Personalization in Circadian Rhythm-Based Event Scheduling

Treating Depression Behaviorally Using Rhythm-Aware Recommendation Systems

A Thesis Prospectus
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By

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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.

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Introduction

On a daily basis, circadian rhythm, fluctuating hormone levels, and other factors heavily affect our performance in both cognitive and physical tasks, yet people are unaware of the timing of their personal rhythms. Our biological clock is an important part of our everyday lives as it affects our nerve conduction, body temperature, and muscular blood flow (Hayes et al., 2010, 675). However, any knowledge regarding our rhythms is not regularly presented to us during our daily lives, leaving us oblivious to potential solutions that would increase productivity, energy levels, and healthiness. This lack of awareness may contribute to the fact that 70% of the population lives contrary to their biological clocks (Roenneberg et al., 2012, 939). This misalignment between social and biological clocks is referred to as "social jetlag," and can lead to reduced cognitive performance on a daily basis, as well as chronic sleep loss. If one's circadian rhythm is continuously disrupted, other negative health effects such as cardiovascular disease, obesity, cancer, and mental health problems may occur, including depression (Abdullah, 2015, 516). Technology has been developed to track circadian rhythm and its misalignment, which realizes benefits of calculating times that users will be most wakeful and productive as well as when they will experience physical and mental exhaustion. With awareness of our rhythms and these time frames, we can optimize our daily schedules to embrace our changing energy levels and cognitive capacities.

A study found that about 15% of people experience depressive disorder in their lifetime, and less than 40% of people with a disorder seeked medical treatment (Kessler et al., 1994,). Studies have found that the act of planning pleasant activities alone helps treat depression, and that in some cases, pleasant activity scheduling can be a stand-alone treatment. (Morin, 2022). Combining pleasant activity planning with a rhythm-aware recommendation system to correctly

time a user's activities could result in enhanced depression relief. As I examine the effect of rhythm-aware technology and personalized scheduling on treating depression, the technology's problem-solving design will be evident. The work of Sarewitz and Nelson (2008) puts forth an STS framework used to evaluate technological fixes based on three major rules. Furthermore, as the technology in this project directly recommends social actions to humans, the framework of technological determinism also comes to the forefront. Technological determinism includes the idea that social progress can be achieved through technological progress. Rhythm-awareness technology will be analyzed through this deterministic lens alongside Sarewitz and Nelson's evaluative framework for technological fixes.

Ultimately, my thesis's technical topic is centered around using health and habit data to recommend a rhythm-aware, optimized schedule to users that promotes sleep quality, exercise recovery and effectiveness, and cognitive function. My STS topic evaluates the potential for rhythm-aware technology in behaviorally treating depression through calculated activity planning and other methods.

Technical Topic

The project's goal is to use data from wearable technology to give users feedback containing their best times to sleep, exercise, and perform cognitive tasks, while making them aware of their daily rhythms. Using technologies that users trust and are commonly used are more correlated with individuals' desire for continued use of wearable fitness devices (Rupp et al., 2016, 1434-1438), so user feedback will be given through Google Calendar and in-home smart technology that is familiar to the user. The recommendation system will be based on extensive research regarding human rhythms combined with survey data from the user. The

survey data that will be collected contains information regarding users' daily habits as well as their social, academic, and sleep schedules. The user's "chronotype", which describes the particular timing of their circadian rhythm, can be assessed using the survey data to aid recommendations (Roenneberg et al., 2007, 429-438). Additionally, sleep quality analysis and user reports of sleep disruptions can be used to predict focus and cognitive strength for the following day (Cardenas-Egusquiza & Berntsen, 2022), which helps schedule the user's best time to perform focused tasks. The first phase of the technical project is to collect baseline data about activity timing, sleep timing, and daily habits from an assortment of college students. In the second phase of the project, this baseline data will be converted into personalized Google Calendar events, laid out in an optimum sequence that promotes the correct use of one's rhythm-based fluctuating abilities. The users receiving these calendar events will provide feedback on each recommendation on the Google interface. This feedback will be used to fine-tune this type of recommendation technology as well as provide insight regarding humans' tendencies to perform activities at times recommended by technology. This Capstone project is advised by Dr. Afsaneh Doryab in collaboration with fellow students Sean Conway and Prachi Sadekar.

STS Topic

"Three rules for technological fixes" by Daniel Sarewitz and Richard Nelson sets forth an evaluative framework to assess how technology may or may not fix a problem. The first rule is that "technology must largely embody the cause-effect relationship connecting problem to solution" (Sarewitz & Nelson, 2008, 871), or that the fix must be "broadly effective" in the current landscape of the problem. The second rule is "the effects of the technological fix must be

assessable using relatively unambiguous or uncontroversial criteria." Lastly, a technological fix is "most likely to contribute decisively… when it focuses on improving a standardized technical core that already exists." Each rule has extensive research material that can be examined further to fully evaluate how successfully data about our daily schedules and human rhythms can be used to suggest healthy activities to those that struggle with depression.

Alongside Sarewitz and Nelson's evaluative framework, technological determinism can be used as a descriptive STS framework to analyze the effects of technology on humans and their behavior. Technological determinism states that technological change is directly active in creating social change, and more specifically, justificatory determinism involves using technology and its progress to justify changes in humans' lives. Activity recommendation systems may change human behavior through the promotion of healthy habits, self-understanding, and work efficiency, while also behaviorally treating depression. These potential results could all be attributed to technology through justificatory technological determinism. One of the considerations that technological determinism may lack is the analysis of the human's ability to choose (Wyatt, 2008), and this research aims to fill that gap by considering multiple features of the user-centered design as well as feedback from lifestyle-planning technology users. Studying the effects of this technology on the actions that users take with an eye for technological determinism and assessing the humans' personal choice will give a deeper understanding of human nature around recommendation systems as well as the depression treatment's success.

Research Methods

The use of these two STS frameworks, one evaluative and one descriptive, in the investigation of rhythm-aware recommendation systems' ability to behaviorally treat depression can be summarized into the research question: "How can human rhythm-aware recommendation systems be used to behaviorally treat depression?" This thesis will use three main data sources: survey data from lifestyle technology users, feedback data from the recommendation system used in the technical project, and a literature review to examine the topic as a "technological fix."

To analyze the prevalence of technological determinism in this topic, survey data from FitBit and Oura online community groups will be collected. The survey's questions will examine lifestyle technology users' likelihood of following recommendations from technology that helps treat depression through healthy activity planning. Additional data to be examined for technological determinism will come from the feedback of the technical project. Participating users will be able to move, keep, or remove recommended activities from their Google Calendar, which partly indicates the technology's effect on their behavior. While these users may not be diagnosed with depression, the data give insight about any control the technology may gain in their daily lives. Lastly, a literature review on recommendation systems for depression routines will be conducted to examine the current state of behavioral depression-treating technology, and evaluate it as a "technological fix" through Sarewitz and Nelson's STS framework. Using these findings, I will be able to answer my aforementioned research question.

Conclusion

My technical thesis work will develop a recommendation system that utilizes survey data and biological data from wearable technology to help users schedule activities in sync with their human rhythms. This system would allow people to know when they are functioning at their highest and lowest, which can be applied in many settings to help increase productivity. Additionally, having self-awareness about biological rhythms will help people adjust their lifestyles to avoid any health risks that come from social jetlag. Feedback regarding the usefulness of these recommended activities will help future researchers fine-tune similar systems and enhance the user experience.

My STS research will examine this technology's application to behavioral depression treatment, evaluating its potential for success and its deterministic effect on humans' actions. This analysis will be done through two STS frameworks, Sarewitz and Nelson's "Three Rules for Technological Fixes" and technological determinism. The STS research will broaden knowledge about humans' response to recommendation systems and how behavioral depression treatment can be more quantified.

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