

# 31547 Medical MRI course: Practical exercise description

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This document describes the obligatory practical data acquisition exercise. The data and the subsequent DataBar analysis of these, form the basis for 2 short, obligatory written assignments as described on the course homepage. This text is aimed at both students and helpers at participating hospitals.

Read this document carefully ahead of the exercise – you don't have time to waste when you are doing measurements. Be sure to arrive timely as specified on the course home page. Be efficient and flexible. Grab the chance, if "the locals" are willing to show you more.

Check your understanding by answering the questions at the end of the exercise description. The group should consult with Lars before going to the hospital departments if there are outstanding issues.

## Format and general issues

Groups of approximately 4 students visit a hospital and conduct measurements under supervision by a local "guide" familiar with the measurement protocols and scanner handling. It is preferred that the students are the ones operating the scanner and conducting the experiments. The guide decides to which extent this is safe/possible.

At the time of the exercise, the students have only been introduced to basic MR and safety, not to the specific measurements performed, so they need support all through the exercise. Active participation of the guide is required for more than just supervising scanner use. It is needed for acquisition of useful data.

Visiting a hospital, the students are covered by the obligatory "secrecy" (*tavshedspligt*). Any information the participants may learn about patients or the medical state of fellow students has to be kept entirely confidential (also to other course participants). By participating in the exercise, you accept this and other conditions given in this document.

The students are offered to volunteer as "test subjects" for the exercise. Each team needs to bring at least one volunteer from their own or another team, so all experience operation of the scanner, and a few get scanned. There are, however, some important considerations you have to make before you go in the scanner room or volunteer. The second last page of this document is dedicated to those. You have to fill it out and sign it before you are allowed to be scanned. Also the local "screening form" (*kontrolskema*) must be filled out and signed before you are allowed to enter the scanner room or be scanned. It is entirely your own decision whether you are willing to go in the scanner room or to be scanned, and you can change your mind at any moment. If

nobody wants to be scanned, the exercise is just stopped, and teams may be re-shuffled for a rerun another day. On the other hand, it is entirely up to the local guide whether you are allowed to go into the scanner room or be scanned.

**If you don't bring a volunteer from another group, then please make sure in advance that at least one person within your group wants to volunteer (and appears suitable for it). If that is not the case, swap time with somebody else from the course who wants to, and let me know about it. Also let me know as soon as possible, if swapping may be a problem. There is typically time for change of scanned person (subject) once during the scanning.**

## Exercise content

The exercise has 2 parts: Structural imaging and spectroscopy. Not all directions given below will be meaningful to the students early in the course, so it is crucial that Lars is contacted by the local guide in advance, if the description is not clear. There is some flexibility in the protocols regarding parameters that are deemed less important. More measurements than those specified will likely be made, e.g. to make accurate positioning of the specified voxels. Such measurements are scanner specific and the choice is left to the local guides.

### Structural imaging

Whole brain imaging with high spatial resolution ( $\simeq 1\text{mm}$ ) in all directions is performed with the purpose of doing  $T_1$ - and PD-mapping by use of software developed in DataBar exercises.

A 3D, spoiled, gradient-echo sequence is used for the purpose (frequency encoding along the length direction of the body to avoid aliasing). The FLASH sequence covered in Lecture 2 and the corresponding DataBar exercise is used. One line of 3D k-space is traversed after each excitation. Excitations are performed with an interval TR of approximately 10 ms (i.e. short compared to that of the DataBar exercise). Avoid lipid-suppression, inversion, slab selection, or other techniques messing up the simple signal equation. Check that the sound is a fairly constant hum (only modulated by phase-encoding gradients).

Acquisitions are repeated with at least 3 tip angles, e.g.  $3^\circ$ ,  $10^\circ$ ,  $20^\circ$ . It is essential that the head does not move during or between the three measurements. The middle tip angle should be close to the Ernst angle for brain tissue at the appropriate field strength,  $\alpha_{\text{Ernst}} = \cos^{-1}(\exp(-\text{TR}/T_1))$ , so that one measurement gives little saturation, one gives medium saturation, and one gives fairly strong saturation of brain tissue). The images will be of varying quality (some will be noisy, but the middle tip angle, at least, should look pretty good).

Parallel imaging may be used to speed up the acquisition, but you shouldn't use less than approximately 4 minutes acquisition time per measurement to get sufficient SNR.

### Spectroscopy

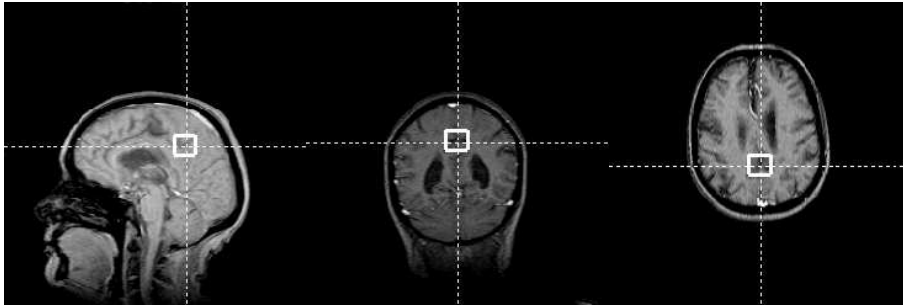
Single voxel spectroscopy is performed in gray brain matter (cortex) with the purpose of demonstrating acquisition and analysis.

Occipital or parietal cortex (gray matter in the back of the head) in the border region between the two hemispheres is chosen since it can be measured with little contamination from white

matter and subcutaneous lipids (stay well away from those). Also the field homogeneity (shim) in this region is normally good.

Use a PRESS-sequence. Voxel:  $(1.5 \text{ cm})^3$  for both positions. TR=3 seconds, TE=144 ms. Repeat and average water suppressed measurements for approximately 3 minutes to improve the SNR. **Also acquire a single non-suppressed water FID in the same voxel position.**

Please document the voxel position by screen shots or by another scanner-supported option. Check for subject motion by acquiring rapid, localizer images immediately before and after the acquisition.



Example of voxel position for gray matter spectroscopy with limited white matter contamination.

## Measurement checklist

Read through this immediately before and after each sub-exercise to check that you really got everything needed.

**Structural imaging** Acquire at least 3 high resolution 3D FLASH images (varying tip angle) covering the entire brain with no significant artifacts, e.g. aliasing inside brain.

**Spectroscopy** Perform localizer measurements immediately before and after spectroscopy to check for motion. Perform shimming (auto is fine, if available) and conduct water suppressed spectroscopy in cortex. Also acquire a single water reference FID in the same position. Document the voxel positioning, e.g. via screen dumps. Write down TE and TR.

No analysis of any data need to be performed on site. The data should preferably be given to the students in Dicom format on CD or USB (the simplest available raw data format for spectroscopy, please). A viewing tool on a CD can be of great help, so please include it, if possible.

## Screening, considerations and consent form

This page raises some issues that you need to consider before you go in the scanner room and before you volunteer as a test subject.

Remember: The magnet is **always** on. If you haven't been explicitly allowed to go in the scanner room by the local guide, you are not allowed to enter under any circumstances.

- If you only want to participate in parts of the exercise that take place outside the scanner room itself, you don't need to fill out any papers.
- If you only want to enter the scanner room (not be scanned), it is sufficient that you fill out and sign the local screening form, and get acceptance of entering after the local guide has checked it. Examples of screening forms for patients and personnel are on CampusNet. Ahead of the exercise, read the short instructions on the personnel form describing precautions to take.
- If you also want to volunteer for a scan, you need to do the above, and think carefully as described below. Also you need to fill out and sign this page.

Considerations you must make before volunteering for being scanned:

- Occasionally, abnormalities are found when scanning normal volunteers. Some of them may be good to know of. For others, you may not be any better off knowing. If something with a potential consequence is seen, you will be told about it (you can't volunteer, and say that you don't want to be told).
- The sequences used for the exercise are not the most sensitive for typical pathologies. Hence, even severe pathology may easily be overlooked. A scan can by no means be thought of as a health check.
- The department doing the scanning is responsible for making sure that you are appropriately referred for further examination, if something unusual requiring action is found. For this, they may need contact information for your own General Practitioner (GP, "praktiserende læge"). Hence you need to specify that in advance below.
- Remember that your fellow students will likely be the first to know, if something abnormal is found (they are covered by the obligatory secrecy, however, "tavshedspligt").
- Remember that even potentially insignificant findings can influence your future options, e.g. whether you can get a life insurance.
- If you have implants or piercings it may be a bad idea to volunteer. Read the screening form in advance, so you know what you will be asked. Mention any such things to the local guide, if you want to be scanned.
- Dress appropriately in advance (avoid metal in bra, for example).
- If you know of some abnormality in advance that may be seen, it is very important that you tell about it before the scanning. It can be shocking for the outside group otherwise.

**If you wish to volunteer for being scanned, write contact information for own GP below, your name and CPR, and sign to confirm that you understand and agree to the conditions mentioned here. Hand the sheet to the local guide only:**

## Check your understanding

Using e.g. the text above, consider the following questions to improve the outcome of the exercise. Your reports rely on your understanding. Do not hand the answers in, but you may want to discuss them with your colleagues.

- How long in advance do you need to arrive at the department? (check course homepage – it depends on the department you visit)
- Which parameters do you need to record during the three measurements? Prepare a sheet in advance to fill out during the exercise.
- How is the FLASH sequence constructed? Which parameters affect image contrast? What is the meaning of *the Ernst angle*, and what are the values of it for gray matter, white matter and cerebrospinal fluid (CSF) at 3T field strength and TR=10 ms?
- What are “FIDs” acquired in the spectroscopy exercise?
- What are the purposes of the two report assignments for which you acquire data as described above?