# Cluster Analysis of fMRI Activation Pattern in a Visual and Auditory Naming Task

**M. Erb[1], B. Steven[2], S. Leins[1], and W. Grodd[1]**

[1]Department of Neuroradiology, University of Tuebingen, Tuebingen, Germany, [2]Department of Neurology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

## Introduction

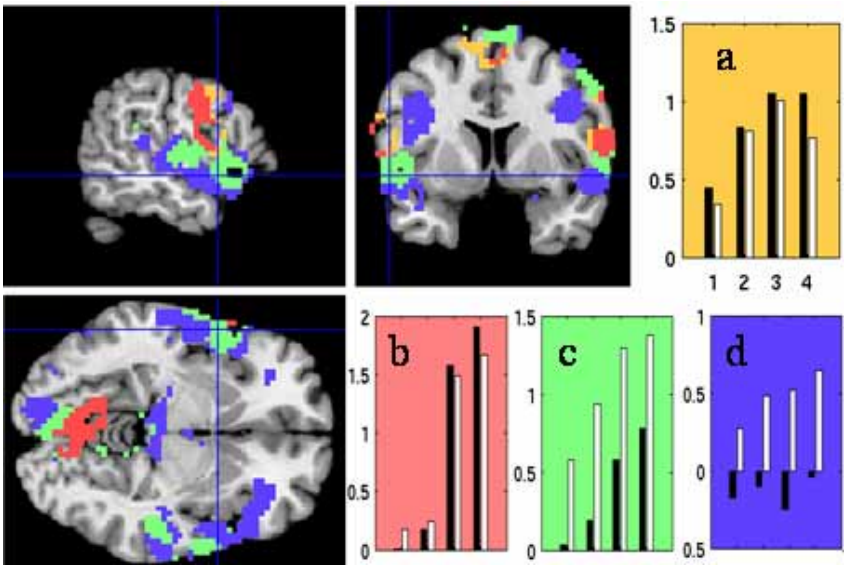
In fMRI, a typical design consists of several tasks, which are performed in different sessions in a blocked manner. For the analysis, a general linear model (GLM) is set up and parameters for the different effects are estimated. Locations with specific patterns of different activation are searched by defining appropriate contrasts for the GLM. With increasing number of different tasks, the number of possible contrasts can become very high. The idea is now to find interesting candidates for contrasts with K-Means cluster analysis (1) of the parameter estimates. In this study, the usefulness of this kind of analysis is demonstrated at the example of a visual and auditory naming task. Although the exact neural pathway for speech production is still a matter of debate it has been suggested that overt and covert speech involve different brain areas. On the other side, visual and auditory stimuli are processed in different primary streams which converge to a common speech path.

## Methods

In this study 12 right handed subjects (7 female) with a mean age of 25.3 years were examined on a 3T scanner (Siemens TimTrio).
They passive perceive or covertly or overtly (whispered and regular overt speech) named objects from their pictures or their characteristic sounds resulting in a 2x4 design with visual or auditory stimulus presentation and four levels of speech production (no, inner, whispered, overt). To avoid direct influence of artifacts caused by speech motion, we used a sparse sampling technique (TR 5s, TA 2.5s) together with block design. Each of the eight task conditions was measured in 71 scans with 7 baseline blocks (5 scans) of scrambled stimuli and 6 activation blocks (6 scans) of intact stimuli.

Data were analysed with SPM2 (Wellcome Department of Imaging Neuroscience, London, UK, http://www.fil.ion.ucl.ac.uk/spm) including realignment with unwarping, normalization to the MNI-template and smoothing with a Gaussian filter (8 mm FWHM). For each subject a general linear model (GLM) was estimated to yield beta values for each of the eight sessions. With this 8 dimensional vector (activation pattern) for each voxel, a cluster analysis was performed using the K-Means method, which requires setting the desired number of clusters K. For a first guess, we decided to use K=15 and Euclidian distance as metric. To reduce the number of voxels by considering only activated positions, a mask was generated from the second level group analysis ($t > 2.72$, $p < 0.01$ uncorrected). Cluster analysis with data from all subjects returned the 15 cluster centers together with the cluster indices for each voxel. With this information, a group volume was calculated by counting the (different) cluster indices over the subjects on each position and choosing the most frequent index. The counts of these cluster indices were stored in a second group volume as probability value. In the same way probability maps were generated for each cluster center to allow visualization of its spatial distribution.

## Results




Appling the functional mask, 25380 voxels were included to the cluster analysis with K=15 cluster centers. The spatial distribution of the individual centers is quite reliable as seen by inspecting the probability maps for each cluster center. The minimal number of matches is 2, the mean value 5.3 with a standard deviation of 1.9.

Consistent with findings from previous fMRI studies, BOLD responses of covertly and overtly produced speech and visual or auditory stimuli did not show the same network. We found very different activation patterns and show here four cluster centers as examples in the figure:
a) We identified several areas where covert and overt speech produced similar activation levels independent of the modality of stimulus presentation: Supplementary motor area, bilateral precentral gyri, left insula lobe, bilateral supramarginal gyri, left middle frontal lobe region, left inferior frontal lobe region and lateral cerebellum on both sides.
b) The BOLD response was greater during both types of overt speech, again for visual (black) and auditory (white) stimuli in: Bilateral primary motor cortex, right insula, left superior frontal gyrus, bilateral superior temporal gyri, bilateral putamen and thalamus, bilateral medial cerebellum, left middle cingulate gyrus, and bilateral calcarine gyri.
c) The activation pattern in the superior temporal gyri showed a gradual increase from covert over whispered to regular overt speech, with higher values for auditory presented stimuli.
d) The activation pattern in the lower part of the superior temporal gyri showed the same gradual increase from covert over whispered to regular overt speech, but only for auditory presented stimuli.

## Discussion

Cluster analysis seems to be helpful to sort the very different activation pattern to classes of response types. Even with the simple K-Means method, we got interesting results. Further efforts have to be done in applying more sophisticated algorithms to determine the adequate number of clusters, e.g. (2) and starting cluster centers. Another modification of the algorithm will be the application of other metrices to yield invariance for scaling effects..

## Acknowledgement

We thanks Cem Calli, Vinod Kumar and Mathias Röger for help with data acquisitions and data evaluation. This work was supported by the Deutsche Forschungsgemeinschaft (DFG) grant TH 812/1-1

## References

1 Seber, G.A.F., Multivariate Observations, Wiley, New York, 1984.
2 Baune A, Sommer FT, Erb M, Wildgruber D, Kardatzki B, Palm G, Grodd W. Dynamical cluster analysis of cortical fMRI activation. Neuroimage. 1999 (5):477-89.