Application of Parallel Factor Analysis to electrophysiological data

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INTRODUCTION
Synchronous firing of action potentials is believed to be one of the crucial mechanisms in the coding of information in the brain. Hence, the examination of the temporal structure of spike trains and the detection of patterns of synchronous firing events between the signals of multi-electrode recordings can provide fundamental insights into possible coding strategies.

We used PARAFAC analysis to investigate the effect of deactivation of the pMS cortex on the functional connectivity in area 18, based on cross-correlation. PARAFAC (Harshman & Lundy (1970) and Carroll & Chang (1970; there referred to as CANDECOMP) is a multi-dimensional decomposition method that generalizes the bilinear principal component analysis (PCA) to higher order arrays. The analysis is constrained to consider only certain interactions among the different dimensions, leading to simple mathematical models. At the same time, the obtained solution is unique - in contrast to PCA, where rotational freedom exists - allowing results to be rotated without reducing the quality of the modelling [2]. PARAFAC thus enables robust multi-dimensional analyses that allow a simple and clear interpretation.

The PARAFAC Model
For a three-way array, the PARAFAC model is given by three loading matrices A, B and C, with elements aij, bjk and cik. The number of components is denoted by F.

The trilinear model minimizes the sum of squares of the residuals eijk in

\[ e_{ijk} = \sum_{f=1}^{F} a_{ijf} b_{jkf} c_{ikf} \]

RESULTS
A Correlations
Stimulus conditions

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The PARAFAC loadings for one factor during bilateral deactivation.

C Spontaneous activity

Already during spontaneous activity, the deactivation effect could be observed.

D Split-half analysis to validate the model

Figure D shows an example of a split-half experiment, which was carried out to validate the model. The data was divided into two halves; every 2nd trial belonged to the same group. PARAFAC was then applied to both halves of the data. The results are very similar, confirming that the model is appropriate for our purpose.

CONCLUSION
Our approach demonstrates that feedback deactivation results in distinct changes of correlation patterns. The different PARAFAC factors (differently coloured lines in the loading plots) nicely differentiate the situations for the different stimulus conditions. Thus, our study shows that PARAFAC is a well-suited tool to decompose multi-dimensional patterns in electrophysiological data and assign them to different biological conditions.

References