Bounce: An Intervention to Increase Physical Activity in Breast Cancer Survivors

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Abstract
Behavior change theories are often applied to the design of technologies for improving health and wellness. However, researchers commonly apply these theories too narrowly or too broadly, resulting in a design process that does not account for the complexities of behavior change. To address this limitation in prior research, we developed a methodological framework that blends abstract theory with contextual relevance. Based on this framework, we developed a set of design guidelines for Bounce – a smartphone application aiming to increase the physical activity of breast cancer survivors.

Author Keywords
Behavioral intervention technologies; conceptual framework; participatory design; thematic analysis

ACM Classification Keywords
H.5.2 User Interfaces: User Design; Theory & Methods. J.3 Life and Medical Sciences: Medical information systems

Introduction
Behavioral intervention technologies (BITs) are behavioral and psychological interventions that use a

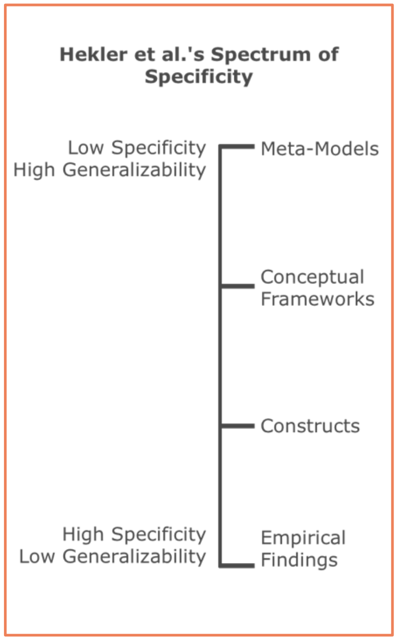


Figure 1: This image shows the Spectrum of Specificity of Behavioral Theories, as described by Hekler et al. in their publication for CHI 2013. Our methodological framework, MeGS, is based on the integration of each discrete marker.

broad range of technologies (i.e., mobile phones and web-based apps) to change behaviors related to health, mental health and wellness [7]. BITs have been used to address health issues such as sedentary behavior and management of chronic physical and mental illnesses. BITs are developed and evaluated using behavior change theories such as Social Cognitive Theory (SCT), the Trans-theoretical Model (TTM), Theory of Planned Behavior, and Self-Determination Theory.

In recent reviews of HCI literature, Hekler et al. [2] and Klasjna et al. [4] argue that a major limitation of BIT design strategies is that they rely too heavily on either abstract theory or empirical findings. Reliance on abstract theory often results in generic design strategies that do not provide useful behavior change tactics for specific user groups. Reliance on empirical findings can lead to designs that are not generalizable. Behavior change is a complex phenomenon influenced by individual, interpersonal, and sociocultural factors. To fully address these factors, BIT designs must integrate abstract theory with contextual relevance.

The contributions of this work are twofold. First, we developed the Methodological Framework for Generalizability and Specificity (MeGS), which balances generalizability with specificity, according to the spectrum defined by Hekler et al. [2] (Figure 1). Second, we applied MeGS to design Bounce, a physical activity intervention for breast cancer survivors. Our use of MeGS in the design of Bounce illustrates how BIT features can be designed by integrating meta-models, conceptual frameworks, theoretical constructs, and empirical findings. Bounce uses SCT and TTM constructs to address the unique barriers to physical activity experienced by breast cancer survivors [6].

Related Work

Researchers in behavioral science, HCI, and related fields have contributed to the development of BITs such as Spaceship Launch [9], iCanFit [3], and UbiFit [1]. These systems deliver interventions for populations who exhibit sedentary lifestyles, such as older cancer survivors and families of lower socio-economic status.

Spaceship Launch is a “family exergame” designed to reduce sedentary behavior in families of lower socio-economic status [9]. Spaceship Launch’s design was informed by insights from participatory design sessions and constructs of SCT, especially observational learning and self-monitoring. UbiFit Garden [1], a mobile app intended to increase physical activity in sedentary populations, was similarly influenced by behavioral constructs related to persuasive technology. Conversely, iCanFit, a mobile health technology for older cancer survivors [3], was based on a full conceptual framework (Theory of Goal Setting) as opposed to individual constructs.

We build on these studies by examining the use of behavior change theories at all levels of specificity. Our contribution is a holistic methodological framework that blends meta-models, conceptual frameworks, constructs, and empirical findings to inform the design of BITs. As an example of our framework in action, we contribute six design guidelines for a survivor-specific BIT and their manifestation as features in Bounce.

Methods

We used an iterative design process driven by: (1) The Spectrum of Specificity of Behavioral Theories, and (2) The Patient-Clinician-Designer Framework (PCD). Our multidisciplinary team of HCI and clinical researchers

SCT Constructs Defined

Verbal persuasion: Telling the person that he or she can do it; strong encouragement.

Social modeling: Showing the person that others like themselves can do it. This should include detailed demonstrations of the small steps taken in the attainment of a complex objective.

Mastery experience: Enabling the person to succeed in attainable but increasingly challenging performances of desired behaviors.

Goal setting: Planned behavior in which intentions are formulated in terms of both long-term and short-term goals that will bring people closer to the changes they desire.

Self-monitoring: The systematic observation of one's own behavior. This includes observing and recording the behavior.

conducted three main research activities: participatory design sessions, a literature review, and semi-structured interviews with survivors.

Spectrum of Specificity and Theoretical Influences
From highest generalizability to highest specificity, we systematically evaluated and applied all four discrete markers of Hekler et al.'s Spectrum of Specificity (Figure 1). We reviewed meta-models, such as the Social-Ecological Model, which suggests that behavior change is influenced by factors at the individual, interpersonal and sociocultural levels. Related to conceptual frameworks, we evaluated the strengths and weaknesses of several behavioral health models including, but not limited to, SCT, TTM, Theory of Planned Behavior, and Self-Determination Theory. We then evaluated the relevance of theoretical constructs to our research on breast cancer survivor barriers.

Patient-Clinician-Designer Framework
To design a BIT for survivors, we needed to approach the task with sensitivity to the needs of patients and clinicians. We thus adopted Patient-Clinician-Designer (PCD) framework, which was first used by Marcu, Bardram, and Gabrielli [5] to design MONARCA. The PCD framework helped us obtain survivor-specific empirical evidence from clinical and user perspectives.

From September through December 2015, we held weekly participatory design sessions in which we discussed past literature on behavior change theories, BITs, and breast cancer survivorship. Our multi-disciplinary team of HCI and clinical researchers allowed for valuable information sharing, pertaining to medical oncology, behavior change theories, and experience with human-centered design principles. We also shared empirical findings from our interviews with survivors, and iterated on a design for Bounce using our framework, MeGS (Figure 2).

Empirical Data Collection and Analysis
A medical oncologist on our team conducted semi-structured interviews with seven survivors to learn about their experiences, preferences, and concerns. Each interview consisted of four sections: general health questions, technology adoption, motivators and barriers to physical activity, and preferences for various design strategies and features displayed in (or absent from) mockups. The interviews were transcribed.

We analyzed this data using thematic analysis, constant comparison, and theoretical sampling. Our approach draws from methods such as inductive thematic analysis and Grounded Theory Method (GTM), which are characterized by constant comparison of data-with-data and data-with-theory. We compared all incoming data from interviews and participatory design sessions to behavior change theories and previously coded data. As higher level themes emerged, we grouped the codes into concepts and eventually categories. We then compared concepts and categories from our empirical data to theoretical constructs of SCT and TTM, adding and removing constructs as new themes emerged.

Findings

In this section, we describe our Methodological Framework for Generalizability and Specificity (MeGS) and how we applied it to the design of Bounce.

TTM Constructs Defined

Consciousness raising: Finding and learning new facts, ideas, and tips that support the healthy behavior change.

Self-reevaluation: Combines both cognitive and affective assessments of one's self-image with and without an unhealthy behavior, such as one's image as a couch potato and an active person.

Helping relationships: Combine caring, trust, openness, and acceptance, as well as support for healthy behavior change. Rapport building, therapeutic alliances, counselor calls, and buddy systems can be sources of social support.

Reinforcements + Group recognition: Specific types of contingency management; procedures for increasing reinforcement and the probability that healthier responses will be repeated.

Methodological Framework for Generalizability and Specificity (MeGS)

Based on our literature review, we found that TTM and SCT were the most commonly used and appropriate models for the design and evaluation of behavioral interventions for breast cancer survivors. Specifically, non-technical interventions for survivors achieved clinical efficacy when they used SCT and TTM to target sedentary behavior [8]. Furthermore, research suggested that due to the complexities of behavior change, TTM was more efficacious when used in combination with another theory such as SCT than when used alone [8]. For these reasons, SCT and TTM appear as *conceptual frameworks* in MeGS (Figure 2).

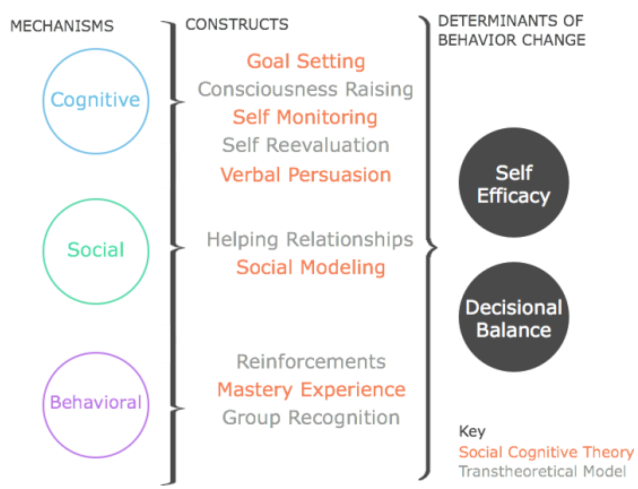


Figure 2: The Methodological Framework for Generalizability and Specificity (MeGS)

According to SCT and TTM, the intention to change a behavior is predicted by one's self-efficacy and decisional balance. Self-efficacy and decisional balance can be affected by the degree to which a person is engaged in various behavior change strategies (constructs of SCT and TTM). According to the Social-Ecological Model (a *meta-model*), behavior change is influenced by factors at the individual, interpersonal, and sociocultural levels [2]. In our methodological framework, these factors are represented as Cognitive, Social, and Behavioral mechanisms, respectively (Figure 2).

Through participatory design sessions we found that breast cancer survivors have unique barriers to physical activity, including cancer-related fatigue and joint pain, functional and emotional wellbeing, and lymphedema, and metabolic abnormalities [6]. Discussions about survivors' barriers helped us to assemble a list of SCT and TTM *constructs* that could be leveraged to support survivors and guide our early mockups of Bounce.

Thematic analysis resulted in 6 design guidelines for a survivor-specific BIT, and a refined list of 10 associated SCT-TTM constructs (Figure 2). Each design guideline represents a specific requirement or need expressed by survivors in the *empirical data*. The following section describes each design guideline, its associated constructs and Bounce features in full detail.

MeGS thus emerged as a result of combining data from all research activities, and analyzing the full spectrum of behavioral theories as defined by Hekler et al. [2] (Figure 1). For definitions of SCT and TTM constructs, as well as a summary of empirical findings paired with SCT-TTM constructs, see side bars on pages 3-5.

Constructs Paired with Empirical Findings

Goal setting: I need a balanced exercise program, tailored to my schedule.
Verbal persuasion: I need reassurance from a cancer exercise specialist.
Self-reevaluation: It's important to maintain my pre-diagnosis identity.
Self-monitoring: It's important to track my progress, steps, and time.
Consciousness raising: I'm afraid to exercise because I fear pain, fatigue, and issues related to surgery.
Helping relationships: I need to connect with survivors like me to motivate myself and other survivors.
Social modeling: I need to see a demonstration, but the model shouldn't be "ripped".
Reinforcements: Icons and rewards must be personal, meaningful, and fun.
Mastery experience: I have a "keep moving" attitude, but I need to take baby steps.
Group recognition: Exercise is more fun with a friend.

Bounce: A Survivor-Specific BIT
In this section, we describe the application of MeGS to Bounce. Each design guideline and associated SCT-TTM construct(s) is operationalized by a BIT feature.

Our first design guideline was that survivors need **flexibility in terms of scheduling their daily exercise, and variation in exercise type.** To address this need, we developed a balanced exercise program that focuses on three exercise categories (Aerobics, Flexibility, and Strength). Bounce prompts users to choose a different exercise category each day, 6 days per week. The exercise categories are arranged in a honeycomb structure (two of each category + one rest day) on the user's profile. This view is intended to help users plan for the week ahead – a key component of goal setting – by allowing them to rearrange the bubbles as they please.

The second design guideline was that survivors need **reassurance that exercises are safe**. Based on past treatments and surgeries, they need to know which exercises are appropriate. We use consciousness raising and verbal persuasion to operationalize this need in two Bounce features: (1) an FAQ tab which explains why exercises are safe (or unsafe), and (2) treatment-specific cautionary warnings displayed above each exercise description, signifying that an exercise has been approved (disapproved) by a cancer exercise specialist.

The third guideline for design was that survivors need **ways to monitor their progress**. For many survivors, walking is a main form of exercise, and they are motivated by visuals about their distance and time. To address this guideline, we used self-reevaluation, self-monitoring, and reinforcement strategies. We provide users with rich data visualizations, such as weekly summaries (Figure 3) to help them monitor their progress and compare their performance to the week prior. Weekly summaries serve as an opportunity for users to reassess their self-image based on progress in the exercise program. The rich data visuals provide reinforcement to users by showing the percent change from week to week.

Fourth, survivors need **opportunities to connect with survivors** who have experienced similar treatments and surgeries, and who are relatively close in age or activity level. We thus developed a social feature that allows users to join or create groups based on special interests, treatment history, concerns, location. This feature supports behavior change by encouraging users to build helping relationships and group recognition.

Fifth, survivors require **demonstrations and explanations of exercises**. Survivors need someone or something to model after. However, our data shows that survivors will not respond well to a "ripped" model. Based on the construct of social modeling, we designed an exercise trainer (Figure 3) to provide two types of instructions for survivors: (1) a written description and (2) a visual step-by-step demonstration. The trainer's body was designed to look non-intimidating, depicting an average middle-aged female body.

Lastly, survivors need **a program that nudges them along slowly** toward their long-term goals. To meet this guideline, we developed incremental levels inspired by the SCT construct, mastery experience. Each level contains three progress indicators – 6-segment circles

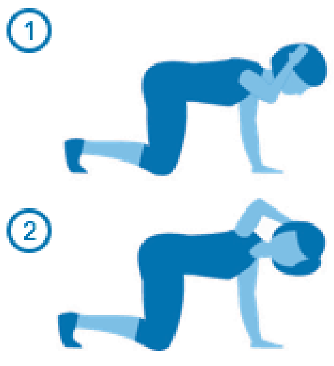
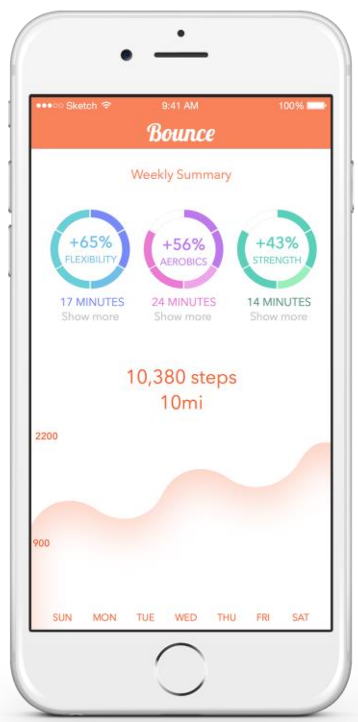


Figure 3: Exercise trainer (top); Weekly summary (bottom)



that show the progress of users based on level of difficulty attempted. This allows users to perform attainable, yet progressively challenging exercises.

Conclusion

As suggested by Hekler et al. [2], we apply the full range of specificity of behavior change to MeGS. MeGS is comprised of three mechanisms of behavior change influenced by the Social-Ecological Model: Cognitive, Social, and Behavioral. We support each mechanism by pairing it with SCT-TTM constructs. In accordance with SCT and TTM, the integration of constructs leads to increased self-efficacy and decisional balance. By applying MeGS to Bounce, we developed a set of design guidelines for a survivor-specific BIT. The resulting features of Bounce demonstrate that MeGS can be used to balance abstract theory and contextual relevance in BIT design for diverse user groups.

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