Designing for Healthy Lifestyles: Design Considerations for Mobile Technologies to Encourage Consumer Health and Wellness

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Sunny Consolvo

Google & University of Washington, USA
sconsolvo@google.com

Predrag Klasnja

University of Michigan, USA
klasnja@umich.edu

David W. McDonald

University of Washington, USA
dwmc@uw.edu

James A. Landay

Cornell University, USA
landay@cornell.edu

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Designing for Healthy Lifestyles: Design Considerations for Mobile Technologies to Encourage Consumer Health and Wellness*

Sunny Consolvo[1], Predrag Klasnja[2], David W. McDonald[3] and James A. Landay[4]

[1] *Google & University of Washington, USA, sconsolvo@google.com*
[2] *University of Michigan, USA, klasnja@umich.edu*
[3] *University of Washington, USA, dwmc@uw.edu*
[4] *Cornell University, USA, landay@cornell.edu*

Abstract

As the rates of lifestyle diseases such as obesity, diabetes, and heart disease continue to rise, the development of effective tools that can help people adopt and sustain healthier habits is becoming ever more important. Mobile computing holds great promise for providing effective support for helping people manage their health in everyday life. Yet, for this promise to be realized, mobile wellness systems need to be well designed, not only in terms of how they implement specific behavior-change techniques but also, among other factors, in terms of how much burden they put on the user, how well they integrate into

* Dr. Consolvo did this work while at the University of Washington and Intel Labs Seattle.

the user's daily life, and how they address the user's privacy concerns. Designing for all of these constraints is difficult, and it is often not clear what tradeoffs particular design decisions have on how a wellness application is experienced and used. In this monograph, we provide an account of different design approaches to common features of mobile wellness applications and we discuss the tradeoffs inherent in those approaches. We also outline the key challenges that HCI researchers and designers will need to address to move the state of the art for mobile wellness technologies forward.

Contents

1

Introduction

The world is facing a health crisis. Physical inactivity, poor diet, and other lifestyle behaviors (e.g., stress and insufficient sleep) are contributing to an epidemic of chronic conditions, including obesity, diabetes, and cardiovascular disease [48, 75]. These conditions now account for over two-thirds of U.S. healthcare expenditures [41], and their cost, in terms of economic impact and human suffering, is continuing to rise both in the United States and in other parts of the world. With an aging population further contributing to the rapidly rising health care costs, health leaders are encouraging people to take more responsibility for their own health behaviors. However, many of us are well aware of how difficult it can be to change our behaviors. As anyone who has ever made a New Year's resolution to get in shape or follow a healthy diet knows, changing one's habits is notoriously difficult. Too many of us end up making the same resolution year in and year out, only to fall back into our old habits after several weeks. The reasons may vary but the end results are often the same: little or no change for the better.

Mobile computing holds great promise for providing effective support for managing health in everyday life. Mobile devices include powerful processors, sensing capabilities, high-resolution display screens, nearly pervasive connectivity, and they go with us everywhere we go. In June 2013, the Pew Research Center reported that more than 90% of American adults own a mobile phone, and more than 50% of American adults own a smartphone [78, 84]. Mobile computing represents a fundamental change in how wellness can be tracked and managed.

The promise of mobile computing has not gone unnoticed. Numerous commercial products have launched, and a growing number of research projects have been reported in the literature. Progress continues to be made in areas from innovations in sensing to new designs of mobile interfaces and techniques for engaging people in the process of managing their health. A number of recent survey articles have focused on a range of issues in mobile health and wellness. Tentori, Hayes, and Reddy [86] review mobile systems that address mobile clinical and end-user health and wellness applications. Tentori et al. focus on the diversity of systems and how each one addresses a specific health challenge. Klasnja and Pratt [53] categorize health interventions that have been developed for mobile phones, and discuss the features of modern smartphones that enable each type of intervention. Another review by Cowan et al. [24] focuses on the types of behavioral theories that are incorporated into mobile health applications that support behavior change. Cowan et al. found that mobile behavior-change applications use only subsets of a few well-established theories. Finally, in health sciences there have been a number of reviews of the use of text messaging (SMS) for supporting health behavior change (e.g., [31]).

While these recent surveys have addressed specific advantages of mobile computing, the types of health applications that can leverage mobile technology, and how those applications incorporate behavioral theory, there has not yet been a review of the design features of those applications and the design challenges and opportunities for mobile health and wellness technologies. Our focus here is to consider some of what has been learned about the design of such technologies and to articulate a set of design challenges that must be overcome for designing effective mobile health and wellness technologies.

The reasons for this focus are twofold. First, data suggest that design problems with current applications are adversely affecting people's ability to use — and thus benefit from — mobile health and wellness applications. While the interest in mobile health applications is rising — for example, Pew recently found that nearly a fifth (19%) of smartphone owners have downloaded at least one health application [32] — continued active use of these applications is very low. A recent survey by the Consumer Health Information Corporation [23] found that 26% of downloaded health applications are used only once, and 74% are abandoned by the 10th use. Usability and design were found to be key considerations related to continued use. Improving the design of mobile health applications is thus critical if the potential of these technologies to help people reach their health goals is to be realized.

Second, while much of what we already know about the effective design of technologies in general will apply in this space, mobile health and wellness technologies have new or additional requirements that take center stage, such as the need to impact deeply-ingrained habits like daily food choices. In addition, these technologies raise a number of evaluation challenges, as those of us coming from an HCI and design background begin to develop systems that must satisfy not only end-users but also researchers and practitioners from the health sciences and related communities. For these reasons, a review of the design aspects of mobile health and wellness technologies seems to be in order. In this monograph, we attempt to provide such a review. Using our own research as examples throughout the review, along with other research and commercial health applications, we provide an account of different design approaches to common features of mobile health and wellness technologies and discuss the tradeoffs inherent in those approaches. We also outline the key challenges that HCI researchers will need to address to move the state of the art for mobile health and wellness technologies forward.

1.1 Our Mobile Technologies to Encourage Physical Activity

Much of the discussion that follows uses our own mobile health and wellness applications as examples to illustrate the issues we discuss. We have been working in the space of mobile technology to encourage health and wellness for many years. In general, our work has focused on people who are motivated to make healthy changes in their everyday lives (e.g., be more physically active and get better sleep), have the ability and desire to do so, but have not yet done so, or at least not done so consistently. That is, our work tends to target people who are in the *contemplation*, *preparation*, and *action* stages of change as defined by the *Transtheoretical Model of Behavior Change* [74]. Most of our work has focused on encouraging people to be physically active, though we have done some work on encouraging healthy eating [unpublished] and sleep habits as well (e.g., [7]).

In this section, we describe key aspects of three of our mobile health projects that attempt to encourage people to engage in physical activity. We cover *Houston* [19], a system to encourage people to take more steps, as well as *UbiFit* [20] and *GoalPost* [66], systems designed to help people incorporate regular and varied physical activity into their everyday lives. These technologies were pilot tested from weeks to months by members of the research team (and sometimes our colleagues and family members) prior to the field studies and deployments with target end-users that are mentioned.

1.1.1 Houston

In our first investigation, we were interested in encouraging *opportunistic physical activities.* That is, we were attempting to help people incorporate simple activities into their everyday lives such as taking the stairs instead of the elevator, or parking further away from their destinations. We were inspired by studies that found that people can achieve health benefits by merely increasing the number of steps they take each day and that social support from friends and family showed an increase in physical activity [15, 16, 89, 95]. With this in mind, we developed an application called *Houston* that encouraged small groups of friends to share their step counts and performance toward a daily step count goal via their mobile phones [19]. *Houston* was designed to promote self-reflection by providing personal awareness of daily step count through a mobile journal, goal-setting by providing progress toward and rewards for achieving a daily step count goal, and social influence by mediating physical activity-related social interaction among friends.

The *Houston* application was developed for the Nokia 6600 mobile phone, and the user's step count was detected by a commercially available pedometer (we used the Omron HJ-112 in our study). The user would read her step count from the pedometer, then enter it into the *Houston* application on the phone. She could enter her current count as often as she liked throughout the day, and she indicated when she was entering her final count for the day. She could enter her step count for today and yesterday, but no further back than that. If she had not reached her goal when entering her current step count, a pop-up message told her how many steps she still had to go (e.g., *"<number of> steps to goal"*). If she had not entered her final step count into *Houston* by the end of the day, she received a reminder on the phone to do so (and again the next morning if she hadn't entered yesterday's final count[1]). *Houston* provided positive messages when the user reached her daily step count goal (e.g., pop-up screens that read *"Congratulations, you have reached your goal!"* and *"<number of> steps over your goal"*), as well as a symbol next to her step count (i.e., an '*') to indicate that her goal was met. Within the *Houston* application, the user could also choose to share her current step count with the members of her group, add notes to her step counts, send messages to the members of her group, and review trending information about her daily step counts and those of the members of her group, provided that they chose to share. She could also receive messages and step counts from the members of her group (see Figure 1.1).

We conducted a three-week field study of the *Houston* application ($N = 13$) in Summer 2005 with three groups of women who were aged 28–42; each group's members were from pre-existing social networks. All participants regularly used mobile phones and wanted to increase their level of physical activity. During the study, participants carried a study-provided phone dedicated to *Houston*'s use, in addition to their personal mobile phone.

We built three versions of *Houston* for the study: baseline, personal, and sharing. During the first week, all three groups of participants

[1] The Omron HJ-112 pedometer that we used in our study supported viewing the user's last seven days of step counts; the pedometer automatically reset itself to 0 steps at 12:00 am.

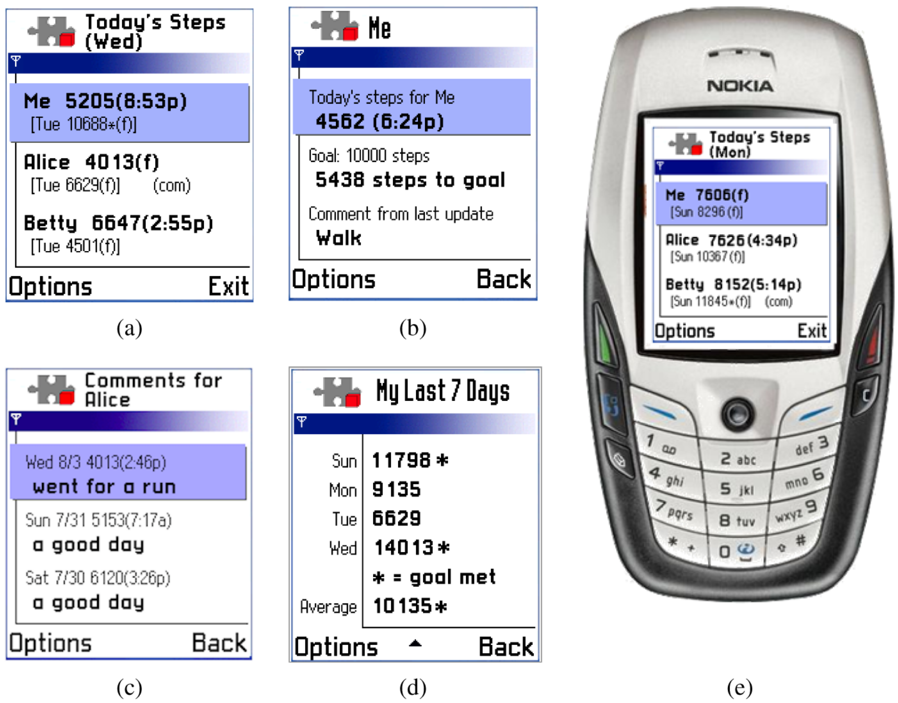


Fig. 1.1 **An overview of Houston**. (a) The main screen showing the user's daily step count for today and yesterday and the same information for members of her group; the "(f)" indicates the final count for the day, and the "(com)" indicates that the count includes a comment; (b) a daily detail screen showing progress toward goal; (c) comments that a member of the user's group, Alice, added to recent days; (d) step count totals for the user's last seven days, including a "*" to indicate days when the daily goal was met, and (e) *Houston* running on a Nokia 6600 mobile phone.

used the *baseline* version, which was used to establish individual daily step count goals and familiarize participants with *Houston*'s interaction model. With the *baseline* version of *Houston*, participants could: enter or edit a step count for today at any time during the day, as often as they wanted; enter or edit a final count for yesterday (e.g., if they did not enter a final count the previous day); and view final daily step counts for the last 7 days. For the remaining two weeks of the study, one of the groups used the *personal* version of *Houston*, while the other two used the *sharing* version. The *personal* version of *Houston* had all of the features of the baseline, and also provided a daily goal, progress toward and recognition for meeting the goal, a daily step count average, and support for adding comments. The *sharing* version had all of the features of the *personal* version as well as additional features to support sharing of physical activity-related information with the other members of the user's group — that is, her "fitness buddies" — through the *Houston* application.

Additional details are described in [19]. Select findings from the three-week field study of *Houston* and how they relate to design are discussed throughout this monograph.

1.1.2 UbiFit

In our second investigation into developing technology to support health and wellness, we continued with the idea of using an application on a mobile phone accompanied by sensing and inference to detect activity. However, we changed our focus from encouraging an increase in daily step count to encouraging people to incorporate regular and varied physical activity into their everyday lives. We also took a step back from incorporating social influence into the system and decided instead to focus solely on the individual. *UbiFit* was designed to promote self-reflection by providing personal awareness of all of the physical activities that the user performs over the course of a week and goal-setting by providing progress toward and rewards for achieving a weekly physical activity goal.

The *UbiFit* application was developed for the Windows Mobile Smartphone, and the user's physical activities were automatically detected by the *Mobile Sensing Platform (MSP)* [17] and manually journaled by the user. The *UbiFit* system consisted of three main components: a glanceable display, an interactive application, and a fitness device (i.e., the MSP). The *glanceable display* used a non-literal but understandable and aesthetically pleasing image that represented key information about the user's physical activity behavior and goal attainment that was available essentially whenever and wherever she was because the display resided on the background screen (or "wallpaper") of her cell phone. For the purposes of our study, we implemented the glanceable display as a garden that bloomed throughout the week as the user performed physical activities. Different types of flowers represented different types of activities: cardiovascular activity, strength training, flexibility training, and walking. Upon meeting her weekly goal, a large butterfly appeared near the upper right corner of her display. Smaller butterflies represented goals attained in recent weeks, serving to reward and remind the user of recent successes. Yellow butterflies represented when the user met her *primary weekly goal*. White butterflies represented when the user met her *alternate weekly goal* — an optional goal that was intended to be less challenging to help the user through difficult periods (such as a busy period at work or a mild illness) in hopes that she would not give up for the week if her primary goal seemed out of reach. At the end of each week, the garden reset. It showed one calendar week's worth of activities (Sunday through Saturday) and four week's worth of goal attainments at a time.

The *interactive application* included detailed information about the user's physical activities and a journal where she could manually add, edit, and delete information about her activities. She could also see her weekly goal and the progress that she was making toward her goal. For the purposes of our field studies (described below), the user had to work with a study researcher to make any changes to her weekly goal; the application did not provide a way for the user to change the goal for herself. The *fitness device* automatically inferred and communicated information about certain types of physical activities (e.g., walking, running, cycling, using the elliptical trainer, and using the stair machine) to the *UbiFit* application on the phone. As with *Houston*, the user could add, edit, or delete activities for today and yesterday, and if nothing had been manually journaled for about two days, a reminder prompt asked if the user had anything to add (see Figure 1.2).

We used an iterative design process to develop *UbiFit*. This process included a paper-based survey, a 3-week field study, and a 3-month field study. The *survey* included a mix of multiple choice and open-ended questions about respondents' use of cell phones, their physical activity goals and practices, and two proposed designs — one of which was an early version of the garden design. Seventy-five people (46 female) who ranged from 18 to 63 years old and lived in 13 states across the United States responded. In the *three-week field study*, which was conducted in

Fig. 1.2 **An overview of *UbiFit*** (a)–(e) show the glanceable display's garden. In (a), the user has not performed any activities yet this week, and she did not meet her goal in any of the prior three weeks. In (b), the user has not performed any activities yet this week, but the three small butterflies indicate that she met her goal in each of the three prior weeks (yellow = primary goal, white = backup goal). In (c), the user has performed one cardio activity so far this week and met her goal last week and three weeks ago. In (d), the user has had an active week, but only performed cardio and walking activities. In (e), the user has had an active week full of variety. In (f), the user is looking at a daily view within the interactive application where her activities are broken down by category. In (g), the fitness device — i.e., the MSP — is shown, and (h) shows the garden as seen on the background screen of a Cingular 2125 Windows Mobile Smartphone.

Summer 2007, 12 participants (six female) who were recruited from the general public used the full *UbiFit* system for 21 to 25 days. Participants were from 25 to 35 years old, lived in the Seattle Metropolitan area, and were regular cell phone users who wanted to increase their physical activity. In the *three-month field study*, 28 participants (15 female) who were recruited from the general public used one of three versions of the *UbiFit* system for three months over the winter holiday season (from November 2007 to February 2008[2]). The three versions were: (a) *full system*, which included all three main components, (b) *no garden*, which included the interactive application and fitness device, but no glanceable display (i.e., there was nothing special about the phone's background screen, nor was there an aesthetic representation of activity), and (c) *no fitness device*, which included the glanceable display and interactive application, but no fitness device (i.e., all activities had to be manually journaled by the user). Participants were aged 25 to 54, lived in the Seattle Metropolitan area, and were regular cell phone users who wanted to increase their physical activity. During both field studies, participants carried a study-provided phone as their personal cell phone (i.e., their personal SIM card was put into a study phone, contacts were transferred over, and participants used the study phone as their personal phone for the duration of the study). Improvements were made to the system after each study. For example, the backup goal was added to the system for the three-month field study based on feedback we received in the three-week field study.

Additional details, including how theories from behavioral and social psychology influenced the design of *UbiFit*, are described in [20, 21, 22]. Select findings from the studies of *UbiFit* and how they relate to design are discussed throughout this monograph.

1.1.3 GoalPost

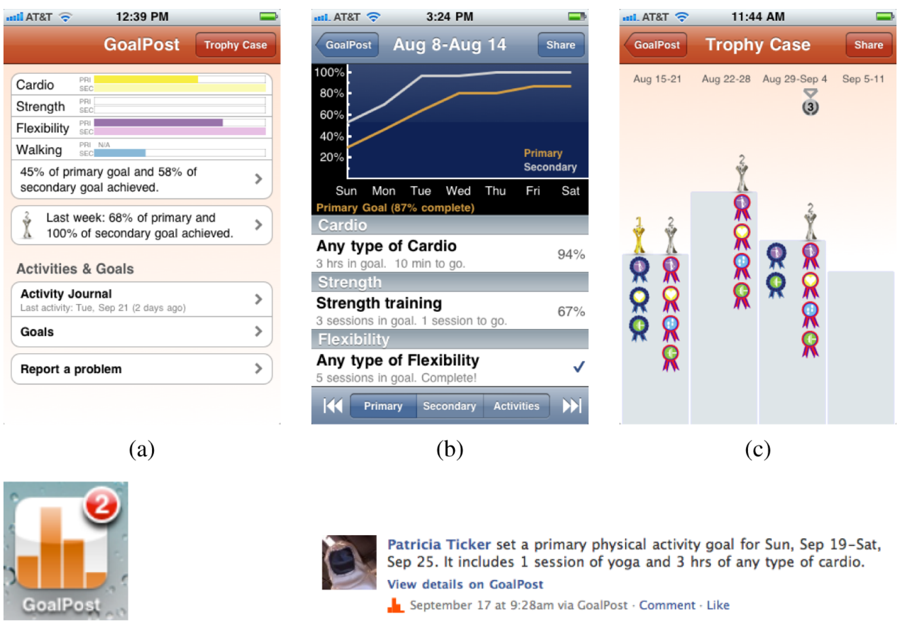
To further investigate some of the strategies that we used in our prior work to encourage regular and varied physical activity, we developed

[2] To put the timing of this work in the context of 3rd party development of smartphone applications, Apple released the original iPhone in June 2007 and launched the iPhone software developer's kit, which enabled 3rd party developers to develop applications for the iPhone, in March 2008. The first Android phone was sold in October 2008.

another mobile-phone application, *GoalPost*. Unlike *UbiFit* and *Houston*, with *GoalPost*, we focused solely on the mobile-phone application; we did not use any type of sensing or inference to detect the user's physical activities. *GoalPost* was designed to support goal-setting by encouraging users to set two goals per week — a primary goal and a secondary goal; rewards by giving users ribbons and trophies as they made progress toward and achieved their weekly goals; self-monitoring via an activity journal that used two styles of reminders to encourage users to record their activities and set their goals, and sharing via a feature that enabled users to easily share their goals, activities performed, and goals achieved with members of their Facebook network.

The *GoalPost* application was developed for the Apple iPhone. All physical activities were manually journaled by the user. As in *UbiFit*, *GoalPost* users set goals for a calendar week (Sunday through Saturday) that were broken down by category — cardio, strength, flexibility, walking, and other. Also as in *UbiFit*, goals could be specified at the category and/or specific activity level (i.e., 90 min of cardio OR 30 min of running and 60 min of elliptical) and could include any or all of the categories. Unlike *UbiFit*, *GoalPost* users could set and change their own goals whenever they wanted from within the application with no involvement from the researchers. When setting their goals, users could pick from a list of predefined activities or create their own. Similar to *UbiFit*, *GoalPost* users were encouraged to set two goals per week — one *Primary* and one *Secondary*. Users could choose whether or not they wanted to set both goals, and they chose how those goals were used (e.g., as a main and a backup in case the main became too challenging, or a main and a stretch to give them something extra for which to strive). Users were responsible for recording their physical activity in *GoalPost*, and they could record any physical activity, whether or not it counted toward a goal.

GoalPost provided users with pop-up reminders on their phone to journal physical activities and set goals, as well as a persistent reminder (in the form of a "notification badge") on the application's icon of how many days since she performed a physical activity. Users earned trophies and ribbons as a reward for completing goals and activity categories within the goals. A ribbon was awarded for each category — cardio, strength, flexibility, walking, and other — within the goal that they completed (blue for categories in their primary goal, red for secondary). A trophy (gold for primary, silver for secondary) was awarded when they completed all elements of their goal. Users were also able to post physical activity-related updates to their Facebook NewsFeed from within the *GoalPost* application. The user could choose to share her activity journal for a day or week, a single activity, a goal(s), progress toward the goal(s), her trophy case, or nothing. If she chose to share, she specified if the update should be shared with a subset of her Facebook network or her entire network (see Figure 1.3).



(d) (e)

Fig. 1.3 **An overview of *GoalPost*.** (a) *GoalPost*'s *main* screen shows progress bars for each activity category of the user's goals as well as a percentage of how much of her goals have been achieved and how she did with respect to her goals last week. In (b), the *Goal* screen shows how the user is doing with respect to her goals this week, both in graph and text form; the user can navigate to the same view for prior weeks. In (c), the user's trophy case is shown; ribbons are for completed categories within a goal (e.g., cardio) and trophies are for achieving the entire goal. In the example, the "3" medal under the date range for Aug 29–Sep 4 shows that the user has met her secondary goal for three straight weeks. In (d), the reminder badge on *GoalPost*'s icon is shown; in the example, the user has not journaled any activities for two days. In (e), example user "Patricia Ticker" shares a goal with her Facebook network.

To help design the *GoalPost* application, we conducted a survey using a convenience sample ($N = 55$) of our friends, family, and colleagues. In the survey, we solicited feedback on configuring goals, providing rewards, and default content for the Facebook NewsFeed updates that could be shared from *GoalPost*. Once the application was built, we conducted a four-week long field study of *GoalPost* in September and October 2010 with 23 participants in the Seattle Metropolitan area who were between the ages of 20 and 50. Participants were recruited from the general public and wanted to increase their physical activity. They also owned an iPhone 3G or more recent version and were willing to download the study application onto their personal phone for the duration of the study.

We built two versions of the *GoalPost* application for the study: *GoalPost* and a subset of *GoalPost* called *GoalLine*. *GoalPost* was the full application as described above. *GoalLine* was just like *GoalPost* except that it did not include the sharing features (i.e., if a participant wanted to post something about her goals or activities to her Facebook network, *GoalLine* did not include any features to facilitate that). Twelve participants used *GoalPost* for the duration of the study, while the other 11 used *GoalLine*.

Additional details are described in [66]. Select findings from the studies of *GoalPost* and how they relate to design of mobile health and wellness applications are discussed throughout this monograph.

1.2 Roadmap

In what follows, we discuss design aspects of the key features of mobile health and wellness technologies that people can use to adopt and sustain a healthier lifestyle. In our discussion, we use examples from our work as well as the work of other commercial products and research projects around mobile health and wellness tools. Our focus is on technologies intended for supporting people who want to change something about their health behaviors. In this monograph, we do not focus on medical or clinical work, nor do we focus on tools that encourage people to change behaviors they do not wish to change.

Most mobile wellness applications are built on top of three common functions: collecting data about health-related behaviors, providing users with feedback about the data they are tracking, and helping users to set and track progress toward goals. In this monograph, we focus on this common base. Of course, wellness applications may use other strategies in addition to these three (see [53] for a review). For instance, social influence — sharing of health-behavior information within the application and on social networks, competition, and provision of social support — is an increasingly common strategy used in wellness applications. Such social features are found both in commercial applications (e.g., Fitbit, Nike+, Jawbone UP) and in research projects (e.g., [8, 19, 35, 47]). Similarly, health is one of the key domains where gamification strategies have been used, and there is a growing number of mobile games designed to promote healthy behaviors (e.g., [38, 61, 72]). Such strategies are important and deserve careful consideration in their own right. Yet, these more advanced intervention strategies are often built on top of behavioral data tracking, self-monitoring and goal-setting, and those foundational features need to be designed well for the more advanced features to be effective. For this reason, we focus on the design of that common foundational base in this review.

One other note on scoping: as we mentioned, there are already a number of reviews that examine the use of SMS to encourage health behavior change. As our interest is in the opportunities that new mobile technologies are creating for supporting health and wellness, our focus in this monograph is on native applications and sensing systems that these new developments have made possible.

The remainder of this review is organized as follows. In Sections 2 through 4, we review the different ways in which behavioral data tracking, self-monitoring feedback, and goal-setting have been implemented in mobile health and wellness applications. For each of these three features, we consider the tradeoffs of different implementations and many outstanding design challenges. Finally, in Section 5, we discuss other areas that we believe need to be further investigated by HCI researchers and designers to truly make these types of mobile health and wellness technologies effective for helping people live healthier lives.

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