fMRI-guided Spectroscopy for Evaluation of Speech-Related Brain Areas in Neuropsychiatry

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Introduction

Spectroscopic evaluation of the human brain in neuropsychiatric disorders suffers from 2 main problems: 1) Intrinsic field inhomogeneity in certain brain regions causes coverage of the whole brain by MRS to be very difficult, especially at short TE. Therefore, in order to obtain optimal results, the regions of final interest should be targeted by smaller MRS-volumes, each optimized individually. 2) In many neuropsychiatric disorders where the target of metabolic inquiry is defined by functionality, the ROI cannot be defined reliably from morphological MRI. Instead the targeted functional ROI must be defined by e.g. fMRI in a previous or preferably the same MR session [1,2]. Primary aim of the present study was therefore to develop a comprehensive fMRI-guided MRS protocol to cover specific functional areas of the brain within a single session and with optimized spectral quality for each targeted region. Aiming at the study of metabolic causes for auditory hallucinations, the main cortical areas of speech processing were selected, i.e. Broca's area with single voxel MRS, and bilateral Heschl's gyrus, and Wernicke's area with a single MRSI slice. These areas cannot be co-recorded in a single short-TE MRSI scan without compromise in data quality because of the frontal and often peripheral location of Broca's area.

Methods

This feasibility study was conducted in 6 subjects on a 3 Tesla MR scanner (Siemens TRIO). The whole study included 3D MRI (3D turbo-flash) for morphologic evaluation and brain segmentation, epi-based fMRI with a verbal fluency task, field homogeneity mapping, optimized short TE PRESS (TE 20 ms, TR 3 s, 16 step phase rotation, outer volume suppression, 128 scans, 14x14x14 mm^3) with acquisition of non-water-suppressed reference scans for eddy-correction and definition of CSF contamination, short TE PRESS MRSI (TE 30 ms, TR 1.7 s, 12 outer volume suppression slices, matrix 24x24 with circular k-space sampling, FOV 160 mm, thickness 15 mm, individually adjusted volume), as well as reference TSE-MRI's coplanar and orthogonal to the MRSI slice. Further MRI scans of 5-10 min can be recorded in the same session after the acquisition of fMRI data to make use of the time needed to prescribe the first single voxel spectrum. The manufacturer's fast automatic post processing for fMRI was used to define ROI coordinates. For MRSI, slice position, orientation and the PRESS-box size was defined by inclusion of three ROIs, i.e. left and right Heschl's gyri from morphological MRI and left sided Wernicke's area from fMRI. The manufacturers auto-align procedure was used to ensure consistency in scan prescription.

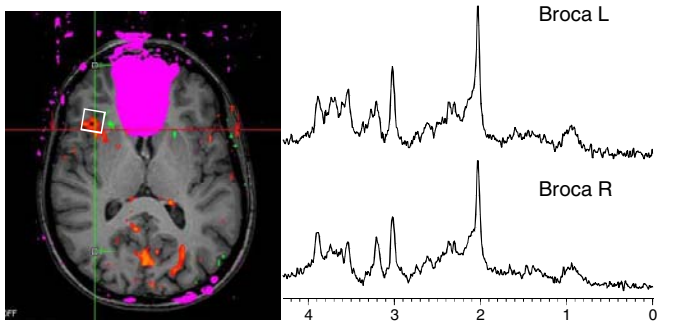

Fig. 1. Red: activated area in verbal fluency paradigm; purple: area of large field inhomogeneity; right: SV spectra scaled by parenchymal water signal

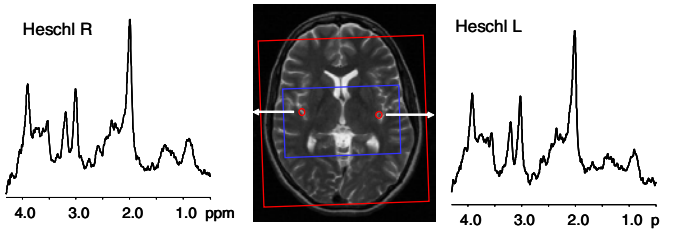

Fig. 2. MRI with position and size of MRSI PRESS-box indicated. Right and left: MRSI spectra from Heschl's gyri.

Results

The prescription and acquisition of structural MRI, fMRI, two single voxel spectra (frontal-lobe language-sensitive region [Broca] in the left hemisphere as well as the homologous area in the right hemisphere), and one MRSI scan could be completed in a single session of less than one hour. Spectral quality was good, even when Broca was located very peripherally. Typical SV spectra for one volunteer and the corresponding functional MRI data defining the placement of the ROI in the dominant, right hemisphere (left-handed subject) is illustrated in Fig. 1. The spectral data quality for the MRSI scan was found to depend on the possibility to restrict the localized (and optimized) ROI in its extension along anterior/posterior direction. Sample spectra from right and left Heschl's gyri are given for the same subject in Fig. 2.

Discussion & Conclusion

A comprehensive protocol for fMRI-guided MRS in neuropsychiatric disorders was established in a tolerable acquisition time of below 1 h. Acquisition of optimized short TE MRS data from the main speech-related brain regions is only possible in a single MR session, if MRS acquisition is divided into SV acquisitions for "difficult" brain regions and a MRSI scan for central locations, and if the placement of the ROIs is guided by fMRI data that can be obtained in the same session. The exact determination of functionally active areas, as well as individual optimization of spectral quality is fundamental (1) in order to avoid miss-localization and (2) to detect localized and potentially subtle metabolic changes.

References

1. Chen et al. *Magn Reson Med* 45**:**349 (2001); **2**. Urrila et al. *J Cereb Blood Flow Metab* 23**:**942 (2003)

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