SNAPSHOT Expose: Stage Based and Social Theory Based Applications to Reduce Stress and Improve Wellbeing

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ABSTRACT
We prototyped two applications to provide tailored, stage-based and social theory-based interventions that help individuals learn the process of reflecting on and changing the behaviors that lead to stress and poor quality of wellbeing. We performed a user study to understand the stress and wellbeing profiles of the users and verified our digital prototypes. The six participants in our user study enjoyed reviewing their data and were curious about patterns in their data.

Author Keywords
Behavioral Change; Stress Reduction; Transtheoretical Model; Intervention; Monitoring; Reflection

ACM Classification Keywords
J.4 Social and Behavioral Sciences

INTRODUCTION
Wearable devices and mobile phone apps have allowed tracking and collecting continuous data (steps, weight, sleep, diet, etc.) and have brought positive benefits of raising consciousness even without ever viewing or using the data. However, there is a need to go beyond just raising consciousness and begin to actually change behaviors to improve mental health and overall wellbeing.

The SNAPSHOT study seeks to measure Sleep, Networks, Affect, Performance, Stress, and Health using Objective Techniques [5]. We have been running this study every semester since fall 2013 to collect one month of data per person from 50 college students who are socially connected. This NIH-funded collaborative research project between the MIT Media Lab and Harvard Medical School Brigham & Women's Hospital has to date collected data from about 210 participants, totaling over 6,000 days of rich data such as physiological, behavioral, environmental and social data using mobile phones, wearable sensors, surveys, and lab studies. We have investigated better behavioral choices for wellbeing and performance and have been developing models to see if it is possible to predict onsets of sadness and stress. Using statistical analysis and machine learning techniques, we have found that people feeling down or sad have behavioral characteristics such as late phone usage, irregular sleep patterns, and consistent location [4, 5, 6].

In this paper, we introduce SNAPSHOT Expose, prototypes of smartphone applications that provide a tailored, staged intervention and social theory based intervention that help individuals learn the process of reflecting on and changing the behaviors that lead to stress and poor wellbeing. We expanded on these two theories by asking questions and doing mini-self experiments to facilitate reflection and insight. We describe how we conceptualized, designed and evaluated the applications with a set of user studies.

OUR GOALS
We aim (1) to explore how to design for monitoring and how to design to promote self-reflection and evaluate the impact of both strategies and (2) to evaluate different strategies for providing impactful self-reflection for each individual participant, in a way that is responsive to their data.

PROTOTYPE
We prototyped two applications: Stage-based application and social model based application.

Stage-based Application
Based on the Transtheoretical Model for behavior change [3], we prototyped an app to encourage users to reduce stress and improve wellbeing through four stages of change:

- Stage 1 (Pre-contemplation): Users begin to collect data by filling out twice-daily surveys to self-report wellbeing measures (alertness, happiness, energy, healthiness, and calmness) and daily activities (sleep, academic and extra-curricular activities, exercise, and social interactions). This data collection continues throughout the use of the app. Users are also given access to review the data (Figure 1). Reviewing data in the app includes a single day's data visualized in bar graphs, dots on a brain (how much they spent time on each activity), and a circle filled with the amount of sleep the user received on that day. Additionally, all of the collected data (both how the user spent his time and wellbeing measures) is summarized in time series plots.
- Stage 2 (Contemplation): Users are given the ability to explore relationships between variables as they complete data collection (e.g., between their activity and their mood) to

CHI 2016, May 7–12, 2016, San Jose, California, USA.

Figure 1. During stage 1 the user can review a summary of how they spent their time and how the felt. The top shows a single day's review and the line graphs show all data collected.

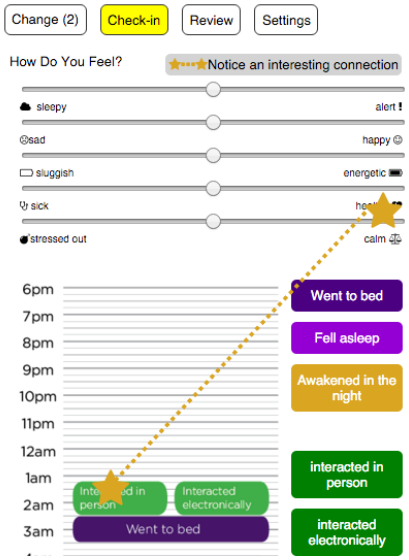

Figure 2. During stage 2, users can save relationships between how they feel and what they are doing using connected stars. These connections are saved and available during a later stage.

cultivate psychological mindedness. To do this, they drag a star over each part of the relationship they'd like to highlight. In Figure 2, users are able to notice and save connections that interest them between how they feel and what they are doing.

- Stage 3 (Preparation): Users are encouraged to begin generating questions based on their data. They are given a framework to identify variables they are interested in and the app helps them turn those into a question. The app requires that they consider and enter a hypothesis of their own before we show them data. After they enter their hypothesis, they are shown data they have collected so far about the relationships they identified. For example, in Figure 3, the user completes a question about sleep duration and overall wellbeing and is asked to write a hypothesis. After they fill out their hypothesis, they are able to see the relationship between their sleep duration and wellbeing score and are asked to fill out what they see the data (Figure 4 for an example). This implementation of the preparation stage relies heavily on helping the user explore the data instead of just viewing the data as many popular health apps do today.

- Stage 4 (Action): Users are encouraged to engage in mini self-experiments to build self-efficacy. After they follow through with seven days of the experiment, they can see their results. For example, in Figure 5 we see several examples of mini-behavior change experiments and in Figure 6 we see how the user is able to personalize their selected experiment of how slightly longer sleep duration affects their stress level. After the user completes seven days of experimentation, they can see their results (Figure 7). In this example, the user reduces stress level by sleeping longer.

In this prototype, we did not implement how the app evaluates which stage each user is and when he/she moves to another stage. However, we could evaluate their behaviors (sleep, exercise, social interactions) and their self-reported stress scale and mental health scores or ask if they are ready to move to next stages.

Social Theory-based Application

Based on observational learning in the social cognitive theory and the social comparison theory [2], we also prototyped stack graphs (8) to compare daily behaviors (sleep, exercise, academic activities, extra-curricular activities, naps) of two groups (stress vs calm, happy vs sad, and good vs poor sleepers) based on the data from the top and the bottom 20% of our first four cohorts.

USER STUDY

After finishing the normal study period of 30 days, some participants participated in an optional follow-up study, where we interviewed 6 participants (Male: 4, Age: 18 - 20) about stress, SNAPSHOT study and our prototypes and asked them to fill out qualitative and quantitative surveys.

In order to evaluate our prototypes and to understand the thought process of a participant when interacting with our prototypes, each participant was given a brief introduction to the prototypes and then asked to interact with them after a prompt was given. These prompts were paired with the four different stages of the stage model and included a typical

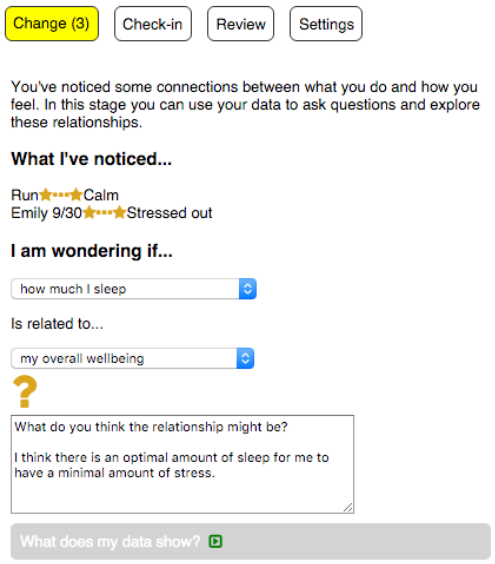

Figure 3. During stage 3 of the app, users are able to see interactions within their personal data. In order to see these, however, users are required to first ask a question and enter a hypothesis of what they think the relationship might be.

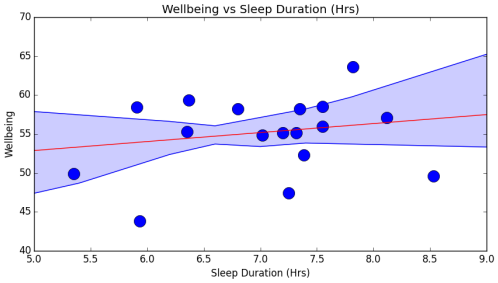

Figure 4. After a user hypothesizes about a relationship (Fig. 3), they can view the actual relationship based on their data and see if the data are consistent with their thinking (or not). In this example, the red line shows the average trend line and the blue region shows the 95% confidence interval of the trend line.

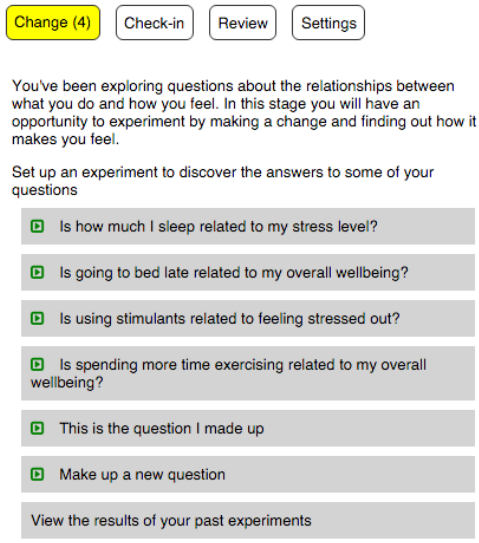

Figure 5. During stage 4, users are encouraged to set up mini-experiments to see if they can improve a part of their wellbeing. This figure shows examples of mini-experiments that a user can choose from or the user can make up her own mini-experiment.

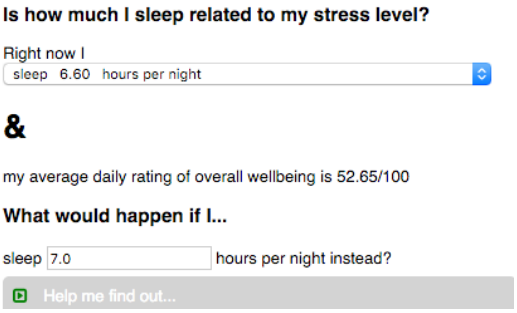

Figure 6. After selecting a mini-experiment in stage 4, the user can set up the details of the mini-experiment about sleep and stress. During this part of the set up the user is shown his averages so that he can make realistic goals.

daily check-in (fill out the daily survey and review the data) (stage 1), noticing a connection between two parameters in a daily survey (stage 2), viewing relationship of the data (stage 3), and setting up and seeing the results of a small behavior change experiment (stage 4). We asked them to think aloud as they reviewed and interpreted their data and asked them questions about it.

In addition, we showed the stack graphs to compare daily behaviors of two groups and asked each participant which graphs they wanted to see and why.

RESULTS

During their individual interviews, all of the participants of this user study reported that they were stressed in general. Their Perceived Stress Scale scores were 17.8-18.5 $\pm$4.6 (pre-SNAPSHOT study) and 16.8 $\pm$3.7 (post-SNAPSHOT study) which were higher than the average of this age population (14.2)[1]. Note that because a participant omitted a pre-study PSS question, we estimated the PSS score for this participant and give a range for the prestudy PSS average. The top two reported stressors were "excessive school work" (100% of participants), and "not enough sleep" (83.3%). They reported that other people around them are highly stressed. Participants also reported that taking a break and doing non-school work, being social, and being organized by using a checklist might help their stress.

In our interviews, we obtained evidence that using this app would make their data more accurate, on time, and complete. Additionally, the participants liked the patterns, data, and charts that were built into the app; however, they reported that these features were more fun than useful. The general emotional response to seeing their data from the SNAPSHOT study varied from surprise and concern to self-awareness.

Participants were very interested in the actual numeric values of the trends in their data and had an idea that theres an "optimal" amount of sleep especially when their data provided

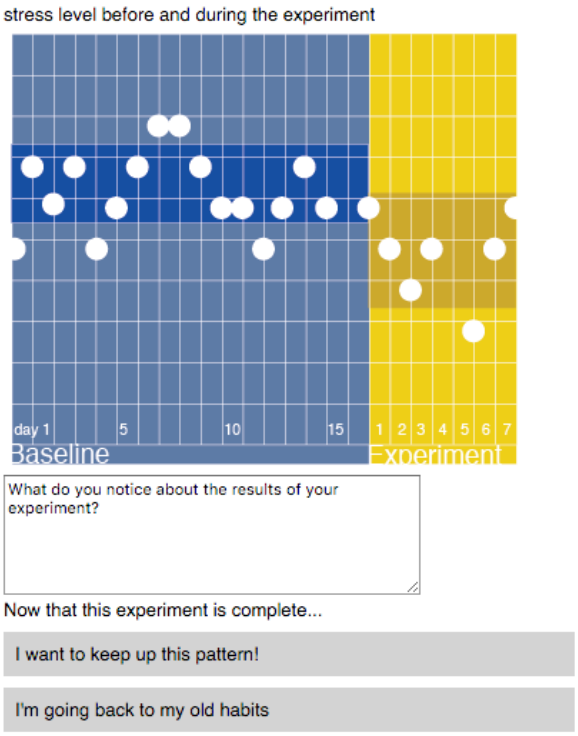

Figure 7. After completing the mini-experiment in stage 4, the user is shown the results. The white dots show data points (day of study on x-axis and stress level on y-axis). In this example, there are about two weeks of baseline behaviors (shown in blue) and one week of experiment behavior (shown in yellow). We see that the experimental behavior resulted in a slightly lower stress level compared to baseline

clear relationships in the visualization. However, they did not feel motivated much to change or capable of change. During this part of the user study, they seemed to like asking questions to understand relationships among their behaviors and mood/wellbeing, and were interested in doing a mini-experiment only once or twice. These results imply that they might be at the pre-contemplation stage of behavior change.

In evaluating the stacked graph comparisons, all of the participants were very interested to know the comparison of their data with others. Participants were most interested in seeing "Stress vs. Calm" and "High vs. Low GPA" comparisons, followed by "Regular vs Irregular sleepers", "Good vs. Poor sleepers" and "High vs. Low Anxiety". After seeing a comparison between two categories of participants, they expressed interest in fitting into one of the two categories or being average. This interest in changing behavior after seeing a comparison with peers is especially motivating; we plan to explore it further.

CONCLUSION AND FUTURE WORK

We prototyped two applications to help users to reflect and change their daily behaviors to reduce their stress and improve their wellbeing. In general, the participants in our study enjoyed reviewing their data and were curious about patterns in their data.

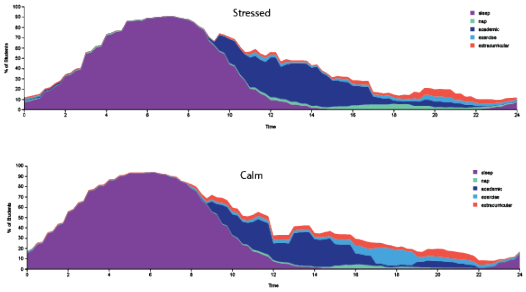

Figure 8. Examples of time stack graphs of daily behaviors of our stress and calm participants. Each graph shows the percentage of students in different activities across a single day. In this example, we can see that there are more calm participants exercising in the evening than stressed participants.

As next steps, we are planning to examine which visualization works better to convey meaningful information to users. Also, we are planning on leveraging social network data in our study to provide socially influencing feedback (e.g. pick a socially centered participant and provide intervention). In addition, we could provide users wellbeing/stress prediction results based on their previous behaviors (sleep, exercise and social interactions) and provide guidance about which behaviors could lead them to better health conditions. Eventually, we will build a real-time intervention system to provide user-tailored advice to reduce stress and prevent mental illness.

ACKNOWLEDGMENTS

We thank all the participants and our SNAPSHOT study collaborators. We also gratefully acknowledge the grant from National Institute of Health (R01GM105018) and Media Lab consortium.

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