The Power of Mobile Notifications to Increase Wellbeing Logging Behavior

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ABSTRACT
Self-logging is a critical component to many wellbeing systems. However, self-logging often is difficult to sustain at regular intervals over many weeks. We demonstrate the power of passive mobile notifications to increase logging of wellbeing data, particularly food intake, in a mobile health service. Adding notifications increased the frequency of logging from 12% in a one-month, ten-user pilot study without reminders to 63% in the full 60-user study with reminders included. We will discuss the benefits of passive notifications over existing interruptive methods.

Author Keywords
Mobile; Notifications; Behavior Change; Wellbeing; Logging; Personal Informatics

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

General Terms
Human Factors; Design; Measurement.

INTRODUCTION
There is currently a growing crisis in wellbeing throughout the world. In the United States, over one third of the population is obese [3], with numbers continuing to grow. Other countries, especially in Europe, are seeing similar trends [2].

Many see mobile devices as the key to helping people discover long-term trends in potentially harmful behaviors and assisting in behavior changes to increase wellbeing. Mobile phones can sense much of a person's context as well as provide an easy means to support self-logging. Mobile phones also have the power to notify users and provide nudges to perform a particular behavior.

Collecting individual sensor data such as step count or weight might show a change in that one aspect over time, however it does not show users what is causing that change. We have found great benefit in combining multiple sensor and contextual data streams together [14], finding significant correlations in these data streams over weeks and months, and presenting these observations directly to users in natural language feeds. This allows people to answer basic questions about their wellbeing. They can see feed items on long-term and periodic trends such as "You gain weight on Sundays," "You eat more on days when you walk less," or "You are happier on days when it's colder."

But calculating these correlations relies on having a significant amount of data for each sensor stream. In addition, the data from multiple sensors has to be supplied on the same day in order to make a correlation, so it is of no use if a user only decides to log sleep on Mondays and Tuesdays but then logs their mood on Fridays and Saturdays. Therefore, we need a way to encourage users to log data for each sensor stream as often as possible.

While some logging can easily be automatic (e.g. location, weather, calendar data, etc.), some by definition require self-logging. Food intake, pain levels, and mood are examples that are quite difficult to automatically determine, but can be quite easy for users to enter on their own. However, in practice, people tend to forget and/or lack the motivation to self-log. In this paper, we will we show how simple status-bar reminders on a mobile phone can increase self-logging frequency by a factor of five.

RELATED WORK
Mobile phones and self-logging have been the focus of many research programs over the past decade. Main research threads have explored using automatic context logging on the phone, allowing manual entry of activity, and the logging of food throughout the day.

Many of the food studies have focused on logging specific individual items that are eaten (e.g. [12]). This can be quite burdensome, as unless one eats fast food or pre-packaged frozen meals, entering every ingredient in the appropriate quantity for each meal can be overwhelming. Work on the PmEB [13] system demonstrated that text message reminders can encourage people to perform detailed food logging. However, in this work participants were told that they had to log each day to be "compliant" with the study and reported not liking the disruptive nature of the SMS reminders. Participants in the PmEB study also expressed frustration over the lack of particular food items in the database. Given this, we chose a much simpler relative logging method as described in the next section which is

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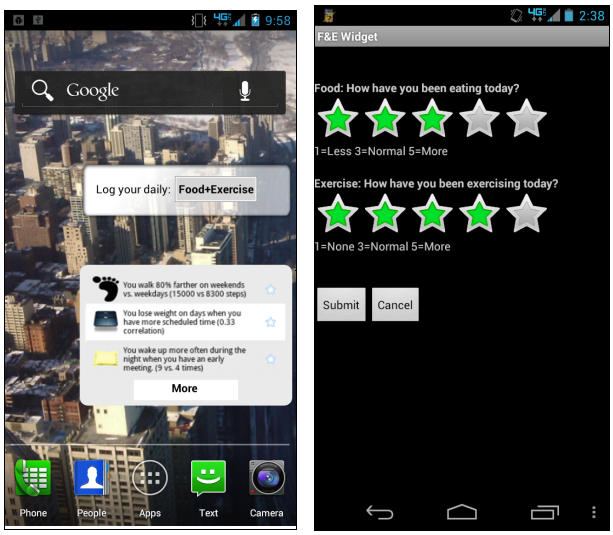

Figure 1: The pilot system provided mashups observations in a widget on the homescreen as well as on a mobile website. Manual logging of food and exercise was accomplished via another widget, which opened the logging screen on the right.

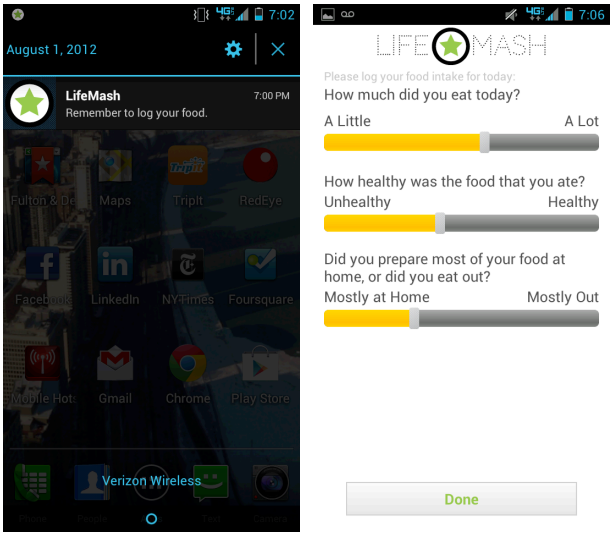

Figure 2: The reminder notification for food logging in the second study. The user could set the time for the reminder to appear in the status bar. Clicking on the notification led directly to the food logging screen on the right.

similar to [10] in that it tracks relative amounts of food instead of specific food items and calories, which are notoriously hard to track accurately (e.g. [11]).

BJ Fogg writes about behavior triggers that can be the spark needed to remind users to do a task that is simple and within their ability [5]. Fogg primarily focused on SMS messages for reminders as they were pervasive at the time on all mobile devices. More on SMS reminders can be found in the edited volume [6]. These systems used active notifications that would ring or vibrate the phone in order to get the user's attention. We were interested in more passive notifications and to measure how notifications influence logging frequency which is missing from related work.

In the fields of social psychology and preventive medicine, Emmons & McCullough [7] demonstrated in an experimental study that persons who kept gratitude journals on a weekly basis exercised more regularly, reported fewer physical symptoms, felt better about their lives as a whole, and were more optimistic about the upcoming week. Kahn et al. [8] highlight the complex dependencies that contextual and behavioral data have with each other, and found that many sources of methods and information need to come together more effectively to create positive behavior changes. This is the basis for our system that combines multiple aspects of wellbeing and context.

A more complete analysis of mobile health and wellbeing solutions can be found in Klasnja and Pratt's [9] survey.

THE HEALTH MASHUPS SYSTEM

Our pilot Health Mashups system is described further in [14]. In this system, users were given a Fitbit to log step count and sleep as well as a WiThings Wi-Fi scale to log their weight. A mobile phone application automatically captured location and calendar data and included widgets on the home screen to manually log food and exercise data as shown in Figure 1.

We will describe the food logging procedure in more detail, as that is the focus on this Note. At the end of each day, users could click on the logging widget on their home screen to launch a screen that enabled easy logging of food and exercise. We chose a simple logging scheme, as previous work with experience sampling has shown the reliability of small, repeating questions asked over time [1]. Therefore, we asked participants to log how much they had eaten that day and their exercise on a 5-point scale.

Over many days and weeks of the study, we could then find patterns that emerged with just this simple data. Did a user tend to eat more on the weekends versus weekdays, did they eat more on days when the walked more, etc. As long as users were roughly self-consistent as to the general amount and healthiness of the food they ate, we could make our correlations without requiring tedious logging of each food item. Users reported finding this process quite easy on a 7-point scale. As described in [14], we found several statistically significant correlations for each user, mainly on the automatically-logged sensors. However, because of the general lack of manual logging in this pilot, we were often not able to make correlations with food or exercise data.

After completing the ten user pilot study, we implemented several changes to the system. We moved from a mobile web application to a native application to reduce latency and allow for deeper interaction with the phone platform. We also added a user-configurable reminder system for data streams that had to be manually logged, hoping to see

increased logging and thus the ability to perform better correlations between data streams.

When the user first launched the updated application, in addition to syncing their Fitbit and WiThings accounts, they were asked if they would like to log food, mood, or pain. For each that they selected, they could set a time (or times for mood and pain) to receive an Android notification to remind them to log. Importantly, this notification was non-interrupting. It would not ring or vibrate their phone, and would just put a small icon in the notification tray (the very small icon in the upper left of Figure 2) that was mixed with other notifications, such as email, missed calls, etc. The next time they picked up their phone, they would see the icon and could easily pull down the notification tray, click on the expanded entry, and be taken straight to the logging screen for that sensor as shown in Figure 2.

In the summer of 2012, we conducted a study with 60 participants using this updated system. Both the pilot and main studies included participants recruited using the same professional recruiting firm with the same screener and began at the same time of year, one year apart. Participants in both studies consisted of a broad range of ages, occupations, and education levels ranging in age from early 20s to 60s, and occupations as diverse as policewomen and chemists.

Both studies included users with a similar mix of motivations for participating and similar technology experience. In both studies, participants were given the same devices (a Fitbit and a WiThings scale) and the same instructions with regards to their use (or non-use) of the system: That "you should use the application as if you just downloaded it from the app store. If you do not find it useful, there is no obligation to use it and no compensation in the study will be tied to your use of the system."

FINDINGS

In our pilot study, the manual food logging was rarely used. In the first week, a few users tried it out, but after day seven, no more than two out of ten users logged food on the same day. After day 12, only one user sporadically logged food for the rest of the month as shown in Figure 3.

This contrasts with the full study with reminders enabled where 63% of users logged food each day. This percentage stayed quite consistent throughout the month, showing the power of simple reminders to promote sustained logging. Logging behavior was also sustained in the full trial with numbers between 55-65% in the second month of the trial.

In our surveys and interviews at the end of the full study, many users reported liking the reminders as they recognized how easy it would be to forget to log. Representative examples include User 28 from Atlanta, who stated that the best feature of the app was: "the reminder feature because half the time I forget to login my information." Also, User 37 from Atlanta told us, "I like that it reminds me to add

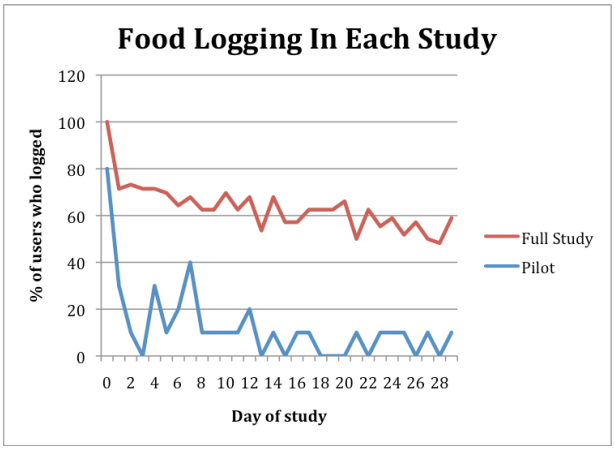

Figure 3: Food logging behavior increased by more than 5x in the full study (with reminders) compared to the pilot.

info in my notification bar. I would surely forget otherwise."

User 10 from Chicago agrees and points to the importance of having a quick action to log: "The online reminders are awesome, makes it so much easier to keep track of stuff because I can get absentminded and lose track of what to do … The questions are easy to answer and make for a quick Q and A." In our case, this logging consisted of just a few 7-point scales in comparison to other food-logging solutions which require complex logging of every food item eaten that can take ten minutes or more per day.

Users were able to set their own times for notifications to appear, and this time became an important moment for reflection. Our participants set a wide variety of times to be reminded to log their daily food and expressed how it was nice that it could fit into their schedules. User 26 from Atlanta told us that "it is a good reminder at the end of the day to write down what type of food I ate [choosing from a 7-point scale on how healthy food intake was as shown in Figure 2]. Healthy or not. I guess through the day you can sometimes forget, but then when it's time to answer to the app, you have a moment of truth."

User 20 from Chicago expanded on this point and spoke of the power of logging to increase reflection each day. "I like that it asks me to log my food and my mood daily. It makes me more conscious of how I'm feeling as well as what I'm eating throughout the day." The more often someone logs, the more opportunities for reflection they get.

The nature of the smart phone being a device that most people use periodically throughout the day leads to more frequent reminders about their wellbeing. User 35 from Atlanta told us: "My phone is always with me and in my hands so therefore I am constantly reminded to use the app." Our ambient notifications indicate both the need to log and also display the new observations that are calculated in a private manner. No revealing health data is ever shown "publicly" on the home screen, keeping the design recommendations of Consolvo et al [4] in mind.

This increased reflection each day and increased data that was provided not only allowed the users to reflect more on their own, but provided for better data analysis. The more days that have multiple data points logged for a given user, the more accurate correlations across sensor streams we can provide. In the month of our pilot study, users averaged only a single day that had both Food and Weight logged, while in the second study they averaged 9 such days in the first month. For the Steps and Food combination, users averaged 2.6 days in the first study and 14.8 days in the second study. This increased amount of data lead directly to the ability to perform a statistical analysis and find significant correlations between the data streams over time. This was not something that could be reliably calculated between these manually logged sensors in the first study.

DISCUSSION

As mentioned above, increased frequency of behavioral data logging leads to the ability to find significant long-term trends in fewer weeks of use. Adding notifications improved logging frequency by over 5x from the pilot study. Beyond leading to better personal analytics, increased logging frequency can also be quite useful for use with medical practitioners. Having a daily log of pain, food intake, mood, or other data can help doctors and nurses to spot patterns that our algorithms may miss. It can give doctors the power to see into a patient's life, and not just a snapshot each year when a patient visits for a checkup. This data can be extremely important in the case of diabetes and other chronic conditions. Often, manual logs for these patients are spotty at best and accurate logs of food, pain, and blood sugar levels can dramatically improve care.

Status bar notifications are an exciting platform for future research and behavior change products. Unlike previous work with text messages, mobile notifications can be non-interrupting, silently placing an icon in the notification tray for later action. They do not ring, do not vibrate, but just sit there waiting to be noticed. These notifications do not get in the way of current activities but can be attended to the next time the user has a few free seconds. They seem to provide just enough pressure to encourage action, but not too much to become annoying (as in [13]). Sustained high logging rates continued throughout the 90 days of the full study.

Based on our findings, in order for notifications to be the most effective over the long-term, they should be:

- Non-interrupting: not ringing or vibrating
- Followed with simple logging: taking action or cancelling the notification should be of similar effort
- User Configurable: time and frequency of notifications set by the user

We have demonstrated the ability for a mobile phone notification to increase the manual logging of food intake from 12% to 63%, a greater than 5x improvement. Increasing the frequency of manual logging has the ability to provide much more reliable data in systems that combine inputs from multiple sources as well as serve as tools for patients in discussions with medical professionals. There is room for further research on how reminders can increase the quality of analysis within a health monitoring system.

REFERENCES

1. Barrett, L. F., Barrett, D. 2001. An Introduction to Computerized Experience Sampling in Psychology. Social Science Computer Review, Vol 19, No 2, 175-185. Sage Publications.
2. BUPA. 2011. http://www.bupa.co.uk/individuals/health-information/directory/o/child-obesity
3. CDC. 2010. U.S. Obesity Trends. http://www.cdc.gov/obesity/data/trends.html
4. Consolvo, S., Everitt, K., Smith, I., and Landay, J. 2006. Design requirements for technologies that encourage physical activity. In Proc. CHI '06.
5. Fogg, B.J. 2009. A behavior model for persuasive design. In Proc Persuasive '09.
6. Fogg, B.J., and Adler, R. Texting 4 Health: A simple powerful way to improve lives. Captology Media. 2009.
7. Emmons, R. A., & McCullough, M. E. (2003). Counting blessings versus burdens: Experimental studies of gratitude and subjective well- being in daily life. Journal of Personality and Social Psychology, 84, 377-389.
8. Kahn, E.B. et al. The effectiveness of interventions to increase physical activity. A systematic review. American Journal of Preventive Medicine 22, 73-107 (2002).
9. Klasnja P., Pratt, W. Healthcare in the pocket: Mapping the space of mobile-phone health interventions. Journal of Biomedical Informatics 45 (2012), p185-198.
10. Korhonen, I., Salminen, J.H., Ahtinen, A., Koskinen, E., Sarela, A., Parkka, J., Lappalainen, R. 2010. Empowering Citizens for Well-being and Chronic Disease Management With Wellness Diary. IEEE Transactions on Information Technology in Biomedicine. 14(2), pp 456-463.
11. Schwartz, J, Byrd-Bredbenner, C. The ability of young adults to estimate portion size and calorie content. Top Clin Nutr 2006; 21: 114-121.
12. Siek, K., Connelly, K., Rogers, Y., Rohwer, P, Lambert, D., Welch, J. 2006. When Do We Eat? An Evaluation of Food Items Input into an Electronic Food Monitoring Application. In Proc Pervasive Health '06.
13. Tsai, C., Lee, G., Raab, F., Norman, G., Sohn, T., Griswold, W., Patrick, K. 2007. Usability and Feasibility of PmEB: A Mobile Phone Application for Monitoring Real Time Caloric Balance. Mobile Networks and Applications. 12(2-3), pp 173-184.
14. Tollmar, K., Bentley, F., Viedma, C. 2012. Mobile Health Mashups: Making sense of multiple streams of wellbeing and contextual data for presentation on a mobile device. In Proc Pervasive Health 2012.