Decomposing Electric Brain Potentials for Audification on a Matrix of Speakers

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Abstract: Audifications of electric brain potentials suffer from the fact that each scalp electrode records a mixture of signals from all neural generators plus muscle artifacts resulting in a opaque and noisy rendition. We apply a recently developed computational technique to separate source signals from the recorded mixtures. These sources are then edited individually and spatialized in a matrix of speakers. The result is a clearer and more transparent audification of electric brain activity.

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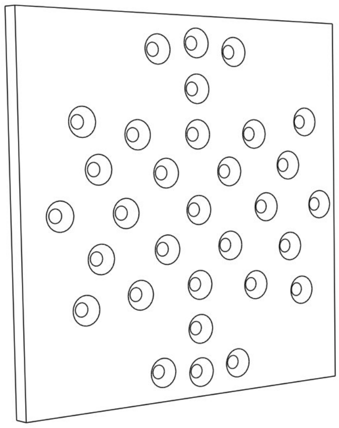
For at least a half century, musicians and sound designers have used audifications of electric brain potentials to perceptualize the functioning of the human brain (e.g., Lucier, 1965; Klein, 2001, 2004; Dean, White, Worall, 2004). However, presenting brain signals in a transparent and appealing manner has proven to be a challenge. One factor contributing to this is the volume conduction in neural tissue, cerebral spinal fluid, the skull, and skin: signals of the various neural generators are transmitted to all electrodes on the scalp such that each electrode records a mixture of all source signals. This poses various problems for audifications: Since the source signals are not separated, it is not possible to edit them individually and to spatialize them freely. The result is an obscured rendition of the signal in which potentially interesting components mask each other. Parameter mapping sonification circumvents this problem by extracting features from the raw signal that are used to control parameters of a sound generator. While this approach produces intriguing results (e.g., Monro, 2004; Potard, Schiemer, 2004; Rangel, 2012), it forgoes the authenticity and immediacy sought by audifications. The present work addresses this problem using a computational technique that has recently been introduced in neuroscience: independent component analysis (ICA) identifies source signals in mixtures heuristically by assuming certain statistical properties of the sources: minimal mutual information (Bell & Sejnowski, 1995) or non-Gaussianity (Hyvärinen & Oja, 2000). In previous work, ICA has successfully been used to separate muscle artifacts such as those generated by eye movements from brain signals (Jung et al., 2000). In the present work, we use ICA to separate source signals from the mixtures recorded at 30 scalp electrodes. The 30 sources obtained from this procedures are individually edited for clarity and presented using a multi-speaker audio system. The result is a transparent and revealing, yet faithful rendition of the recorded brain signals.

Methods and Materials

The EEG signals were acquired in a psycholinguistic experiment that studied human language processing (von der Malsburg et al., 2013). In each recording session, a participant read 360 sentences with varying grammatical structures. The signals were recorded in a shielded chamber at 30 scalp sites following an extension of the 10-20 electrode layout. The sampling rate was 512 Hz. The recording sessions lasted about an hour. BrainVision Analyzer 2 (Brain Products GmbH, Munich) was used to band-pass filter the raw data and to conduct independent component analysis. The source signals recovered by ICA were then further edited using the Soundhack software by Tom Erbe.

Sound projection

Our demo will be presented using a custom made 120cm x 120cm sound module on which 30 speakers are arranged in the layout of the electrodes on the scalp (see figure). Each source signal will be assigned to the position where it was most active. The spatial arrangement of the sources will therefore resemble their distribution during the experiment while preserving a clear separability of the signals. Audio samples can be found here: http://sinuous.de/soundpanel.html.



References

Bell, Anthony, and Terrence Sejnowski. "An Information-Maximization Approach to Blind Separation and Blind Deconvolution," *Neural Computation* 7, 1129–1159. 1995.

Hyvärinen, Aapo, and Erkki Oja. "Independent component analysis: Algorithms and applications," *Neural Networks* 13, 411–430. 2000.

Jung Tzyy-Ping, Scott Makeig, Colin Humphries, Te-Won Lee, Martin McKeown, Vicente Iragui, and Terrence Sejnowski. "Removing electroencephalographic artifacts by blind source separation," *Psycholphysiology* 37. 163–178. 2000.

von der Malsburg, Titus, Paul Metzner, Shravan Vasishth, and Frank Rösler. "Co-registration of eye movements and brain potentials as a tool for research on reading and language comprehension." In Johansson, R., editor, *Proceedings of the 17th European Conference on Eye Movements*, Lund, Sweden. 2013.