# Multivariate Sonification of Epileptic Rhythms for Real-time Applications

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Auditory displays present a new platform to represent complex data sets. They provide efficient information about data features, for example, when monitoring or interacting with multivariate time series [1]. The human auditory sense seems to be particularly optimized for the detection and interpretation of multiple rhythmic events in real time [2], which may be of practical importance in the context of the epileptic EEG.

We propose the multivariate event-based sonification of epileptic EEG. A simple decomposition of rhythmic activity is used to define events. Features of the time series are used to control sound parameters like level, duration and brightness in order to support multi-faceted perception of abnormal rhythms in single time series. In addition, features across time series are implemented. We present examples of sound files created from surface EEGs of patients with partial and generalized seizures.

Fig, 1 shows the waveform of a sound produced from transient rhythmic fronto-central focal activity in the alpha band. The focal activity is clearly separated as rhythmic bursts from the zero-level background in the audio-file. The spatial distribution and spatial correlations of this activity contribute to the creation of an "auditory object", an easy-to memorize perceptible gestalt [3].

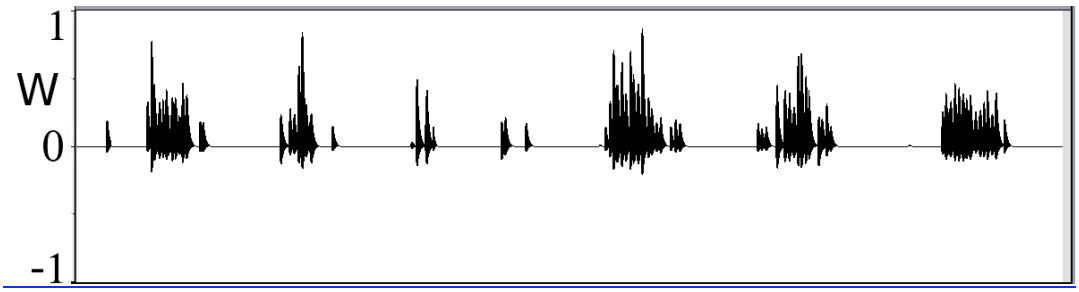


Fig. 1: Waveform of sound from interictal focal activity.

The method allows sensitive detection of temporal correlations within a signal (across frequency bands) and of spatio-temporal correlations between neighboring and distant sites on the scalp. We discuss efficient filtering of background activity and artifacts, and the demonstrate that in particular the features across time series facilitate the differentiation of epileptic from other rhythmic events. The method is applicable in real-time monitoring (as a complement to visual observation) and for EEG feedback tasks where screen observation is impractical or undesirable.

[1] W.T. Fitch, G. Kramer, in: G. Kramer (ed.), *Auditory Display – Sonification, Audification, and Auditory Interfaces*, Addison-Wesley, Reading 1994, p. 307.
[2] S. Handel, *Listening*, MIT Press, Cambridge, 1989, chapter 11.
[3] T.D. Griffiths, J.D. Warren, Nat. Rev. Neurosci. 5(11), Nov., 2004, p. 887.

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