wellcome centre human neuroimaging

Transcranial direct current stimulation with functional magnetic resonance imaging	SOP version: 10
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Standard Operating Procedure (SOP)

Transcranial direct current stimulation with functional magnetic resonance imaging

Procedure pre-requisites

Contraindications and special considerations

When tDCS is integrated with MR, participant safety standards for both MR and tDCS should be adhered to as follows:

1) Participants should be screened using the safety checklist for MRI contraindications (e.g., any metallic implants including intracranial electrodes, cardiac pacemaker, shrapnel, surgical clips etc. susceptible to electrical current or magnetic fields) prior to recruitment.

2) Participants to be screened for any additional tDCS-specific contraindications – these contraindications may be study-specific. This includes presence of severe or frequent headache, any scalp or chronic skin condition: e.g., psoriasis or eczema where tDCS could aggravate the condition, or adverse reactions to a previous tDCS treatment. History of seizure and brain injury are usually not strict contraindications in themselves – for example, history of stroke is an inclusion criteria in our clinical studies, in patients who have been 1 year seizure free. Thair and colleagues (c.f., Thair et al., 2017) in their tDCS beginner's implementation guide have summarized general tDCS participant exclusion criteria and provided helpful Screening Questionnaires (c.f., Thair et al., 2017). Dedicated safety assessment should specifically be made for any indwelling medical devices and metallic implants (even if MRI compatible) that may change tDCS current flow (see Datta et al., 2010 for details).

Areas and environments

Control Room

This is the area that contains the operating PC for the scanner and the peripheral testing equipment. This falls within the outer-controlled area of the MRI environment. Consequently, personnel working in this environment must be trained in accordance with local policy. Participants entering this area must have been screened in accordance with local policy.

Scan Room

This is the room that contains the MRI system. This falls within the inner-controlled area of the MRI environment. Personnel working in this environment must be trained in accordance with local policy. Participants entering this area must have been screened in accordance with local policy.

Testing Room

This is an area external to the MRI environment that offers suitable facilities to prepare the participant for an MRI scan with tDCS. Ideally, this will offer privacy, must be large enough for three persons and provide adequate seating to allow for tDCS set-up, application and impedance testing.

Equipment List

1. *MRI-compatible non-invasive brain stimulation system:*

We use the NeuroConn DC-stimulator (Figure 1)
https://www.neurocaregroup.com/dc_stimulator_mr.html

- MRI-compatible tDCS equipment:
  a. Electrodes
  b. Electrode cable
  c. Inner- Box
  d. Box cable (Ethernet cable)
- Non MRI-Compatible tDCS equipment:
  e. Outer-Box
  f. Stimulator cable
  g. DC-Stimulator (NeuroConn)

Items e-g should be placed in a radiofrequency (RF) shielded box (Faraday cage) in the Control Room. The cables are connected via a waveguide between the Control Room and the Scan Room.

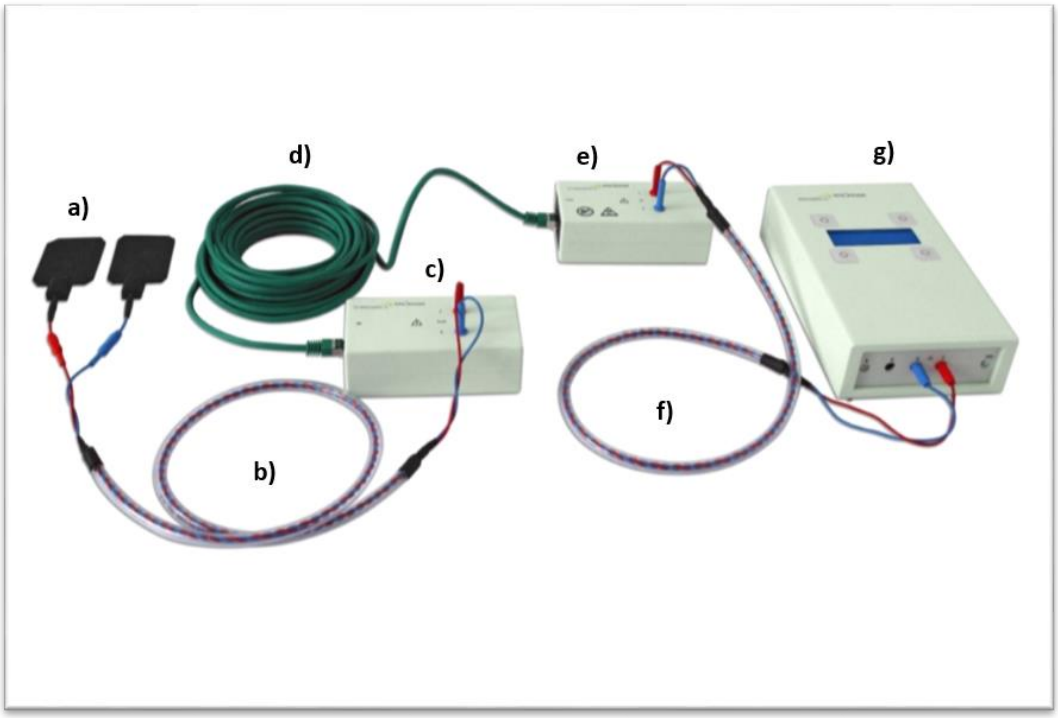

Figure 1 – tDCS equipment. MRI-compatible equipment: (**a**) rubber electrodes, (**b**) twisted electrode cable with current limiting resistors 5,4 kOhm, (**c**) Inner-Box, (**d**) box cable. **Non-MR-compatible equipment:** (**e**) Outer-Box with attenuation circuit to eliminate RF interferences from outside the scanner 10-300 MHz, (**f)** twisted stimulator cable, (**g**) DC-Stimulator PLUS**.** Picture copyright: neuroCare Group GmbH 2020.

2. tDCS contact medium and electrode placement

To provide uniform current distribution throughout the prolonged fMRI experiment we use:

(i) EEG conductive paste (e.g., Ten20) as the MR electrode contact medium rather than saline soaked sponges or low viscosity electrode gel. This avoids premature drying which would result in an increase in resistance and risk to the participant of pain and skin burning. Using electrical conductance paste avoids these risks and the adhesive quality of the paste assists in affixing the electrode to the targeted location/scalp.

(ii) 3M Coban elastic wrap bandage to also comfortably and fully secure the electrode placement. Both the paste and bandage together improve stability of the scalp contact with the tDCS MR electrode even during our prolonged (i.e., 40 min) overt speech fMRI paradigms that have higher associated head movements.

3. RF Shielded Box

In the Control Room, we installed a bespoke RF Shielded Box – this box is made from aluminium by the UCL Department of Chemistry, it was lined with beryllium copper shielding from RS Components (www.uk.rs-online.com/web/p/shielding-strips) (Figure 2.A). The box is secured on a wooden shelf next to the waveguides. The box houses the DC-Stimulator (Figure. 2. B), a Fibre-Optic Trigger Box to start the stimulator, and the leads connecting the stimulator to an RF filter box (Outer-Box, Figure 1.e) which is placed in the waveguide. The addition of the RF shielded box was required in our laboratory to minimise any RF interference between the Scan Room and the external environment, with a 3 Tesla MR scanner in the adjacent room. What is important here is that this equipment doesn't act as a conduit causing RF to leak from the room and that the equipment doesn't allow too much, if any, noise into the room to degrade the fMRI.

The lid is kept on during the scanning and a small window in the lid allows the stimulator display screen to be monitored to ensure it is functioning correctly. The DC-Stimulator is removed at the end of each session, while the RF Shielded Box containing only the Fibre-Optic Box, the leads and the outer-box in the waveguide are left in place.

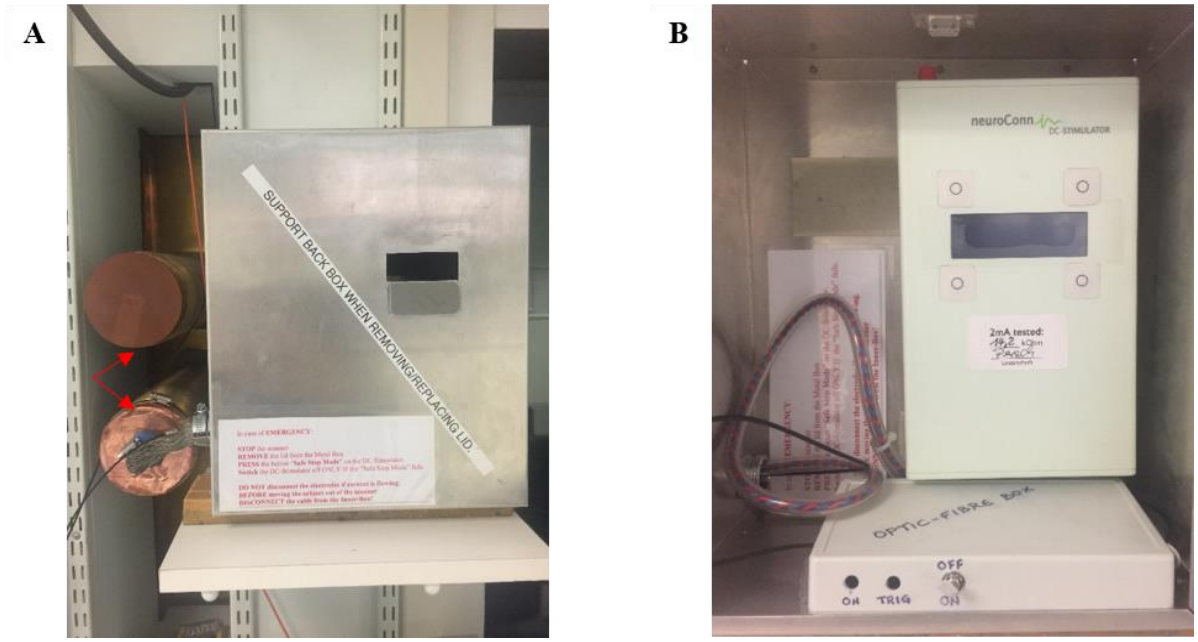

Figure 2 – RF Shielded Box. (**A**) RF Shielded Box with lid on – the red arrows indicate the waveguides. (**B**) Placement of the DC Stimulator and Fibre Optic Box inside the RF Shielded Box.

4. Fibre-Optic Trigger Box

The Fibre-Optic Trigger Box was built in-house at the WCHN; it is powered by a 9V battery and seated with Velcro within the RF Shielded Box (Figure 2). It is used to electrically isolate the NeuroConn DC-Stimulator from the Stimulus PC, preventing the transmission of RF noise into the RF Shielded Box. The Stimulus PC generates a fibre-optic signal and the Fibre-Optic Trigger Box converts this signal into an electrical trigger, enabling operation of the NeuroConn DC-Stimulator via the Stimulus PC.

Additional items need for the Trigger Box:

(i) Trigger leads

(ii) Fibre optic cable (https://uk.rs-online.com/web/)

5. Foam-base

The tailor-made Foam-base assembled in-house at WCHN (Figure 3) comprises:

- An MR bore-shaped foam block (black) purchased from Drayton Foam (http://www.draytonfoam.co.uk), with blue plastic components fixed on top of it and a plastic underlay (not shown) so it sits neatly in MRI bore.

In operation, the Foam-base secures the Inner-Box is positioned both centrally and consistently within the bore of the MRI system. This careful and fixed positioning prevents cable loops forming, maximises the distance between the transmit coil and the tDCS leads and ensures equipment placement is consistently replicated across scanning sessions

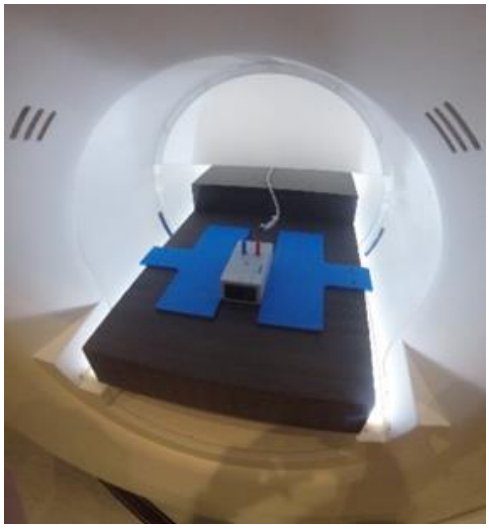

Figure 3 – Foam-base for tDCS. Shown in the scanner bore with the Inner-Box and tDCS electrode cabling in place.

6. MRI scanner

- Siemens Prisma 3 Tesla with 20 channel head coil

The present protocol was optimised for a Siemens Prisma scanner. However, the NeuroConn DC-Stimulator is compatible with several models, and this fMRI-tDCS protocol can be recreated in any scanner through appropriate modification of the outlined procedures.

7. Sandbags

The tDCS box cable is run from the rear bore entry to the waveguide, hugging the perimeter of the room whenever possible. Siemens positioning sandbags are used to secure the box cable to the floor of the Scan Room to minimise the risk of creating a trip hazard. The sandbags are labelled 'Floor' and must not subsequently be used within the scanner bore.

8. Stimulus PC

For the experimental paradigm a computer that:

- Runs the software controlling the cognitive paradigm and therefore the NeuroConn DC-Stimulator (in these experiments this was MATLAB 2014a (The MathWorks, Inc., Natick, Massachusetts, United States) and COGENT 2000 developed by the Cogent 2000 team at the FIL and the ICN and Cogent Graphics developed by John Romaya at the LON at the Wellcome Department of Imaging Neuroscience.
- Receives MRI sequence triggers via a serial port.
- Outputs a fibre optic signal via parallel port to the Fibre-Optic Trigger Box.

9. Paradigm-specific equipment

This experiment delivered auditory stimuli and recorded overt spoken responses in the scanner using:

- An MR-compatible set of headphones (MR Confon, Magdeburg, Germany; www.mr-confon.de)
- A dual-channel, noise-cancelling fibre optical microphone system (FOMRI III, http://www.optoacoustics.com).

These are not essential for an fMRI-tDCS set up, and could easily be adapted for other cognitive paradigms.

Persons and Responsibilities

Person 1

Researcher primarily responsible for the tDCS equipment; this includes the setting up of equipment within the Scan Room and monitoring the Outer-Box during scanning.

Person 2

Researcher primarily responsible for the participant. Person 2 will take the lead in explaining the procedure to the participant, placing the electrodes, guiding the patient into the Scan room to test the electrodes, and helping Person 3 set up for the scan. Person 2 will also be responsible for disconnecting the electrodes within the Scan Room at the end of the scanning session.

Person 3

A radiographer or Qualified User (QU) who will be present throughout the scan. They will be responsible for completing the MRI safety screening, participant care and positioning. During the scan Person 3 will also be responsible for operating the MRI scanner in accordance with the local rules. Including recording details of the imaging data acquisition, Specific Absorption Rate (SAR) levels and performing quality assurance of the images, in particular assessing them for evidence of participant movement and artefact, e.g. increased noise levels.

Preparation

Prior to beginning the imaging session, the Control Room, Scan Room and the participant must be suitably prepared. What follows is a detailed guide of how to do each.

1. Control Room Preparation

Check connection at Fibre-Optic trigger box (Person 1)

1. Ensure only one fibre-optic cable is entering the RF shielded box and interfacing with the Fibre-Optic Trigger Box.
2. This ensures RF integrity and electrical isolation.

Check the 9V battery (Person 1)

1. Ensure 9V battery is charged and fully operational (Figure 4) by switching the small lever to the on position, both a red light (battery 'on' status) and a green light (trigger 'on' status) should come on.
2. If only the red light comes on, it means that the battery is charged but the trigger from the Stimulus PC is not correctly configured.
3. With our system, type 'outportb (888,0)' in the MATLAB command window *(N.B: make sure the trigger is plugged in the parallel port of the Stimulus PC*). This will ensure the DC-Stimulator is triggered to start when given the future MATLAB command during the experiment.
4. If no red light comes on, replace the battery.

Figure 4 – The Fibre-Optic Box and cables. (**a**) Fibre-Optic cable (black); (**b**) Fibre-Optic Trigger Box containing the 9V battery.

Secure the DC-Stimulator (Person 1)

1. Velcro strips are used to secure the DC-Stimulators' position inside the RF Shielded box (Figure 2.b).
2. Connect the four jacks using their colour coded sockets as marked; red-anode (socket 1) and blue-cathode (socket 2) for electrodes, black (socket 3) and white (socket 4) for trigger (Figure 5).

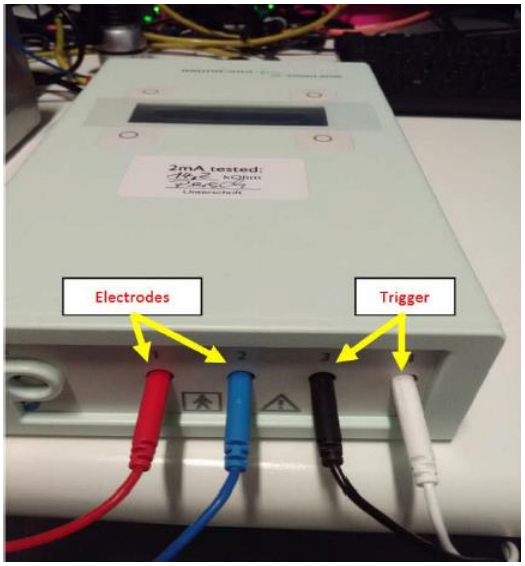

Figure 5 – MR compatible DC-Stimulator connections (red-anode and blue-cathode for electrodes, black and white for trigger).

Check ancillary equipment (Person 2)

Other equipment that required setup for these particular experiments were:

- FOMRI Confon headphones and microphone
- Stimulus PC for the task
- Physiological data recording

2. Scan Room Preparation

Position Foam-base for tDCS unit in the scanner bore (Person 1)

1. Position and align the tailor-made Foam-base for tDCS in the rear section of the bore of the MRI scanner, aligning the posterior edges of the base and scanner (Figure 6).
2. Place the Inner-Box onto the Foam-base between the blue support pads as shown in Figure 3. This will ensure positioning is consistent throughout the experiments and across participants.

   See Figure 7 for a detailed schematic of the room layout and equipment positioning.

Connect the box cable (Person 1)

1. First, connect the box cable to the Inner-Box.

2. The Outer-Box is kept inside the waveguide and positioned against the Control Room end of the waveguide. The Outer-Box contains ferrite components and therefore **MUST NEVER** enter the Scan Room.
3. To ensure the Outer-Box cannot be pulled into the Scan Room, as the cable is laid on the floor during room preparation, the Outer-Box is connected to the box cable **LAST**.

Positioning the box cables (Person 1)

1. The box cables should follow the path depicted in the room schematic (Figure 7). These should run parallel to the bore, without loops and away from the participant to prevent the risk of eddy current induction and potential RF burns.
2. This cable runs from the Inner-Box inside the rear of the scanner bore to the back wall. It then follows the perimeter of the Scan Room (in this case the rear and left walls) to reach the Outer-Box in the waveguide.
3. It is positioned close to the wall edges, running as straight as possible without creating any loops. To achieve this, multiple sandbags and a cable protector are used as shown.
4. Once the participant is in position, they will be connected to the tDCS equipment. It is therefore important that the participant/scanner bed not be moved without disconnecting these. Tailor-made warning signs stating "CHECK electrode cables are disconnected before moving the bed" are therefore placed over the scanner controls (Figure 8) for the duration of the scanning session.

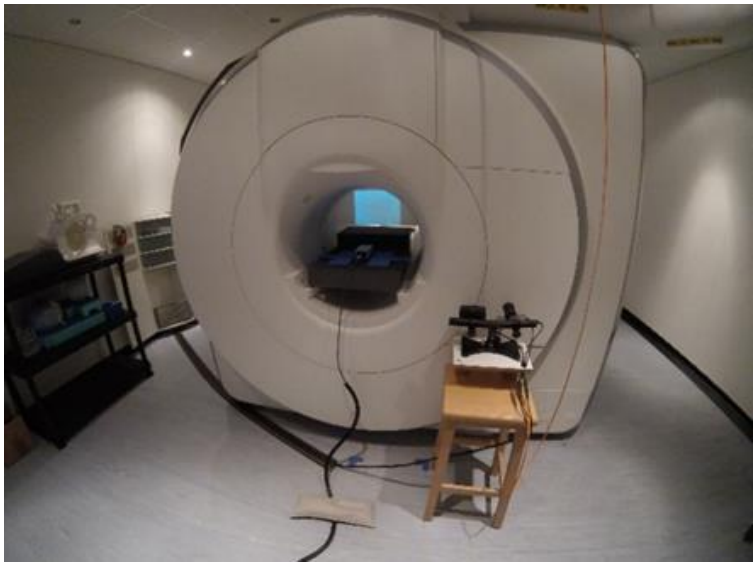

Figure 6 – Route for Box Cables in scanner room. Photo taken from the back of the scanner: Foam-base in the scanner bore, with the Inner-Box on top.

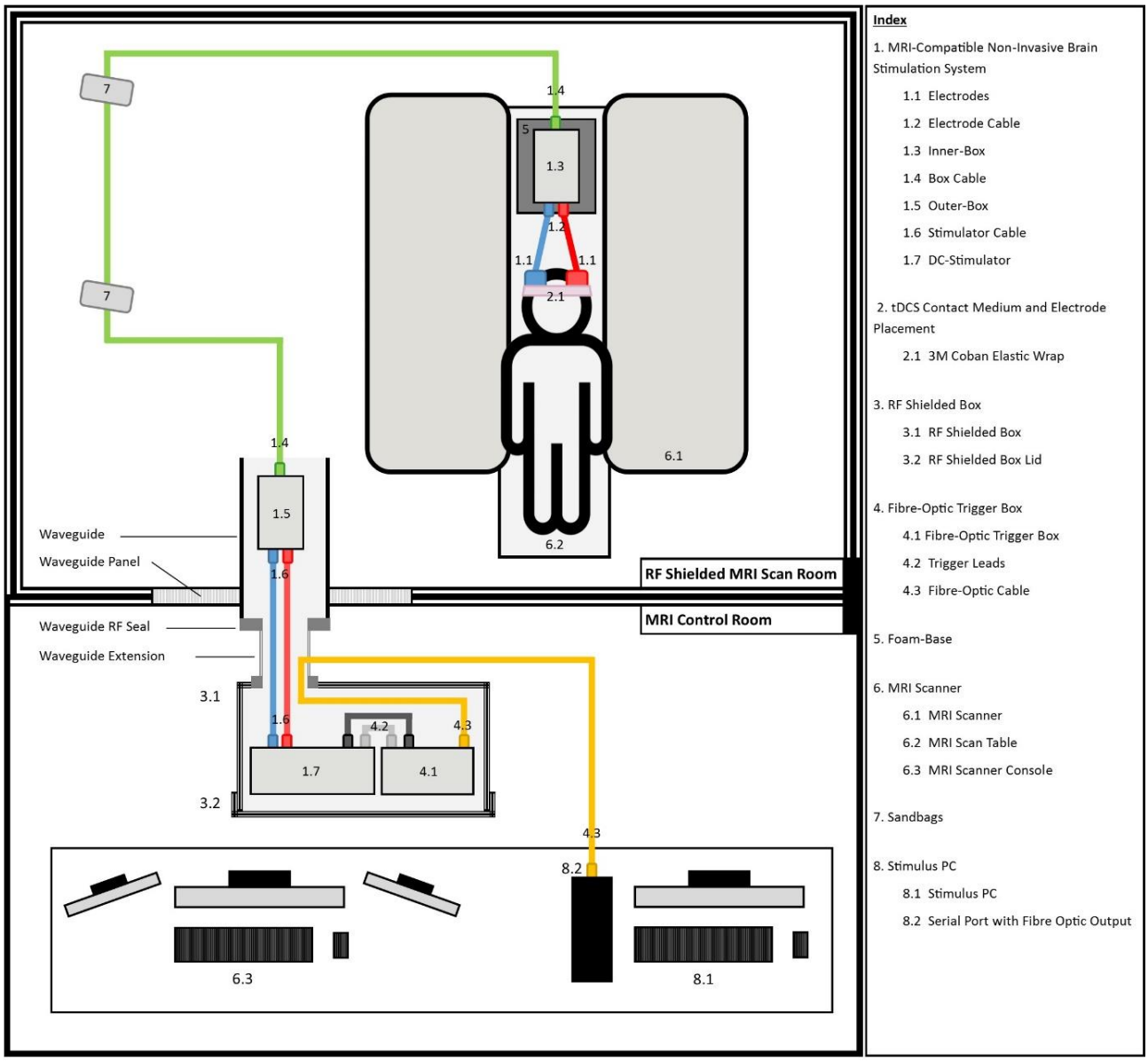

Figure 7 – Schematic depicting full room layout. Image demonstrates the full set up of the tDCS and cable routes, with the participant positioned inside the scanner bore.

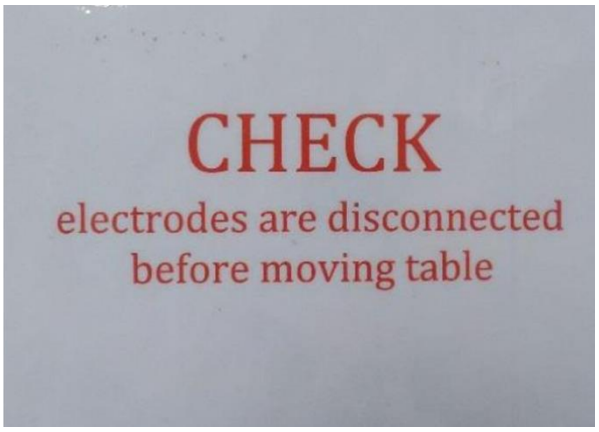

Figure 8 – Warning Reminders. Photos taken from the front of the scanner. Warning signs to be put over the table controls on the scanner as a reminder not to move the bed/participant before disconnecting the electrode cables.

3. Participant Preparation

When tDCS is integrated with MR, participant safety standards for both MR and tDCS should be adhered to and participants pre-screened for both in advance of coming in for testing.

Participant Safety Screening (Person 3)

1. In the Testing Room, the radiographer will perform and cross-check the MR safety screening.
2. The participant should be ready to enter the MR environment (appropriate clothing, no jewellery, etc.).
3. Once the above is complete, tDCS safety screening is then cross-checked and completed.
4. When both safety checks are completed, then proceed with tDCS preparation.

tDCS Preparation (Person 2)

MR electrode positioning

In order to acquire good tDCS combined with MR data, careful preparation/placement of electrodes, stable fixation of the electrodes to the head, etc. remain critical considerations, as they are with tDCS alone (Woods et al., 2016). Scalp measurements are taken to ensure the correct placement of anodal and cathodal electrodes. The tDCS montage is chosen to accommodate the needs of the specific experimental procedure. In this case the stimulation site was the inferior frontal cortex (FC5 in a 10-20 EEG nomenclature) and was the site for the anodal electrode. The cathodal electrode was placed on the contralateral supra-orbital position (FP2; see Figure 9) as in DaSilva (2011). However, the steps listed below can be applied to any tDCS montage regardless of the stimulation site and stimulation parameters.

1. Inspect the participants' skin to ensure there are no pre-existing lesions or allergies.

2. Clean the skin surface using suitable wipes.
3. Ensure any residue of face creams, hair products etc. is removed to ensure optimum conductivity.
4. Apply a layer of electrode-conductive paste (Ten20) on the MR biocarbon electrode surface. This should be a thick film (~3mm) of paste with thickness of paste prep kept consistent across sessions to provide sufficient distance between the electrodes and the scalp. This ensures that stimulation is delivered evenly across the electrode and also prevents direct contact between the skin and the electrodes, which is mandatory for functional safety and to prevent skin damage (Bikson et al., 2016).
5. Move participants' hair out of the way and apply pressure on the electrode when placing it on the skin/scalp. This ensures both MR-compatible electrodes are lying flat on the participants' skin surface for maximum comfort and achieving lower impedance.
6. The adhesive quality of the paste assists in affixing the electrode to the targeted location/scalp, but additional MR-compatible 3M Coban bandage wraps placed around the head, over the site of the electrodes, are also used for fully secure placement. This keeps the electrodes comfortably and securely in place (maximising skin contact and conductivity) throughout the experiment (Figure 9).

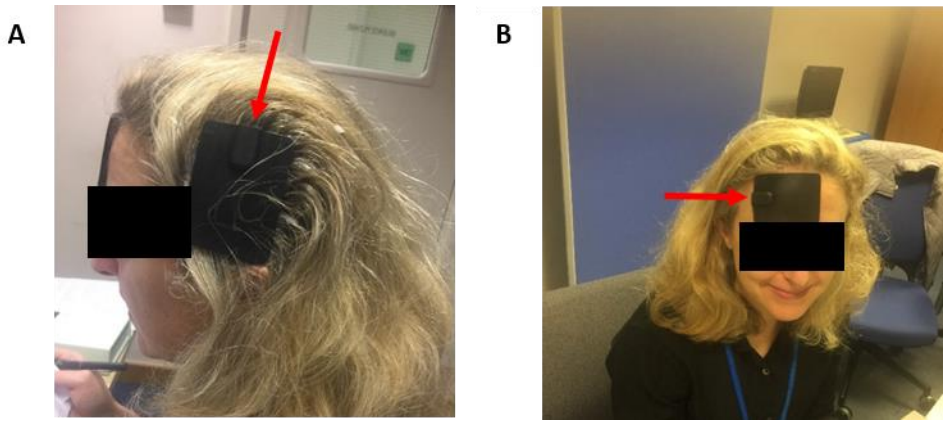

Figure 9 – Electrode Placement. (**A**) Red arrow indicates placement of the anodal electrode on the participant's inferior frontal cortex (FC5) according to the 10-20 EEG nomenclature; (**B**) red arrow shows placement of the cathodal electrode on the contralateral frontopolar cortex (FP2).

Impedance Check and 'tDCS taster' (Person 2, within the Testing Room)

Impedance is checked to ensure there is good skin conductance and stability of electrode placement. The 'tDCS taster' allows the participant to experience the skin sensation when tDCS is delivered. This means they can more accurately: 1) rate the tDCS sensation strength, 2) ensure they are feeling comfortable with it, i.e. it is tolerable, and 3) agree they are willing to go ahead with the experimental procedure.

1. Attach the electrode cable leads to the electrodes.
2. Take care to ensure the electrode cable is straight, not creating any loops, not twisted nor braided. Place in adherence with the Manufacturers MR safety guidelines.
3. Attach the electrode cable to an external DC-Stimulator (i.e., a second non-MR DC-Stimulator different to the one in the RF Shielded box).
4. Turn the DC-Stimulator on with (for our experiment) the following 'tDCS-taster' parameters:
   a. Duration: 60 seconds.
   b. Fade In/Out: 15 seconds.
   c. Current: 2mA.
5. Record the impedance displayed. The desired value within the Testing Room outside of the MR environment is ≤ 10 kΩ. Wait for stimulation to finish.
6. Ask the participant to rate the sensation of the stimulation on a 0-10 scale, 0 being nothing detected and 10 being unbearable.
   a. 0-5 = Proceed.
   b. 6-10 = Ask participant to describe their feeling or discomfort. Ensure they are happy to proceed.

   Comfort ratings for this protocol show a favourable tolerability profile. Most often reported effects are tingling and itching sensations under the electrodes consistent with previous reported tolerable and minor tDCS effects (Poreisz et al., 2007, Fertonani et al., 2015). The sensation of phosphenes elicited by abrupt current on- or offset is avoided by the long ramping up of current intensity.
7. Repeat steps 1-6 if required for the participant to feel comfortable.
8. If the participant is not happy to proceed at any point, the experiment is stopped.
9. If the participant is happy to proceed, they can be taken into the MR Scan Room for the internal impedance check, having been MR safety screened (*Person 3*).

Procedures within the MR Scan Room

1. Impedance Check

As the MR-tDCS equipment has high-ohmic resistors in the stimulating circuit (in this case 10 kOhm) to prevent the induction of eddy currents within the stimulating leads, and the participant will have moved their head since leaving the Testing Room, the impedance is checked again in the Scan Room. This will ensure that the electrodes are still correctly in place and securely attached to the skin. This is done before the participant is positioned onto the scanner bed, so that any electrode placement issues can be rectified easily.

1. Attach the MR-compatible electrode cables to the electrodes on the participant's head – red anode, blue cathode (*Person 2*).
2. Slowly walk the participant to the rear of the scanner (*Person 2*).

3. Attach the MR-Compatible electrode cable to the DC-Stimulator via the Inner-Box, with the participant standing close to the back of the scanner bore (*Person 2*).
4. Person 2 should communicate to *Person 1* when they are ready for the impedance check to begin.
5. Run the impedance test from the RF Shielded Box without delivering stimulation (*Person 1*).
6. Check the impedance is within an acceptable range (i.e., 10-20 kΩ; cf. Woods et al., 2016) and record the number *(Person 1*).
7. If the impedance is not in range, check the electrodes to ensure that they have a secure fit to the scalp under, and only under, the electrodes with sufficient conductive paste evenly spread across the electrodes (*Person 2*).
8. Repeat until the desired range is achieved.
9. Switch off the DC-Stimulator in the RF-Shielded Box (*Person 1*).
10. Unplug cables from the Inner-Box but keep the electrode cables connected to the electrodes (*Person* 2).
11. Double check with the participant that they are happy to continue (*Person 2*). If they are not, terminate the experiment.

2. Participant set-up for fMRI-tDCS

1. Slowly guide the participant from the back of the scanner bore to the scanner bed.
2. Position the participant as per routine fMRI experimental protocols, but being careful that the electrodes do not move. It is vital to ensure that the electrodes are not in contact with the head coil, or headphones, to prevent electrode displacement and any unexpected interactions between the stimulator and the scanner. (*Person 3*).
3. Remind the participant that once the experiment starts, they may feel sensations from the tDCS stimulation (similar to experiences outside of the scanner during the tDCS 'taster' session, *Person 2*).
4. Remind the participant to squeeze the call bell at any time if they feel uncomfortable or want to stop, at which point they would be taken out of the scanner immediately (*Person 3*).
5. Once the anterior element of the head coil is in place, guide the electrode cables through openings in the head coil, exiting the right side of participant's headcoil in accordance with the manufacturer's DC stimulator MR application note: Single Channel fMRI-tES (https://www.neurocaregroup.com/dc_stimulator_mr.html).
6. The cable is lightly taped to the back of the head coil, taking care not to alter the positioning of the electrodes. This aims to ensure that the electrode cables do not get caught in the mechanisms of the bed as it moves to the scanner's isocentre (*Person 2 and 3*).
7. Move the participant to isocentre (*Person 3*).
8. Untape the electrode cables and connect them to the tDCS Inner-Box, which in our set-up is on the Foam-base. Ensure there are no loops in the cable (*Person* 2).

9. The electrode cable is then taped to the Foam-base to be kept as straight as possible and centred with respect to the bore throughout the experimental procedure (Figure 6).

3. fMRI experiment procedure

Participant monitoring

During the fMRI experiment, *Person 2* constantly ensures that the participant is comfortable and at ease. To achieve the latter – for the purposes of this specific study – the participant is being monitored by two Scan Room cameras (front and back) and via a pulse oximeter. Furthermore, the participant is in constant contact with *Person 2* through the optical FOMRI Microphone. However, the use of the microphone, cameras and the pulse oximeter are optional and not essential to conducting a tDCS-fMRI study.

tDCS set-up prior to scanning (Person 1)

1. Turn the Stimulator ON.
2. At this point the electrode cable and Inner-Box are fully connected; once more check the impedance is within the range specified (for our experiments we used a range of 10-20 kΩ), and consistent with the impedance level noted during the internal impedance check (the check in the Scan Room prior to positioning for MRI).
3. Close the lid of the RF Shielded box within the Control Room.

Delivering the stimulation

1. Remind the participant of the sensation they may feel during the fMRI run (*Person 2*).
2. Provide the participant with instructions regarding the experimental tasks they are to carry out as part of the fMRI experiment (*Person 2*).
3. Before each separate scanning run, check the participant is at ease and willing to continue.
4. When ready, indicate to *Person 3* the scanning run can start (*Person 2*).
5. The stimulation is triggered by a scanner pulse at a given slice in the acquisition sequence.
6. Monitor the impedance throughout the whole experiment (*Person 1*).
7. Note what the impedance level is during the stimulation period (*Person 1*).

MRI Quality Control (Person 3)

1. Never shim or run sequences while the tDCS box is open.
2. Regularly check images for RF interference, with particular focus on background noise levels, which should be stable over time and of significantly lower signal intensity than voxels within the head.

MRI Sequences

The specific absorption rate (SAR), characterising power deposition and the associated risk of RF-induced heating, should be minimised during scanning. Standard 2D-Echo Planar Imaging (EPI) sequences, as used in the present studies, generally result in low SAR levels. However, the technique of multiband/simultaneous multi-slice, which is increasingly popular, will increase the SAR level. To enable correction of image distortions caused by inhomogeneity in the main magnetic field (B_0), field mapping data are often acquired. The standard, Siemens-provided (gre_field_mapping_1acq_rl), field mapping sequence was modified to reduce SAR in these studies by decreasing the excitation flip angle (from 90^0 to 45^0) as a further risk mitigation step.

Performing a structural scan

The participant should be taken out of the bore first, and disconnected from the tDCS equipment as the structural MRI sequences may have high SAR levels and the tDCS equipment is not necessary.

1. Disconnect the electrode cable carefully from in the Inner-Box – prior to moving the participant from the isocentre (*Person 2*).
2. Move the participant slowly out of the bore (*Person 3*).
3. Allow them to sit up and remove the electrode cable.
4. The MR electrodes and bandage may remain on during the structural scan.
5. Reposition the participant and perform the structural scan.

Procedure end and equipment removal

Removing participant from the bore

1. Switch the DC-Stimulator to OFF.
2. Disconnect the electrode cable from the Inner-Box BEFORE moving participant out of the scanner (Person 2).
3. Move the participant slowly from the scanner *(Person 3).*
4. Remove the anterior element of the head coil carefully to avoid the electrodes getting caught.
5. Allow the participant to sit up, then remove the electrodes *(Person 2).*
6. Accompany the participant back to the Testing Room *(Person 2).*

Post-MRI (Person 2)

1. Ask the participant to rate the tDCS strength and report if they experienced any adverse sensations due to the tDCS stimulation. Importantly, from a research reproducibility perspective, with the equipment outlined in this protocol, sham conditions, where a few seconds of stimulation that does not change cortical excitability (Nitsche et al., 2008) but generates equivalent sensations for participants (itching, tingling etc.) can be achieved. This enables double blind experiments to be carried out.
2. Wash any paste from the electrodes and disinfect with appropriate wipes.

Post-MRI (Person 1)

1. Remove all equipment from the Scan Room and leave as found (reposition any equipment that was moved to facilitate the experiment).
2. Remove the electrode cable and Inner-Box from the bore, and store outside of the Scan Room in the manufacturers' storage case.
3. Remove the Foam-base and store securely in the Scan Room.
4. Remove the DC-Stimulator from the RF Shielded Box, and store together with the electrodes, electrode cable, and the Inner-Box outside of the Scan Room in the manufacturers' storage case.
5. Switch the Fibre-Optic Box off.
6. Close the RF Shielded box using lid (Figure 2).
7. Leave the Outer-Box and stimulator cable inside the waveguide at all times – DO NOT REMOVE when leaving. The Outer-Box should ALWAYS be positioned at the Control Room end of the waveguide.

Emergency Procedures

Considering the complexity of conducting a concurrent fMRI-tDCS study, the present protocol provides guidelines on how to safely remove a participant in case they feel unwell or choose to terminate the experiment. If this happens while the stimulation is being delivered, there are specific steps that should be taken to enable the safe removal of the participant from the scanner bore. To ensure the efficient removal of a participant in case of emergency, each person present will perform a separate duty. A minimum of three people is required for safety reasons, i.e. a radiographer plus two experienced researchers.

1. **Person 3 (radiographer)** stops the scanner.
2. **Person 2** informs the participant 'we are coming in'.
3. **Person 1** removes the lid from the RF Shielded Box and if tDCS is still being delivered stops the stimulation by using the 'Safe Stop Mode' feature of the NeuroConn DC stimulator (Figure 10), then switches the DC-Stimulator off. The DC-Stimulator should only be directly switched off if stimulation is not being delivered (i.e., already terminated) or in the (extremely unlikely) case that the 'Safe Stop Mode' fails.
4. **Person 2** goes directly to the back of the scanner ready to disconnect the electrodes.
5. **Person 3** goes into position to remove the participant from the scanner bore.
6. **Person 1** states loudly 'safe to disconnect' when the DC-Stimulator is off.
7. **Person 2** then disconnects the electrode cable and states 'safe to move bed' to the radiographer. The electrodes are not to be disconnected if current is still flowing as this may cause a strong stimulus to be delivered (cf. pages 14-15 and 106-108 of Neuro-Conn DC- stimulator MR Manufacturer's Manual).
8. **Person 3** then moves the bed and participant out.
9. In the unlikely event a **trolley evacuation** is deemed necessary, *Person 1 and 2* will disconnect the box cable from the Outer-Box and remove the box cable from the evacuation doorway. Then normal trolley emergency procedure is followed.

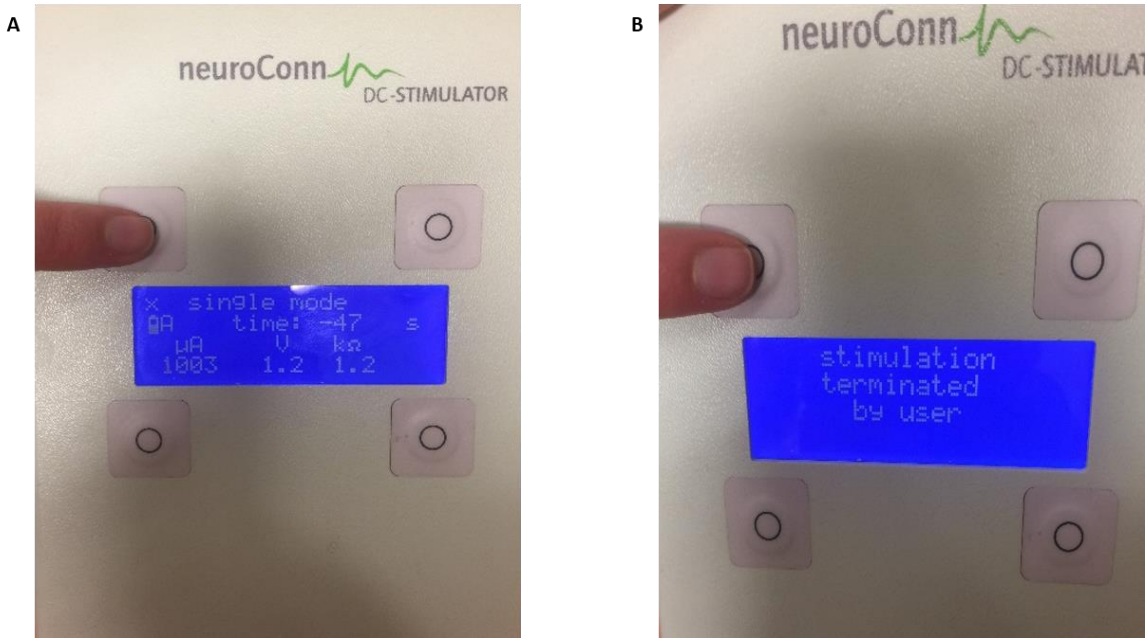

Figure 10 – **Safe Mode of tDCS.** (**A**) 'Safe Stop Mode' (i.e., top-left) button to stop the DC-Stimulator in case of an emergency; (**B**) message of successfully terminated stimulation.

THERE ARE NO FURTHER PROCEDURAL STEPS TO THIS DOCUMENT