I AM. – Harnessing the Power of Affirmation
(Technical Paper)

Electricity – The Solution to the Mental Health Crisis and the Future of Medicine
(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By
Pierson Shamaiengar

October 27, 2022

Technical Team Members:

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Rosanne Vrugtman, PhD

Bryn E. Seabrook, PhD, Department of Engineering and Society

Introduction

The answer to the mental health epidemic in the United States isn't drugs, its electricity. For more than a century, alternative medical treatments that focused on the electrical component of human biology rather than the chemical component have shown great promise in curing a variety of human ailments, but very few of them are known to the public today. The world's pharmaceutical industry is worth $1.42 trillion dollars as of 2021 and U.S, healthcare spending alone surpassed $4.1 trillion in 2020, but is all of that money providing the best possible care (Mikulic, 2022; *National Health Expenditure Data, 2022*)? New treatments are being developed that a safer, cheaper, and sometimes more effective than what is easily available on the market today. One of these promising new alternatives is transcranial magnetic stimulation (TMS) which has had significant success in treating drug-resistant depression with very few adverse side effects (Mayo Foundation for Medical Education and Research, 2018). If this treatment, and others like it, were made more widely available it would allow for a significant reduction in depressive mental health disorders and pave the way for the developments of similar technology in all areas of medicine.

One of the great boons that evolved out of the rapid expansion in popularity for mindfulness and related mediative activities in the United States is the ability for the layman to cope with life changes and stress in novel ways – at least to the western world. Perhaps the most well-known of these is mediation, whose use more than tripled within US adults from 2012 to 2017 alone, but many more of these practices have surfaced including one with significant potential to help students (Clarke et al., 2018). Research from Carnegie Melon has shown that proper use of self-affirmations can improve problem solving performance and protect against the

performance effects of stress (CMU, 2013). This project will explore an application to help every student reap the benefits of positive affirmation.

Technical

The core question is how can simple technology be implemented to improve the performance and alleviate some of the stresses that exist in the modern classroom? For this project, one of the answers is positive self-affirmation. Research has shown that this practice boosts one's psychological resources for coping with threats and stress as well as directly improving problem solving skills of over-stressed individuals. These finding are especially pertinent for women in STEM and related fields where they may be under stereotype threats. In studies, women performed worse on difficult assessments that were categorized as determining math intelligence or when they were directly told that women are inferior at the particular task. However, the group of women that self-affirmed before the tests had improved performance even while under such a threat (Martens, Johns, Greenberg, & Schimel, 2005). Whether the goal is to overcome excessive levels of stress to improve performance or to level the playing field in stereotyped areas, it is clear that self-affirmation can have a positive impact on student performance.

The crucial assumption for this application is that teachers want to improve student performance and student lives and are lacking in simple, accessible ways accomplish this goal. So, the first of two primary features is the delivery of the affirmations to students before examinations. Teachers will be able to register their classes, invite students, and provide the dates and times for key assessments within their course curricula. Using this information, the app will deliver to each student, either through text or notification, an opportunity for affirmation at a set time before the beginning of the examination.

The second feature set for this application comes from a body of research relating to optimal student performance based on affective state. Even in a world with greatly facilitated communication, many teachers are not aware of the moods of individual students and their classes as a whole. This leaves gaps in an educator's ability to adjust their classroom activity to create moods that are more conducive to learning than others. Studies have also shown that the emotional climate within the classroom has significant impact on student motivation and performance (Reyes et al., 2012). To solve these issues, the application will work as a mood tracker for the class. Implementation of this can vary by teacher, with the option to track mood weekly, by class, or by assignment. It will also provide a complementary post-examination mood evaluation to follow the affirmations that were given beforehand. With the goal of simplicity, these mood evaluations will only ask students to rate how they are feeling out of a selection of mood options. The app will then aggregate all of this data and allow the teacher to have a clear understanding of how the assignments and material are affecting the students over the course of the class. The ultimate goal is that this information can be used by educators to create ideal emotional learning environments and course correct quickly when students' moods fall below optimal learning levels (Creswell et al., 2013).

STS Topic

Is electricity the future of medicine? The answer to that question may have more to do with money than it has to do with science, but current breakthroughs in bioelectronics and electroceuticals are laying the ground work for that future. The goal of this paper is to examine these technologies and understand where progress is being made and which diseases or conditions currently have solutions with strong scientific support. The hope is that this

investigation will bring more attention to a lesser-known facet of medical treatment, inform readers who may not be aware of these treatments, and spur continued research in this field.

Perhaps the most well-known in this class of medical techniques are those used for depression, specifically electroconvulsive therapy (ECT) and TMS. ECT, which has been in use since 1938, is still one of the most effective treatments available with approximately 80% of patients showing substantial improvements (*What is electroconvulsive therapy, 2019*). In a meta-analytic review against traditional methods ECT was superior in every comparison: against simulated ECT, against placebo, and against three different classes of antidepressants (Pagnin et al., 2004). TMS, comparatively, is a second method of treating patients that have been nonresponsive to drug therapy but uses magnetic pulses as opposed to electric currents (Mayo Foundation for Medical Education and Research, 2022). This key difference allows TMS to be a noninvasive outpatient procedure where each visit lasts less than an hour and results in virtually zero serious negative side effects (risk of seizure less than 0.01%) (*TMS (transcranial magnetic stimulation): What it is, 2022*). Despite this low risk, the potential benefits are still remarkably high. The efficacy of TMS has been consistently proven to help up to 60% of difficult-to-treat patients and provide remission to 33% (Stern, 2020). Given these benefits and minimal side effects, one might question why it isn't a standard first treatment for individuals suffering from depression. The answer is largely financial. Although it is now covered by most of the major insurance companies, to qualify for the treatment a diagnosed patient must have tried and failed at least two depression medications and experienced no significant improvement in talk therapy (Bermudes, 2021). This is one of the ways the drug and insurance industries have kept it from replacing many anti-depression medications that are currently used.

ECT and TMS are not the only therapies currently out there, however, and depression not the only condition being remedied by electric devices. In the 1980's, neurosurgeon Kevin Tracey led a team of researchers at Weill Cornell Medical Center that discovered the inflammation producing molecule Tumor Necrosis Factor (TNF), which can lead to death if overproduced (*Kevin J. Tracey, MD.*, 2021). This finding led to the development of monoclonal anti-TNF, a drug used to halt the production of TNF in the body which has been used successfully on a variety of inflammatory conditions. However, Tracey would later discover that electrical stimulation to the vagus nerve, which plays an important role in TNF production, stopped the creation of the molecule faster and more precisely than the drug that had been developed (Fox, 2017). He would go on to found Setpoint Medical Corporation which develops devices for this purpose (Balch, 2022).

Tracey's work on TNF is but one of numerous examples where new advances in bioelectric medicine are outperforming their pharmaceutical counterparts. In fact, his research is not even the only modern use of vagus nerve stimulation (VNS), nor the only device the implements it. VNS has been studied for over 20 years in the treatment of numerous health complications including autoimmune disorders, sepsis, and epilepsy – for which studies have found that after 2 years, 50% of patients experience more than 50% reduced seizure frequency with only rare adverse side effects (González, Yengo-Kahn, & Englot, 2019). Similar treatments are also being studied in patients with post-traumatic stress disorder and, more recently, long COVID-19 (Lamb, Porges, Lewis, & Williamson, 2017; *Pilot study suggests long covid could be linked to the effects of SARS-COV-2 on the vagus nerve, 2022*).

This paper will analyze these various technologies, devices, and the general concept of electricity as medicine through the lens of technological momentum. This theory is a synthesis of technological determinism and social construction which posits that social development both shapes and is shaped by technology. It also takes in to account the crucial role that time plays in the evolution and impact of technologies. This is pertinent because the theories behind ECT and VNS, for example, have been around for a century or more but only recently have these entered the purview of mainstream medical practice. This has been enabled by more recent advancements in research and technology that have also resulted in a change of public perception. Further, many people in today's society are looking for solutions to depression and other conditions that are safe and effective but don't require long term drug use. As a result, these alternative therapies have become increasingly successful, well regarded, and paved the way for bioelectric applications in variety of medical areas.

Research Question and Methods

Research Question: Do bioelectric medical solutions offer treatments that are more effective, safer, or cheaper than traditional treatment options and for which ailments are they available.

To answer this question the primary research methods that will be employed are documentary analysis and discourse analysis. The former involves a study of primary sources which, in this case, will consist largely of collecting data and evidence from medical journals and studies that have evaluated these treatments. This is necessary because, to understand the efficacy of alternative treatment methods, they must be scientifically verifiable and accessing these sources will be the only way to definitively assess that and compare them to current treatments. The second method, discourse analysis, is similar to the previous but will gather evidence from more diverse sources to understand the whole of the dialog surrounding the

question. This is important because not all of the treatments in this category have been rigorously studied yet. Nonetheless, a large volume of anecdotal evidence supports and opposes a variety of these technologies and any attempt to forecast the future of medicine in this up-and-coming area needs to consider even those options for which research has not been published.

Conclusion

This paper investigates the possibilities of alternative medical treatments for a variety of diseases and ailments. It looks at the inception of electrically based healing and the various medical technologies that have been created in this field in the past century. In particular, it examines TMS and its effectiveness and risks compared to drug treatments. And lastly, it explores new potential technologies and the diseases that could be treated with similar technologies if more research was carried out in this field.

The technical portion of this paper explores the development of an educational application that empowers students and teachers to improve the learning experience in the classroom. It analyzes research on the type of affirmations and mindful activities to best understand how easily-performed practices can have an impact on performance and the ability to cope with stress and stereotype threats. Further, it looks at the benefits of teacher awareness of the student mood to be able to optimize the learning environment. Finally, it provides a simple interface for fulfilling both of these goals.

References

Mikulic, M. (n.d.). *Topic: Global Pharmaceutical Industry*. Statista. Retrieved November 11, 2022, from https://www.statista.com/topics/1764/global-pharmaceutical-industry/#topicOverview

National Health Expenditure Data. CMS. (n.d.). Retrieved November 11, 2022, from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData

Mayo Foundation for Medical Education and Research. (2018, November 27). *Transcranial magnetic stimulation*. Mayo Clinic. Retrieved November 11, 2022, from https://www.mayoclinic.org/tests-procedures/transcranial-magnetic-stimulation/about/pac-20384625

Clarke, T. C., Barnes, P. M., Black, L. I., Stussman, B. J., & Nahin, R. L. (2018). Use of Yoga, Meditation, and Chiropractors Among U.S. Adults Aged 18 and Over. *NCHS data brief,* (325), 1–8.

(CMU), C. M. U. (n.d.). *Benefits of self-affirmation*. CMU. Retrieved November 11, 2022, from https://www.cmu.edu/homepage/health/2013/summer/benefits-of-self-affirmation.shtml

Martens, A., Johns, M., Greenberg, J., & Schimel, J. (2005, July 7). *Combating stereotype threat: The effect of self-affirmation on women's intellectual performance*. Journal of Experimental Social Psychology. Retrieved November 11, 2022, from https://www.sciencedirect.com/science/article/abs/pii/S0022103105000545

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, *104*(3), 700–712. https://doi.org/10.1037/a0027268

Creswell, J. D., Dutcher, J. M., Klein, W. M., Harris, P. R., & Levine, J. M. (2013). Self-affirmation improves problem-solving under stress. *PLoS ONE*, *8*(5). https://doi.org/10.1371/journal.pone.0062593

Bauld, A. (n.d.). *Happy students are motivated students*. Harvard Graduate School of Education. Retrieved November 11, 2022, from https://www.gse.harvard.edu/news/ed/21/05/happy-students-are-motivated-students

What is electroconvulsive therapy (ECT)? Psychiatry.org - What is Electroconvulsive Therapy (ECT)? (n.d.). Retrieved November 11, 2022, from https://www.psychiatry.org/patients-families/ect#:~:text=Does%20ECT%20Work%3F,approximately%2080%20percent%20of%20patients.

Pagnin, D., de Queiroz, V., Pini, S., & Cassano, G. B. (2004). Efficacy of ECT in depression: A meta-analytic review. *The Journal of ECT*, *20*(1), 13–20. https://doi.org/10.1097/00124509-200403000-00004

Mayo Foundation for Medical Education and Research. (2022, October 14). *Depression (major depressive disorder)*. Mayo Clinic. Retrieved November 11, 2022, from https://www.mayoclinic.org/diseases-conditions/depression/diagnosis-treatment/drc-20356013

TMS (transcranial magnetic stimulation): What it is. Cleveland Clinic. (n.d.). Retrieved November 11, 2022, from https://my.clevelandclinic.org/health/treatments/17827-transcranial-magnetic-stimulation-tms

Adam P. Stern, M. D. (2020, October 27). *Transcranial magnetic stimulation (TMS): Hope for stubborn depression*. Harvard Health. Retrieved November 11, 2022, from https://www.health.harvard.edu/blog/transcranial-magnetic-stimulation-for-depression-2018022313335

Bermudes, R. A. (2021). Guidance on navigating insurance plans for TMS-eligible patients. *Psychiatric News*, *56*(10). https://doi.org/10.1176/appi.pn.2021.10.36

Fox, D. (2017). The shock tactics set to shake up immunology. *Nature*, *545*(7652), 20–22. https://doi.org/10.1038/545020a

Balch, B. (2022, June 14). *Electricity as medicine*. AAMC. Retrieved November 11, 2022, from https://www.aamc.org/news-insights/electricity-medicine

González, H. F. J., Yengo-Kahn, A., & Englot, D. J. (2019). Vagus nerve stimulation for the treatment of epilepsy. *Neurosurgery Clinics of North America*, *30*(2), 219–230. https://doi.org/10.1016/j.nec.2018.12.005

Lamb, D. G., Porges, E. C., Lewis, G. F., & Williamson, J. B. (2017). Non-invasive vagal nerve stimulation effects on hyperarousal and autonomic state in patients with posttraumatic stress disorder and history of mild traumatic brain injury: Preliminary evidence. *Frontiers in Medicine*, *4*. https://doi.org/10.3389/fmed.2017.00124

Pilot study suggests long covid could be linked to the effects of SARS-COV-2 on the vagus nerve. EurekAlert! (n.d.). Retrieved November 11, 2022, from https://www.eurekalert.org/news-releases/943102

Kevin J. Tracey, MD. Kevin J. Tracey, MD | Northwell Health. (n.d.). Retrieved November 11, 2022, from https://feinstein.northwell.edu/institutes-researchers/our-researchers/kevin-j-tracey-md

Rizvi, S., & Khan, A. M. (2019). Use of transcranial magnetic stimulation for depression. *Cureus*. https://doi.org/10.7759/cureus.4736