Personalized Behavior-Powered Systems for Guiding Self-Experiments

Nediyana Daskalova
Brown University
Providence, RI 02912, USA
nediyana_daskalova@brown.edu

CHI'18 Extended Abstracts, April 21–26, 2018, Montreal, QC, Canada
ACM 978-1-4503-5621-3/18/04.
https://doi.org/10.1145/3170427.3173017

Abstract
The goal of my research is to study how individuals perform self-experiments and to build behavior-powered systems that help them run such experiments. I have developed SleepCoacher, a sleep-tracking system that provides and evaluates the effect of actionable personalized recommendations for improving sleep. Going further, my aim is to expand beyond sleep and develop the first guided self-experimentation system, which educates users about health interventions and helps them plan and carry out their own experiments. My thesis aims to use self-experimentation to help people take better care of their well-being by uncovering the hidden causal relationships in their lives.

Author Keywords
self-experiments; personal informatics; sleep recommendations; self-tracking

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Research Situation
My research focuses on building systems that help people leverage their own data so they can improve their health by performing a self-experiment, (i.e. an experiment on themselves [7]). The sleep-tracking smartphone applica-

Thesis Research Question

How can personal informatics data be used to automatically generate personalized actionable recommendations that can improve a person's well-being when they follow guided self-experiments?

To answer this research question, I intend to (1) study how we can help novices perform self-experiments and (2) develop the first guided self-experimentation system, which would educate users about intervention-based self-experiments and help them plan and carry out their own experiments.

tion I developed, SleepCoacher, collects data from sensors and the user and provides actionable personalized recommendations and guides users through a self-experiment to determine the effect of those recommendations. My aim is to expand this system to other health domains and build a behavior-powered tool for guiding self-experiments.

In addition to my work at Brown, I have also completed two research internships. In 2016, I was an intern at Yahoo, focusing on another form of personal informatics, email. There, I studied how people use email and how we can build systems that recommend relevant coupon emails to users [1, 2]. In 2017, I was an intern at Microsoft Research, where I focused on analyzing the sleep data of Microsoft Band users to provide cohort-based recommendations.

Context and Motivation

At Brown University I have had the opportunity to collaborate with sleep experts on this vital aspect of well-being. Over 40 million people in the United States suffer from long-term sleep disorders, and an additional 20 million suffer from occasional sleep problems, many of which can be alleviated by changing certain behaviors.

The current paradigm in health tracking research, as performed in fields such as public health, social sciences, and research initiatives like mHealth [6], is to find generalizable effects that can be disseminated to the public. However, by definition, there only has to be a small effect on a subset of that population for those studies to claim a positive result. For example, a general recommendation to "go to bed earlier" may improve the average productivity across a large study population, but may be detrimental to those with eveningness chronotype. My research challenges this paradigm by enabling people to perform experiments on themselves, so they can find outcomes that work for them.

My work uses self-experimentation to help people to uncover the hidden causal relationships in their lives. However, while novices are eager to find out more about themselves and to improve their lives, they do not necessarily know what to change to achieve the desired result. Moreover, not everyone is trained to conduct such experiments. To this end, my thesis aims to revolutionize the methods, tools, and understanding of people running self-experiments.

Preliminary Work

In my undergraduate program, I worked on a pioneering attempt to use experience prototypes to inform the design of self-monitoring tools that give suggestions for sleep improvement. This research [4] identified the lack of healthy sleep behaviors as the major deterrent to students' wellness, and paved the way for my current research.

A major finding from this project was the need for a system that was both as largely available as a smartphone and as powerful as a sleep clinician. While at Brown, I developed SleepCoacher – a sleep-tracking smartphone application that collects data from sensors and user input. With the phone on the bed, the application tracks the user's movement and environmental noise and sends the data to a server when tracking is finished. SleepCoacher then provides recommendations for improving sleep based on each individual's collected data. The system was developed in collaboration with sleep experts from medical backgrounds and the developers of a popular sleep-tracking app. Through a study we found that the more a user adhered to our study design and recommendations, the greater the change in improvement. All participants with adherence rate higher than 80% improved their sleep.

My work on SleepCoacher [5], led to two main contributions: (1) a framework for guiding users through cyclical

personalized micro-experiments, observing the impact of data-driven recommendations over time and improving the target variables iteratively; and (2) the actual open-source SleepCoacher system, which implements this framework for the purpose of improving sleep.

Building SleepCoacher was the first step towards a general behavior-powered system for guiding self-experiments as it embodied a successful framework for running mini-experiments in cycles. The system guided users through the whole experiment, while traditional self-experimenters have to design everything themselves. Unfortunately, without the necessary training in designing scientifically rigorous experiments, people's studies are bound to be internally flawed and affected by confounding variables.

At Brown University, we were in the perfect setting to study novice self-experimenters by asking a cohort of students in a human-computer interaction seminar to perform self-experiments of their own choosing. We had the opportunity to observe the successes and pitfalls of the students, which allowed us to generate a set of guidelines for running successful self-experiments. We then asked a second cohort of students to conduct their own self-experiments following those guidelines, so that we could further iterate on them.

Based on the findings from both cohorts, we proposed a set of guidelines for running self-experiments that address the pitfalls encountered by students, such as inadequate study design and analysis methods [3]. My work on this topic also presented broader implications for future self-experimenters and designers of tools for self-experimentation.

Proposed Work

The self-experiments guidelines we developed are the first step towards revolutionizing the current experimental paradigm of research on personal informatics. SleepCoacher is a modified implementation of the self-experimental framework, and it was used to further support the decisions behind some of the self-experiment guidelines. Going further, my research will focus on developing the first guided self-experimentation system, Self-E, which would educate users about intervention-based self-experiments and help them plan and carry out their own experiments.

Building a Self-Experimentation System: Self-E

Self-E would let the user choose which behaviors to change and then it would automatically break down the behavior change experiment into a series of steps, and communicate them to the user through actionable messages. The proposed work has broad implications for societal health and well-being. In the age of Youtube do-it-yourself, Self-E operationalizes the self-experiment so that anyone can learn about cause and effect for variables they care about, even if their responses and habits are different from others. These variables could include factors about diet, productivity, exercise, sleep, etc. It empowers people to conduct rigorous conclusive analysis of behavior change without having to know details about experimental design and statistical analysis. Future work will also comprise two major studies.

Study One: Thompson Sampling

From my research, I have discovered that tracking fatigue and the lack of useful information to the user during the self-experiment phase are fundamental hurdles to a wider adoption of self-experimentation. However, I have realized these problems can be reduced for the user by applying an idea from Bayesian statistics. We are going to modify SleepCoacher to implement a Bayesian analysis of the data so that participants can end their self-experiments at any point without a set length. This method will lead us towards our vision of perpetual self-experiments, where users can continuously receive recommendations and change

Expected Contributions

My thesis research will contribute to the understanding of how novices conduct self-experiments, as well as how personal informatics fit in their daily lives on a larger scale.

My work will result in two systems for self-experimentation: SleepCoacher and Self-E, advancing the knowledge about how novices perform self-experiments, how we can build tools to help people self-experiment, and what analysis methods are best suited for such experiments.

My goal is to create guided self-experimentation tools that are publicly available to a large number of users, thus focusing on the direct impact towards improving people's lives.

little snippets of their behavior to constantly improve their well-being. The SleepCoacher application is already on the Google Play Store, recruiting a diverse group of users.

Study Two: Evaluation of Self-E
With Self-E we will study how users perform experiments and how content they are with what they have learned from them. We will evaluate this work with two diverse populations – mental health patients from Rhode Island Hospital and veterans from Providence's VA.

Conclusion

My research focuses on designing, building, and evaluating behavior-powered systems that aim to help individuals improve their lives through a structured self-experiments paradigm. SleepCoacher, as the first sleep-tracking phone application of this kind, guided users through applying a behavior change intervention and analyzed its results. The self-experimentation guidelines we developed will be applied in a new smartphone application and further improved. I want to leverage people's individual differences by using their own data to help them reach an optimal state of wellness. My overall vision is provide people the opportunity to iterate on their own lives, as a lifelong self-experiment in health and wellness.

Acknowledgements

I would like to thank my advisor Jeff Huang for his help, support, and academic advising. This research was supported by NSF grant IIS-1656763 and the Brown University Seed Award.

REFERENCES

1. Frank Bentley, Nediyana Daskalova, and Nazanin Andalibi. 2017. If a person is emailing you, it just doesn't make sense: Exploring Changing Consumer Behaviors in Email. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 85–95.
2. Nediyana Daskalova, Frank R Bentley, and Nazanin Andalibi. 2017a. It's All About Coupons: Exploring Coupon Use Behaviors in Email. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, 1152–1160.
3. Nediyana Daskalova, Karthik Desingh, Alexandra Papoutsaki, Diane Schulze, Han Sha, and Jeff Huang. 2017b. Lessons Learned from Two Cohorts of Personal Informatics Self-Experiments. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 1, 3 (2017), 46.
4. Nediyana Daskalova, Nathalie Ford, Ann Hu, Kyle Moorehead, Benjamin Wagnon, and Janet Davis. 2014. Informing Design of Suggestion and Self-Monitoring Tools Through Participatory Experience Prototypes. In *Proceedings of the 9th International Conference on Persuasive Technology - Volume 8462 (PERSUASIVE 2014)*. 68–79.
5. Nediyana Daskalova, Danaë Metaxa-Kakavouli, Adrienne Tran, Nicole Nugent, Julie Boergers, John McGeary, and Jeff Huang. 2016. SleepCoacher: A Personalized Automated Self-Experimentation System for Sleep Recommendations. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology (UIST '16)*. 347–358.
6. Deborah Estrin and Ida Sim. 2010. Open mHealth architecture: an engine for health care innovation. *Science* 330, 6005 (2010), 759–760.
7. Allen B Weisse. 2012. Self-experimentation and its role in medical research. *Texas Heart Institute Journal* 39, 1 (2012), 51.