First Idea Set for the International Workshop on Health Behavior Change and Maintenance

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Q1: What do you think are the 'necessary ingredients' to develop models of health-related behavior that can account for momentary, short-term and long-term behavior change?

I assume that any model that could account for momentary, short-term, and long-term behavior change with useful accuracy will need to be highly *individualized*. Such a model would encompass chief determinants of health-related behaviors of a particular person and could predict, with a reasonable level of confidence, how the person would likely behave in a particular situation. I take the word "situation" broadly here, to indicate the current configuration of the relevant determinants of the person's behavior. A short but not terribly helpful answer to the above question, then, is that accurate models of health behavior (and behavior change) require knowledge of the determinants of a person's behavior, how these determinants change over time (e.g., as a person starts to develop a new exercise habit), and which of them are active at a given time.

The devil, of course, is in the details. The work in social, behavioral, clinical, and personality psychology makes it clear that such a model of behavior would be inherently complex. The determinants of behavior are many, including dispositional tendencies (chronic influences of the learning history and innate dispositions), the acute state of the person (e.g., the person's stress level, if the person is hungry, which goals are currently active, etc.), and the outside environment in which the person finds herself (who the person is with, where, what they are doing, etc.). A kind of model I am envisioning would take the values of such determinants as inputs and provide the probability of the person engaging in a target behavior under those circumstances as an output.

Having such a highly personalized model of health behavior would enable a wide range of behavior change interventions, including effective just-in-time interventions to support coping in high risk situations, interventions in which the person can reflect on her own patterns to develop strategies for dealing with specific problems or discover new opportunities for healthy behavior and so on.

This vision for the future of health behavior models has several implications. First, it is clear that the kind of model I have in mind requires a great deal of data. One option is that the data would be generated over extended periods of time (say, months) as the person goes about her daily life, with sensing data being supplemented with lightweight data labeling and self-report by the user herself. Another option is that an initial model could be created in a simulation, such as "the simulated situations" paradigm used by Shoda and Leetiernan (2007) to determine individuals' behavioral signatures for different types of situations, and that the initial model would then get tuned over time as actual behavior is observed. Second, the kind of model I envision would be inherently dynamic. The weights of behavior determinants would need to adjust over time as, say, the strength of a health goal increases or new situation-behavior links are created. Third, the accuracy of the model would greatly depend on the ability to capture chief determinants of a particular health-related behavior. It is not clear to me how completely we might be able to do this, even with

advances in technology. For instance, although I fully expect sensing to get better, enabling automatic collection of data about a diverse set of physiological states and activities, I don't have a good sense of how, on an ongoing basis, we would capture data about cognitive variables such as goal strength or achievement motivation. Administering a battery of questionnaires over and over again would get very old very quickly. Yet, insofar as such variables substantially influence a person's behavior, they would need to be included in the model.

Returning to the original question, I see dense person-level data as a chief requirement for the development of better models of behavior change. Although it is not clear yet how we will collect all the data that are needed to model behavior in (close to) real time, the range of data about activities and states that can be collected on an ongoing basis continues to grow. A related requirement is the availability of lightweight methods for assessing behavioral determinants which cannot be sensed directly. Pollak et al.'s 2011 CHI paper on using photos to assess affect is a good example of the kinds of methods I have in mind. Finally, a new generation of models will require algorithms that can extract patterns out of the behavioral, cognitive, physiological, and contextual data, and dynamically adjust resulting models as new data are gathered and as the person's behavior changes.

Q2: How might high-frequency human-computer interaction be used to support longitudinal engagement with a wellness system?

With the rapid growth in smartphones and tablets, people increasingly have powerful computers always within reach. Individuals reach for these devices throughout the day for many different purposes, including to check their calendars, read and answer email, play games, look up information on the web, find local businesses and so on. The frequency of interaction with these devices opens up a number of opportunities for supporting long-term engagement with a wellness system. The following are some of the ways I think this can happen:

- The wellness system can be designed to continuously provide new, relevant information pertinent to the user's health goals. Leveraging large social networks such as Twitter and Facebook and the information about the user available to the system (e.g., location, the user's calendar), a wellness application could provide an ongoing stream of tips, opportunities for healthy activities that are appropriate for the user's current situation (location, amount of time before the next meeting, etc.), information about what other people with similar health goals are doing to improve their health, and so on. The key feature here, I think, is to have a steady stream of *fresh and relevant* content that can motivate the user or provide her with information she can use in her current situation to advance her health goals.
- The frequency of interaction that individuals have with their devices also enables us to design systems that can smartly adjust to the user's current needs in order to provide the right level of support for the user's current goals and abilities. For instance, when a person is trying to establish a new habit—say, regular physical activity—the system might need to support detailed tracking, explicit goal setting and monitoring of goal progress, positive feedback for small successes, frequent reminders and so on. Yet, as the physical activity habit starts to take hold, some of these features might automatically fade into the background, decreasing the effort the user needs to put in to use the system. Eventually, the system might only monitor activity in the background, and popping up only

occasionally to provide positive feedback, to help the user reassess her goals, or to provide additional support if it notices that the user's regular routine has been disrupted for several days. This kind of ability to fade into the background and then reemerge when needed could go a long way toward keeping individuals using a wellness system over the long term, but it would only be possible if the system could monitor enough of users' activities and states to have a reasonably accurate picture of what is currently needed. Frequent interactions with the devices with the wellness system would be a key requirement for this.

- As demonstrated by Consolvo et al.'s (2009) UbiFit project, frequent interactions with mobile devices enable wellness systems that can support ongoing ambient awareness of the user's health goals and progress on those goals. This awareness, in turn, can make the health goals chronically cognitively accessible (Higgins et al, 1996), increasing the likelihood that the user will act on them and engage in activities that advance her health (as well as continue to use the wellness system itself).

- Another way in which wellness system can foster long-term engagement is by providing engaging micro-activities that individuals can use during the short breaks in their daily routines (while waiting in the line at the grocery store, when they have a couple of minutes before the next meeting, etc.). Currently, such time gaps are often filled with games and social media tools like Facebook. Wellness systems that offered engaging quizzes, games, updates from others with similar health goals and other types of content that can be accessed repeatedly and quickly (and which is compelling enough that people might want to do it instead of checking Twitter), could greatly increase the "stickiness" of a wellness application.

- Finally, although all too frequently gamification has been offered as a cure to all technology engagement ills, some forms of it might in fact be very helpful for supporting long-term engagement with health tools. In particular, long-term quests that users can work on over weeks, months, or even years, might be a form of games that can keep users engaged with a wellness application over the long term. The game of conquering the world used by the Nike+ website is a version of this idea. James Landay and his students have been working on a similar concept with a mobile game they are calling "Who is Zuki?" In the game, users follow a character called Zuki about whom they know very little. As users do and record physical activity over time, more and more information about the character is revealed and his life story unfolds. Games like this, if they are well crafted, could be a great motivator for long-term use of wellness systems.

Q3: Devices and software applications that claim to promote health and behavior change are being introduced at a rapid pace, but with little or no rigorous validation. Does this, or should this, impact future research and development of health behavior measurement and motivation systems?

I see three broad directions that research on technologies for health behavior change can take, two of which run in parallel to commercial developments and one of which involves direct collaboration between research and industry. The first direction has to do with the invention and development of new approaches to supporting health behavior change. With their expertise in health, behavioral, and computer sciences, researchers can develop and test new ways in which technology can support health behavior change. Some of these new approaches will rely on technologies which are not yet ready for commercial use (think wearable sensors circa 2006 or 2007); some will be drawn from

new work in psychology or will be made possible by new modes of interaction developed in HCI. This form of research pushes boundaries, tries new ideas that might fail, and demonstrates promising directions are can be perfected by industry in the future. This view of research closely matches the traditional model of research in computer science.

A second direction has to with evaluation, and specifically with building up a solid knowledge base about the effectiveness of and design requirements for different types of behavior change interventions. I see research in this area as involving rigorous, multi-method evaluations of individual intervention types and their combinations, as well as the development of taxonomies of basic behavior change intervention types (e.g., see Michie et al., 2011). This type of research generates knowledge about relative efficacy of different approaches to supporting behavior change (e.g., is manual journaling or automated sensing a more effective form of self-monitoring for encouraging physical activity?) and about the specific ways an intervention approach needs to be designed to maximize its effectiveness (e.g., for a goal setting intervention, how often should the system prompt the user to review her goals?).

Finally, I see a possibility of research-industry collaborations in which researchers team up with companies that develop health applications to study interesting questions in large user populations. Facebook, for instance, is famous for making changes to their application based on A/B testing of different versions of the application across hundreds of millions of users. Although most health apps don't have that kind of reach, many are used by hundreds of thousands or even millions of people. Those user populations are much larger than study populations of even largest randomized controlled trials, making it possible to investigate questions related to how technologies for health behavior change work with precision and power that we have not had before. In this respect, the recent flood of commercial applications for health behavior change is a positive development not only for consumers who are getting sophisticated and inexpensive tools for managing their health but also for researchers who, if productive relationships with companies that make these tools can be developed, are gaining access to very large study populations who use health behavior tools in their daily lives.

Q4: What could participants in the meeting collectively do before, during, and after the meeting to significantly impact the field of health behavior change and maintenance? Be as concrete as you can, and think boldly.

One of the main things that I hope this workshop can accomplish is to articulate clearly what the central problems are that need to be solved to enable a fuller understanding of the behavior change process and the development of more effective tools for supporting behavior change and maintenance. Where should we, as a community, be focusing our efforts to create the biggest impact in this field? What are the problems and what types of expertise are needed to solve them? If we can leave the workshop with a draft of the important hard problems—articulated as precisely as possible—I think the workshop will have been a huge success. As such, beginning to generate this list now—potentially in some kind of a shared document—would be a great first step.

Another important outcome of this workshop could be a set of ideas about what a more robust model of health behavior change might look like and which elements it will likely need to contain to dynamically model health behavior and health behavior change over time. In particular, what form should different behavioral determinants take within the model? How do we represent influence of

the learning history? At which level should a person's activities or context be modeled? What types of algorithms can detect influences of different determinants and their relationships? If we could make some initial progress on answering such questions—and specifying what other ones need to be answered—the workshop will make a huge contribution to this complex field. I am greatly looking forward to what we come up with together.