SmartExam-aided functional MRI protocols

University of Bonn benefits from SmartExam for 3.0T fMRI of higher order motor regions

The accuracy of functional localizer tasks in individuals undergoing functional MRI (fMRI) studies depends upon a number of methodological issues. Using a SmartExam-aided slice orientation approach on the Achieva 3.0T whole body MRI scanner allowed the Bonn group to automate, standardize and accelerate its fMRI protocols.

Functional allocation to cortical and subcortical brain regions is a critical issue in pre- and post-operative assessment of patients undergoing neurosurgical interventions. Different functional localizer tasks have been implemented for allocation of eloquent language and motor areas in the human brain. Beyond task characteristics, patient compliance and other methodological factors, an accurate and reproducible volume selection and slice orientation is of critical importance for repeated (e.g. pre/post-operative) longitudinal fMRI tasks in patients.

SmartExam has been developed to optimize scan reproducibility using automated planning routines based on the detection of anatomical landmarks in the survey scan. To illustrate the benefits of this automated planning routine in fMRI work, the research group in Bonn will share some of its experiences with SmartExam-aided functional localizer tasks at 3.0T.

The work of the Bonn research group, led by Prof. H. Boecker, Head FE Functional Neuroimaging, department of Radiology, University of Bonn benefits from SmartExam for 3.0T fMRI of higher order motor regions.

Fig. 1.

Imaging protocol with SmartExam-aided automated volume selection and angulation parallel to the AC-PC line.
of Bonn, Germany, is dedicated to studies of motor control mechanisms in health and disease conditions.

“We are particularly interested in higher order motor regions like the supplementary motor area (SMA), where functional localizer tasks are currently explored in healthy volunteers and patients undergoing neurosurgical intervention in this territory,” says Prof. Boecker. “The SMA is located in the mesial part of the premotor cortex (PMC) and can be separated into two functionally distinct units, the pre-SMA and the SMA proper. The pre-SMA is located grossly anterior to the cortical projection of the anterior commissure (AC) and is involved in premotor planning and cognitive aspects of motor control; on the other hand, the SMA proper is located grossly posterior to the cortical projection of the AC and is more related to motor execution.”

The Bonn research group uses SmartExam routinely on its Achieva 3.0T in different scientific protocols to plan echo-planar imaging (EPI) scans parallel to the AC-PC line, which connects the anterior and posterior commissures. As shown in Fig. 1, SmartExam was used for automated volume selection and angulation parallel to the AC-PC line. The fMRI studies were performed on a Philips Achieva 3.0T system using an

Fig. 2. Comparison between manual planning and SmartExam.

Functional (EPI) scans in 10 separate scanning sessions of one subject. T1-weighted images used for planning were identical for both procedures (a and c; T1 TFE, TE/TR/Flip = 1.4 ms/3.127 ms/8°, spatial resolution 2.20 x 0.98 x 0.98 mm).
8-channel SENSE Head coil and a single-shot gradient echo EPI sequence \( (TE/TR/Flip = 35\, \text{ms}/2600\, \text{ms}/90^\circ) \), spatial resolution: \( 3.6 \times 3.6 \times 3.6 \, \text{mm} \).

“SmartExam works very efficiently and speeds up the whole routine,” says Prof. Boecker. “Indeed, due to the reproducibility of the procedure, fMRI protocols for clinical studies can be run in an automated manner, minimizing variance due to subtle differences in head position. This is, likewise, beneficial for scientific trials because standardization and reproducibility are of major importance.”

The Bonn team exemplified accuracy and reproducibility of SmartExam-aided planning in a series of fMRI sessions in a single subject. Sessions were separated by short breaks with the subject outside the scanner. Fig. 2 displays images from five sessions with manual planning and five using SmartExam-aided planning. In spite of a variable position of the head in the head coil (Fig. 2a), acceptable reproducibility between sessions was achieved after manual planning by an experienced user (Fig. 2b). SmartExam (Fig. 2c and d) speeded up the planning routine, while delivering highly reproducible slice orientations and locations (Fig. 2d). Differences (shifts and rotations relative to the x-, y- and z-axis) between EPI images of different sessions were in the range of a few millimeters or degrees (Fig. 3), exemplifying the high accuracy of the automated planning approach.

High reproducibility at the acquisition stage helps standardize and automate functional imaging protocols and subsequent data processing. In their recent work on premotor cortical function, the Bonn researchers robustly demonstrated segregated activation foci...
according to the functional subdivision of the SMA on single-subject analyses acquired with SmartExam-aided AC-PC alignment. This was possible by directly contrasting the planning phase prior to movement onset with the execution phase in volunteers trained to perform a four-digit finger sequence. As shown in Fig. 4, planning-related activity exceeds execution-related activity in the pre-SMA territory ($Y$ coordinate $\geq 0$) in 10 of 12 subjects.

“This is a highly consistent pattern of premotor activation in individual subjects,” says Prof. Boecker. “This approach may be valuable as a functional localizer task in pre-operative patients with lesions in the mesial premotor cortex. It is very likely that SmartExam-aided imaging will prove particularly beneficial in longitudinal patient studies without spatial normalization routines. These studies are on the way.”