fMRI Made Easy with an Integrated Siemens and NordicNeuroLab Solution

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BOLD fMRI is emerging as standard method of care for presurgical planning – mapping eloquent regions of the brain before brain surgery. What used to be a complicated setup available only to researchers is now available in the clinical radiology department. NordicNeuroLab provides a complete and easy-to-use fMRI solution – all necessary equipment for fMRI and nordicAktiva stimulus presentation software seamlessly integrated with the Siemens Numaris platform. This allows the user to run the paradigms directly from the Siemens Numaris interface, enhancing workflow for the MR technologist.

What is BOLD fMRI?

BOLD fMRI is the study of neuronal activity using MRI (Fig. 1). When a particular part of the brain becomes active as a response to a stimulus or task, there is increased flow of oxygen-rich blood into this region. Because of the difference in MR signal properties between the blood cells that carry oxygen compared to those that do not, this increase in blood supply can be detected using MRI. However, due to the level of sensitivity required to detect this signal difference, a specialized pulse sequence is needed on the MR scanner. This dynamic series measures the signal changes throughout the brain while a person is cued to perform a particular task. Task performance alternates with cycles of rest (20-30 seconds cycles), allowing a comparison of signal change in the brain due to the task. The description and timing of the cueing task are referred to as the fMRI paradigm.

Typical brain regions that can be mapped using fMRI are the motor cortex (finger tapping, toe movement, tongue movement), sensory regions (visual cortex, auditory cortex) and speech centers.

Why is fMRI important?

One goal of pre-operative surgical planning is to differentiate eloquent areas in the brain from pathology – those regions of the cortex in which injury produces cognitive or motor deficit – and to understand the relationship between eloquent cortex and pathology. The goal is to accurately delineate tissue pathology from surrounding eloquent cortex and vital connections between brain regions to aid in decision making that will maintain a balance between taking a more aggressive resection approach and reducing postoperative deficits. Furthermore, tumors and other pathologies can push brain activity regions out of their expected position, so mapping is critical to ensure maximum safe resection and for determining point of entry. This is of particular interest for determining language lateralization. Language representation can be investigated noninvasively using fMRI. This will reduce the risk of aphasia or other language deficits post surgery [1].

In addition to providing critical information in advance of the surgery, BOLD fMRI maps can be used within surgical navigation systems during brain surgery to guide intra-operative decision-making. The use of BOLD fMRI results preoperatively or intraoperatively has the potential to reduce neurological deficits by influencing the surgical approach, allowing for

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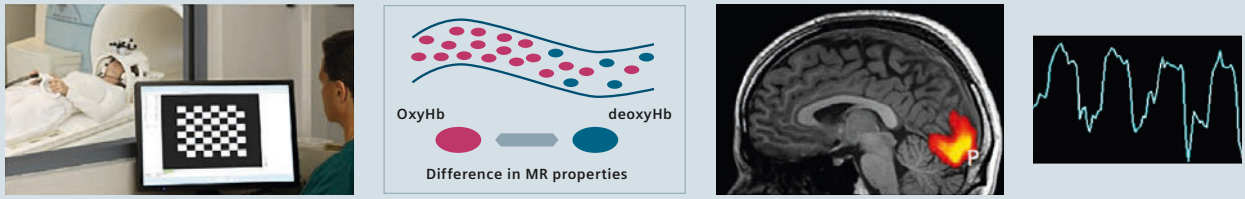


1 When a particular part of the brain becomes active, there will be an increased local blood flow. This can be detected using MRI, and will lead to an increased signal in the activated area.

more radical tumor resection while potentially reducing craniotomy size, reducing operating time and the need of awake surgery [1-4].

What equipment is needed for BOLD fMRI?

A high-quality fMRI study will require the patient to be cued to perform a particular cognitive or motor task while in the MR scanner. They can be presented with a visual stimulus (such as flickering checkerboard), be asked to read text (language study) or be cued to make finger movements using a response device. To present the stimuli, as well as inform the patient about whether they should perform a task or simply rest, a display needs to be available for the patient inside the MR bore. The patient can view the display via an MR compatible display attached to the head coil, NordicNeuroLab (NNL) VisualSystem, (Fig. 2A), or via a mirror mounted on top of the headcoil, which presents the image from an MR compatible monitor placed outside the MR scanner (NNL InroomViewingDevice, Fig. 2B). It is also possible to present stimuli to the patient via audio, using the NNL AudioSystem MR compatible headphones (Fig. 2A). These can also be used for patient communication. Patients can respond to language or motor tasks using the NNL ResponseGrip, which also provide a means of monitoring patient responses to various tasks (Fig. 2A).

All equipment used in the MR room must be MR compatible, that is, it must be able to operate safely in a strong magnetic field without causing distortions or artefacts in the MR image.

2 The NNL VisualSystem attached to the headcoil **(2A)**, or the NNL InroomViewingDevice **(2B)** are displaying the paradigm during fMRI. The NNL AudioSystem and ResponseGrip **(2A)** are used to provide audio stimuli and to collect patient response.

2A

2B

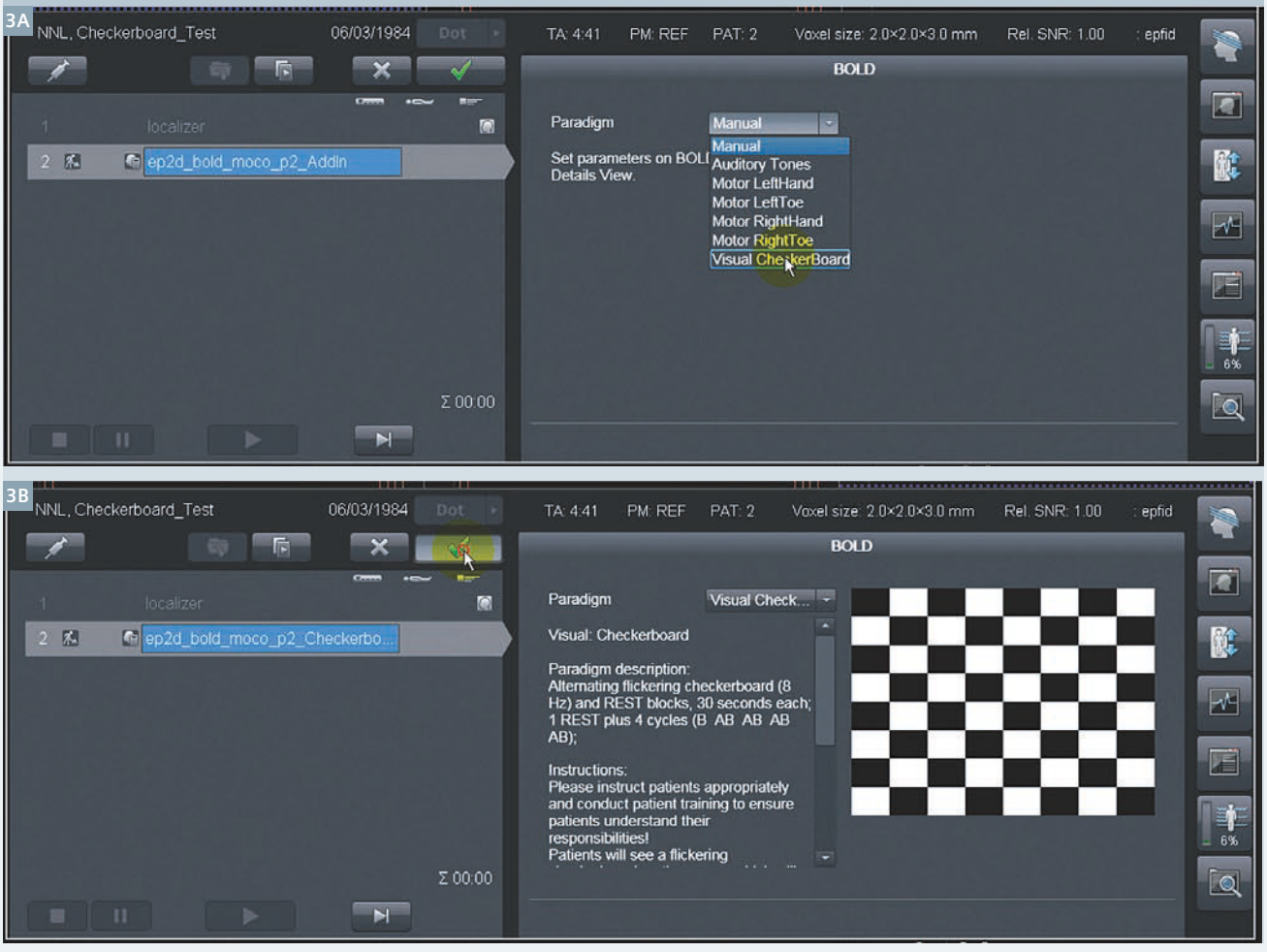
"We have been using the NNL fMRI equipment for about 10 years now in a clinical as well as a scientific setting. The efficiency using the products is very high, because of their easy usability and robustness.

We are very satisfied with our decision to use NNL equipment."

Professor Dr. Bernd Weber
Head of NeuroCognition, Imaging, Life&Brain Center, Bonn, Germany

The appropriate BOLD paradigm is presented using the nordicAktiva software, which contains a library of stimulus paradigms covering a wide range of cognitive, language and motor tasks. Enabling the BOLD Dot AddIn integration between the Siemens Numaris platform and nordicAktiva allows the paradigm to be selected and started from within the Numaris environment (Fig. 3). The MR acquisition must be synchronized with the timing of the paradigm, and this is taken care of by the NNL SyncBox which correlates the scanner's trigger pulse to the onset of the paradigm.

3 When enabling the BOLD Dot AddIn, the user can select the paradigm directly in Siemens Numaris **(3A)**. The lower image **(3B)** shows that a visual stimulation paradigm has been selected.



How to select the appropriate fMRI task?

The aim of presurgical fMRI is to map relevant regions surrounding pathology, so the type of paradigm to be done will be specific to the cortical region of interest (e.g. motor cortex). Tasks are selected that target the regions of interest and are possible for the patient to perform easily. The patient should be trained on each task to ensure that they completely understand the instructions and are able to perform the tasks well.

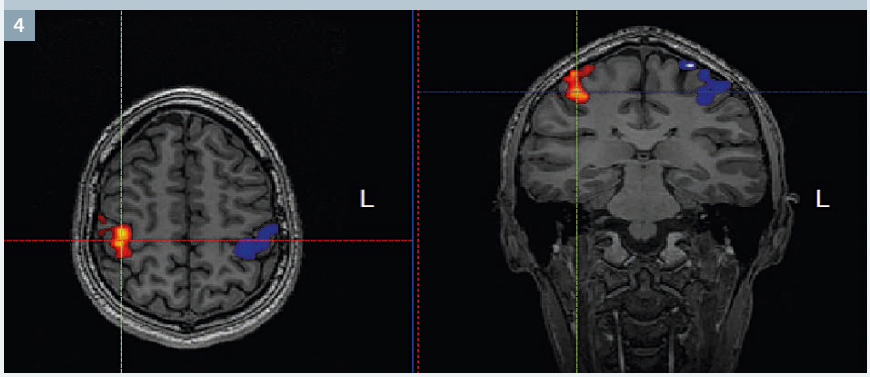
Task selection can be done directly from the Siemens Numaris workstation (Fig. 3). The paradigm will then be displayed visually on the device inside the MR scanner (NNL VisualSystem or NNL InroomViewingDevice), or aurally, via the headphones, depending on paradigm chosen. The NNL SyncBox will ensure that the paradigm presentation and MR image acquisition are synchronized precisely. A typical fMRI task alternates between a period of rest and activity (30 seconds, for approximately 4 cycles, about 5 minutes in total).

Once the fMRI session is complete, fMRI image data must be processed before the results can be sent to PACS or used for surgical planning (Fig. 4).

How to do fMRI:

1. Select paradigms based on location of pathology and functions to map.
2. Train patient to ensure they understand and can perform the tasks.
3. Select paradigm on Siemens Numaris.
4. Run the fMRI using the NNL fMRI equipment for displaying the paradigm to the patient.
5. After fMRI: send data to workstation dedicated for fMRI postprocessing.

4 BOLD fMRI results of left (red) and right (blue) finger tapping from a healthy volunteer.



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Different NNL packages may be available for different MR systems in the US. Please contact your local sales representative for details.