

Multichannel ABR

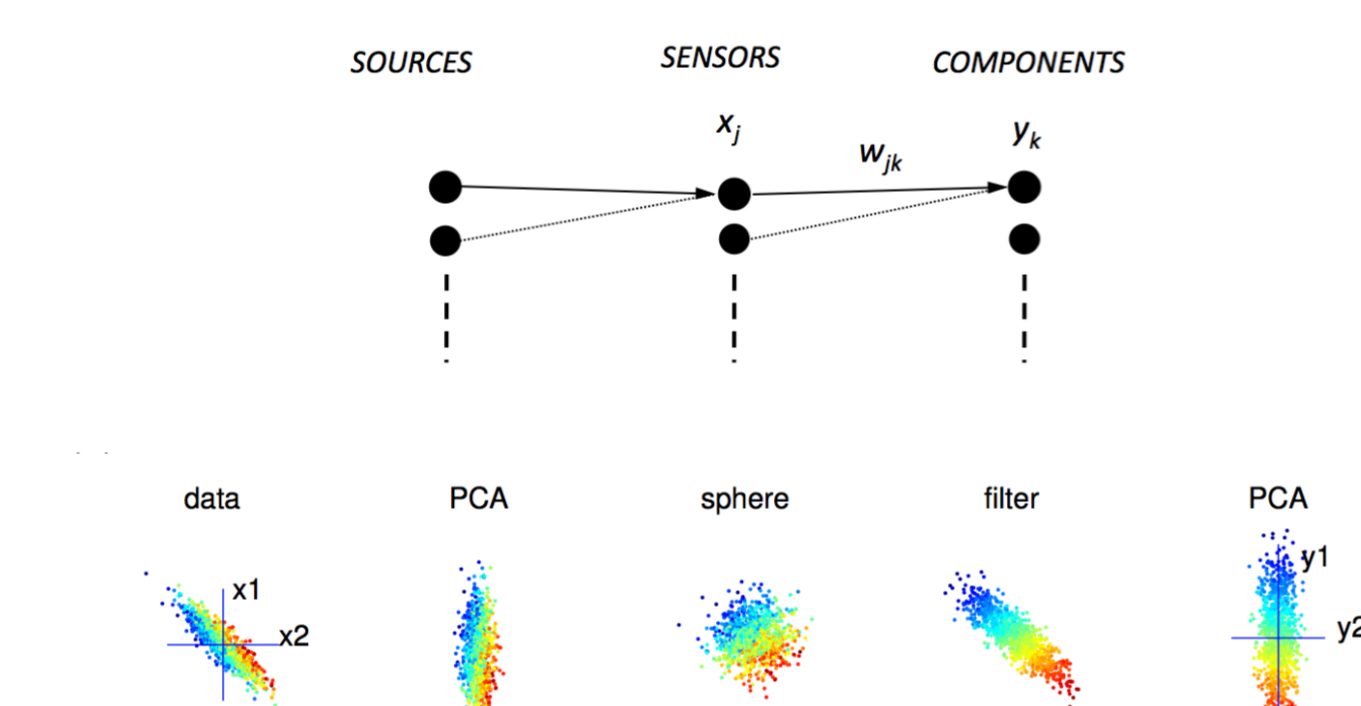
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MOTIVATION

The ABR (Auditory Brainstem Response) is widely used as a tool to assess the integrity of the first stages of the auditory system, clinically and in human and animal research. The measured signal is tiny relative to noise, and requires averaging over many trials. Furthermore, responses from different auditory processing sites are overlapped and are distinguishable only by their latency. Multichannel recording and analysis may overcome these limits.

THE DSS ALGORITHM

Denoising Source Separation (DSS) finds the optimal linear combination of sensor or electrode waveforms, specific to some criterion (Sarela & Valpola 2005; also known as Common Spatial Patterns, CSP; Koles et al 1990). Here, the criterion to be optimized is repeatability over trials (de Cheveigné & Simon 2007).



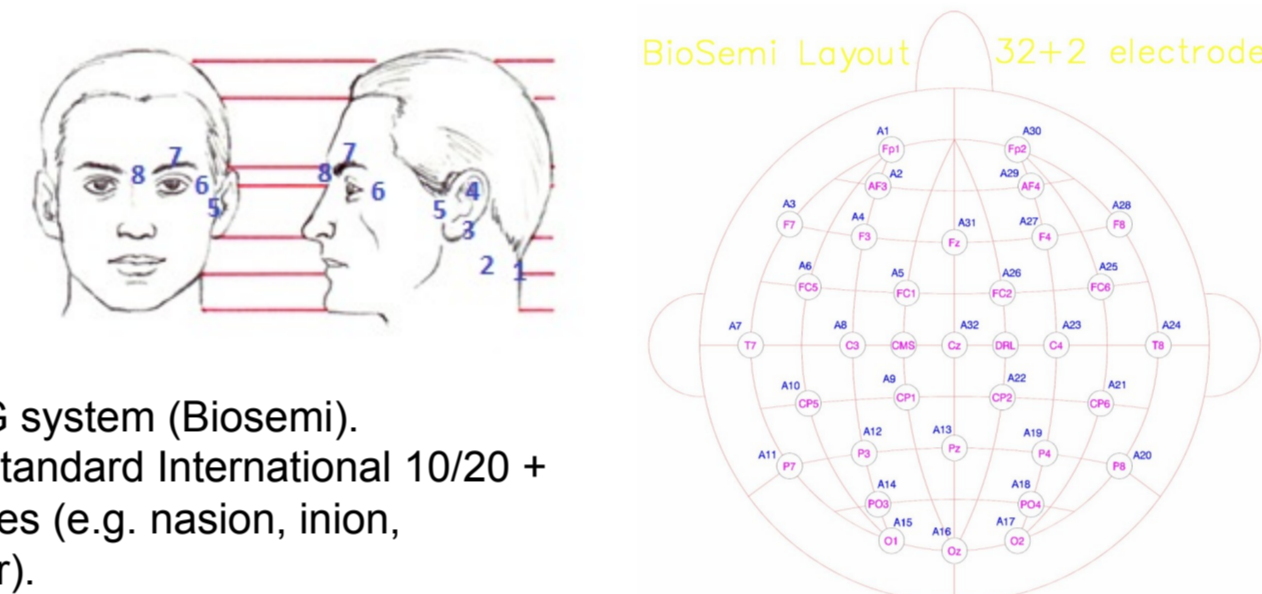
In Matlab:
 $c0 = x1 \cdot x1 + x2 \cdot x2$; $c1 = x1 \cdot x1$;
 $[V, D] = eig(c0, c1)$; $V = real(V)$; $D = real(D)$;
 $[~, idx] = sort(diag(D), 'descend')$; $V = V(:, idx)$;
 $z1 = x1 \cdot V$; $z2 = x2 \cdot V$;

- References:
- Sarela, J. Valpola H (2005). Denoising source separation. *Journal of Machine Learning Research* 6:233-272, 2005.
 - Koles, Z. J., Lazar, M. S. & Zhou, S. Z. Spatial patterns underlying population differences in the background EEG. *Brain topography* 2, 275-284 (1990).
 - Adachi, Y., Fujii, S., Kawabata, S., de Cheveigné, A. and Kato (2010). The detection of MEG signals from deep sources by a SQUID system for spinal cord evoked field. *Biomag*: 79-18.
 - de Cheveigné A, Simon JZ. (2008). Denoising based on spatial filtering. *J Neurosci Methods* 171: 331-339
 - de Cheveigné A (2010). Time-shift denoising source separation. *J. Neurosci. Methods*, 189:113-120.
 - de Cheveigné, A., Parra, LC (2013) A flexible method for multichannel data analysis, submitted.

METHODS

Recording:

32+8 channel EEG system (Biosemi). Electrode layout: standard International 10/20 + additional electrodes (e.g. nasion,inion, mastoid, pericardial).



Stimuli:

Clicks, alternating polarities, 2000 repeats, 70 dB nH, Sennheiser HD250 headphones, 11-25% ICI designed to avoid 1/50Hz (line noise), 1/10 Hz (alpha).

Analysis:

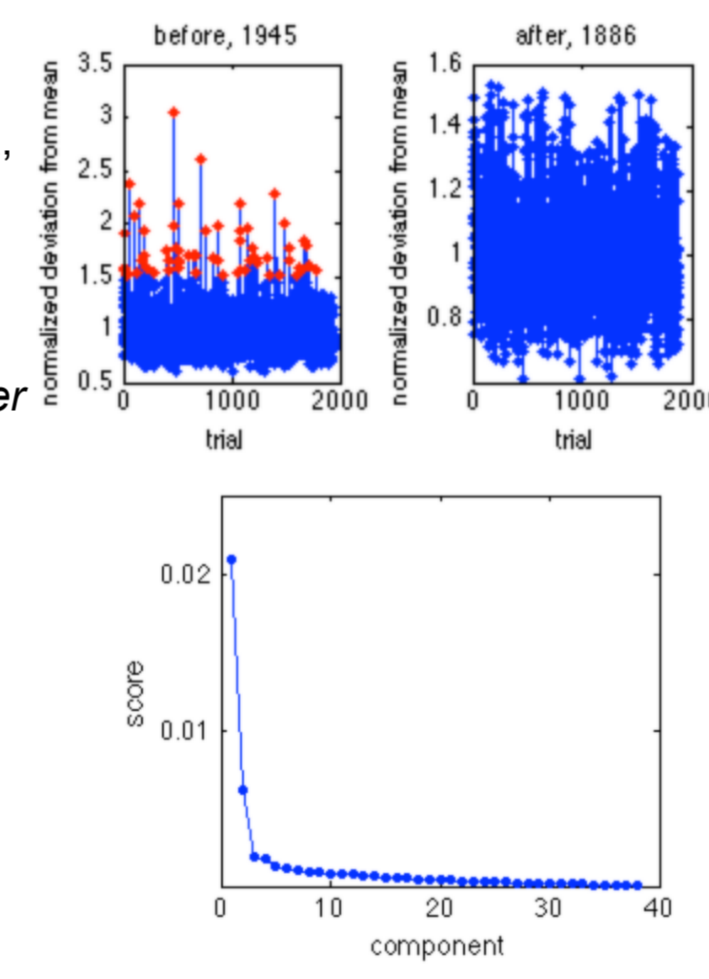
- (1) calculate $C0$ = covariance of raw data,
- (2) calculate $C1$ = covariance of trial-averaged data,
- (3) derive DSS matrix, apply to data,
- (4) select "best" component (s).

preprocessing:

- (1) remove mean over initial 300ms to avoid HP filter glitch,
- (2) HP filter: 50 Hz cutoff,
- (3) cut into epochs,
- (4) subtract stimulus artifact,
- (5) remove outlier trials based on eccentricity from mean,
- (6) remove mean.

electrode sensitivity analysis:

- (1) normalized cross-correlation with best DSS
- (2) leave-one out, measure best score

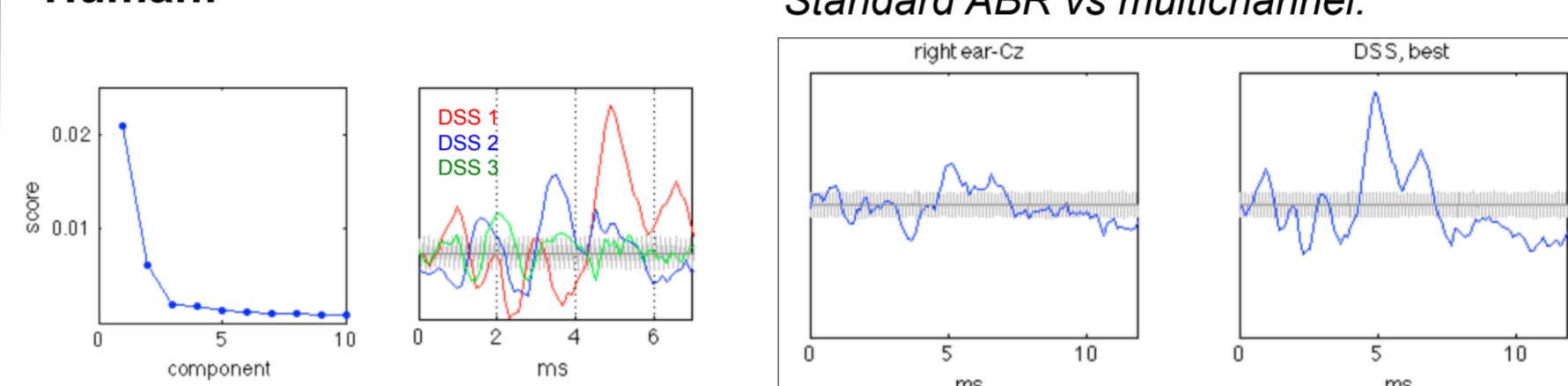


Acknowledgments

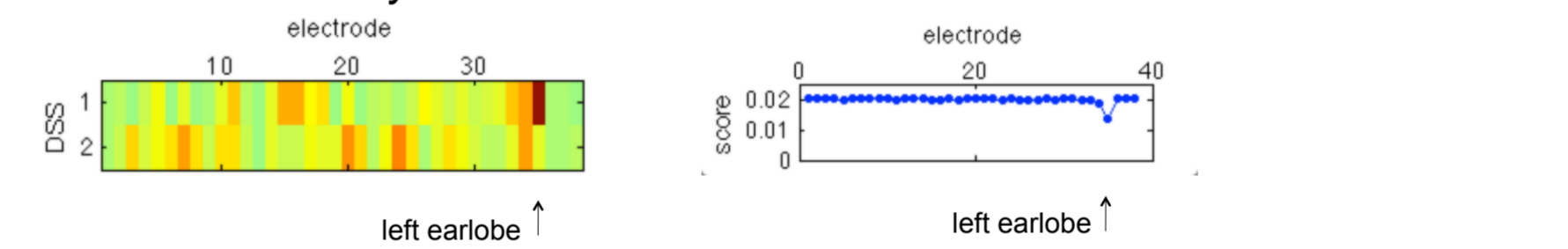
Dorothee Arzouman recorded the data. Tim Schoof and Stuart Rosen provided electrical ABR data, and Yoshiaki Adachi provided magnetic ABR data on which the algorithm was tested. Thanks also to Timan Sander-Thoemmes for collaboration on an early magnetic ABR experiment. Lucy Anderson provided mouse ABR data. Thanks to Jennifer Linden and Roland Schaeffe for discussions on animal ABR.

RESULTS

Human:

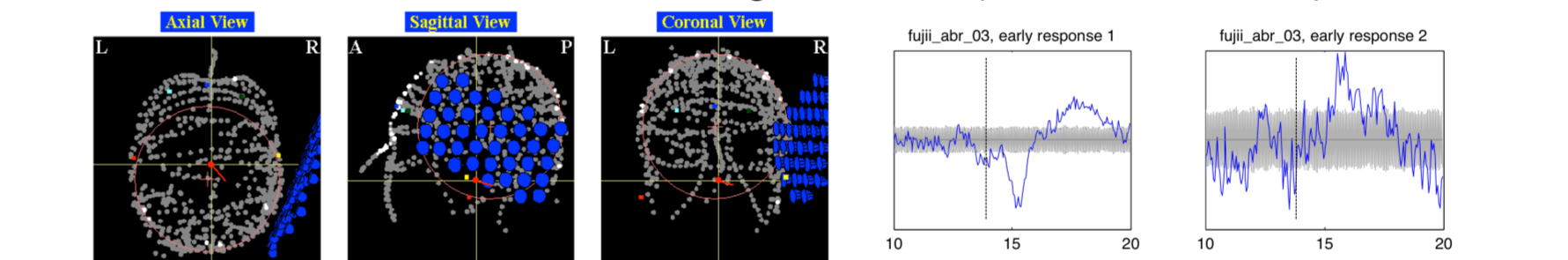


Electrode sensitivity:



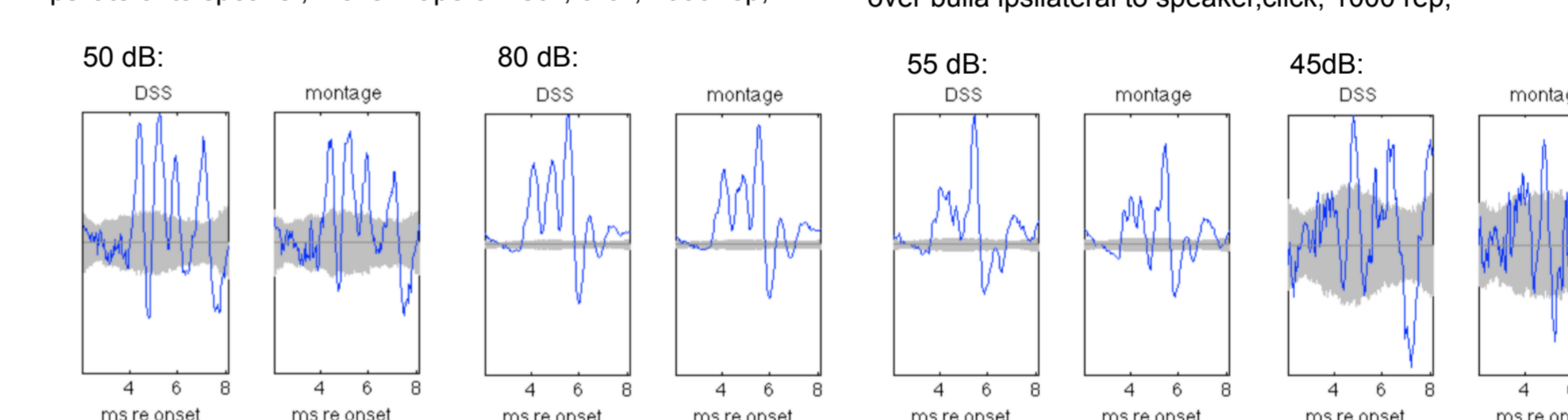
Human magnetic:

ABR measured with 120-channel magnetometer (Adachi et al 2010)



Mouse:

2 electrodes parallel to each other on midline, 1 over bulla (ipsilateral to speaker), 1 over nape of neck, click, 1000 rep.



CONCLUSIONS

Multichannel ABR can:
 - improve signal-to-noise ratio and reduce recording time,
 - potentially help separate responses from different sources in the brainstem.