Automated Protocol for ERP Component Separation (APECS):
Effects of Spatial Sampling on Blink Removal using Independent Components Analysis

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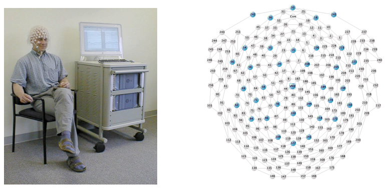
INTRODUCTION

- ❑ Electrical activity resulting from eye blinks is a major source of contamination in EEG.
- ❑ There are multiple methods for coping with ocular artifacts, including various ICA and BSS algorithms (Infomax, FastICA, SOBI, etc.).
- ❑ APECS stands for ***A**utomated **P**rotocol for **E**lectromagnetic **C**omponent **S**eparation*. Together with a set of metrics for evaluation of decomposition results, APECS provides a framework for comparing the success of different methods for removing ocular artifacts from EEG.
- ❑ Here we illustrate the use of APECS to evaluate effects of **Channel Density** and **Number of Samples** on the quality of blink removal, using the Infomax algorithm [3].

EEG DATA

EEG Acquisition & Data Preprocessing

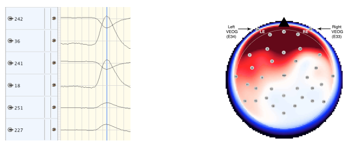
- 256 scalp sites; vertex reference (Geodesic Sensor Net).
- .01 Hz to 100 Hz analogue filter; 250 samples/sec.
- All trials with artifacts detected & eliminated.
- Digital 30 Hz bandpass filter applied offline.
- Data subsampled to create different channel densities & different #samples (see **Experiment Design**, upper right)



(A) (B)

Figure 1. (A) EGI system; (B) Layout for 256-channel array

ANATOMY OF A BLINK



(A) (B)

Figure 2. (A) Timecourse of a blink (1sec); (B) Topography of an average blink (red = positive; blue = negative)

APECS FRAMEWORK

❑ ICA decomposition of data & extraction of blinks

- ➢ **Infomax algorithm**
  - Trains the weights of a single layer forward feed network to maximize information transfer from input to output
  - Maximizes entropy of and mutual information between output channels to generate independent components
  - Implemented with default sigmoidal non-linearity and identity matrix seed

❑ Evaluation Metrics — cf. [2] for further details

- ➢ Quantitative Metrics
- ➢ Qualitative Metrics

CURRENT RESEARCH QUESTIONS

❑ What are the effects of channel density on the efficacy of ICA for extraction of blink activity?

- ➢ Evidence for blink splitting
- ➢ Evidence for "false positives"

❑ How are these effects revealed through the use of multiple metrics for evaluation of data decomposition?

- ➢ **SPATIAL**: Correlation of each independent component with blink template [1]
- ➢ **TEMPORAL**: Blink-locked activity, averaged over 2 second and 400 millisecond segments (BERPs)
- ➢ **STATISTICAL**: Mean negentropy for each run

EXPERIMENT DESIGN

❑ Variations in ***Channel Density***

- ➢ The original 256-channel data were downsampled:
  - 127 channel datasets
  - 69 channels datasets
  - 34 channels datasets
  - 22 channels datasets

❑ Variations in ***#Samples***/(#Channels)^2

- ➢ The full dataset (111k samples) was downsampled to examine effects of different ratios of #Samples/Channel Density

❑ Creation of ***Blink Template***

- ➢ Blink events manually marked in the raw EEG.
- ➢ Data segmented, timelocked to peak of blink.
- ➢ Blink segments averaged to create a blink template.

QUANTITATIVE METRICS

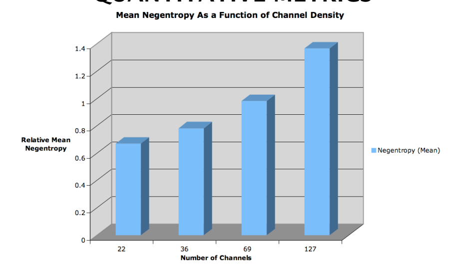


Figure 3. Mean negentropy for 111,000 dataset as a function of channel density.

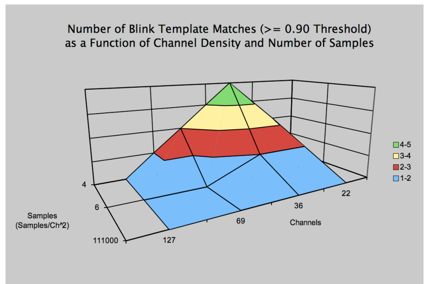


Figure 4. Number of template matches and BERP correlations as a function of channel density and number of samples/channel^2 density.

Primary Template *r*	Secondary Template *r*	BERP *r*
22 Channel Data		
Ratio of Sample / Channel ^{2} = 6		
0.999	0.904 (IC #11)	0.9552 (IC #07)
Ratio of Sample / Channel ^{2} = 8		
0.999	0.965 (IC #02)	0.9781 (IC #02)
36 Channel Data		
Ratio of Sample / Channel ^{2} = 6		
1.000	0.939 (IC #08)	0.8653 (IC #08)
Ratio of Sample / Channel ^{2} = 8		
1.000	0.930 (IC #16)	0.8229 (IC #16)
69 Channel Data		
Ratio of Sample / Channel ^{2} = 4		
0.999	0.912 (IC #27)	0.8326 (IC #62)

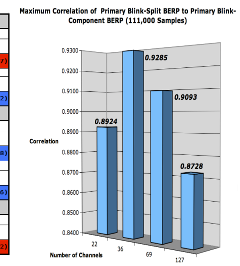


Figure 5. Relationships between number of template matches, BERP correlations and blink splitting as a function of channel density and number of samples/channel^2 density.

QUALITATIVE METRICS

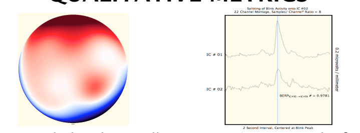


Figure 6. Blink splitting illustration: L) Topography for IC #02. Blink template correlation = 0.965. R) BERP for IC#02.

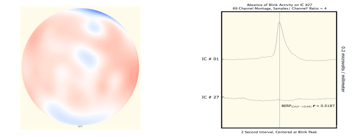


Figure 7. Illustration of how reliance on spatial metric can lead to false positives: L) Topography for IC #27. Blink template correlation = 0.912. R) BERP for IC#27.

CONCLUSIONS

❑ Multiple metrics provide both complementary & convergent information

- ➢ Convergence of metrics provides increased confidence in component classification
- ➢ Divergence of metrics provides additional information, to help avoid false positives. E.g., Correlations to blink template not always diagnostic (depends on channel density, #samples)

❑ ICA decomposition appears to be more reliable for dense-array datasets

- ➢ As channel density increases, there is less evidence of blink splitting
- ➢ As channel density increases, mean negentropy also increases, suggesting improved separation of linearly independent components.

REFERENCES

[1] Dien, J. (October 1, 2004). Dien ICA Toolbox. Lawrence, KA.

[2] Glass, K., G. Frishkoff, et al. (2004). A Framework for Evaluating ICA Methods of Artifact Removal from Multichannel EEG. Proceedings of ICA 2004 Conference, Grenada, Spain.

[3] Makeig, S., A. J. Bell, et al. (1996). "Independent Component Analysis of Electroencephalographic Data." Advances in Neural Information Processing Systems **8**: 145—151.

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