MRI Wiki

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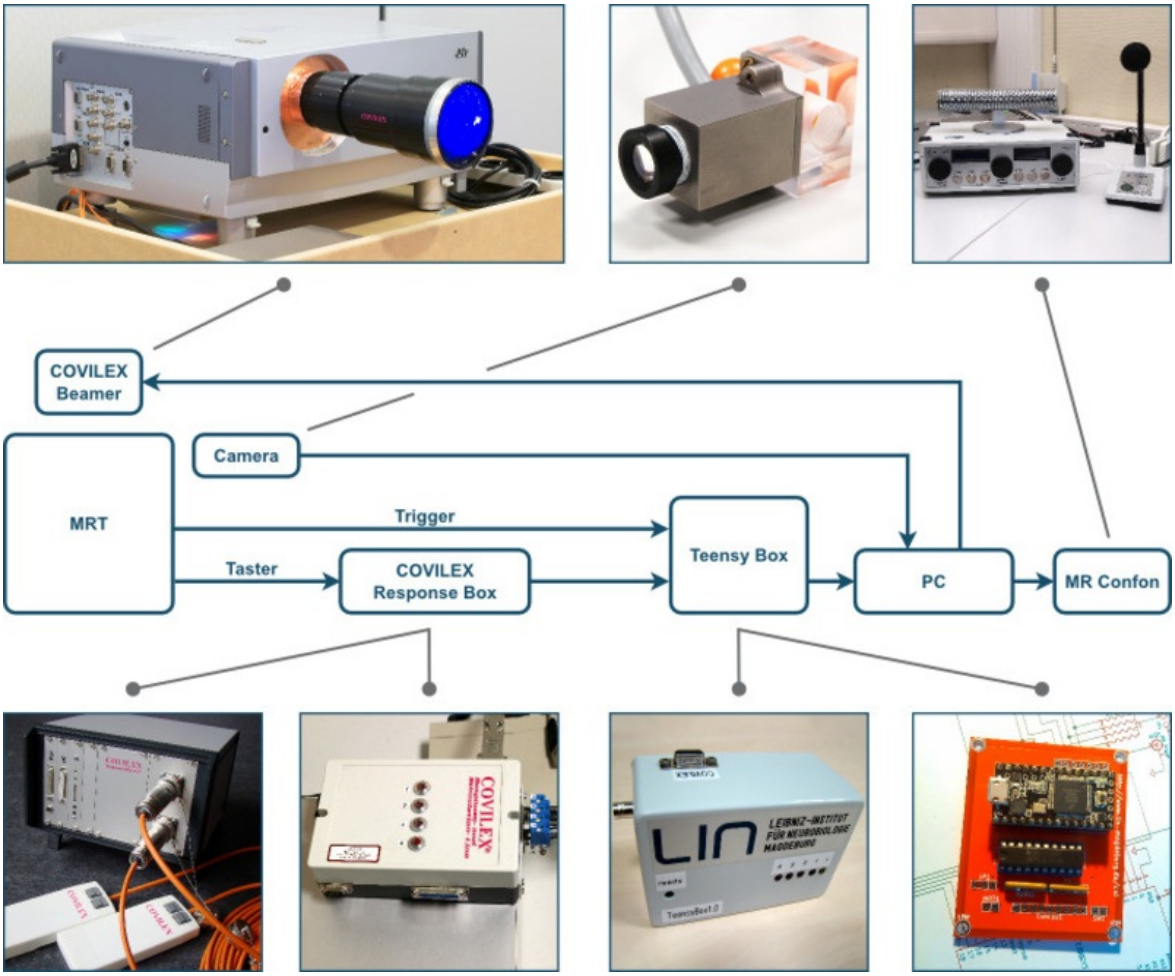
Table of Contents

Our wiki features detailed information and photos of the technical equipment at our 3T and 7T magnetic resonance scanners to support design and setup of experiments.

Each section contains information for both scanners, answering relevant technical questions before an experiment about available coils, auditory and visual stimulation, subject response, physiological measurements and in-house developments separate sections. Additionally, it shows the inter-connection of the devices at the scanners clearly in a schematic figure.

Overview

The figure below shows our MRI setup schematically, how the devices are inter-connected and the direction of data flow. In addition, the figure serves as table of content for the MRI wiki section.



Stimulation PCs

7T Magnetom

Operating system	Microsoft Windows 7 (64bit) / Ubuntu Linux 18.04
CPU	Intel Core i7 4x4.0GHz
RAM	16 GB
Sound card	Creative X-Fi Titanium HD
Graphics card	NVIDIA GeForce GTX770 2GB VRAM
Optical drive	DVD+-RW drive

Software	• MATLAB R2007b with tool boxes:
	  ◦ Simulink, Bioinformatics Toolbox
	  ◦ Image Processing Toolbox
	  ◦ Neural Network Toolbox
	  ◦ Signal Processing Toolbox
	  ◦ Statistics Toolbox
	  ◦ Symbolic Math Toolbox
	  ◦ Virtual Reality Toolbox
	• Presentation Version 16.3 & 18.1

	• Psychtoolbox 3.0.12 • Libre Office Portable 4.1 • Foxit Reader Portable 6.2
Interfaces	• USB 3.0 • 1x Parallel • 1x Seriell • 1x DVI • 1x VGA • PS/2
External devices	TerraTec Aureon 7.1 USB sound card for additional stimulus presentation PCs

3T Achieva dStream

Operating system	Microsoft Windows 7 (64bit) / Debian GNU/Linux 8
CPU	Intel Xeon E5-1630 4x3.7GHz
RAM	32 GB
Sound card	onboard
Graphics card	NVIDIA Quadro M4000 8 GB
Optical drive	DVD+-RW drive

Software	• Window 7
	  ◦ Presentation Version 16.3
	  ◦ Libre Office Portable 4.2
	  ◦ Foxit Reader Portable 6.2
	  ◦ VLC 2.1
	• Debian 8
	  ◦ PsychoPy 2
	  ◦ Psychtoolbox

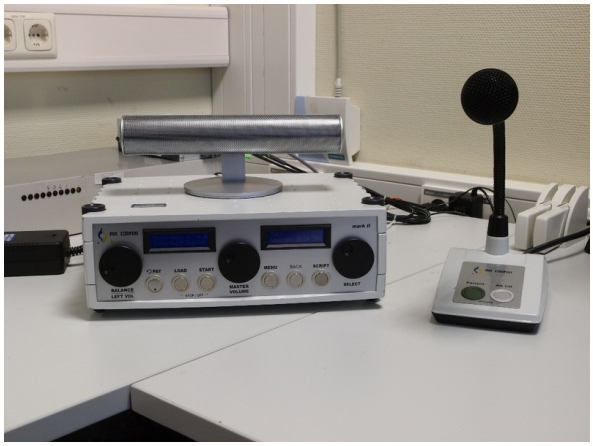
Interfaces	• USB 3.0 • 1x HDMI • PS/2

Auditory Stimulation

7T Magnetom & 3T Achieva dStream

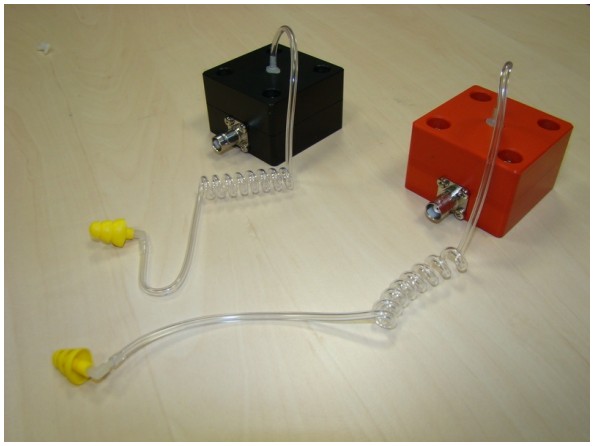
MARK2+

The audio presentation system with MR compatible headphones unites brilliant sound quality and excellent passive damping for reducing noise pollution during MR measurement. Optical S/PDIF input.



7T only

Additional voice recording of subjects is possible through a dual channel microphone (recording happends on PC / Laptop with special Software). For for use in narrow coils we provide our in-house developed small in-ear headphones, which propagate sound through a flexible air tube.



Visual Stimulation

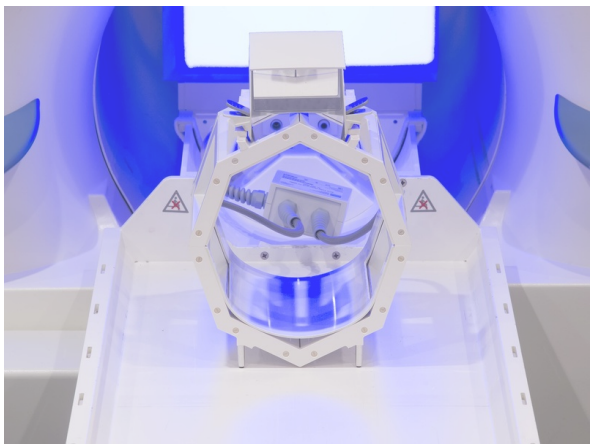
7T Magnetom

Mirror and Screen

The mirror is an IR-reflecting first surface mirror.

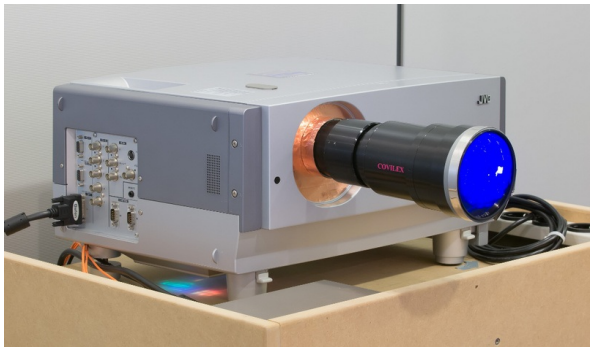
Table 1. New projector JVC DLR-RS49E

Resolution	1920x1080 FullHD in 16:9 aspect ratio
Distance eye-screen	100cm
Visual stimulus size	horizontal: 229mm; vertical: 129mm; restricted binocular view
Distance screen – projector	627cm
Screen orientation	dull side facing subject
Filter	reduces luminance to about 400 cd/m²



The projector is controlled through a HDMI extender system (Gefen EXT-DVI-1500HD-CO). This extender systen receives the PC's graphics signal (HDMI) via a HDMI dual link video splitter. The projector is used for image projection on a projection wall, which is mounted to the ending of the bed. The projector can also be used with a 4:3 aspect ratio. Simply connect the old screen and the projector will automatically switch to 4:3.

- Extendersystem: Fibre Optic HDMI Extender
- HDMI-Video-Splitter: Lindy 38158 HDMI/DVI Video Splitter



3T Achieva dStream

Mirror and Screen

The mirror is an IR-reflecting first surface mirror.

Table 2. Screen parameters

Distance eye-screen	60cm
Visual stimulus size	horizontal: 25.6°; vertical: 20.5°; full binocular view
Screen orientation	glossy side facing subject

Projector JVC DLA RS66E

The device is operated using resolution of 1280x1024 pixels in 5:4 aspect ratio (native 3840x2160 pixels full resolution). We use a gray filter of 13.7% transmission (http://www.hahnelicht.de/graufilter_neutral.html 0.9ND Nr. 211) to reduce light intensity.

Glasses

Glasses are available thanks to special production of an MRI-compatible spectacle frame for corrective lenses (-6 to +6 diopters in 0.5 increments).

Response

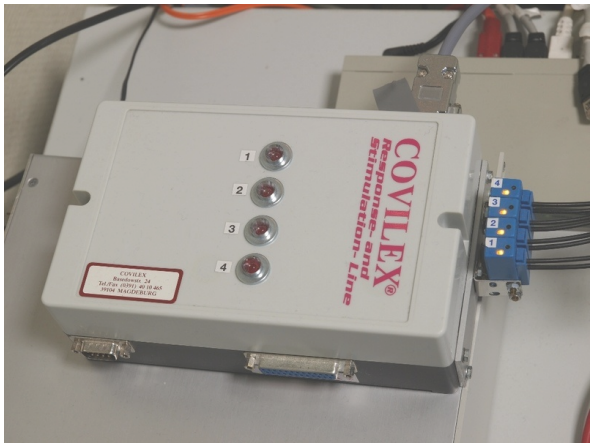
7T Magnetom

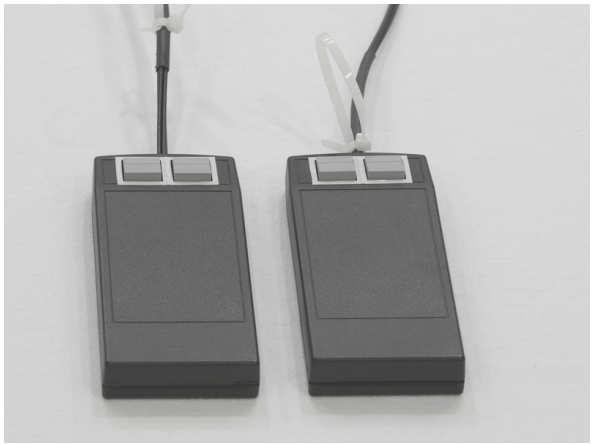
WormyBox

The WormyBox synchronizes both stimulus presentation on a PC (using the software Presentation) and the button press information of the COVILEX ResponseBox1.0 in time with the MRI measurement. It converts and prolongs the optical MR trigger signal (10us) into a TTL signal (10ms) and sends it to PIN 10 and PIN 12 of the parallel output. The button press responses of the COVILEX ResponseBox1.0 are processed and sent to parallel port.

COVILEX ResponseBox1.0

Acquisition of button press responses of subjetcs - binary on/off data. The optical signal is converted into a TTL signal or OpenCollector and output via a DSub9 connector.





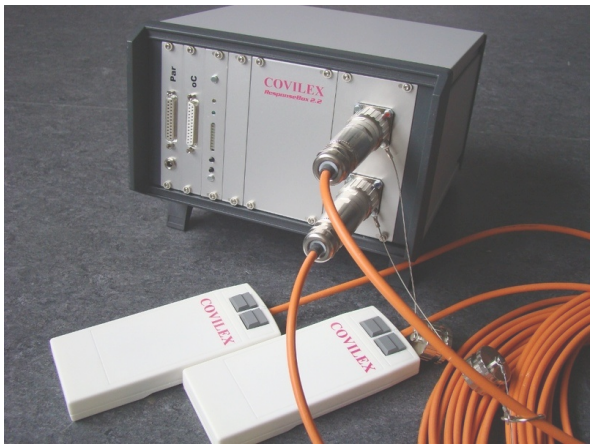
3T Achieva dStream

COVILEX ResponseBox1.2

DSub25 output instead of DSub9.

COVILEX ResponseBox2.0

Acquisition and evaluation of dynamic button press responses of subjects. The device delivers continuous distance/time data (decided, hesitant, inconsistent etc. button presses). The processed optical singals are continuously output at 500Hz via a DSub25 connector as 8-bit digital signal.



Physiological Data

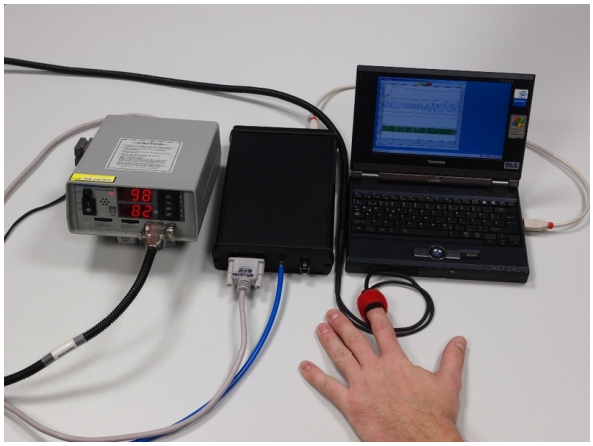
7T Magnetom

NONIN Puls Oxymeter 8600-FO

Non-invasive determination of SpO2 and pulse through measuring light absorption or light emission while irradiating the skin (percutaneously). For digital recording and subsequent analysis of acquired physiological data our in-house developed setup is used, consisting of the hardware "PhysioBox" and the software "Physiolog". The PhysioBox employs the module National Instruments USB 6008 with pressure sensor (Honeywell 40PC001B1A). The Software "Physiolog" written in Python samples the data at 200 Hz and store them as CSV file. The aquisition will wait for the first MR trigger.

Table 3. CSV output: 4 rows (200 Hz)

row 1	respiration
row 2	pulse
row 3	SpO2
row 4	MR trigger



Signal detector and interface for easyACT

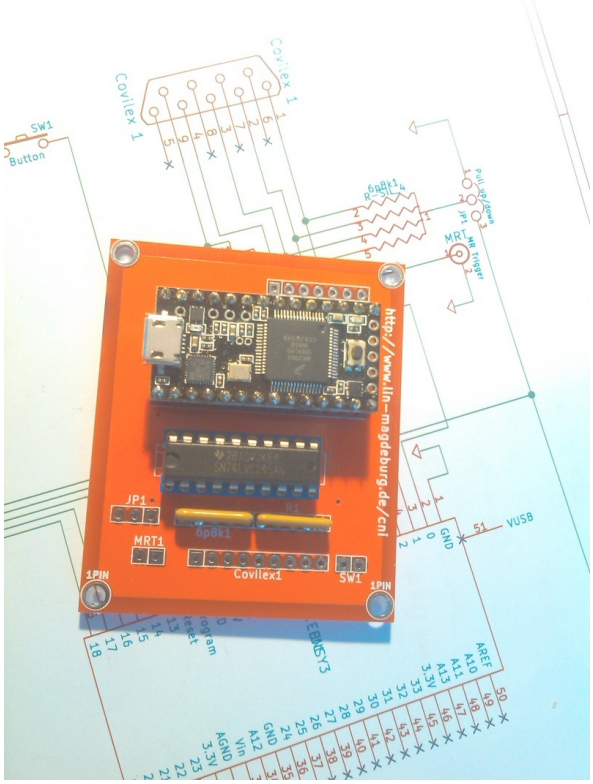
The standard ECG signal at 7T is not reliable. For ECG triggered MRI we use the easyACT device. This device non-invasively captures acoustic signals produced by heart beat, which are output as TTL signal. For more information see http://www.mritools.de/index.php/products/easyact

3T Achieva dStream

We offer the standard Philips physiological recording setup. ECG sampling frequency 496Hz, respiration & pulse 100Hz.

Teensy Box

Inspired by the excellent Wiki page of the Stanford university and the pages of Chris Rorden's Neuropsychology Lab Chris Rorden's Neuropsychology Lab we built our own Teensy Boxes to convert the TTL signals from the MR scanner and the response to a more useful one.



Via USB cable the Teensy Box is connected with your stimulus PC / Laptop and will be recognized as USB HID keyboard without driver installation (Windows, Mac OS, Linux). We use a Teensy board programmed using a simple teensyduino sketch. All variants listen for input pulses from the MR scanner and for pulses from the response buttons. The input is converted to keyboard events:

MR Trigger	*t*
Response Button 1	*1*
Response Button 2	*2*
Response Button 3	*3*
Response Button 4	*4*

Teensy Boxes are offered at the following devices:

7T Magnetom

The Teensy Box at the 7T (Siemens) only has the standard features.

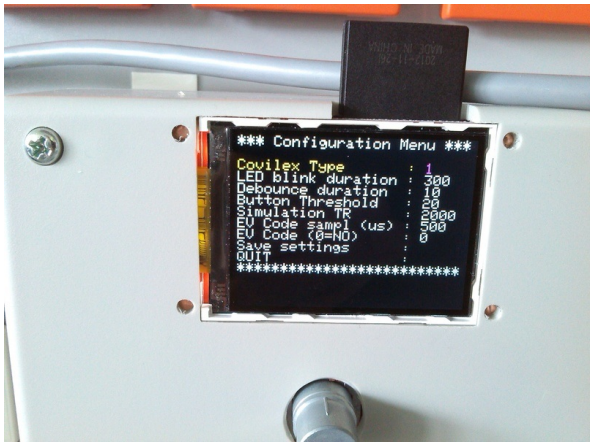
3T Achieva dStream

The Teensy Box at the 3T Achieva dStream (Philips) has an LCD display, an SD card slot and a rotary knob. Please hold the knob and plug in the USB cable to enter the configuration menu. In the menu you can choose the *Covilex type*:

1) Covilex 1.x, Standard behavior as mentioned above 2) Covilex 2.x, Store dynamic response data on SD card (csv file). In addition values above *button threshold* will be converted into key events (*1*, *2*) 3) Simulation mode. Send a *t* every *Simulation TR*

Save settings will save the actual settings permanently in the EEPROM.

QUIT will use the current settings. After restart the saved settings will be used.



The acquisition of the dynamic data will wait for the first MR trigger. To simulate a trigger, push the button. The button will also start the simulation in simulation mode.

To stop the acquisition / simulation, push the button again.

During the experiment the trigger and responses are displayed and counted. In case of dynamic data, the response is plotted in real time.

Emulation of parallel port

The Teensy Box can emulate a parallel port to send event codes to other modalities (e.g. EEG) via serial port. To use this feature you need a driver for your OS.

This feature is only available in Covilex 1.x mode.

Disconnect the Covilex 2.x Box and connect the D-SUB 25 cable with e.g. your EEG system. Enable *EV code* (1) in the configuration menu.

Configure your software to use the serial port as output port (Linux: /dev/ttyACM0. Windows: our stimulation PC: COM9)

Any event code will now send to the parallel port with a default speed of 2 kHz. Recording button press duration / FlipFlop option

For measuring button press duration the menu option "FlipFlop" has to be set to 1. This will enable recording both button press and release with two separate events.

FlipFlop option

The FlipFlop option is accessible from the menu and offers two modes.

- Mode 0: Original behavior, transmitting only the event of button press (not release) via USB.
- Mode 1: Both button press and release events are transmitted to enable recording button press duration.

See table below for detailed event codes.

Response button	Press event code	Release event code
1	1	5
2	2	6
3	3	7
4	4	8

Using PsychtoolBox under Linux

For using the TeensyBox as keyboard device in PsychtoolBox, please use USB-ID 6, as shown exemplary in source code snippet below:

```octave
[keyboardIndices, productNames, allInfos] = GetKeyboardIndices;
deviceid = keyboardIndices(6);
productNames{6}
KbQueueCreate(deviceid);
```

Other sites

DZNE Magdeburg: Verio

We built a Teensy Box for the 3T Verio (Siemens) at the DZNE in 2013. It has the standard features and a button to simulate a trigger.

DZNE Magdeburg: TMS

We built a Teensy Box for the Transcranial magnetic stimulation system at the DZNE in 2014. Any event code sent via serial port by the stimulation software will produce a TTL signal. Each TTL signal triggers a TMS pulse.

Umeå University, Sweden: 3T GE

We built a Teensy box for a 3T GE scanner to convert the MR trigger in 2014.

Institute for Neurology, Magdeburg: 3T Prisma

We built a Teensy Box for the 3T Prisma (Siemens) similar to the Verio version without button in 2014.

Magdeburg: 3T Skyra

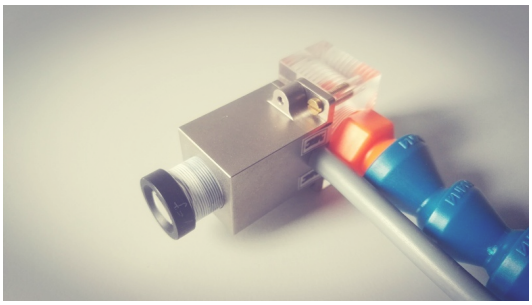
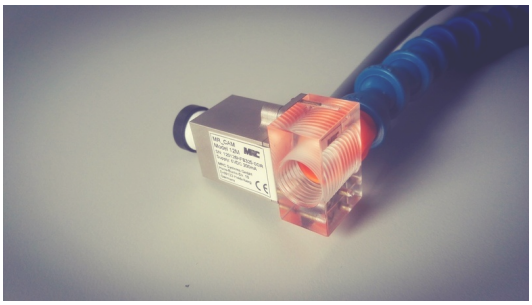
We built a Teensy Box for the 3T Skyra (Siemens) similar to the Verio version in 2015.

Eye Tracker

7T Magnetom

MR-compatible camera - MRC MR_cm_12M CCIR s/w Sensor, 1/3" (PAL)

For eye tracking and observation of the subject and laboratory during MRI measurement. The camera is used in conjunction with the software Pupil Tracker (video resolution: 320x240 pixels) and a DVD / HDD video recorder. Additionally the camera is IR-sensitive. We provide the following lenses L12mf4f, L12mf6f and L12mf16f with focal distances f=4mm, f=6mm and f=16mm respectively.

DVD / HDD Video Recorder Pioneer DVR-520H

The video recorder has an internal hard disk of 80GB and may also record video directly to DVD.

3T Achieva dStream

The scanner is compatible with and prepared for the eye tracker Eyelink 1000 (http://www.sr-research.com).

EEG Setup

At the 3T scanner, EEG can be recorded simultaneously to MRI scans with 64 channel Brainvision BrainAmp ExG.

ExG Input box


64 channel EEG cap in different sizes (54, 56, 58, 60 cm).

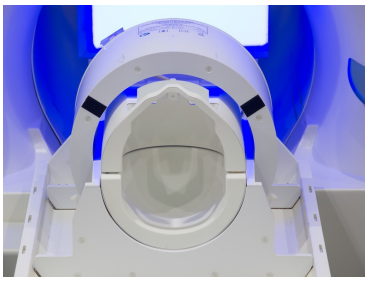
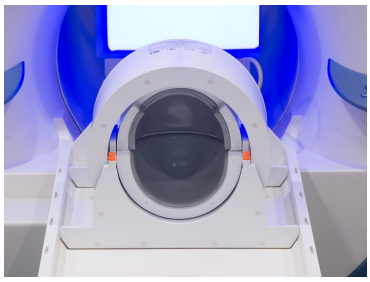
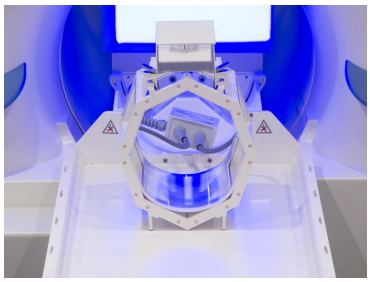
Coils

7T Magnetom

Whole-body gradient coil SC72 (70mT/m, 200 T/m/s)

The magnetic field gradient necessary for imaging is produced by this additional coil.

Head coils

		
Siemens (Nova Medical) TxRx 32-Channel Head Coil with mirror mount for visual stimuli	Siemens (Nova Medical) TxRx 24-Channel Head Coil (no visual stimulation)	Rapid Biomedical 8-Channel TxRx Head Coil with mirror mount for visual stimuli

More coils:

- Siemens (Quality Elektronics) TxRx 28-Channel Knee Coil (knee coil)
- Siemens Basic Coil
- Siemens (Invivo) TRH-297-Quad Head Coil (CP coil)
- Doty Scientific Single Channel (primate head coil)

3T Achieva dStream

		
32-Channel Sense-Head Coil with mirror mount for visual stimuli	Head-Neck-Spine-Coil	Head-Spine-Coil

Technical Data

7T Magnetom (Siemens)

- Magnet:
  - 60 cm bore size
  - 90 cm warm bore, passively shielded with 230t of iron
  - magnet weight approx. 32t
  - 1H Lamor frequency 297.14 MHz
  - 5-6 l/d liquid Helium boil off
- Gradient:
  - SC72 gradient coil (70mT/m, 200mT/m/s)
- Console:
  - Siemens Syngo VB17
  - Standard single channel operation mode
  - 8 channel TX Array Step2 (research mode)
  - dynamic shimming setup (research mode)

3.0T Achiva dStream (Philips)

- Magnet:
  - 3T active shielded
  - zero boil off magnet.
  - 60 cm bore size.
- Gradient:
  - Quasar dual channel gradient coil:
  - 40 mT/m with 200 mT/m/s or
  - 80 mT/m with 100 mT/m/s slew rate.
- Console:
  - Philips Achiva 5.4. Two channel TX mode

Contraindications

Contraindications to be considered when searching for MRI subjects:

- active implants (i.e., cardiac pacemaker, cochlear implants, nervous or bone growth stimulator, defibrillator, infusion pump)
- foreign objects in body (i.e., mechanical contraceptives, removable tooth implants, braces, joint prostheses, metal splinters from war or gunshot injuries)
- heart, head or vesicle surgery
- tattoos
- non-removable body jewelery
- medical patches/plasters
- claustrophobia
- pregnancy
- epileptic attacks (also when occurred in family)
- under medication or drugs influcence

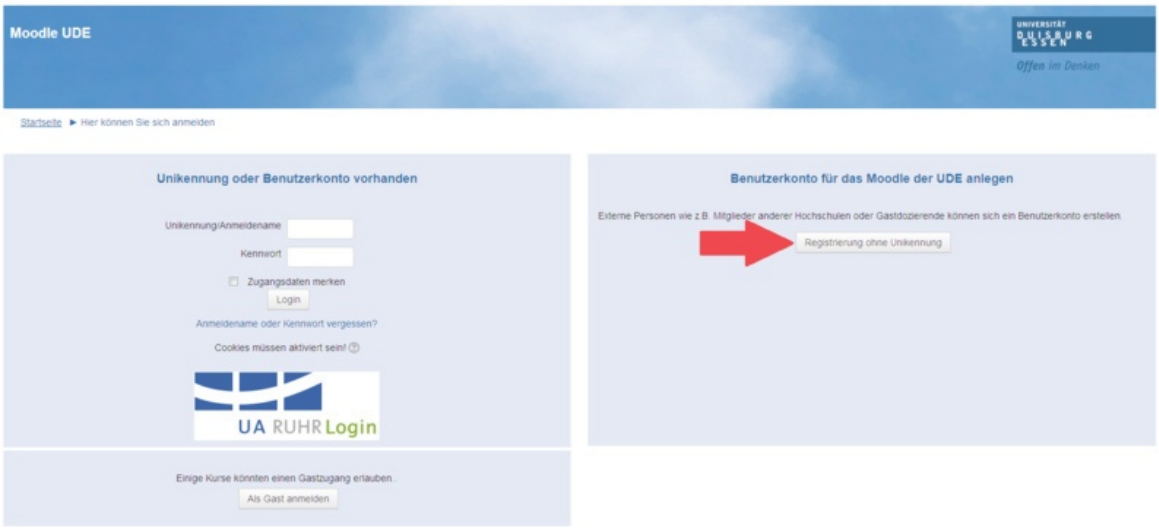
MR Safety Briefing

2018 the annual MR safety briefing in a lecture hall was replaced by an online course. Those online MRI safety instructions were developed in the context of homogenization of access to German ultrahigh-field MRI sites.The MR safety instruction is a necessary pre-condition for the work at the MRT. The employees of the MR laboratories, study directors, medical technical assistants, physicians and persons who accompany studies on MRI must regularly (usually annually) participate in such safety instruction. This online MR safety instruction (GUFI Online MR Safety Training) has been developed in the context of the homogenization of access to the German ultrahigh-field MRI sites (https://www.mr-gufi.de).

The registration for the GUFI Online MR Safety Training

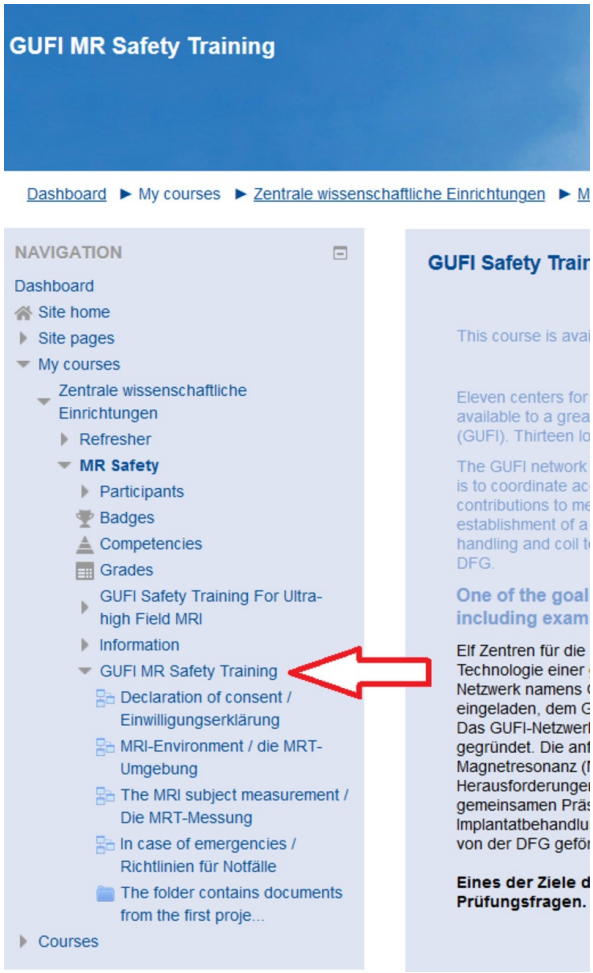
The URL to the online MR safety training is: https://moodle.uni-due.de/course/view.php?id=12066

Registration is required for **first** participation in the online MR safety training. Each participant first creates a user account. With the user account data and a so-called enrollment key (contact the person in charge), participation in the Online MR Safety Training is possible. The enrollment key (**Gufimd18**) is **only** necessary for the **first registration**.



How do I get to the lessons?

The online MR safety training is structured in **three lessons**, with **test questions** at the End of each lesson. At the End of the course **all lessons** must be completed with **a test**. To pass, only one question per lesson may be answered incorrectly.

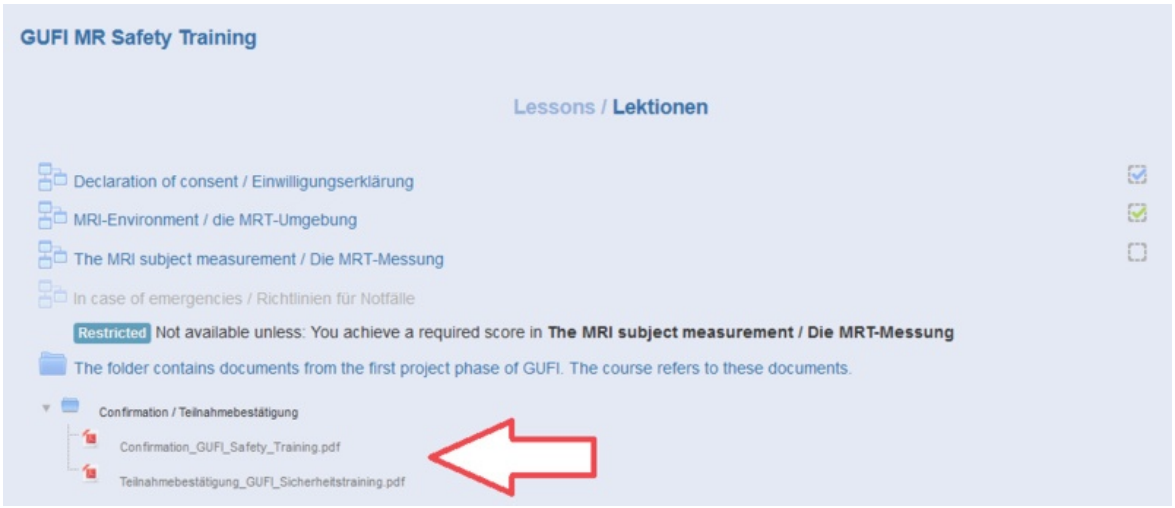


You can find the lessons via the navigation menu → GUFI MR Safety Training or at the end of the homepage. Before you can start with the lessons, you have to agree to the storage of the data - **declaration of consent**. Afterwards all lessons can be processed.

If the lesson is successfully completed, the lesson are ticked green in the box, otherwise red cross. The course is considered completed when all lessons are checked.

Confimation

After successful completion please download the confirmation of participation:



and filled in, signed and handed over to the respective person in charge.

Participation at a safety briefing has to be documented by the operator of the facility. Thus, the instructed persons shall hand in the signed confirmation of participation to the person responsible for the facility:

- 7T (H.92): Dr. Jörg Stadler (LIN)
- 3T Philips (LIN) Dr. Jörg Stadler
- 3T Prisma und Skyra (H.65 und H.60a): Dr. Claus Tempelmann (Neurologie)
- 3T Skyra (Stimulate): Cindy Lübeck (Stimulate)
- 3T MR-PET (H.64): Peter Schulze (DZNE)

The test results of the online MR safety training are only stored for the purpose of conducting the MR safety instruction. The test result data will be deleted after one year at the latest - or before that, if requested by the participant.

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