A case study of BSUED: Behavioral Science-informed User Experience Design

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Abstract
The skyrocketing costs of healthcare, the obesity epidemic, and the rapid ageing of the global population collectively create a critical need for evidence-based strategies for promoting health and wellness. Smartphone apps offer new opportunities for promoting health but despite the promise of these apps, most lack an evidence-informed, theoretical rationale underlying the methods for behavior change. The MILES (Mobile Interventions for Lifestyle Exercise at Stanford) group is developing three theoretically-based applications that use different motivational frames for promoting behavior change and health. In this paper, we will discuss our behavioral science-informed user design (or BSUED) process.

Keywords
Smartphone apps, health promotion, behavioral science

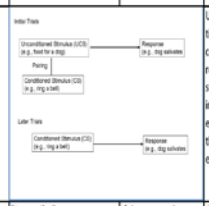
ACM Classification Keywords
J.3 Life and Medical Sciences; J.4 Social & Behavioral Sciences; D.2.10 Design; H.5.2 User Interfaces

General Terms
Design, Theory

Introduction
The major killers of U.S. adults are cardiovascular disease, cancer, and other diseases of ageing which are significantly linked with daily health behaviors, including regular physical activity [1]. Relatively few American adults engage in sufficient health-enhancing

Behavioral Science Summary Sheet

Health Behavior Change Research/Clinical Psychology

Theoretical Construct	Description	What it does	Intervention Examples
Classical Conditioning			Used in Alcohol treatment. Bars, certain people, times of day (eg, after work) are often conditioned stimuli for drinking (i.e., they have repeatedly been paired with the unconditioned stimulus, alcohol). In treatment, alcoholics are initially told to stay away from these places but eventually are brought to the places to pair them with no alcohol. Eventually they are exposed to alcohol itself but does not drink.
Behavioral Routines	"Auto-pilot"	If done enough, many behaviors can be done with little conscious thought.	Creating routines by doing the same behavior during the same time of day, at the same location, with the same people (or alone), each time. Driving to work or other common places is a good example of this principle at work.
Social Support	encouragement/ engagement of family friends in changing a behavior	Strong predictor of physical activity; reduces the impact of stress on health outcomes (e.g., heart disease)	Group sessions utilize social support to function well; social support is also discussed in sessions, to gauge the supportiveness of a person's context for new behaviors (and if possible, to engage others in the behavior change process); Walking groups and neighborhood walking also developed; assertiveness training can be part of treatment to help increase social support
Modeling	Teaching a behavior by showing it to someone rather than verbally explaining	Can be used well via "role-models" for good and bad behaviors; people tend to mimic actions of others	Therapists dealing with mental illness often do a lot of "modeling" of appropriate interpersonal behaviors within sessions; Therapists also use "role-plays" as a way to model behavior by having each person act out situations; health promotion research has used peer-mentors as models, along with modeling of proper exercise technique
Social Norms	what others are perceived to be doing	creates a strong nudge for specific behaviors	Campus campaigns (e.g., 70% of students don't drink); Towel reuse in a hotel (e.g., study compared different labels of specificity on the towel racks: a) 70% of people in this town put the towels back; b) 70% in this hotel; c) 70% of previous guests in this room. group C resulted in greatest increase of towel reuse.

Eric Hekler 2/1/2010

figure 1. Example page of the behavior change cheat sheets. For the full sheets, contact Eric Hekler,

behaviors such as physical activity [1]. Traditional approaches to promoting health behaviors have typically involved resource-intensive, face-to-face strategies delivered in clinical settings. Such approaches typically are limited in their ability to create health habits, given that they are often time-limited and require individuals to regularly travel to specific locations. They also often lack appropriate techniques for monitoring daily fluctuations in health behaviors.

The advent of smartphones has created new opportunities for personal health informatics. In particular, the increasing inclusion of sensors (e.g., accelerometers, GPS, gyroscope) and other capabilities (e.g., feedback delivery, onboard computing, and "cloud" connectivity), create new opportunities for health promotion via already owned technologies. Many businesses are exploring "consumer-driven healthcare" [e.g., 2] and, in particular, working on developing smartphone based applications. There are a huge number of "Apps" for different smartphones (e.g., iPhone, Android) that make claims about improving health. Despite the rapid growth of these applications, few are evidence-informed and often lack a theoretical basis that takes advantages of established behavior change mechanisms and insights from behavioral science. This lack of theory likely limits the impact of these applications.

The MILES project

The MILES (Mobile Interventions for Lifestyle Exercise at Stanford) Project was conducted to directly respond to the lack of theoretically driven smartphone applications. In particular, our interdisciplinary group, which includes behavioral scientists, HCI computer scientists, product designers, exercise physiologists, and physicians, is focused on developing theoretically meaningful smartphone apps for promoting increased physical activity and decreased sedentary behaviors that will be tested in a randomized controlled study.

Behavioral Science-informed User Experience Design (BSUED)

Behavioral scientists often identify a theory (e.g., social cognitive theory, [3]) and then develop an intervention. Although focus groups are conducted, the development is largely driven by the theory. In contrast, user experience design starts with insights gained via ethnographic interviews and observation with less emphasis on prior work. In our design process, we sought to take advantage of both behavioral science and user experience design. To do this we developed the behavioral science-informed user experience design (or BSUED) process. This process adds two components to user experience design: a) the "behavioral science summary sheets;" and b) clustering of techniques /constructs into "motivational frames."

Within these summary sheets (see figure 1), theoretically derived and/or empirically informed constructs and techniques often used to create behavior change in the scientific literature were identified and briefly described in lay terms. For example, the concept of "self-efficacy" was identified and described as "confidence in one's ability to engage in an action (e.g., I'm 80% confident that I can walk 30 minutes a day)." Beyond a description, there was also an answer to the question, "what it does" (e.g.,, self-efficacy has been shown to consistently predict physical activity engagement and maintenance of activity) along with intervention examples (i.e., "Setting goals that are slightly difficult but doable; increasing difficulty over

figure 2. "Cognitive" app, glanceable display.

figure 3. "Social" app, glanceable display.

time; Discuss potential barriers and make plans to deal with them."). We identified 39 theoretical constructs, behavioral principles, and/or techniques that our behavioral science team deemed important for our non-behavioral scientist colleagues to use during development.

Following development of the summaries, our team clustered these constructs and techniques into "motivational frames." We did this: a) to identify patterns within the constructs; b) to help frame our intervention development; and c) to guide later testing of the constructs within a randomized controlled study. We define a motivational frame as the underlying latent structure of a cluster of behavior change techniques that taps more fundamental processes of behavior change. For example, one motivational frame we identified was the "social" frame. Within this frame, the underlying motivators for behavior change harness interpersonal relationships (e.g., constructs such as social support, social norms, competition, & collaboration). We identified two other motivational frames that we called the "cognitive" frame and the "emotional" frame. Problem-solving and cost-benefit analyses are both prime examples of a "cognitive" process as they both involve attempting to rationally work through a problem to come to the most logical conclusion. We also included explicit goal-setting that included quantifiable goals and planning as part of the "cognitive" frame. In contrast, the "emotional" frame promotes behavior change primarily through emotions. This is best exemplified by operant conditioning principles (for a lay description of operant condition see:[4]) and, in particular, positive reinforcement or the pairing of a positive reward following a desired behavior (e.g., receiving praise immediately after a walk). These techniques are vital to game dynamics.

Concurrently to developing the motivational frames, we also conducted needs finding ethnographic interviews among our target population of inactive mid-life and older adults. With the theories and underlying needs defined, we then utilized an iterative brainstorming and user experience design process whereby we developed several concepts for each frame via brainstorming, narrowed them to a few prototypes, sought user feedback and then iterated. The first half of our user studies focused on understanding our participants' health and motivations for health. During the second half, we received feedback on several paper prototypes of concepts based on the behavioral science techniques and motivational frames (e.g., approximately 4 for each frame). From this, we gained important insights into key user-centered design parameters for our applications (e.g., the need for redundancy in our system to accommodate inexperienced users).

System Design

Based on the BSUED process, our team has developed three applications for each motivational frame (see figures 2-4). All applications utilize previously validated technological methods for behavior change including passively monitoring physical activity and sedentary behavior using the Android smart-phone's built-in accelerometers [5] and providing feedback via push, pull, and glanceable display [6] interactions. The major differences for these apps focus on the feedback we give based on the different motivational frames. For example, the "cognitive" app provides feedback about activity quantitatively and utilizes goal-setting, problem-solving, and feedback presented via graphs,

figure 3. "Emotional" app, glanceable display.

meters, and other quantitative visual feedback (figure 2). All feedback about activity is framed relative to others in the "social' app (figure 3). In particular, on the live wallpaper, an individual's progress related to being active is directly compared with others progress towards being more active. In addition, individuals have the option of joining teams and discussing progress via message boards. The "emotional" app utilizes an avatar to give feedback about physical activity (figure 4). With this frame, no numbers are explicitly given but instead feedback is provided via the avatar. For example, as an individual becomes more active, the avatar responds with being more active, happier, and more playful.

In our future work, we plan to test these applications in tandem via a randomized controlled study. This study will focus on identifying not only if the applications work better than an attention-only control (i.e., a calorie tracker app) but also if there are any factors that predict who responds best to which application. In particular, we hypothesize that the three motivational frames capture different needs and desires for behavior change. For example, during a presentation of this work, the principal investigator (ACK) asked the audience to raise their hands and identify which application they would respond best too. Results were striking with an almost even split in the room for each of the three apps. We plan to fully test if individuals are good at predicting the interventions they will respond best too or if trait characteristics (e.g., extraversion) may be better predictors.

Conclusion

The BSUED process is designed to take advantage of prior behavioral science knowledge while also take advantage of key insights that can be gained from user experience design. The BSUED approach should allow for rapid and focused prototyping of ideas that avoids "reinventing the wheel." In addition, with a strong theoretical backing, these applications could readily lend themselves to testing theories of behavior change. This latter point is particularly important for the development of evidence-informed, tailored intervention strategies for promoting population health.

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