

Designing Consumer-Focused Health Improvement Systems

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Abstract: Consumers today can track health-related data via many different types of wearable devices and sensors. Health improvement systems which integrate data from personal devices and sensors with intelligent behavior modification applications can support the initiation and maintenance of behavior changes that are necessary to achieve health-related goals. The COMBI (Computerized Behavior Intervention) model and the application based on this model (eMate) demonstrate the integration of theories of behavior change in a framework on which to build an intelligent behavior modification system (Klein et al, 2014). The application, eMate, validated in several health-related settings, provides a functioning example of a consumer-focused health improvement system. Recent research highlights the importance of customizing behavior modification systems to support different user characteristics and changes over time. In this paper we present an extension of the COMBI model as an Internet of Things ecosystem which explicitly incorporates multiple types of personalization, autonomous data collection by tracking devices and sensors, and integration of actors from the user's social networks as well as healthcare professionals. Related to this extended model, the following guidelines for the design and development of consumer-focused health improvement systems are presented: (1) Personalization is essential and users should be viewed as co-designers of their personalized health improvement systems. (2) Personal monitoring devices and sensors can measure performance on relevant metrics autonomously and this data can be compared to established norms, based on user characteristics, to determine appropriate feedback. (3) The health behavior modification application must be dynamic and adapt over time to changes in the user's context and performance. (4) The system should facilitate interaction with healthcare providers and the user's social network.

Keywords: intelligent behavior modification, persuasive system design, internet of things

1. Introduction

With the advent of consumer-focused wearable devices to track health-related data, consumers changed from being passive recipients of healthcare services to active participants in the management of their own health data. The goal for most consumer use of these health-tracking systems is to improve some aspect of health. However, unless there are changes in behavior and strategies for maintaining it, behavior tends to return to the pre-use state (Klasnja et al, 2011). By integrating existing theories of behavior change with current practices in Internet of Things ecosystems, we can better design and develop consumer-focused healthcare improvement systems that will be utilized over time to achieve the desired results.

For the ultimate goal of improved health to be achieved, these systems must have the ability to change behavior. From research on behavior change and persuasive system design, we know that user characteristics and the context may influence which methods of persuasion are most effective (Oinas-Kukkonen & Harjumaa, 2009), which implies that health improvement systems should provide some method of personalization or customization, both automatically and under the control of the user.

User characteristics, context and the development of habits are important parameters when designing and using health wearables and their related applications. To build in the ability for the system to change, users should be involved throughout the design process to identify the types of personalization that are particularly relevant in this context. Data collected by sensors, tracking devices or provided by the user can be used to personalize the system functions and interactions, which can contribute to higher user satisfaction with the received outcomes and thus on-going use of the system which will support the desired changes in behavior (Rothman, 2000).

2. Theory-Based Model of Behavior Change

There are a number of well-researched theories that have been applied to the study of behavioral intentions and behavior change. One of the most comprehensive is the Transtheoretical Model (Prochaska, 2013) which addresses behavior change as a dynamic process composed of the six stages illustrated in Figure 1. Precontemplation is the state wherein the individual is unaware of the problem. Contemplation begins when the individual becomes aware of the problem and is thinking about doing something to address it, but without

any concrete plan. Once the individual decides to take action in the near future and has a definite action plan in place, we say that she is in the preparation stage. In the action stage the individual actually makes the change in behavior. Once the new behavior has been followed for at least six months the individual is in the maintenance phase. When the individual permanently abandons the behavior change, either in the action or maintenance stage, we would say she moves to the termination stage. As the arrows in Figure 1 show, it is possible for an individual to regress to an earlier stage or get stalled at contemplation, preparation, or at the action stage. Awareness, motivation, and commitment are viewed as underlying behavior change, impacting each other, intention and behavior.

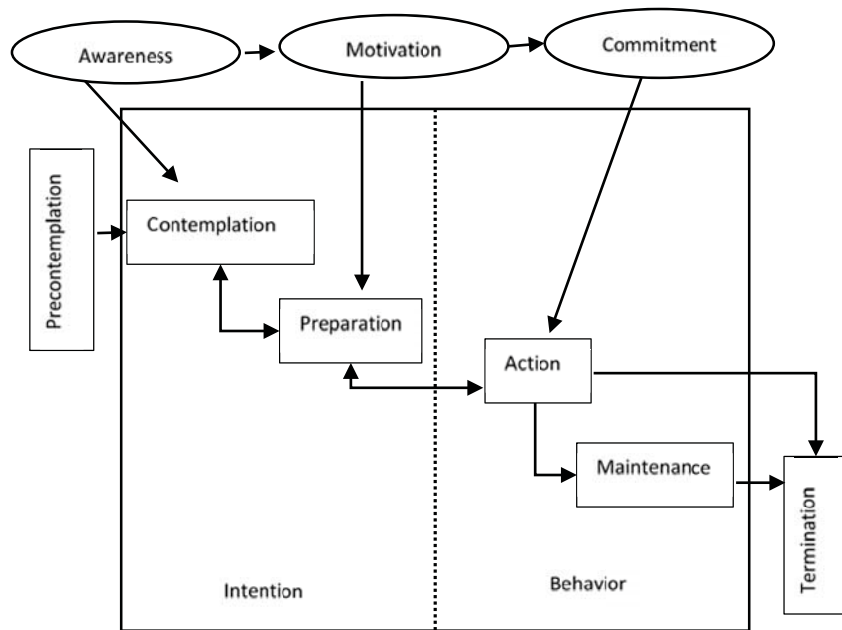


Figure 1: The Transtheoretical Model (TM), adapted from Prochaska (2013)

Klein et al, (2014) combined the Transtheoretical Model with Social Cognitive and Self-Regulation Theories (Bandura, 1991), the Theory of Planned Behavior (Ajzen and Madden, 1986), the Relapse Prevention Model (Marlatt and Gordon, 1980), and the Health Belief Model (Janz and Becker, 1984) to produce an integrated model, COMBI (Computerized Behavior Intervention), focusing on the four stages that make up intention and behavior (contemplation, preparation, action and maintenance, as shown in Fig. 1). From the contributing theories, a number of factors were identified as contributing to awareness, motivation, and commitment. These include cues (environmental or physical), threat (susceptibility and severity), attitude (positive and negative beliefs, emotions, and social norms), self-efficacy (skills and ability to address barriers), coping strategies, and mood. COMBI was used as the foundation for the creation of an intelligent coaching application (eMate) which has been evaluated in several healthcare environments.

3. Extended Model for a Health Improvement System

We build on the comprehensive COMBI model and its instantiation in eMate to propose an extension that makes explicit the use of personal monitoring devices and other sensors, the importance of individual differences as reflected in user-directed and autonomous customization and personalization and the role of social support. These have been shown in contemporary research to be related to positive outcomes of system use (Fritz et al, 2014; Laranja et al, 2015; Lee et al, 2015).

Figure 2 puts the Intention and Behavior constructs from COMBI into a high-level model of a consumer-focused health improvement system. This Internet of Things ecosystem is comprised of the following components: one or more personal monitoring devices and sensors that track performance and other metrics (e.g. location, heartrate, weight); the intelligent health behavior modification application that stores and shares the user's health-related data; the user of the health improvement system, who (ideally) progresses from contemplation to preparation into action and eventually reaches the maintenance stage; a healthcare provider who provides knowledge and support in goal setting based on information about the user's health

provided by the health behavior modification application; and interaction with friends, relatives, and other members of the user's social support structure. The expected manner in which this system would function is described below.

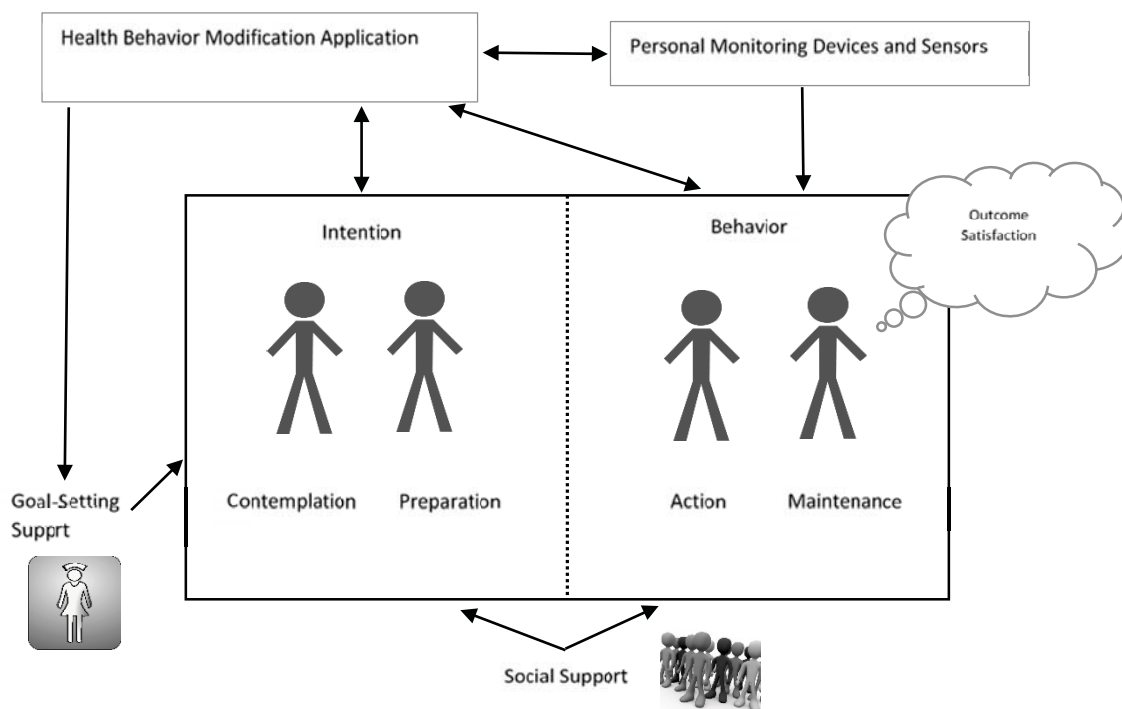


Figure 2: Proposed model for a consumer-focused health improvement system

Once the individual has decided to do something about her health issues via the health improvement system, she is prompted to provide details about herself and her condition and to set individualized goals for behavior modification. This is most effective when the goal-setting process is structured and supported by experts such as medical practitioners who can assist an actively-engaged patient in setting goals that are personally relevant (Maes and Karoly, 2005). In addition to providing personalized recommendations for goals, the system enables interaction with a healthcare professional when setting goals. Because different personality types respond differently to different types of feedback and coaching, the user can specify preferences regarding feedback and coaching as (Heimpel et al, 2006).

Performance data is collected autonomously by the monitoring device(s) and/or sensor(s). In addition, the user may enter other data which cannot be captured by the devices and sensors. To provide appropriate feedback and support for goal achievement, the system periodically determines and confirms the user's status.

This cycle of collecting performance data, determining status and confirming it, and providing interventions continues through the action and maintenance phases. Periodically the user is asked about any changes in preferences for feedback, any changes in goals and any changes to attitude, beliefs, perceived severity and so on. This allows for more individualized and interactive feedback systems that respond to changes in context and behavior over time, which have been shown to provide significant improvements in goal achievement and continuance of use (Prochaska, 2013).

Social support is shown as contributing both to intention and behavior. It is possible that a user's social network of friends, family and other connections may provide encouragement or social pressure that helps to convince the user to address the health issue, to identify personally-relevant goals, to plan and take action, and/or to maintain the behavior change (Taylor, 2011).

4. Guidelines for creating consumer-focused health-tracking systems

From the model shown in Figure 2 we can extract a number of guidelines relevant to the design of consumer-focused health-tracking systems.

- Personalization is essential. Users should be viewed as co-designers of their personalized health improvement system. In the model above, users can customize the system in several ways.
- Personal monitoring devices and sensors can measure performance on relevant metrics autonomously. This data can be compared to established norms, based on user characteristics, to determine appropriate feedback.
- The health behavior modification application must be dynamic and adapt over time to changes in the user's context and performance.
- The system should enable interaction with healthcare providers and the user's social network.

5. Conclusions and Future Directions

Based on the eMate application (Klein et al, 2014), we know that it is possible to build a theory-based intelligent behavior modification system that can adapt to dynamic user contexts. We believe that the extended model described in this paper has potential, but needs to be validated.

The next step will be to create our own mock-up or prototype of a system for one particular personal health management area which incorporates multiple types of personalization, sensor devices, interfaces for healthcare provider support in goal-setting, and interfaces for social support. Then the model could be heuristically validated. Expert panels could be used to evaluate different aspects of the model. The usability inspection method (Nielsen, 1994) could be used to evaluate the interface from a user perspective. The prototype of the system could also be evaluated from the perspective of health care providers who could assess whether the system model appears to offer the capabilities they would need to adequately participate in the management of the health of their patients, particularly in the area of goal setting. The mock-up or prototype may be used as a mediating artefact (Vygotsky, 1978) in a third expert panel that would examine the theoretical foundation of the model to determine if there are any additional theories related to behavior modification that should be included in the model.

Acknowledgements

This work was partially financed by the Knowledge Foundation through the Internet of Things and People research profile.

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