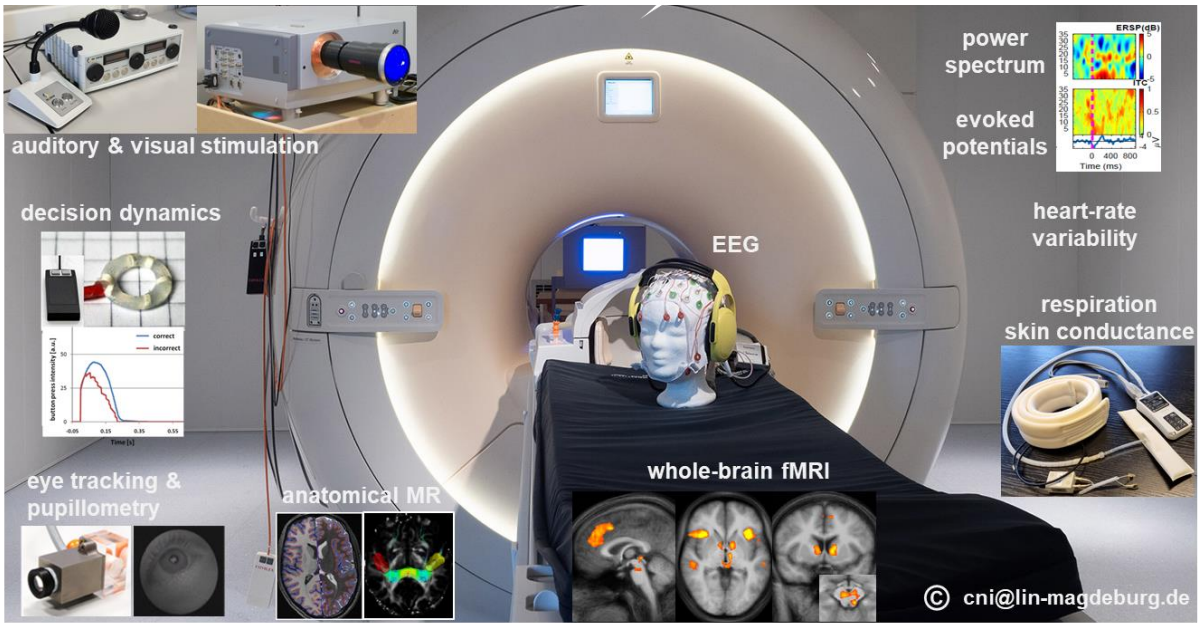
Multimodal 3 Tesla MRI Lab

cni combinatorial neuroimaging



MR-Imaging

CNI provides access to a 3 Tesla MRI scanner (Philips Achieva dStream) equipped with a 32-channel head coil and a dual channel gradient coil (slew rate: 40 mT/m, 200 mT/m/s or 80 mT/m, 100 mT/m/s).

The MR scanner generates a trigger signal that synchronizes all events of an fMRI experiment. The TTL signal is converted into a USB keyboard event “t” by a Teensy microcontroller (cf. Rorden & Hanayik, J Neurosci Methods, 2014) and fed into all hardware devices used for stimulation and data recording.

Realtime fMRI analysis can be performed with Turbo BrainVoyager 4.4, installed on a Windows PC that receives the MR images via the Philips DRIN interface.

Stimulation devices

The timing of stimulus events and the participants’ responses can be controlled by the software Presentation (Neurobehavioral Systems) or Psychtoolbox in Matlab (MathWorks) or PsychoPy® running on a PC with Windows and Ubuntu operating system.

The PC is equipped with an Intel(R) Xeon(R) W-2255 CPU @ 3.70GHz, 3696 Mhz, 10 Cores, 20 Logical Processors; 128 GB RAM, NVIDIA High Definition on board sound card, NVIDIA Quadro P400 2 GB graphic card.

Auditory stimuli are presented via the Mark II+ (MR-Confon, Magdeburg, Germany) audio control unit to MR compatible electrodynamic headphones with integrated ear muffs that provide passive damping of ambient scanner noise by ~ 24dB. Earplugs (Bilsom 303) further reduce the noise by ~ 29 dB (SNR).

Background scanner noise spectrogram can be recorded for each specific MR-sequence (cf. Angenstein et al., Hearing Research, 2016).

Timing of sound stimulation can be determined with a set-up for direct recording of the audio signal connected to a BrainAmp ExG AUX box (Brain Products, Gilching, Germany).

Visual stimuli are presented at a resolution of 1280x1024 and 60 Hz via a DVI splitter (Gefen EXT-DVI-142DL) and a video projector (JVC DLA RS66E) onto a rear projection screen. The light of the projector is reduced by a grey filter (ND09) to 1/8. The screen inside the scanner bore is at 60 cm distance to an IR reflecting mirror attached to the head coil. Full binocular view is 25.6° in horizontal and 20.5° in vertical direction.

Timing of visual stimuli at the screen can be determined with a photo diode connected to a BrainAmp ExG AUX box.

Participants' vision can be corrected by glasses by Cambridge Research Systems (UK) with -6 to +6 diopters in 0.5 increments to be used with an MRI-compatible spectacle frame by Mallinis (Magdeburg, Germany).

Response Devices

Decisions of the participants are recorded with the ResponseBox 1.2 by Covilex (Magdeburg, Germany) that includes two response pads with two buttons each. The signal from the response buttons is converted by a Teensy microcontroller into USB keyboard events '1' - '4' with a Teensyduino sketch and fed into the stimulation PC. For recording the duration of a button press, the release of a button is coded by additional events '5' - '8'.

The **button press dynamic** is recorded with the ResponseBox 2.0 by Covilex (Magdeburg, Germany) that includes a response pad with two buttons. The device delivers continuous 8-bit data at a sampling rate of 500 Hz at a Sub-D 25 plug. A Teensy samples the data at 1kHz and stores it in a csv file. The Teensy simultaneously converts left and right button presses that exceed a defined threshold into USB keyboard events '1' or '2' to be handled by the stimulation PC.

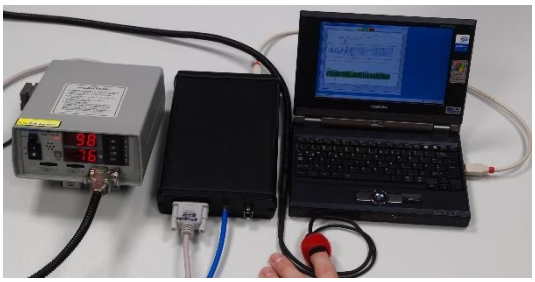
In addition or instead of manual responses, a custom made device allows the recording of decisions via two **foot pedals**.

A **Joystick** by Hybridmojo (San Mateo CA, USA) with 5 tactile buttons (1 shaft mounted, 4 on the body) can be used when more complex motor interaction is needed.

An MR-compatible dual channel microphone can be used for recording the participant's **verbal responses** via optical input to the Mark II audio control unit by MR-Confon (Magdeburg, Germany) and fed into a PC for separating the voice from the background scanner noise e.g. using the sound software Audacity (cf. Bethmann et al., PLOS ONE, 2012).

Physiological Recording

Respiration and heart rate is recorded with Invivo MRI Sensors at a sampling rate of 100 Hz and stored on the MRI acquisition PC. Philips also provides a device for ECG triggered imaging, storing all data at 496 Hz sampling rate.



A Nonin 8600FO Pulse Oxymeter can be used for monitoring of blood oxygen saturation. Data logging synchronized to the MR trigger is done on a dedicated PC.

Eye Tracking

The MRI-compatible EyeLink 1000 (SR-research, Ottawa, Canada) can be used for eye tracking and pupillometry at 1kHz temporal resolution, <0.5° average accuracy, and 0.01° root mean square (RMS). Calibration is performed with a randomized 9-dot grid displayed with a resolution of 1280 by 1024 until the EyeLink's recommended thresholds are reached. Interfacing with Presentation or Matlab can be done via TCP/IP.

An Ogama work flow with customized scripts for extracting and converting eye-tracking data is provided at https://github.com/brains-on-code/simultaneous-fmri-and-eyetracking.

In addition, eye tracking and video recording (e.g. for monitoring of face expressions, head motion, or hand movements) can be performed with the MR compatible camera 12M by MRC Systems (Heidelberg, Germany) using the MRC-Software for synchronized recording of pupil size and gaze direction with a resolution of 640x480 pixel and a frame rate of 60 Hz.

EEG-Recording

A 64 channel EEG (including ECG) is recorded at 5 kHz using two 32-channel amplifiers BrainAmp MRplus (Brain Products GmbH, Gilching, Germany) positioned on a wooden table detached from the MR scanner. A bipolar 16 channel amplifier BrainAmp ExG MR is used to record 2 EOG, 4 EMG (Corrugator, Zygomaticus) channels as well as signals from 4 carbon wire loops (CWL) for correcting pulse and motion related artifacts (cf. van der Meer et al., NeuroImage, 2016). Another BrainAmp ExG MR amplifier with an ExG AUX box is used at the foot of the participant for recording skin conductance (GSR). All signals are synchronized with the MR trigger via a Sync box and two USB2 adapter. All data, including timing information about audio and visual stimulation (see above) are recorded with the BrainVision Recorder software.

The separate Windows-PC allows for **real-time EEG analysis** including CWL artifact correction.