Optimizing Mental Health Through Sensing Technology and Lean Interventions

Stephen M. Schueller*, Sohrob Saeb, Christopher J. Karr, David C. Mohr
*Lead Proposer

College student mental health is a growing concern throughout the nation yet insufficient resources has led to many who seeks services to be met with long-waiting lists and little support. As such, a growing need is to develop novel resources to promote student mental health in cost-effective ways. We propose two related areas, sensing technology and lean interventions, in which the technological infrastructure and recent research suggests could provide low-cost, scalable, and effective solutions to improve mental health.

Major mental health concerns in college populations are common mental health disorders such as depression and anxiety. These disorders have high prevalence and typically occur in young adulthood consistent with the age range of college students. Therefore, many students may come to college never having experienced a mental health disorder and be unaware of early signs and symptoms. Efficient methods of monitoring and identification could help curb this issue, especially if early risk factors could be identified. One possible method of monitoring involves the use of smartphone sensors that can continuously monitor an individual's context including physical activity, location, and environment. Depression and anxiety are associated with several behavioral components (e.g., distractibility, reduction in activity, psychomotor retardation, sleep disturbances), some of which may be detectable using smartphone sensors. Our group has a history of research in this domain that has demonstrated that smartphones can detect social patterns among depressed patients[1] and that clinically-relevant features computed from smartphone data (e.g., circadian movement, normalized entropy, location variance) are strongly predictive of depressive symptoms.[2] Circadian movement refers to the regularity of one's movement in a 24-hour rhythm. Normalized entropy refers to movement between favorite locations. Location variance refers to GPS mobility independent of location. These clinically-relevant features are important because they provide potentially actionable information that could potentially guide subsequent interventions. For example, the insight that behavior that habitual behavior (such as wake-up time and arrival at recurring locations) is a strong predictor of depression suggests that students might be supported through small reminders and notifications to help keep them on schedule.

Although these findings draw from a small sample of adults, we have recently conducted work cross-validating these features in the *StudentLife* dataset obtained from undergraduate and graduate students. The relationship between circadian movement, normalized entropy, and location variance and depression were similar in this dataset (r = -.52, r = -.45, r = -.46, respectively) to those obtained in the initial investigation. In lines with these findings, we propose that a major challenge in the use of smartphone sensors to the prediction of mental health is the creation of clinically-meaningful, behavioral features. These features help translate data obtained from smartphone sensors into actionable information that can be made meaningful to students. Actionable information can be tied to lean, albeit effective interventions addressing the concerns and context tied to the information gained.

Along these lines, a related area is the creation of low-cost, scalable solutions. A major challenge for technology-based interventions is that although they are effective, they tend to be underutilized by target populations. Uptake is small, and even among those who do use an intervention; a large portion will stop using it after a few interactions. Supported interventions, those that use human support, tend to have better engagement, but are less scalable and sustainable from a cost-perspective. Our team has made efforts to develop interventions that can be effective through short interactions that mirror the way that people interact with common technologies like Internet websites and mobile apps. An early study explored the use of a smartphone application that used entered mood ratings to deploy tailored feedback to be responsive to times and situations of need.[2] Although promising, automated solutions can only provide responses that have been previously specified and lag behind the sophistication present in many behavior change interventions. More recent work has begun to explore how peers can contribute to the benefit of an individual. A recent illustration of this is a crowdsourced peer-to-peer web-based platform designed to teach cognitive restructuring, a core skill in the treatment of depression and anxiety.[3] This platform makes use of crowdwork powered by users as well as cheaply recruited supporters through Amazon's Mechanical Turk. A user could enter a negative thought and receive a response in an average of 8 minutes while at the same time completing psychoeducational material and engaging in practice exercises they help generate responses for other users. This platform effectively reduced negative thinking which had impacts on the depressive symptoms of the users. This example highlights the need to

build resources with an eye towards the unique affordances offered by technological solutions and an understanding of the interaction style and decision considerations paramount to create behaviorally intervention technologies.

We have argued elsewhere that technological interventions need to follow technological advances rather than drawing too heavily from the traditional face-to-face practices of the past.[4] We present illustrations from our own work to highlight the potential of smartphone sensors and lean interventions to contribute to the mental health of college student populations. In both these instances knowledge from the crowd is used to contribute to the benefit of an individual. In sensor technology, information obtained from populations of students can identify behavioral patterns that might suggest intervention for a given person. In lean interventions, minimal engagement can lead to near immediate benefit for the individual powered by sensor technology and automated, algorithm generated responses or short instances of crowdwork. The grand challenge we propose is linking sensor technology with intervention technology in ways that make use of the strengths of both disciplines, technology and behavior change. The ultimate goal of such an endeavor would be to create automated technologies that could either deliver personalized interventions or enlist relevant peers to deliver in-the-moment support based on one's current behavioral patterns or context. Sensor data alone is insufficient to address this need as it fails to produce actionable information and provide clear avenues for change. Sensor solutions must begin to create meaningful features and relevant interventions that can explain and fit into the patterns of people's everyday lives. Content experts and peers can be leveraged to help identify the meaning underlying specific behavioral sequences and contribute to creating personalized, contextualized responses.

Background and Credentials: Stephen Schueller is an Assistant Professor in the Department of Preventive Medicine at Northwestern University and a member of the Center for Behavioral Intervention Technologies. He received his PhD in clinical psychology from the University of Pennsylvania and completed his clinical internship and postdoctoral fellowship at the University of California, San Francisco. His research focuses on the creation, evaluation, and dissemination of Internet and mobile-based interventions for the treatment and prevention of depression and the promotion of well-being. He holds a K08 career development award from the National Institute of Mental Health to create and evaluate a mobile platform to increase the impact of psychotherapy for depression through supporting patients' use of skills outside of sessions and increasing clinicians' knowledge of out-of-session behavior. He has worked on developing recommendation frameworks for positive psychology interventions, worldwide smoking cessation websites, and various Internet websites and mobile apps for the treatment and prevention of depression. He has 27 peer-reviewed journal articles, 14 of which are first authored, edited the *Handbook of Positive Psychological Interventions,* and served as a guest editor for a special issue of the *Journal of Positive Psychology on* behavioral intervention technologies. His expertise in the area of the design and dissemination of technology interventions for well-being has led to invitations to speak at the Massachusetts Institute of Technology (MIT) Media Lab, the University of Washington, and the Institute of Psychiatry at King's College, London, presented on keynote invited symposiums at the European Conference of Positive Psychology and the US National Institute of Mental Health, and presented an invited workshop at the World Congress of Positive Psychology.

References

1. Burns, M. N., Begale, M., Duffecy, J., Gergle, D., Karr, C. J., Giangrande, E., & Mohr, D. C. (2011). Harnessing context sensing to develop a mobile intervention for depression. *Journal of Medical Internet Research*, *13*, e55.
2. Saeb, S., Zhang, M., Karr, C. J., Schueller, S. M., Corden, M. E., Kording, K. P., & Mohr, D. C. (in press). Smartphone sensor correlates of depressive symptom severity in daily-life behavior: An exploratory study. *Journal of Medical Internet Research.*
3. Morris, R. R., Schueller, S. M., & Picard, R. W. (2015). Efficacy of a web-based, crowdsourced peer-to-peer cognitive reappraisal platform for depression: Randomized controlled trial. *Journal of Medical Internet research*, *17*, e72.
4. Schueller, S. M., Muñoz, R. F., & Mohr, D. C. (2013). Realizing the potential of behavioral intervention technologies. *Current Directions in Psychological Science*, *22*, 478-483.