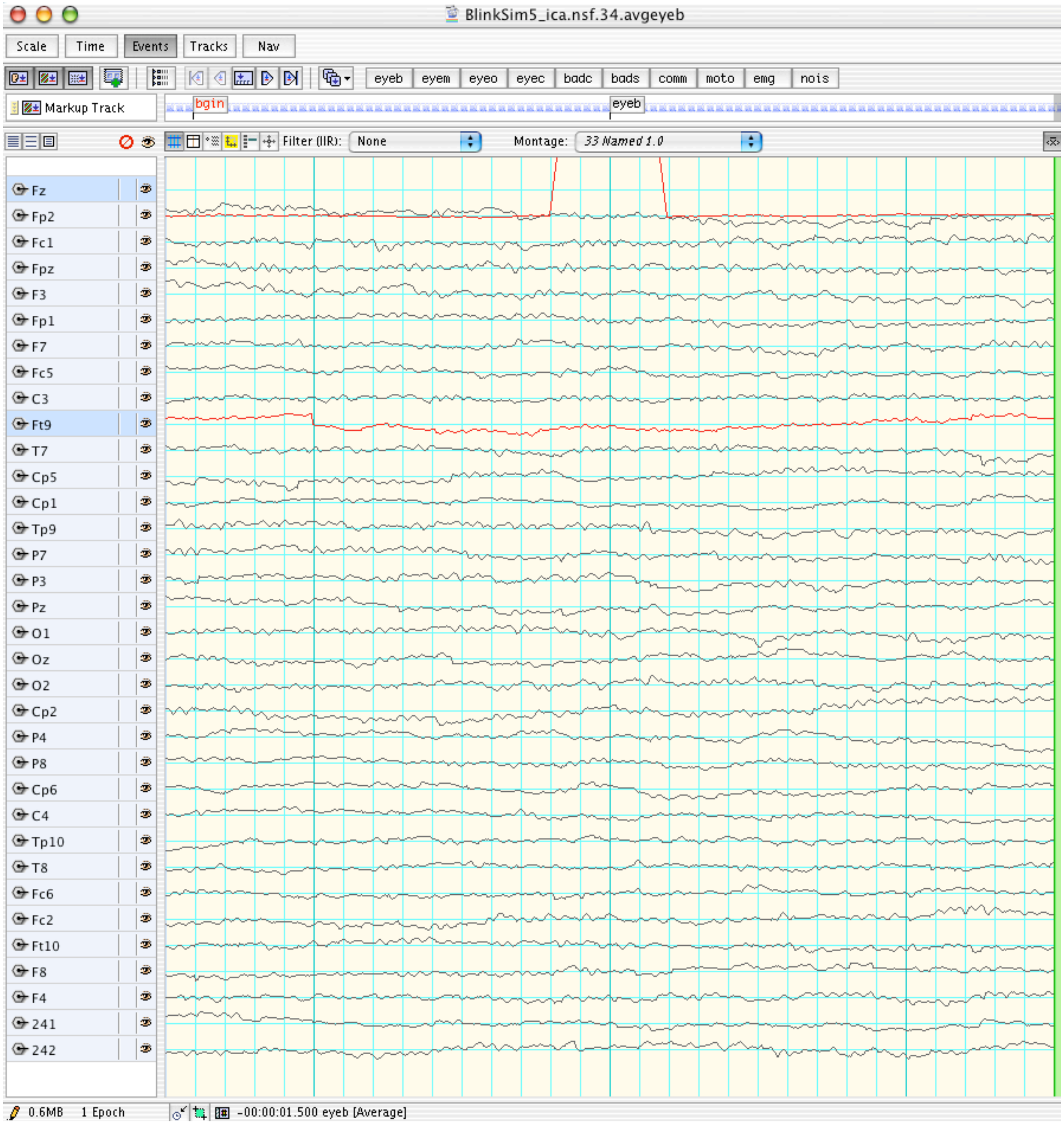


Figure 2. Indendent components for Dataset #5 (not filtered), from Infomax run. *NOTE: In this (and all similar figures), the labels to the left of the waveforms should be replaced by IC#1…. IC#34.*

Figure 3 shows the topography (source projection) for each blink-related component. The correlation between IC#1 and the blink template was exactly 1.00: thus, the topography of IC#1 is identical to that of the blink template. On the other hand, IC#10 correlated ~.8 with the blink template.

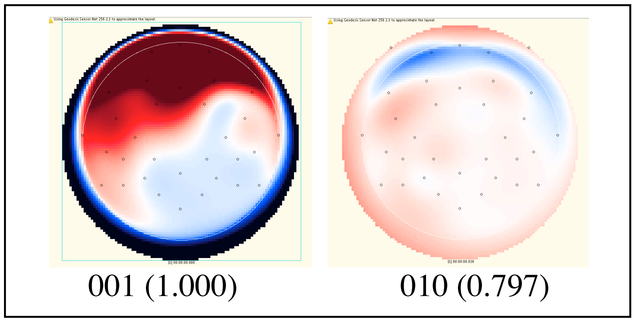


Figure 3. Two (of 34) independent components met criteria in Infomax run

While the results of the three FastICA runs were more variable, in each case we obtained one component whose projection was a perfect (1.00) match to the blink template.

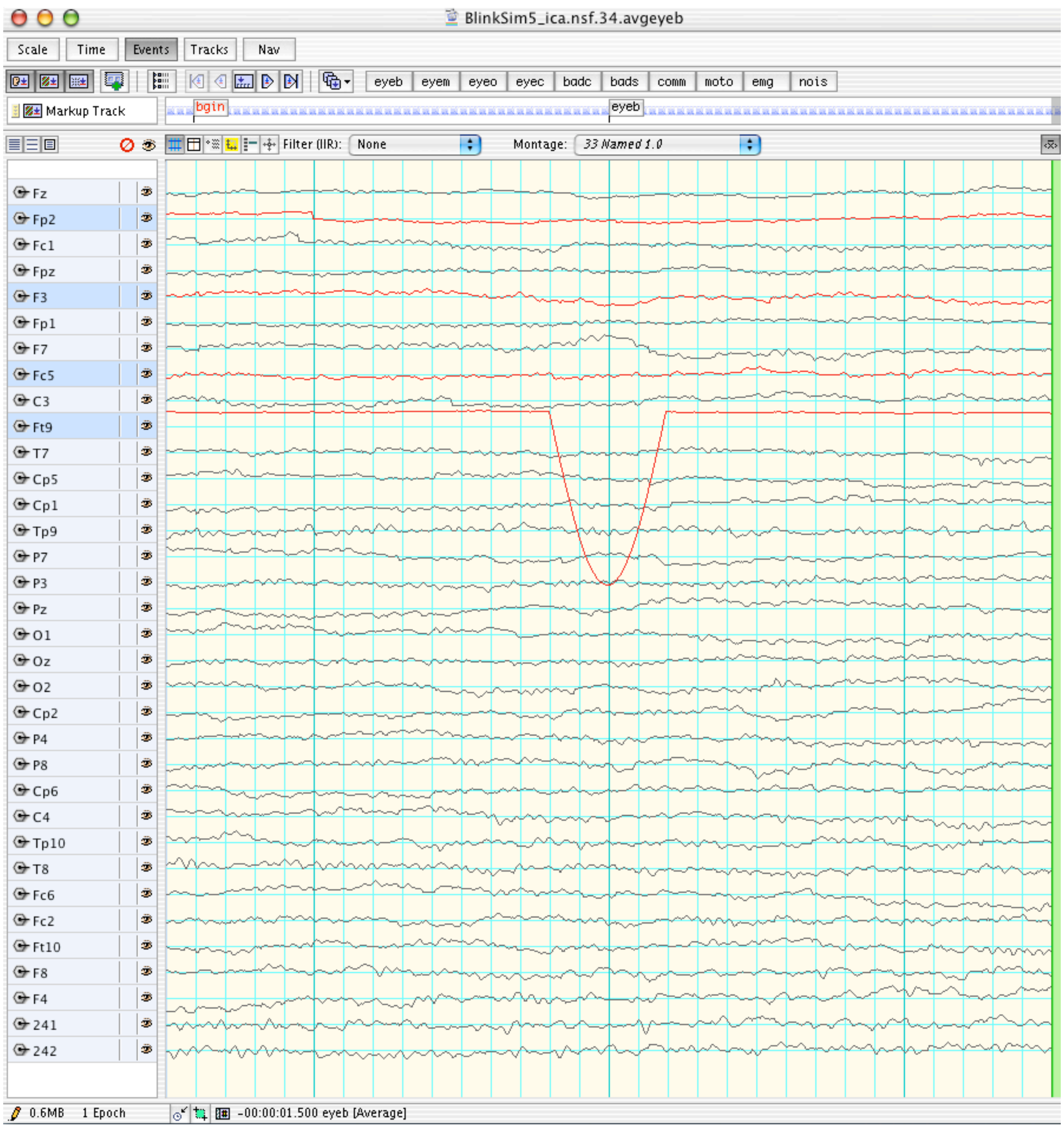


Figure 4. Indendent components for Dataset #5 (not filtered), from FastICA (run 1).

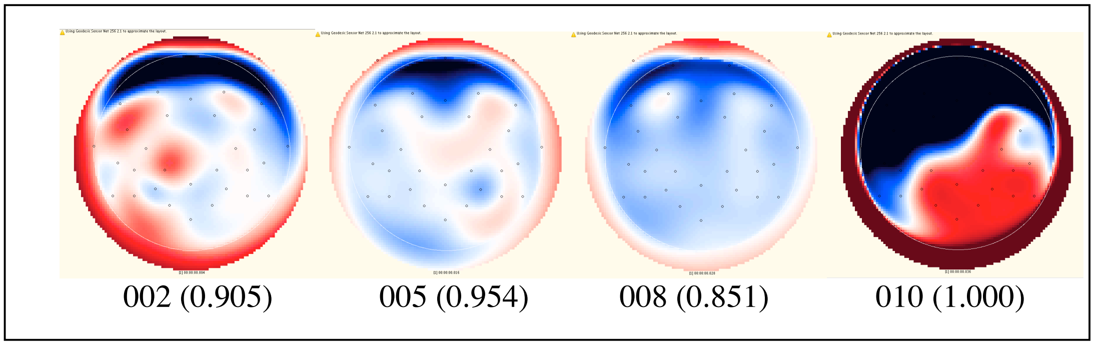


Figure 5. Four (of 34) independent components met criteria in FastICA run 1

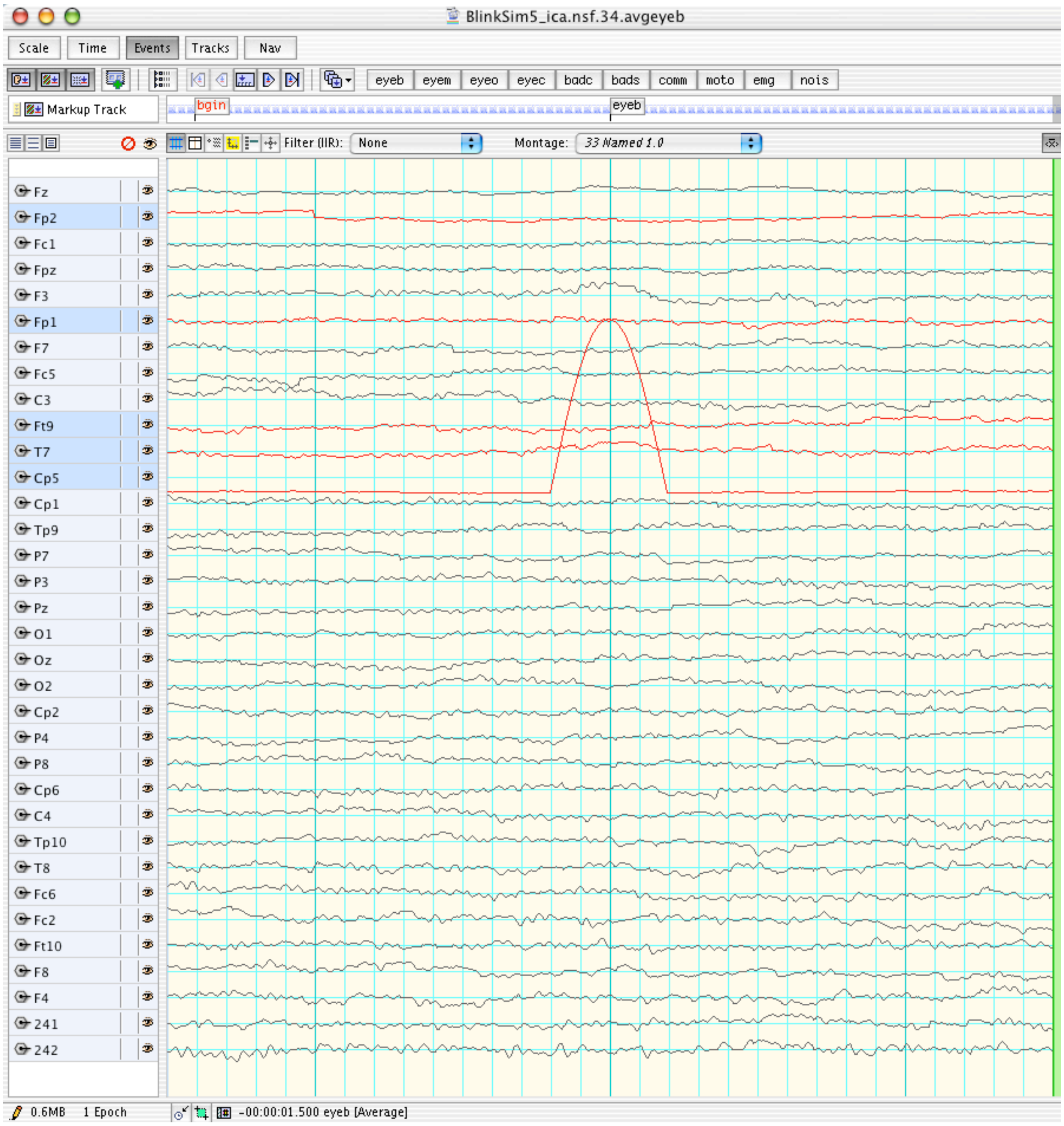


Figure 6. Indendent components for Dataset #5 (not filtered), from FastICA (run 2).

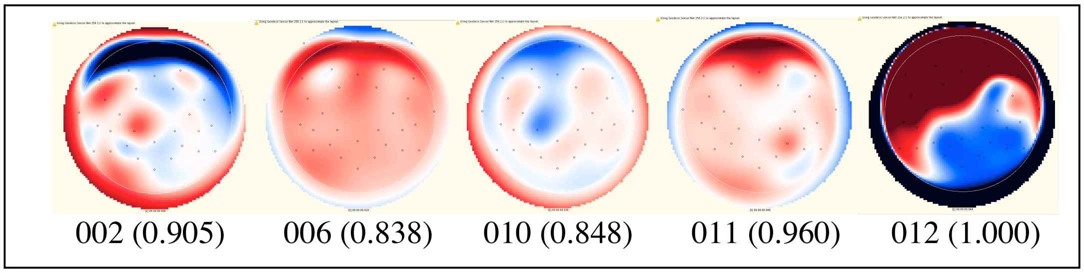


Figure 7. Five (of 34) independent components met criteria in FastICA run 2

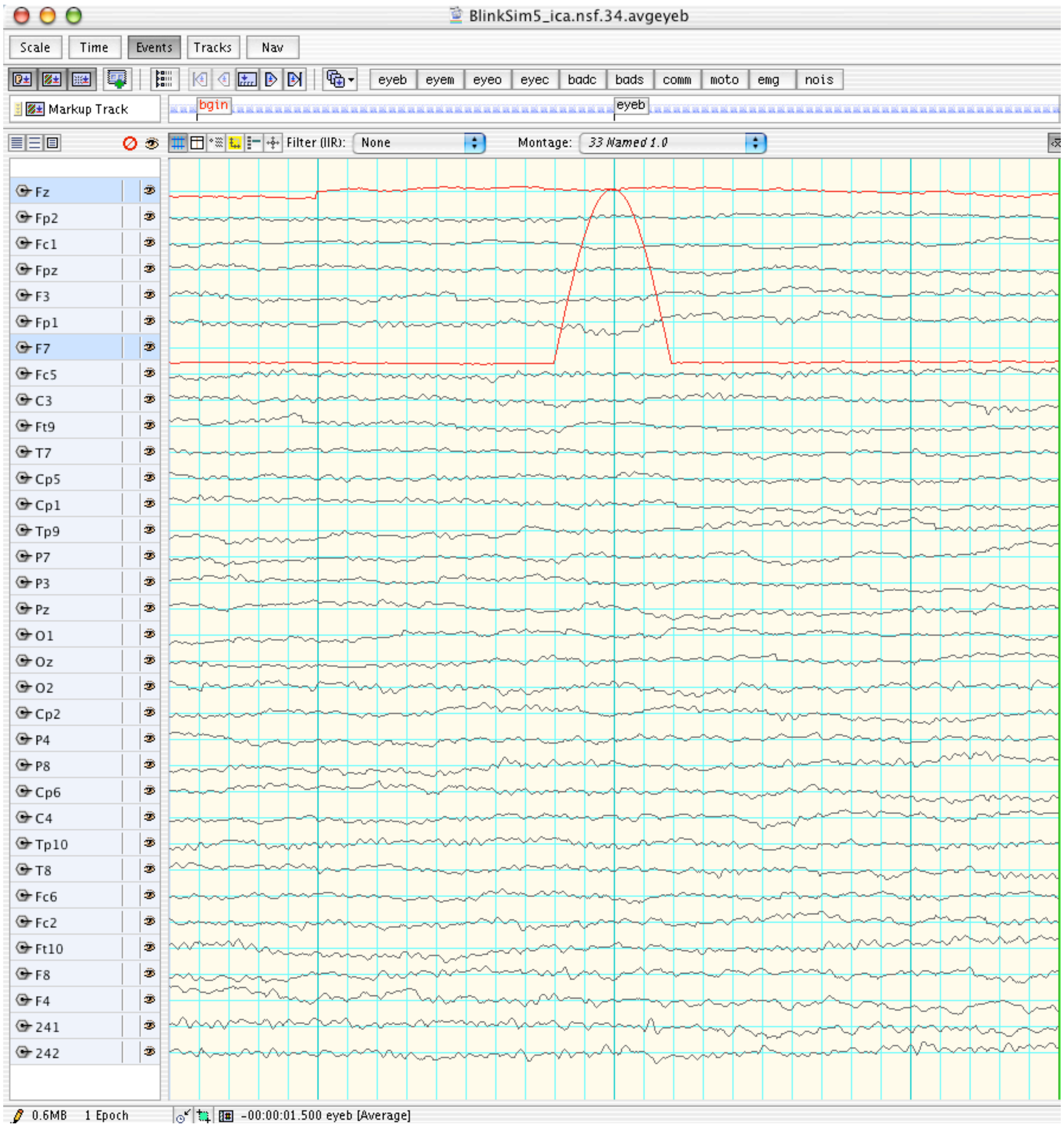


Figure 8. Indendent components for Dataset #5 (not filtered), from FastICA (run 3).

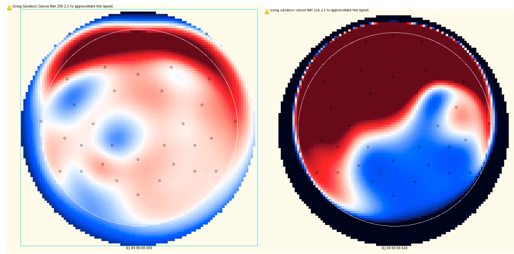

001 (0.906) 007 (1.000)

Figure 9. Two (of 34) independent components met criteria in FastICA run 3

ICA results for bandpass-filtered data

For each of the prior ICA runs, we obtained one component that was a perfect match to the blink template (the "phasic" blink component), and a second component that had a slower pattern or activation and was less strongly correlated with the blink template. We guessed that this second component might reflect amplifer recovery subsequent to the real (physiologically generated) blinks that had been removed from the original data. To remove this slow-wave activity, we then applied a .5–20hz bandpass filter to the data and performed another sequence of ICA runs to re-examine the efficacy of the two algorithms in the absence of the slow blink-related activity.

As predicted, the Infomax run yielded a single match — a component that had a phasic (blink-like) timecourse, and whose projection was a perfect match to the blink template. None of the independent components from this run corresponded to the slow, blink-related component that was extracted from the data before applying the bandpass filter.

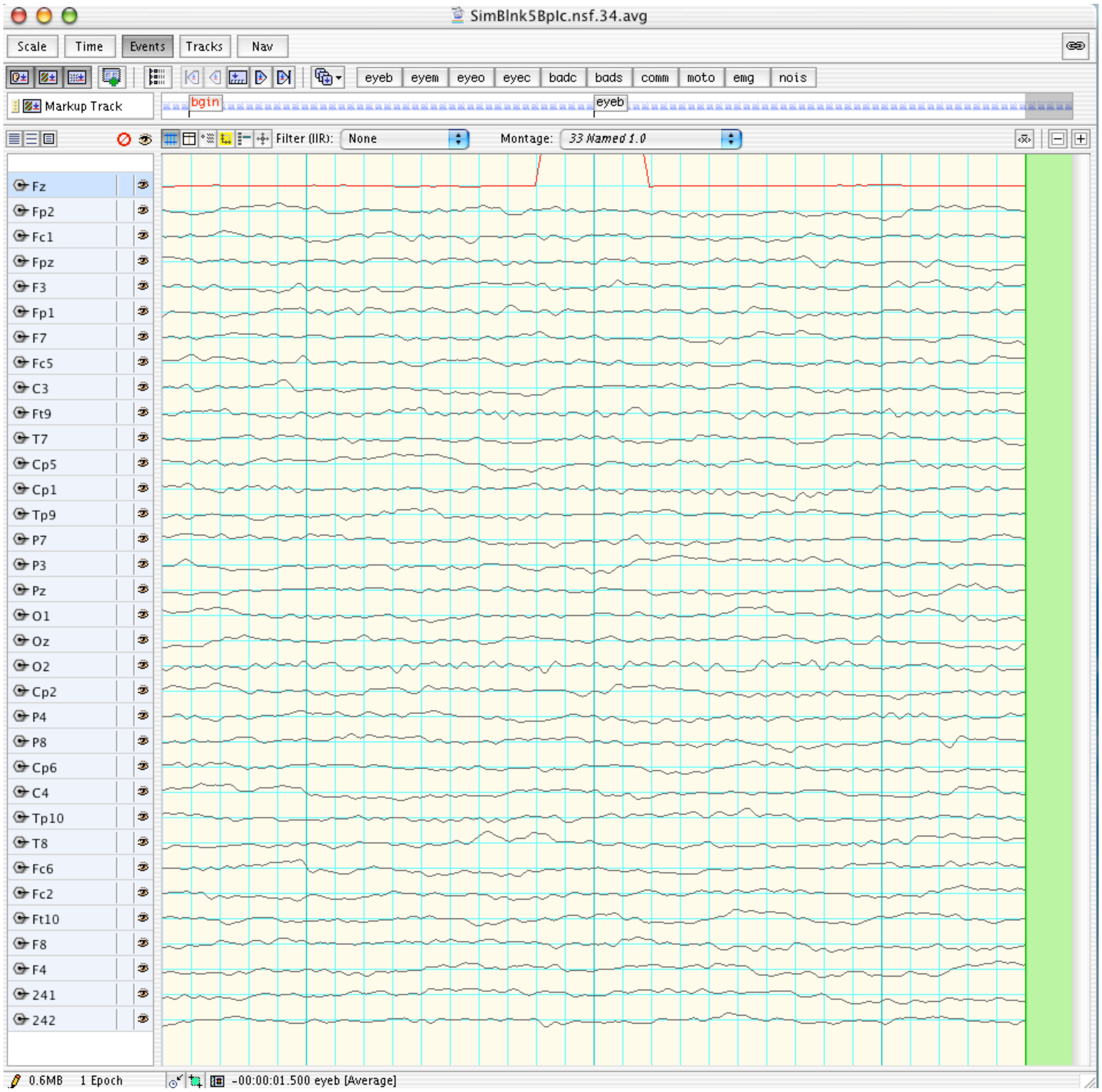


Figure 10. Indendent components for Dataset #5 (bandpass filtered), from Infomax run

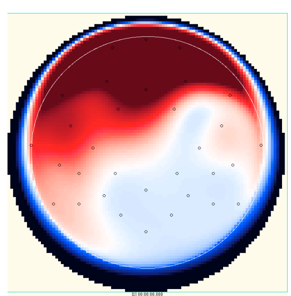

001 (1.000)

Figure 11. One (of 34) independent components met criteria in Infomax run (bandpass-filtered data)

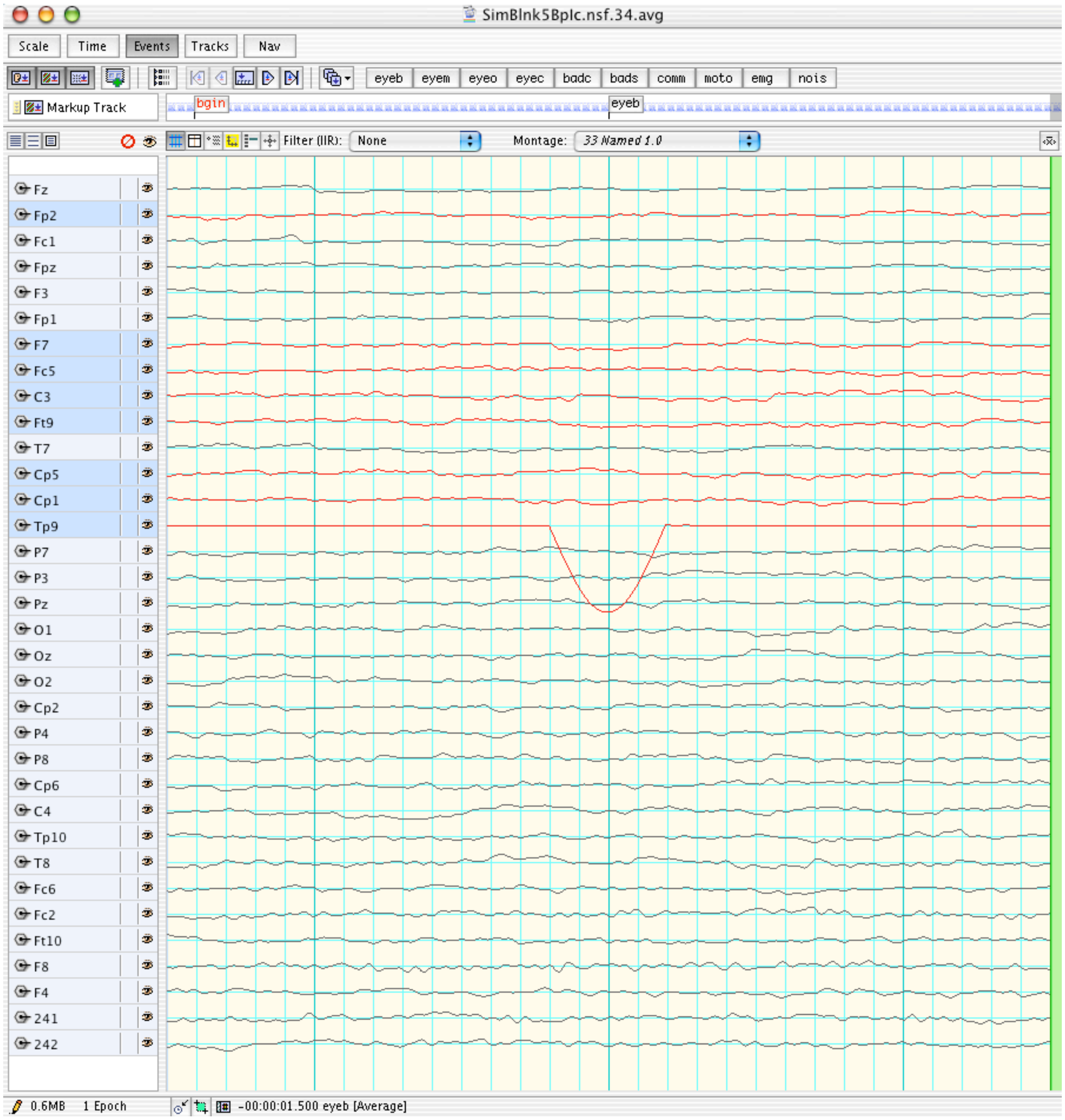


Figure 12. Indendent components for Dataset #5 (bandpass filtered), from FastICA run 1

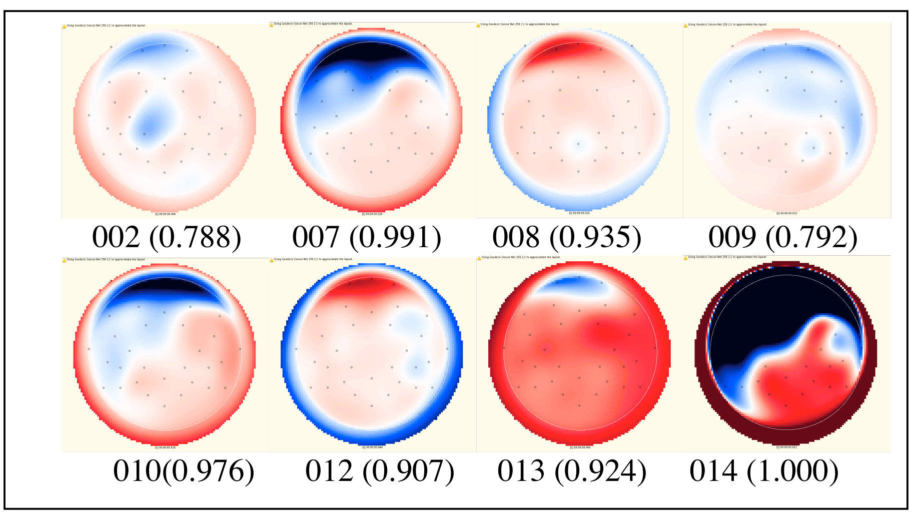


Figure 13. Eight (of 34) independent components met criteria in FastICA run 1

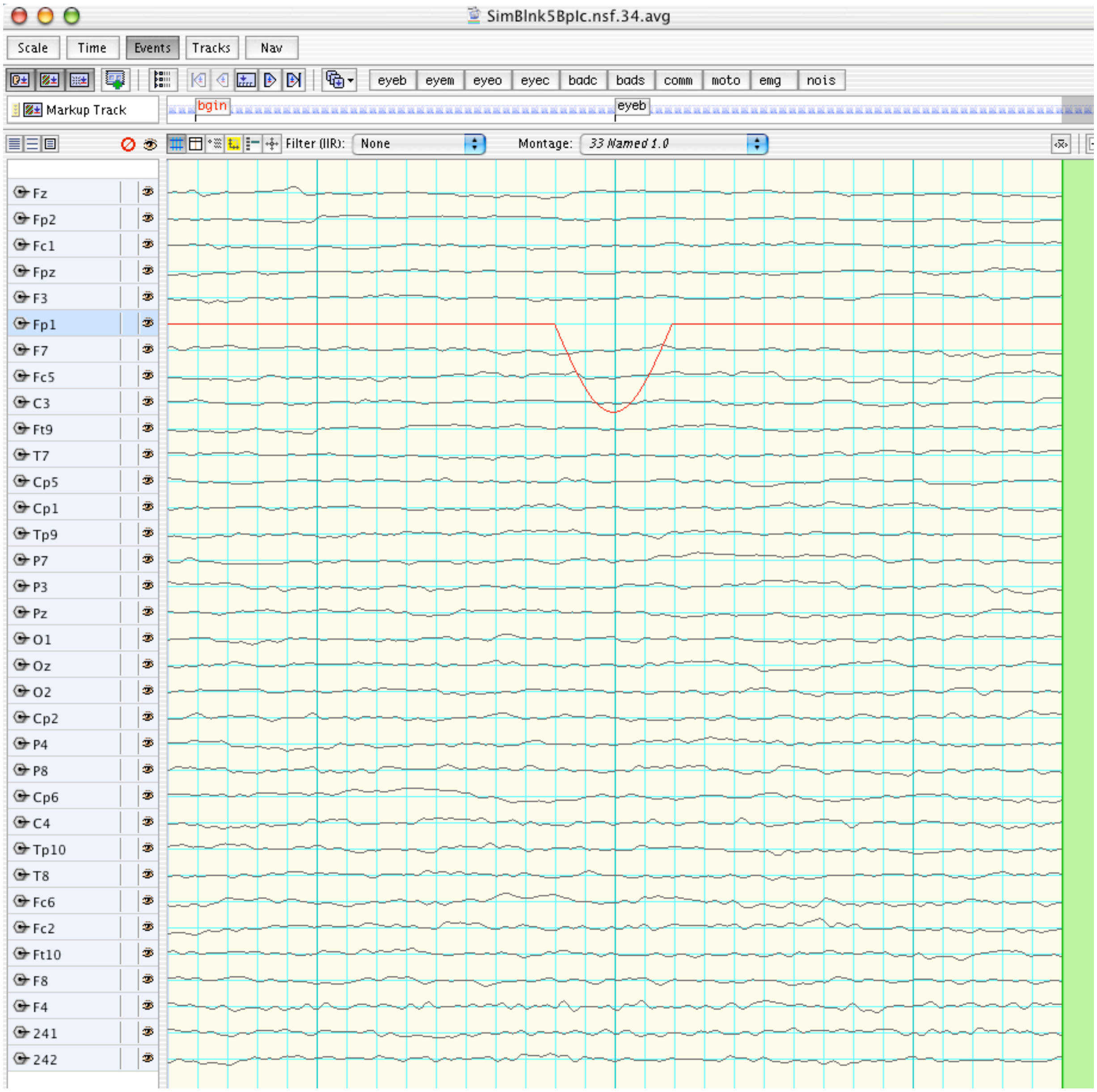


Figure 14. Indendent components for Dataset #5 (bandpass filtered), from FastICA run 2

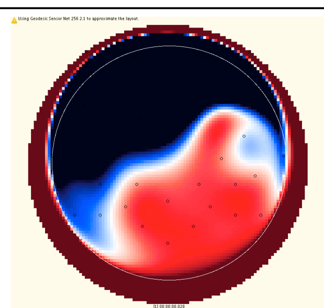

006 (1.000)

Figure 15. One (of 34) independent components met criteria in FastICA run 2

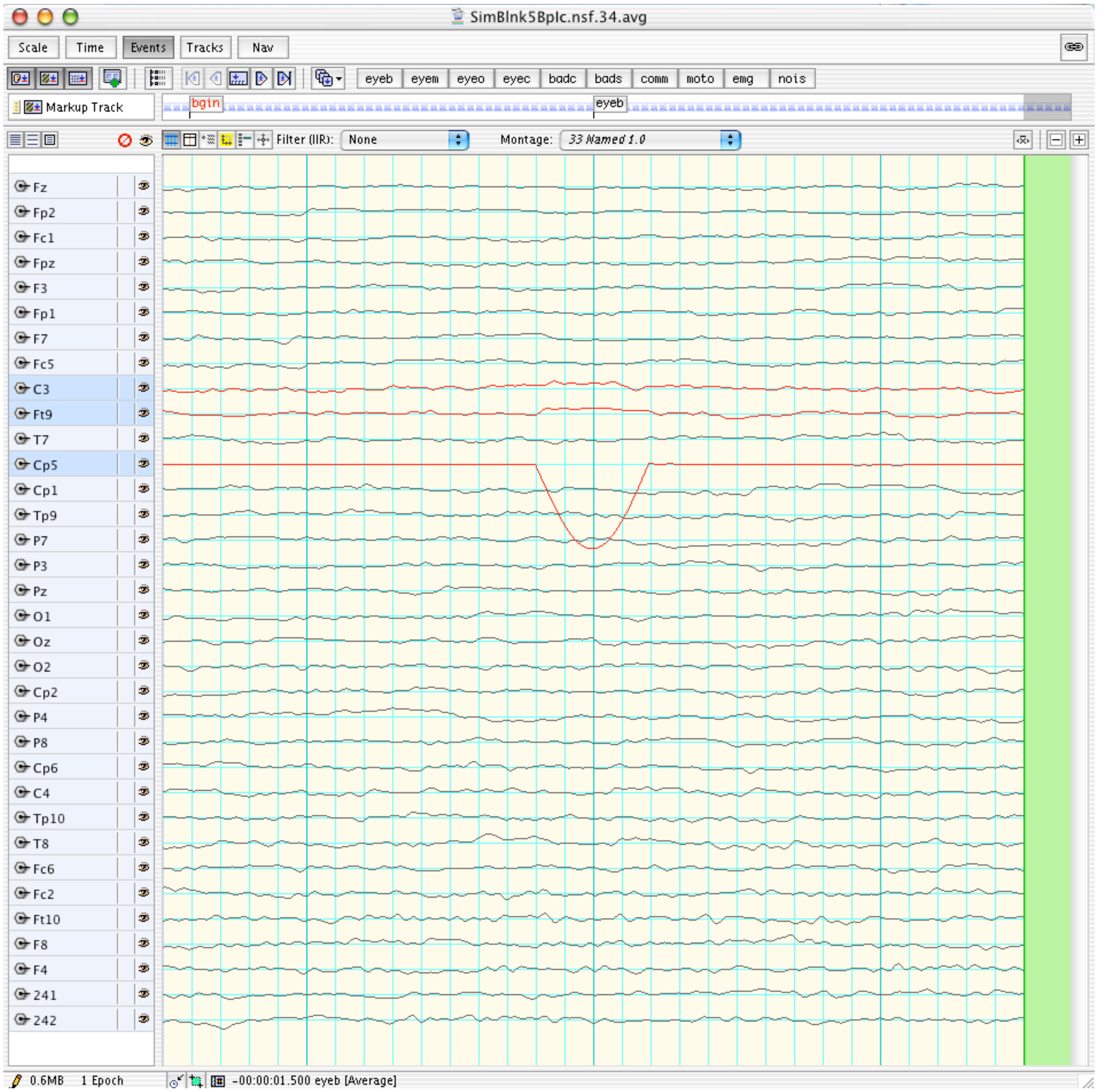
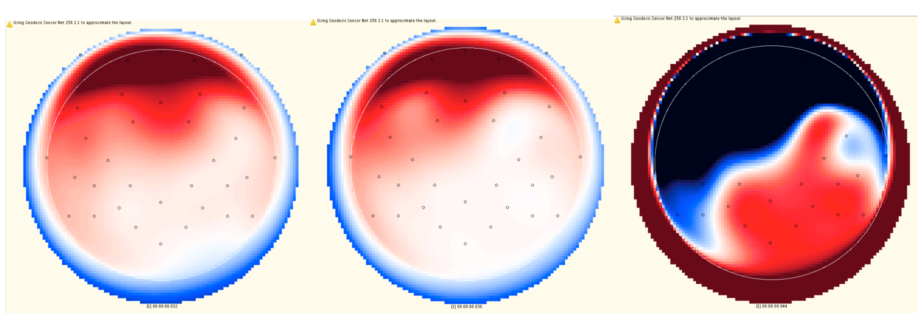


Figure 16. Indendent components for Dataset #5 (bandpass filtered), from FastICA run 3

Bandpass-filtered Data: Indendent components. 3 ICA Activation(s) met criteria # 2 (polarity inversion) AND Criteria # 3 (match blink template at threshold=.75):



009 (0.987) 010 (0.993) 012 (1.000)

Figure 17. One (of 34) independent components met criteria in FastICA run 2

Summary & Conclusions

We report the discovery of two blink-related ICA sources with different frequency characteristics (one is fast, the other slow). The slow component is eliminated when the data are bandpass filtered from .5 to 20hz prior to ICA. Two conclusions may be drawn from the present results. First, in analysis of latent components, spectral analysis can provide useful information to help identify and classify the components. For example, spectral analyses could identify components that are relatively fast (such as EKG spikes) or slow (such as skin potentials, or AC activity that is related to the recording time-constant).

Second, to achieve a successful ICA run, it is not sufficient to identify a component whose projection correlates perfectly with a pre-defined, spatial template. Even in this (ideal) case, it is still possible to have misallocation of variance among the activations, or independent components.