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Study Protocol

Official Study Title:

Mind-body Awareness Training and Brain-computer Interface

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Title: Mind-Body Awareness Training and Brain-Computer Interface

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Purpose of the Study:

The general goal of the proposed research is to investigate whether and how experience with MBAT can improve subjects' ability to learn and use a sensorimotor-rhythm-based BCI. The specific aims of the proposed research are as follows: Aim 1: We will test whether MBAT training has significant impact on learning of BCI skills. We will study human subjects with various levels of MBAT experience and compare them with controls. Aim 2: We will use and further develop novel multimodal neuroimaging methods, along with extensive behavioral testing, to identify the neurocognitive components of MBAT that aid learning of BCI skills. Comprehensive analyses will combine imaging and neurocognitive results to identify brain regions responsible for the factors that produce improvement in BCI. The successful completion of the proposed research may allow MBAT training to become a best practice in BCI use, increasing BCI signal quality and reducing its training time. It will also better the understanding on how mind-body intervention works through innovative neuroimaging approaches. Understanding the neurocognitive basis of improvement may allow the production of enhanced training regimens, both with and without MBAT, including MBAT-like training specifically tailored to optimize BCI.

Study Procedures:

1 Sub-studies:

There are three primary planned substudies that combine different experimental conditions, populations, and measures.

Substudy 1 involves naïve subjects only, who will undergo baseline neurocognitive measures (NCM), brain computer interface (BCI), and (optionally) fMRI/EEG prior to an 8 week intervention of either 8 weeks of MBSR, or an 8 week waiting period followed by the option to attend an MBSR class after completion of the study. Subjects will be randomly assigned to MBSR, or waitlist control groups, with selection for balancing baseline BCI performance, NCMs, and/or other factors between groups.

Following intervention, subjects will undergo post-intervention NCM and (optionally) an fMRI/EEG session. BCI training will consist of one or more BCI sessions. Post-BCI NCM may also be included. The substudy will conclude either at the end of BCI training, after an optional post-BCI NCM session, or after a final optional fMRI/EEG session. Participants may be contacted about follow-up sessions as described in 12.

Substudy 2 involves subjects with at least 1 year or longer meditation/yoga experience. They will undergo a series of BCI sessions, NCM and (optionally) an fMRI/EEG session.

Substudy 3 involves exploration of brief 20-min meditation to assess its effect on BCI.

Depending on research goals and availability, subjects may also be asked to come in for NCM, fMRI/EEG, or BCI sessions during intervention weeks (i.e. interleaved with classes).

2 Screening Procedures

After a potential subject responds to recruitment notices by making initial email or phone contact with the investigator, an email or phone interview will be arranged to discuss the study and its associated risks and to complete the pre-screening form (a questionnaire including questions addressing most of the inclusion and exclusion criteria).

Subjects who are interested in participating and who are not excluded during pre-screening will be invited to visit the laboratory to have a more detailed discussion, complete the consent paperwork, and undergo the formal screening process. The completed screening form will be reviewed by the principal investigator, co-investigator, or trained research assistants to determine subject eligibility.

After consent and screening, initial experimental procedures may begin on the same day.

3 Surveys

Participants may be asked to complete brief surveys that provide subjective measures of cognitive factors such as stress or mindfulness.

4 EEG Capping

For any experimental sessions involving EEG, a cap covered in many EEG electrodes will be placed on the subject's scalp. They will be seated in a comfortable position. Conductive gel will be placed in each electrode to reduce electrical impedance and improve recording quality.

5 Neurocognitive Measures

To quantify aspects of cognition and brain function, subjects will participate in several short neurocognitive tasks. These will aim to quantify sustained attention, motor imagery ability, ERD/ERS generation, and other related factors. During these tasks, subjects may view visual stimuli on a computer screen, responding by pressing a key on a keyboard, interacting with simple objects (e.g. picking up a small rectangular prism with sensors to measure grasp force), or otherwise moving or imagining moving their body at specific time points. EEG may be recorded throughout the neurocognitive tasks.

6 BCI (Brain-computer interface)

In the sessions with BCI tasks, subjects will be wearing an EEG cap, and seated in front of a computer monitor. They will be asked to move or think about moving various body parts (e.g. clenching a fist) while viewing visual stimuli on a computer monitor. Visual stimuli may respond in real-time based on the recorded EEG signals.

Subjects may be asked to listen to some auditory stimuli, presented through speakers or headphones at a comfortable volume, prior to performing BCI. These audio recordings could include guided meditation, or a control condition such as a passage read aloud from a book.

7 MRI/fMRI with (optional) EEG

Only the participants that are eligible to undergo MRI scanning and interested in participating in the optional MRI/fMRI with (optional) EEG experiments will undergo the following procedures. Before each MRI experiment, subjects will be asked to complete a subject safety screening form. Subjects will be asked to change into scrubs or gowns prior to being scanned to minimize the risk of injury due to MRI-incompatible clothing.

In fMRI alone experiments, subjects will be instructed to lie in an MRI scanner quietly. The subject may be asked to perform certain movement or cognitive tasks. The structural MRI images will also be acquired from the subjects while they are in the MRI scanner.

If subjects feel uncomfortable at any point during the recording, we will act immediately to either adjust the stimulation setting or terminate the experiment depending on the subjects' request. Furthermore, subjects will hold an emergency squeeze ball during the experiments, and they can abort the stimulation immediately if they have difficulty in communicating with the investigators during the recording.

8 MBSR

Mind-body stress reduction (MBSR) is a standardized 8-week group-based program designed to reduce stress and manage difficult emotions through training in mindfulness. Mindfulness in MBSR refers to a particular type of attention focused on the present moment, nonjudgmental awareness, and acceptance. We will recruit subjects who attend the MBSR training at the University of Pittsburgh Medical Center's Center for Integrative Medicine (UPMC-CIM). Classes will be taught at either the UPMC Herberman Conference Center at UPMC Shadyside (5230 Centre Ave. Pittsburgh, PA) or the UPMC-CIM (580 S. Aiken Ave, suite 310, Pittsburgh, PA), based on classroom availability. To encourage practice, we will telephone subjects weekly, to identify obstacles to practice. Subjects will be dropped from the study if their class attendance falls below 80%. A calendar/diary will be provided to help participants track their practice time. Participants may be requested to attend an orientation session before the class.

9 Yoga Nidra

Yoga Nidra will be explored as a form of mind-body awareness training with a less rigidly defined curriculum than MBSR. Classes will be taught by a certified Yoga instructor at the locations described for MBSR above. Participants will be asked to attend four 1 hour classes per week for 6-8 weeks. Similar to the MBSR intervention, subject participation will be monitored with weekly telephone check-ins and class attendance. The same drop criteria as specified above for MBSR will be employed for the Yoga Nidra study.

10 Mindful Living: an Introduction to Meditation and Mindfulness

Students will engage in a study of meditation and mindfulness from both practical and theoretical perspectives. Coursework will be evidence based with a focus on inquiry and constructive learning. Attention will be given to the greater historic and cultural context of meditation, critical perspectives on modern secular mindfulness in the west and reviewing the efficacy of the research available, and application of mental and somatic practices. Special focus will be presented towards understanding stress and the management of it. Students will be expected to develop a daily home practice of meditation and mindful somatic work. There is no prerequisite of previous meditation experience, though an interest in the topic will support development within the coursework.

11 Waitlist Control Intervention

Waitlist control conditions are often employed in studies using MBSR as an active intervention. Offering a free MBSR course to control participants would increase the incentive to continue participation in the study. The free MBSR course would only be offered to participants who complete BCI training.

12 Subject Compensation

The interventions (MBSR, Yoga Nidra) will be reimbursed upon completion of the study; no additional compensation will be provided for the classes. Subjects will be compensated $15/hour for time spent participating in non-MRI experiments in the lab. Subjects will be compensated $20/hour for time spent during MRI sessions. Subjects may receive a ticket to validate the cost of parking during each in-lab experiment. Monetary compensation will be in the

form of a check or cash. compensation will be provided either directly to the subject after each experimental session, or mailed to the subject later.

13 Optional Follow-up

After the completion of the BCI training, participants may be asked to participate in follow-up sessions and surveys. Follow-up sessions could include one or more of the above listed experiments. A typical follow up series may be 1-3 BCI training sessions 3 months after the completion of the initial BCI training. Participants will be asked whether we may contact them after the completion of the BCI training.

14 Analysis of de-identified data

Data collected from collaborators in the field may be analyzed in order to explain fundamental processes involved in mind body awareness training, brain computer interface, and their interaction. All data will be stripped of any identifiable information before transfer to Carnegie Mellon University. Analysis of the de-identified data will be conducted at CMU and the information gleaned may be integrated with the data collected at CMU.

Participant Information:

Age range: 18-64 years old, inclusive

Inclusion and Exclusion Criteria:

Inclusion criteria for all subjects will be:

- Apparently healthy volunteers
- Age 18-64, inclusive.
- Willing and able to provide written consent.
- Able to communicate in the English language.

Exclusion criteria for all subjects will be:

- Any past BCI experience.
- Pregnancy
- Any breathing, movement, or visual disorders.
- Any active neurological or mental disorders.
- History of epilepsy.
- History of a vascular or cardiac disorder (e.g. heart disease)
- History of a metabolic disorder (e.g. diabetes)
- Any other condition which would make the subject, in the opinion of the investigator, unsuitable for the study.

Exclusion criteria that would prevent subjects from participating in the optional MRI component will be:

- Any MRI incompatible indwelling metal objects or implantable devices, including but not limited to the following (dental mental is allowable):
    - Cardiac pacemaker
    - Implanted cardiac defibrillator
    - Carotid artery vascular clamp
    - Intravascular stents, filters, or coils
    - Aortic clip
    - Internal pacing wires
    - Vascular access port and/or catheter

    - Swan-Ganz catheter
    - Shunt (spinal or intraventricular)
    - Aneurysm clip(s)
    - Neurostimulator
    - Electrodes (on body, head, or brain)
    - Heart valve prosthesis
    - Any type of prosthesis (eye, penile, etc.)
    - Artificial limb or joint replacement
    - Bone growth/fusion stimulator
    - Bone/joint pin, screw, nail, wire, plate
    - Metal rods in bones
    - Harrington rods (spine)
    - Metal or wire mesh implants
    - Wire sutures or surgical staples
    - Insulin pump or infusion device
    - Any metal fragments (i.e. metal shop)
    - Any implant held in place by a magnet
    - Cochlear, otologic, or ear implant
- Claustrophobia
- Hearing aid use

The proposed subject population does not include non-English speakers, as there is no direct benefit to participation. The proposed subject population is expected to include all socioeconomic levels, both genders, and minority groups. Subjects in later recruiting stages may be selected based on matching baseline BCI performance, age, gender, and/or education levels to existing subjects to minimize bias between groups.

Several groups of subjects will be recruited for different substudies: subjects naïve to both BCI and MBAT, subjects with recent MBSR training, and long-term meditators.

Subjects (N=180) naïve to both BCI and MBAT will be recruited with study advertisements posted on the Carnegie Mellon University campus. Subjects in this group will be excluded for significant past yoga or meditation experience, with specific exclusion criteria defined as:

- Any yoga/meditation in the last three months.
- More than 12 yoga/meditation classes in the last 12 months.
- Approximately weekly yoga/meditation for a year or more at any point in the past.

Subjects (N=45) having undergone MBSR training in the last 12 months will be recruited from the University of Pittsburgh Medical Center's Center for Integrative Medicine (UPMC-CIM). Inclusion criteria for this group will require having completed one 8 week MBSR course in the last 12 months.

Subjects (N=45) with long-term meditation experience will be recruited from the UPMC-CIM and local Yoga studios. Inclusion criteria for this group will require self-reported meditation/yoga practice for at least one year, at least 2 times week, for at least 1 hour each.

Risks and Benefits:

Benefits:

No direct benefits to the subjects are anticipated. This exploratory research may lead to societal benefits in the form of future advances in BCI training that aid in providing alternate methods for communication and rehabilitation for individuals suffering from neurological disorders and injuries.

Potential risks:

There are no significant risks reasonably expected in this study.

1. Risks of Collecting Personal Information

The primary risk of collecting personal information is a breach of confidentiality of such personal information about the subject.

2. Risks of MRI

The risks of 3T MRI include the potential dislodging of any indwelling metals (stents, joint implants that are not titanium, wire sutures, aneurysm clips, shrapnel, etc.), disrupting indwelling medical devices (cardiac pacemakers, medication pumps, heart valve replacements, etc.), the risk of metal projectiles (coins, keys, hairpins, oxygen cylinders, etc.) inadvertently presented during the MRI scan, and the unknown effects of MRI on the unborn fetus. The noise inside the magnet is loud and can mildly disturb subject's hearing temporarily. Transient dizziness is sometimes reported by subjects upon removal from the magnet. Strong claustrophobia is a contraindication.

3. Risks of EEG/EMG/ECG

There is a minor risk that subjects may feel slight discomfort while wearing the EEG cap (similar to wearing a tight hat). Minor discomfort may be felt from removal of medical tape or adhesive used to attach EMG/ECG electrodes.

4. Risks of breach of confidentiality

There is a potential for breach of confidentiality, however every attempt will be made to minimize these risks.

How potential risks will be managed or minimized?

1. Minimizing Risks of Collecting Personal Information

Subjects will be asked for only personal information relevant to the study. Only the principal investigator and research associates/assistants under his direct supervision working on the project will have access to identifying information. Subjects will be assigned codes that will be used during all data analysis. The file containing study ID codes and identifying information for all subjects in the study will be encrypted on a computer in a locked room. Subject names or other directly identifiable information will not appear on any reports, publications, or other disclosures of study outcomes. Any information that is included in published manuscripts will not be linked to any other information that would identify the subject.

2. Steps to Minimize Risks of MRI

In the MRI screening process, we will ask subjects if they have any medical conditions and if they are taking any medications. This is important to know so that only those subjects who meet the inclusion and exclusion criteria are accepted into the study. Subjects will also be screened for previous surgeries that might include noncompatible metal (nonferrous metals are compatible), indwelling medical devices, etc. Those who report having devices or noncompatible metals will be excluded. Females who have any reason to believe that they are pregnant will be

excluded from the study. Claustrophobia will be screened for in advance. Subjects will wear earplugs and headphones during the MRI to protect against excessive noise.

There is also a risk of heating or dislodgement of any metal objects. Therefore, subjects will be asked to remove all jewelry and piercings and female subjects will be encouraged not to wear an underwire bra during the scanning session. If the subject wears eyeglasses, they will take those off and will use non-metallic glasses matching their prescription, taken from a set of such glasses used by our laboratory for MRI studies.

At the completion of the MRI session, we will manage the potential dizziness in subjects by having them remain seated for one or two minutes and then walk them to the waiting area carefully. Subjects will not be dismissed until dizziness has subsided. In the experience of the study's investigators, recovery from light-headedness has never taken more than just a few minutes.

3. Steps to Minimize Risks of EEG

Appropriate size of caps will be used and fine adjustments will be made to minimize the potential discomfort from wearing the EEG cap as much as possible.

4. Steps to minimize Risks of breach of confidentiality

Subjects will be asked for only personal information relevant to the study. Only the principal investigator and research associates/assistants under his direct supervision working on the project will have access to identifying information. Subjects will be assigned codes that will be used during all data analysis. The file containing study ID codes and identifying information for all subjects in the study will be encrypted on a computer in a locked room. Subject names or other directly identifiable information will not appear on any reports, publications, or other disclosures of study outcomes. Any information that is included in published manuscripts will not be linked to any other information that would identify the subject.

Collaborating Investigators:

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