PSYC 592-004 – Human Brain Stimulation

Fridays, 10:30am – 1:10pm.

Instructor

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Office Location

David King Hall, Room 2055

Office Hours

By appointment

Grade Criteria

Grade	Percent
A	90-100%
B	80-89.9%
C	70-79.9%
D	60-69.9%
F	Below 60%

Course Overview

For almost as long as modern science has been around, humans have been trying to devise methods to stimulate their brains, beyond the senses that nature provides. This course will be focused on an overview of these methods, their strengths, and shortcomings. We will focus here specifically on non-invasive methods, eschewing the ones that require opening of the skull (deep brain stimulation, microstimulation, etc.). By the time this course is over, you will understand and have some experience with various methods used by neuroscientists, and further be able to critically evaluate if a study's claims are correct.

Evaluation Criteria

Paper Reviews (30%): The content of this course will primarily focus on discussion. The initial run of classes will consist of plenary lectures on various stimulation methods. Once these lectures are over, we will switch to a seminar style, in which we will review brain stimulation papers every week. Two papers will be assigned each week, available on Blackboard. You are required to read both papers, pick one, and write a review/critique of that paper on Blackboard. **Reviews must be posted by 7pm on Thursday evening**. These reviews will contribute to your grade for the course.

Paper Presentations (30%): Once the paper reviews begin, one of you will give a presentation each week on one of the papers* (two presentations per class). The presentation should take the form of a powerpoint lecture, in which you discuss the background of the paper, the methods, results, and conclusions, along with your commentary. You will be able to sign up for your **two papers** on the first day of class or any day thereafter. The format of the discussion will take the place of a journal club, and so all students are expected to participate in the discussion. In-class participation is part of your grade (10%).

*If you do not see any papers that are of interest to you, you are free to suggest an alternate paper if you have one in mind. You must speak with me to propose your alternate paper.

Proposal Paper (30%): There is no final exam for this course. Instead, you will be required to write a paper to be turned in by December 19th. The paper will take the form of an experiment proposal, in which you will propose to run a brain stimulation study, using any of the methods discussed in class. The topic of the paper is entirely up to you, but you will be required to write an introduction, methods, expected results, and brief discussion section, with a bibliography. The page limit is 10 pages (not including bibliography).

General Policy

Honor Code: George Mason University has an Honor Code, which requires all members of this community to maintain the highest standards of academic honesty and integrity. Cheating, plagiarism, lying, and stealing are all prohibited. All violations of the Honor Code will be reported to the Honor Committee. See honorcode.gmu.edu for detailed

information.

Plagiarism is the unacknowledged use of another person's labor, another person's ideas, another person's words, or another person's assistance. Unless otherwise stated in class, all work done for courses -- papers, examinations, homework exercises, laboratory reports, oral presentations -- is expected to be the individual effort of the student presenting the work. Any assistance must be reported to the instructor. If the work has entailed consulting other resources -- journals, books, or other media -- these resources must be cited in a manner appropriate to the course. Everything used from other sources -- suggestions for organization of ideas, ideas themselves, or actual language -- must be cited. Failure to cite borrowed material constitutes plagiarism. Undocumented use of materials from the World Wide Web is plagiarism. If you are caught plagiarizing or cheating, you will be referred to the honor committee and, if found guilty, will fail the assignment, and, depending upon the severity of the violation, you may fail the class.

Disability Statement: If you are a student with a disability and you need academic accommodations, please see me and contact the Disability Resource Services (DRS) at 703-993-2474. All academic accommodations must be arranged through that office. Please see me as soon as possible about this, as I will not adjust grades for exams after they have been given.

Make-up policy: Make-up exams will only be given if exceptional circumstances are claimed AND substantiated. I must see proof of what you are claiming to verify that it is true.

Add/Drop Deadlines: Please note that the *last day to add classes* is **August 31st**. The last day to drop a course *with no tuition penalty* is also **September 8th**. The last day to drop *with a 50% tuition penalty* is **September 15th**. The final day to *drop with a 100% tuition penalty* is **September 28th**.

Official Communications via GMU E-mail: Mason uses electronic mail to provide official information to students. Examples include communications from course instructors, notices from the library, notices about academic standing, financial aid information, class materials, assignments, questions, and instructor feedback. Students are responsible for the content of university communication sent to their Mason e-mail account and are required to activate that account and check it regularly. If class has to be canceled, you will be informed via e-mail. Information will be provided in the e-mail about making up the missed class.

Technology: For this class, you will be asked to give presentations. This will require that you have access to a computer with some type of presentation software (PowerPoint, Keynote, etc.). For all class communications, we will be using the application Zoom (http://www.zoom.us/). To aid in the synchronous learning environment for class, we will also be using the application Slack (https://slack.com/) for all communication within and between classes. Slack is an application that can be run within a browser window, as a stand-alone application, or on your phone (not recommended for this class). It is recommended that you have both Slack and Zoom open while the class is going on.

Course Schedule:

Date	Lecture topics/Activities
8/28	Introduction to Course and Brain Stimulation Methods
9/4	Transcranial Magnetic Stimulation
9/11	Transcranial Electrical Stimulation
9/18	Seminar Begins

12/15	Papers Due

Course Readings

Introduction to Course (8/28)

Parkin, B. L., Ekhtiari, H., & Walsh, V. F. (2015). Non-invasive human brain stimulation in cognitive neuroscience: a primer. *Neuron*, *87*(5), 932-945.

Bergmann, T. O., & Hartwigsen, G. (2020). Inferring Causality from Noninvasive Brain Stimulation in Cognitive Neuroscience. *Journal of Cognitive Neuroscience*, 1-29.

Polania, R., Nitsche, M. A., & Ruff, C. C. (2018). Studying and modifying brain function with non-invasive brain stimulation. *Nature neuroscience*, 21(2), 174-187.

Transcranial Magnetic Stimulation (9/4)

Walsh, V., & Cowey, A. (2000). Transcranial magnetic stimulation and cognitive neuroscience. *Nature Reviews Neuroscience*, *1*(1), 73-80.

De Graaf, T. A., & Sack, A. T. (2011). Null results in TMS: from absence of evidence to evidence of absence. *Neuroscience & Biobehavioral Reviews*, *35*(3), 871-877.

Silvanto, J., Muggleton, N., & Walsh, V. (2008). State-dependency in brain stimulation studies of perception and cognition. *Trends in cognitive sciences*, *12*(12), 447-454.

Fox, M. D., Halko, M. A., Eldaief, M. C., & Pascual-Leone, A. (2012). Measuring and manipulating brain connectivity with resting state functional connectivity magnetic resonance imaging (fcMRI) and transcranial magnetic stimulation (TMS). *Neuroimage*, *62*(4), 2232-2243.

Transcranial Electrical Stimulation (9/11)

Nitsche, M. A., Cohen, L. G., Wassermann, E. M., Priori, A., Lang, N., Antal, A., ... & Pascual-Leone, A. (2008). Transcranial direct current stimulation: state of the art 2008. *Brain stimulation*, *1*(3), 206-223.

Herrmann, C. S., Rach, S., Neuling, T., & Strüber, D. (2013). Transcranial alternating current stimulation: a review of the underlying mechanisms and modulation of cognitive processes. *Frontiers in human neuroscience*, *7*.

Horvath, J. C., Carter, O., & Forte, J. D. (2014). Transcranial direct current stimulation: five important issues we aren't discussing (but probably should be). *Frontiers in systems neuroscience*, *8*, 2.

Horvath, J. C., Forte, J. D., & Carter, O. (2015). Quantitative review finds no evidence of cognitive effects in healthy populations from single-session transcranial direct current stimulation (tDCS). *Brain stimulation*, *8*(3), 535-550.

9/18 Readings – "Classic" TMS Effects

Pascual-Leone, A., & Walsh, V. (2001). Fast backprojections from the motion to the primary visual area necessary for visual awareness. *Science*, *292*(5516), 510-512.

Huang, Y. Z., Edwards, M. J., Rounis, E., Bhatia, K. P., & Rothwell, J. C. (2005). Theta burst stimulation of the human motor cortex. *Neuron*, *45*(2), 201-206.

9/25 Readings – "Classic" tES Effects

Nitsche, M. A., Schauenburg, A., Lang, N., Liebetanz, D., Exner, C., Paulus, W., & Tergau, F. (2003). Facilitation of implicit motor learning by weak transcranial direct current stimulation of the primary motor cortex in the human. *Journal of cognitive neuroscience*, *15*(4), 619-626.

Kanai, R., Chaieb, L., Antal, A., Walsh, V., & Paulus, W. (2008). Frequency-dependent electrical stimulation of the visual cortex. *Current Biology*, *18*(23), 1839-1843.

*Kar, K., & Krekelberg, B. (2012). Transcranial electrical stimulation over visual cortex evokes phosphenes with a retinal origin. *Journal of neurophysiology*, *108*(8), 2173-2178.

10/02 Readings – TMS/tES Mechanisms

Allen, E. A., Pasley, B. N., Duong, T., & Freeman, R. D. (2007). Transcranial magnetic stimulation elicits coupled neural and hemodynamic consequences. *Science*, *317*(5846), 1918-1921.

Vöröslakos, M., Takeuchi, Y., Brinyiczki, K., Zombori, T., Oliva, A., Fernández-Ruiz, A., ... & Berényi, A. (2018). Direct effects of transcranial electric stimulation on brain circuits in rats and humans. *Nature communications*, 9(1), 1-17.

Asamoah, B., Khatoun, A., & Mc Laughlin, M. (2019). tACS motor system effects can be caused by transcutaneous stimulation of peripheral nerves. *Nature communications*, 10(1), 1-16.

10/09 Readings – "Newer" tES Effects

Fertonani, A., Pirulli, C., & Miniussi, C. (2011). Random noise stimulation improves neuroplasticity in perceptual learning. *The Journal of Neuroscience*, *31*(43), 15416-15423.

Cappelletti, M., Gessaroli, E., Hithersay, R., Mitolo, M., Didino, D., Kanai, R., ... & Walsh, V. (2013). Transfer of cognitive training across magnitude dimensions achieved with concurrent brain stimulation of the parietal lobe. *The Journal of neuroscience*, *33*(37), 14899-14907.

10/16 Readings – fMRI-Guided Stimulation

Feredoes, E., Tononi, G., & Postle, B. R. (2007). The neural bases of the short-term storage of verbal information are anatomically variable across individuals. *The Journal of Neuroscience*, *27*(41), 11003-11008.

Sack, A. T., Kadosh, R. C., Schuhmann, T., Moerel, M., Walsh, V., & Goebel, R. (2009). Optimizing functional accuracy of TMS in cognitive studies: a comparison of methods. *Journal of Cognitive Neuroscience*, *21*(2), 207-221.

10/23 Readings – "Weird" Techniques

Legon, W., Sato, T. F., Opitz, A., Mueller, J., Barbour, A., Williams, A., & Tyler, W. J. (2014). Transcranial focused ultrasound modulates the activity of primary somatosensory cortex in humans. *Nature neuroscience*, *17*(2), 322-329.

Gonzalez-Rosa, J. J., Soto-Leon, V., Real, P., Carrasco-Lopez, C., Foffani, G., Strange, B. A., & Oliviero, A. (2015). Static magnetic field stimulation over the visual cortex increases alpha oscillations and slows visual search in humans. *The Journal of Neuroscience*, *35*(24), 9182-9193.

*Rohan, M., Parow, A., Stoll, A. L., Demopulos, C., Friedman, S., Dager, S., ... & Renshaw, P. F. (2004). Low-field magnetic stimulation in bipolar depression using an MRI-based stimulator. *American Journal of Psychiatry*, *161*(1), 93-98.

10/30 Readings – Rhythmic TMS

Chanes, L., Quentin, R., Tallon-Baudry, C., & Valero-Cabré, A. (2013). Causal frequency-specific contributions of frontal spatiotemporal patterns induced by non-invasive neurostimulation to human visual performance. *The Journal of Neuroscience*, *33*(11), 5000-5005.

Thut, G., Veniero, D., Romei, V., Miniussi, C., Schyns, P., & Gross, J. (2011). Rhythmic TMS causes local entrainment of natural oscillatory signatures. *Current biology*, *21*(14), 1176-1185.

11/06 Readings – State Dependent TMS

Perini, F., Cattaneo, L., Carrasco, M., & Schwarzbach, J. V. (2012). Occipital transcranial magnetic stimulation has an activity-dependent suppressive effect. *The Journal of Neuroscience*, *32*(36), 12361-12365.

Schwarzkopf, D. S., Silvanto, J., & Rees, G. (2011). Stochastic resonance effects reveal the neural mechanisms of transcranial magnetic stimulation. *The Journal of neuroscience*, *31*(9), 3143-3147.

11/13 Readings - TMS-EEG

Morishima, Y., Akaishi, R., Yamada, Y., Okuda, J., Toma, K., & Sakai, K. (2009). Task-specific signal transmission from prefrontal cortex in visual selective attention. *Nature neuroscience*, *12*(1), 85-91.

Taylor, P. C., Nobre, A. C., & Rushworth, M. F. (2007). FEF TMS affects visual cortical activity. *Cerebral Cortex*, *17*(2), 391-399.

11/20 Readings - TMS-Connectivity

Wang, J. X., Rogers, L. M., Gross, E. Z., Ryals, A. J., Dokucu, M. E., Brandstatt, K. L., ... & Voss, J. L. (2014). Targeted enhancement of cortical-hippocampal brain networks and associative memory. *Science*, *345*(6200), 1054-1057.

Koch, G., Cercignani, M., Bonnì, S., Giacobbe, V., Bucchi, G., Versace, V., ... & Bozzali, M. (2011). Asymmetry of parietal interhemispheric connections in humans. *The Journal of Neuroscience*, *31*(24), 8967-8975.

<u>12/4 Readings – "New Tricks"</u>

Brittain, J. S., Probert-Smith, P., Aziz, T. Z., & Brown, P. (2013). Tremor suppression by rhythmic transcranial current stimulation. *Current Biology*, *23*(5), 436-440.

Klein-Flügge, M. C., Nobbs, D., Pitcher, J. B., & Bestmann, S. (2013). Variability of human corticospinal excitability tracks the state of action preparation. *The Journal of Neuroscience*, *33*(13), 5564-5572.

*Sun, L., Peräkylä, J., Kovalainen, A., Ogawa, K. H., Karhunen, P. J., & Hartikainen, K. M. (2016). Human brain reacts to transcranial extraocular light. PloS one, 11(2), e0149525.