Design Requirements for Technologies that Encourage Physical Activity

Sunny Consolvo[1, 2], Katherine Everitt[3], Ian Smith[1], & James A. Landay[1, 3]

[1]Intel Research Seattle
1100 NE 45th Street, 6th Floor
Seattle, WA 98105 USA
[sunny.consolvo,ian.e.smith, james.a.landay]@intel.com

[2]University of Washington
The Information School
Box 352840
Seattle, WA 98195-2840 USA
consolvo@u.washington.edu

[3]University of Washington
Computer Science & Engineering
Box 352350
Seattle, WA 98195-2350 USA
[everitt,landay]@cs.washington.edu

ABSTRACT

Overweight and obesity are a global epidemic, with over one billion overweight adults worldwide (300+ million of whom are obese). Obesity is linked to several serious health problems and medical conditions. Medical experts agree that physical activity is critical to maintaining fitness, reducing weight, and improving health, yet many people have difficulty increasing and maintaining physical activity in everyday life. Clinical studies have shown that health benefits can occur from simply increasing the number of steps one takes each day and that social support can motivate people to stay active. In this paper, we describe *Houston*, a prototype mobile phone application for encouraging activity by sharing step count with friends. We also present four design requirements for technologies that encourage physical activity that we derived from a three-week long *in situ* pilot study that was conducted with women who wanted to increase their physical activity.

Author Keywords

design requirements, fitness, physical activity, pedometer, mobile phone, obesity, overweight, social support.

ACM Classification Keywords

H.5.2 [User Interfaces]: User-centered design; H.5.3 [Group and Organization Interfaces]: Evaluation/methodology, Asynchronous interaction.

INTRODUCTION

To help address the global epidemic of overweight and obesity, we are investigating how technology could help encourage people to sustain an increased level of physical activity, which medical experts agree is critical to maintaining fitness, reducing weight, and improving health.

We are specifically interested in encouraging *opportunistic physical activities*. These are where a person incorporates activities into her normal, everyday life to increase her overall level of physical activity (*e.g.*, walking instead of driving to work, taking the stairs, or parking further away from her destination). We are also interested in encouraging *structured exercise*, where a person elevates her heart rate for an extended period (*e.g.,* going for a run or swim).

In our first investigation, we focus on encouraging people to add opportunistic physical activities to their lives, without discouraging structured exercise. Studies have shown that people can achieve health benefits by merely increasing the number of steps they take each day and that support from friends and family has consistently been related to an increase in physical activity [3, 4, 17, 19]. However, with today's hectic lifestyles, many people have difficulty fitting exercise into their lives and spending quality time with their friends. A mobile device such as a mobile phone can provide relevant information *at the right time and place*, and may help encourage opportunistic activities [6]. Based on these findings, we investigate if technology could encourage physical activity by providing personal awareness of activity level and mediating physical activity-related social interaction among friends.

We use daily step count as a measure of physical activity and a mobile phone-based fitness journal we developed to track and share progress toward a daily step count goal within a small group of friends. We realize that investigating the effect of the technology on sustained behavior change will require a longitudinal study and thus have taken a user-centered design approach starting with a three-week long *in situ* pilot study. We evaluated an early-stage prototype of the mobile phone application with three groups of women who wanted to increase their levels of physical activity, were interested in preventing weight gain, and in many cases, had a goal of losing some weight. The results of the pilot study are being used to inform the design of a new application we are building to enable a longitudinal study to examine effects on behavior.

In this paper, we focus our discussion on the four key design requirements for technologies that encourage physical activity that we derived from our analysis of the qualitative data collected from the pilot study: 1) Give users proper credit for activities, 2) Provide personal awareness of activity level, 3) Support social influence, and 4) Consider the practical constraints of users' lifestyles.

This paper is structured as follows: first, we show the importance of this research by offering a background on the current global overweight and obesity epidemic. Next, we describe *Houston*, our prototype mobile phone-based fitness journal. We follow with the pilot study methodology and discuss the results with respect to the four key design requirements we discovered. We then discuss related work in the area of technologies that encourage physical activity, and conclude with our plans for future work.

The overweight and obesity epidemic

According to the U.S. Surgeon General and the Centers for Disease Control and Prevention (CDC) [3, 19], overweight and obesity in the U.S. are an epidemic, affecting over 60% of adults—and the problem is not unique to the U.S. The World Health Organization [23] reports that overweight and obesity have become a *global epidemic*, with over one billion overweight adults worldwide. In many industrialized societies including the U.K., Eastern Europe, and China, obesity rates have more than tripled since 1980, and rates are increasing even faster in some developing countries.

Overweight and obesity are risk factors for many diseases and conditions including diabetes, heart disease, stroke, hypertension, osteoarthritis, sleep apnea, and some cancers [22]. In 2000, over $100 billion USD in direct and indirect costs were attributable to obesity. As a result of this epidemic, the U.S. Surgeon General issued a call to action in 2001 to *prevent* and *decrease* overweight and obesity. Among the main principles addressed in the call is to help people balance "healthful eating with regular physical activity to achieve and maintain a healthy or healthier body weight" [20]. The CDC also emphasizes the value of physical activity, calling it "a key part of any weight loss effort" [3]. Yet despite the benefits of physical activity, our society is becoming increasingly sedentary, and technology may be in part to blame [19, p.6]. We believe that research in using technology to *encourage* physical activity is timely and can make a significant positive impact on the world.

Next, we describe the mobile phone-based fitness journal prototype we developed to track and share progress toward a daily step count goal within a small group of friends.

PROTOTYPE DESIGN & IMPLEMENTATION

Our prototype is composed of two pieces of commodity hardware—a pedometer and mobile phone—and our custom software, *Houston,* that runs on the phone. In this section, we describe the pedometer, mobile phone, and software that were used in the *in situ* pilot study.

Pedometer: Omron HJ-112 Digital Premium Pedometer

A pedometer is a wearable measurement device (usually clipped to the waistband above the thigh's midline—Figure 1b) that uses an accelerometer(s) or spring-set horizontal arm to count the number of steps the wearer takes. It is a commonly used instrument to approximate a person's level of physical activity. Many fitness programs (*e.g.,* 10k steps/day programs) encourage users to wear the pedometer during all waking hours to monitor *total daily step count* and not just steps taken during structured exercise, as would be captured if worn only during a run or fitness walk. Tudor-Locke offers a nice discussion of pedometry, including a history and use in fitness programs in [18].

Though Houston could be used with any pedometer, we needed to provide one for use in our pilot study. After informal testing with our colleagues who used several different models for many weeks, we chose the *Omron HJ-112 Digital Premium Pedometer* (Figure 1a & 1b), as it was found to be far more accurate in everyday life than others and was ranked the #1 pedometer by Consumer Reports [5].

a) b) c)

Figure 1. a) The Omron HJ-112 pedometer, b) the pedometer in use, and c) the Nokia 6600 mobile phone running Houston.

Mobile Phone: Nokia 6600

Our vision is that Houston will run on the user's personal mobile phone, enabling her to journal, receive feedback, and communicate with others whenever and wherever she is with a device she already carries. However, for the purposes of our pilot study, we needed to use a mobile phone on which we could develop software. We chose the Nokia 6600 mobile phone (Figure 1c). While its large size (108.6mm x 58.2mm x 23.7mm) is unfortunate, this class of phone (Nokia Series 60) is often chosen for application prototyping as it offers a significantly richer development environment than most alternatives and the ability to use most of the phone's features programmatically.

Software: Houston

We developed a mobile phone-based fitness journal, *Houston*, to track and share progress toward a daily step count goal within a small group of friends. The software is written in Python using the Nokia Series 60 platform.

We built three versions of Houston for the pilot study: baseline, personal, and sharing. During the first week, all three groups used the *baseline* version, which familiarized participants with Houston's interaction model, while we gathered the data we needed to establish their individual daily step count goals. For the remaining two weeks of the study, we were interested in getting feedback on which features of Houston were important, which were not, and what was missing to help inform future design. To see if traditional means of communication were sufficient or if technology-mediated physical activity-related social interaction was of strong value, we provided two groups with the *sharing* version of Houston, and one group with the *personal* version. Next, we describe each version.

Baseline version

The *baseline* software was used to establish individual daily step count goals and familiarize participants with Houston's interaction model. With this version, participants could:

- enter/edit a step count for today at any time during the day, as often as they wanted,
- enter/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.

When a participant entered/edited her step count, a message was sent to our server with the update, and the phone was updated with the new information[1]. After 9pm, Houston prompted participants to enter their final daily count. If they did not enter a final count, they were prompted again the next day. Participants were only able to enter a final daily count for today and yesterday (*e.g.,* on Wednesday, they could no longer enter a final count for Monday—we did this to encourage active participation in the pilot study).

Personal version

The *personal* software had all 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. Participants could:

- view the daily goal and progress toward that goal,
- receive recognition for meeting the goal,
- view their average daily step count based on their counts from the last 7 days,
- add an optional comment[2] to a step count, and
- view a list of recent comments.

In short, this version was an enhanced, mobile fitness journal with recognition for meeting the goal.

Sharing version

The *sharing* software had all of the features of the personal version (and thus the baseline version) as well as additional features to support sharing of physical activity-related information with members of their group (*i.e.,* "fitness buddies"). It enabled participants to:

- send their step count and an optional comment to any/all of their fitness buddies,
- see buddies' progress with respect to goals,
- see trending information: the last 7 days, recent comments, goals, and averages for all buddies,
- send a message[3] to any/all buddies, and
- request a step count from any/all buddies.

This version was an enhanced, mobile fitness journal with recognition for meeting the goal that also mediated physical activity-related social interaction among friends.

User interaction

Figure 2 shows several of the sharing version's screens. The *Main screen* (Figure 2a) displays the latest step count updates for all group members; '*' following a count indicates that the user met her goal; a time stamp indicates when the count was updated or shows an '(f)' if the user specified that it is the day's final count; and '(com)' indicates that the last update included a comment. Yesterday's final count is also shown (below today's count). The user's detail screen (Figure 2b) displays her last updated step count for today, how many steps to/over her goal, and any comment from her last update. Additionally, she can see recent comments that she or any buddy entered (Figure 2c), and up to the last 7 days of step counts for herself and her fitness buddies (Figure 2d).

This work was not trying to evaluate the usability of the application per se, but to explore the concept as a precursor to future work. We chose the Python prototyping platform because it provided a rapid-development environment that insulated the programmer from many of the phone's peculiarities. This allows for quick development of stable applications so the core ideas on which they are based can be evaluated *in situ*. Due to the nature of Python and the limitations of the Nokia 60s series platform, the interface is admittedly not elegant, *e.g.,* no icons or graphs, however it was sufficient for the early stage of the work.

For the pilot study, Houston ran on (but did not require) a dedicated phone (*i.e.,* based on previous experiences [7, 15], participants' personal SIM cards were not used in the study phones). However, with product-quality software, we envision such software being used on users' personal phones outside of the study environment.

---

[1] If the participant was out of range, her phone was updated but the information was not sent to our server. We were able to retrieve any untransmitted data from the phones after the study.

[2] Participants could use a default comment *(went for a walk*, *went for a run*, *a good day*, :), *a bad day)* or type their own.

[3] Unlike comments, messages were independent of step count updates. Participants could chose from *Good job!*, *Wow!*, *Get moving :)*, *Wanna walk?*, and *Up for lunch?* or type their own.

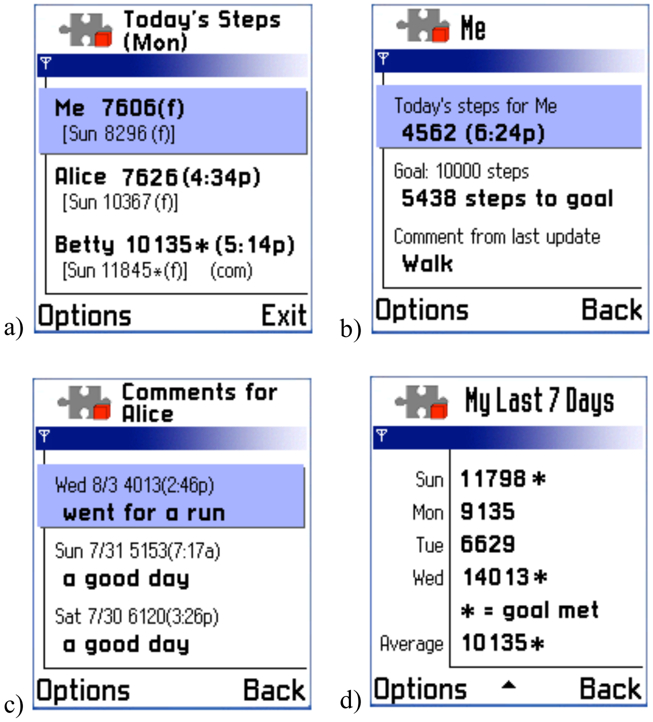

Figure 2: Houston screen shots. (a) Main screen, (b) detail screen, (c) recent comments, and (d) trending information.

Control of data

Whenever people share information about themselves, issues of privacy are raised. The two main sharing issues in our pilot study were with the participants' fitness buddies (for those with the sharing version) and the researchers (for all groups). Regarding fitness buddies, the choice of whether or not to share was completely in the participant's control. Each time she entered or edited her step count, she chose whether to share with all buddies, a specific buddy, or none of her buddies. Her buddies *did not* receive notification that she updated without sharing with them.

Regarding sharing with the researchers, this was merely a condition of the study. However, participants controlled when and what they updated; in fact, we cannot guarantee that the counts they uploaded were their actual daily counts. We also made efforts to protect their identities; communications did not include personally identifying information unless the participant explicitly included such information in a custom comment or message. Though all system communications were centralized through our server, this could easily be modified to a peer-to-peer architecture and encrypted for use outside of the study environment.

IN SITU PILOT STUDY OF HOUSTON

In this section, we describe the details of the *in situ* pilot study where three groups of women from the Seattle area used Houston for a few weeks during their everyday lives.

Participants

We used a homogeneous sampling strategy where participants were three groups of female friends (N=13) aged 28-42. The study ran for about three weeks, most of which took place *in situ* during the participants' normal lives. Each group consisted of four to five friends who knew each other (in two groups, one member knew only one or two others in the group) and were not planning to be out of town for more than three days during the study.

All participants wanted to increase their levels of physical activity, prevent weight gain, and in many cases, lose some weight. All used mobile phones and were married or had a significant other; five had children. Most were employed for wages, one was a full-time graduate student, one a homemaker, and two self-employed. Occupations included dental hygienist, sales, fashion designer, interior designer, and teacher. Two groups were recruited by a market research agency, and we recruited the third group ourselves.

Method

During recruiting, participants were screened for their current and near-future commitment to moderate physical activity using the *Sample Physical Activity Questionnaire to Determine Stage of Change* [21], which classifies people into precontemplation, contemplation, preparation, action, and maintenance stages based on the stages through which people progress when modifying an addictive behavior [14]. People who had no intention of introducing physical activity into their lives in the next six months (*precontemplation*) were not invited to participate; people who were maintaining moderate physical activity regularly (*maintenance*) were only invited if they wanted to increase their level in the next six months. One participant was classified in the *contemplation* stage, one in *action*, two in *preparation*, and nine in *maintenance*.

Participation included a phone interview where a subset of the *Behavior Risk Factor Surveillance System Survey Questionnaire* was administered [2]; several paper-and-pencil questionnaires including the *Barriers to Being Active Quiz* [21], the *International Physical Activity Questionnaire* [8], and questionnaires of our own design to learn about participants' use of technologies, relation to the women in their group, etc; use of Houston—one week with the *baseline* version to determine a daily goal and two weeks with the goal (Groups 1 & 2 used the *sharing* version and Group 3 used the *personal* version); and three in-person interviews—prior to using Houston, after the first week (conducted as a group when possible), and at the end.

In-person interviews were audio recorded and transcribed. Participants received up to $260 USD in American Express Gift Cheques for participating; the amount was based on participating in the interviews and entering the final daily step count into the phone (all participants received $260). Incentive was *not* based on sharing with buddies or using features other than entering final daily count.

Individual goals were established using a modification of the guidelines set by the President's Council on Physical Fitness and Sports' *Walking Works* program [13] where participants record their final step count every day for one week, take the highest count (rounded to the next thousand), and use that as a daily goal for the next two weeks. However, based on data from week one that showed one unrepresentatively high step count for several participants, we modified the calculation by rounding up from the *second highest* count. Participants' goals ranged from 9k to 19k steps/day (mean: 10,923; median: 10k).

We also calculated participants' Body Mass Index (BMI). BMI [12] is a formula that uses weight and height to determine if a person is underweight, normal, overweight, or obese. BMI is significantly correlated to body fatness, and while it is not a perfect measure, it is commonly used to determine overweight and obesity and also to describe study populations when reporting the results of fitness and diet interventions. Participants' BMIs ranged from 18.4 – 27.2kg/m^2 (mean: 22.2, median: 21.4). One participant was classified as *underweight*, two *overweight,* and 10 *normal*[4].

RESULTS

Overall, the feedback about Houston was very positive, and their experiences inspired several participants to plan for increased physical activity moving forward. For example, two participants expect to go for fitness walks with friends instead of previous get-togethers where they would *"just sit around and chat."* Another participant mapped out various neighborhood walks that she plans to continue. Others were pleased by the support from their spouses and children; walking often became a regular family activity.

Yet, factors such as the study's "short" duration, unforeseen events, the limitation of Houston not being on the participants' personal mobile phones, and the fact that introducing a monitoring device inherently affects behavior [18] prevented us from finding truly convincing quantitative effects on activity level. However, while our main contribution in this work is the design requirements, we also present a brief quantitative analysis.

Next, we discuss quantitative data from the pilot study and follow with four key design requirements for technologies that encourage physical activity. We also offer an additional challenge for future designs that emerged from our analysis.

Quantitative Analysis

Examples of unforeseen events involved two participants who were on track to meet their goals when something happened during the final two weeks of the study that led to a drastic reduction in their step counts (one went from an average of 11,706 to 6,350 when school started and another became ill, dropping her average from 10,664 to 3,501).

However, we compared the percentage of days that goals were met between the sharing (Groups 1 & 2) and personal (Group 3) groups (Figure 3). After removing data from those two events, we found that the sharing groups were significantly *more likely* to meet their goal ($t=2.60$, $p<0.05$). We caution that data was not collected over a long period, therefore we cannot confidently state that this was due to Houston. However, our use of a baseline period and the statistically significant data regarding performance suggests that something other than novelty affected behavior.

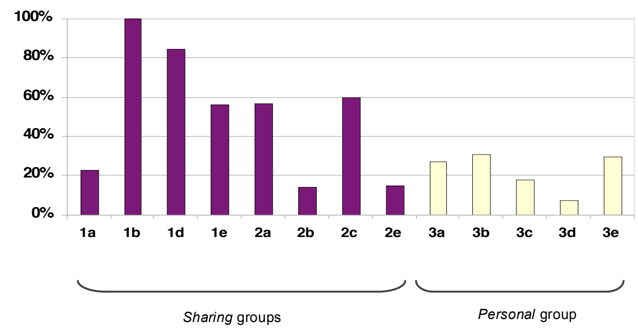

Figure 3. Percentage of days participants met their goals.

Further analysis (with the same data removed as above) revealed that average daily step counts increased for seven participants from the baseline week to the two weeks with the goal. Daily averages increased from 5% to 61% (median: 30%; the increase to average daily step count was from 180 to 4,587 steps/day, median: 2,234), though there was no statistical significance based on which group the participants were in. It was rare for participants to miss their goal by 1,000 or fewer steps; instead, on days when they *missed* their goals, they missed by an average of 4,319 steps. Additionally, there was high variance within step counts; highest counts were from 11,517 to 22,173 (median: 15,649) and lowest from 1,098 to 5,802 (median: 2,767).

We turn now to the focus of our discussion and present the design requirements for technologies that encourage physical activity that we derived from the qualitative data.

Key Design Requirements for Technologies that Encourage Physical Activity

Several themes emerged from our analysis of the qualitative data, which we present as four key design requirements of technologies that encourage physical activity:

1. Give users proper credit for activities,
2. Provide personal awareness of activity level,
3. Support social influence, and
4. Consider the practical constraints of users' lifestyles.

[4] Despite the seemingly high number of participants classified as "normal," we note that: (1) all were interested in preventing weight gain and wanted to increase physical activity, (2) many had a goal of losing weight, and (3) the BMI classifications are somewhat broad, *e.g.,* an adult who is 5'-5" tall has a "normal" BMI if s/he weighs between 111 – 149.5 lbs.

In this section, we describe what it means to support each requirement, offering several examples from the data.

1. Give users proper credit for their activities

Commercially available devices for monitoring physical activity do not truly represent the overall activity levels of many people, so technologies that aim to encourage physical activity must account for the inadequacies. In particular, our results show that the pedometer often provided *deceptive measurements* of physical activity, and that even when representative of actual activity, the measurement alone did not provide *sufficient information*.

Deceptive measurements. Several participants found that the measurement provided by the pedometer over-, or more often under-represented their overall level of physical activity. Activities that were under-represented (or completely ignored) included cycling (outdoor and on a stationary bike), swimming, climbing, strength training, and vigorous gardening. As one participant explained, *"It* [the pedometer] *was good at step count. But like, for example, one day I went bike riding for 10 miles. And I don't think it registered anything for that entire time. So you'll look on my step count and say, 'Oh, you only did 3,000. That's not an active day.' And for one time that's accurate and then for the next day, it's inaccurate 'cause I also biked 10 miles that it doesn't show."* Another participant expressed her frustration, *"So it's like my main source of exercise* [climbing] *doesn't register."*

Conversely, participants noticed that all steps are counted equally, yet they do not necessarily require equal effort. In one participant's words, *"You can take a lot of little steps to get somewhere. And wow, your step count sounds great, you know? Or you can take two normal steps, you know? And so – and it didn't factor that out."* At times, this actually discouraged vigorous physical activity, *e.g.,* one participant saw a fitness buddy walking up a steep hill, looking rather tired. The participant suggested that her buddy walk in a flat area, as *"it* [the pedometer] *didn't seem to care whether you went up and down hills or whether you walk on flats, so why kill yourself?"* The fact that the pedometer *discouraged* a more vigorous (and healthy) type of walking was unfortunate.

Sufficient information. Participants often wanted to supplement their measurement with information to describe why it may or may not be representative of their day (*e.g.,* 3,000 steps + *10 mile bike ride*). Yet, even when the measurement accurately represented the day, it did not convey *why*. For example, is the step count low because of illness? Injury? Perhaps just a lazy day? Deadline at work? Or how did she get that high count? Go for a hike? Start walking to work? Through comments, Houston offered some support for this need, though it could be improved, as inputting text on mobile phones is difficult.

While it may seem that these limitations are unique to pedometers, we could not find a commodity device that would properly detect all (or even most) types of the participants' physical activities, particularly when the other three requirements are considered. To address the issue of proper credit for activities, it is important for designers to understand the common physical activities of their target population, the limitations of the measurement device, and provide users with the ability to supplement/edit measurements with additional information.

2. Provide personal awareness of activity level

Overall, participants were intrigued to know their real step counts; *e.g., "I thought it was interesting to see how many steps you really took in a day. And a lot of times you think you're busy. You think you're moving around, but you're really not getting that many steps. And so you really have to do something extra like go for the walk or go for the run to really get up to that goal."* She further offered, *"you know, maybe you're busy…doing things around the house or shopping or doing errands, but you're in the car a lot and so you're really not getting as many steps* [as you think]*."*

We found three important types of personal awareness to provide: a history of past behavior, current status, and activity level performance.

History of past behavior. Most participants found value in Houston's trending information. One participant explained how she appreciated having one less thing to think about: *"I like knowing what days I was getting what amount of activity, rather than just thinking, 'hmm. You know, I really haven't done much in the last few days.' This time I could look back and know exactly which days I'd done what…There's a certain amount of mental demand on my time that I don't want to spend energy thinking, did I work out that much yesterday? Did I not?'"* Another participant explained how the *last 7 days* feature impacted her, "*I'd go, oh gosh, I had a really good day on Monday because I went out and walked and it's now Thursday and I haven't done any exercise. And you know, you better get your – your behind out to the park tomorrow."*

In fact, several participants wanted more than seven days worth of information. Suggestions were from three weeks to one year. When participants were suggesting the longer time frames (*e.g.,* months to a year), they were hoping to find patterns of success and failure that could help them figure out when they were particularly active or inactive to plan for a more successful future.

Current status. Many participants checked their pedometer frequently throughout the day. Because they knew their current step count and how many steps they still needed to meet their goal, they often found time for unplanned physical activity in an effort to meet their goal. As one participant explained, *"...I'd look down* [at the pedometer] *and go, 'oh man, you're not anywhere near* [your goal]. *You better go take a walk.' And so I would."* This suggests that technologies need to provide feedback throughout the day, wherever the user is.

Activity level performance. Most participants were motivated by knowing their performance with respect to their goal. Specifically, they wanted to know how many steps they needed to meet their goal, and they enjoyed receiving recognition for meeting it. One participant recounted, *"I'd be constantly checking it* [the pedometer] *to see where I was as far as meeting the goal for the day. And I – and it made me, I guess, motivated to make the goal quicker 'cause I wanted to – to get it over with*." Additionally, participants were motivated by the recognition Houston provided when they met their goal (specifically, the congratulations pop-up screen and the '*' following step counts, *e.g.,* in Figure 2a & 2d). One participant was surprised by how much the '*' did for her, *"It was kind of cool to have that* [the '*']. *It was like, oh, a star…Gosh how the little things, you know. The little things that count, the star."* And of course, the more stars, the better, *"It was like, yes, I rock!...and it was fun to go back* [in last 7 days] *and go, yes, there's my star for that day…"*

3. Support social influence

While different classes of influence affected participants, all but one were motivated by social influence (or could imagine being motivated if they participated with different buddies). The three classes of influence that had impact were social pressure, social support, and communication.

Social pressure. Because participants were sharing activity level and progress toward their goal with buddies, they felt pressure to make their goal, beat a buddy, or not have the lowest step count. One participant explained how she was motivated to meet her goal because her buddies would know if she did not, *"I wasn't gonna let them see that I wasn't gonna meet my goal."* Yet others were inspired to beat a buddy's count, *"*[a buddy] *just started contacting me like 'how many steps do you have?' And then I would tell her. She's like, 'well, I have this many.' And so we were sort of competing with each other."* Another participant mentioned how she did not want to have the lowest step count of the group, *"I didn't want to be the one with the least amount of step count. And I found there was somebody who had less than me, so I felt okay about mine."*

Social support. Similar to the recognition provided by Houston, participants enjoyed receiving recognition and encouragement from their buddies. One participant described what it felt like when she received *Wow!* and *Good job!* messages from her buddies, *"I thought it was great. It made me feel good."* Another explained, *"I got a couple of 'wows' and couple of 'good jobs' and several custom messages. It's fun. It's a – it's a fun form of communication."* Others enjoyed seeing messages like *'Let's go girls'* from their buddies.

Often, social support came from just knowing how buddies were doing. For example, one participant described how she was motivated by a buddy's good day, *"We were all at a party and we were sharing our goals…Somebody had really high steps that day and I'm like, I'm gonna get high steps tomorrow"* (and she did).

Communication. Some of the problems in giving users proper credit for activities became more important when step counts were shared with buddies. As one participant summarized, *"…the numbers don't communicate everything. And so if you're sharing information with somebody, you kind of want to share a little bit more about what you did."* One participant mentioned how important it was to be able to add comments to her step count on some low count days, *"I felt it was like a little deceptive. I felt like it was gonna be broadcast to my friends and they'd say, oh, she didn't do anything. When in reality I had."* When thinking about what it would be like to have Houston's sharing features, one of the participants who used the *personal* version reflected on the importance of comments, *"Cause then I'd be like explaining, yeah, I sat on my butt today. You know? Or was climbing or whatever."*

4. *Consider the practical constraints of users' lifestyles*

When designing activity-enabling technologies for everyday life, several practical constraints must be considered. Two areas where Houston did well were that communication with buddies was *integrated with the application* itself—*e.g.,* participants did not have to mentally switch tasks to share with their buddies, and it provided easy access to *current and past activity information* for the participant and her buddies (though the usability of the actual interface could be improved).

The most common complaint, aside from improper credit for activity level, was that the pedometer and phone were large and unattractive (Figure 4). Simply put, the devices were out of place with many outfits; there was not always a reasonable place to clip the pedometer; and the devices drew unwanted attention from others. This suggests that technologies that encourage physical activity should either not require the user to wear any new devices or if devices must be carried or worn, form factor is critical.

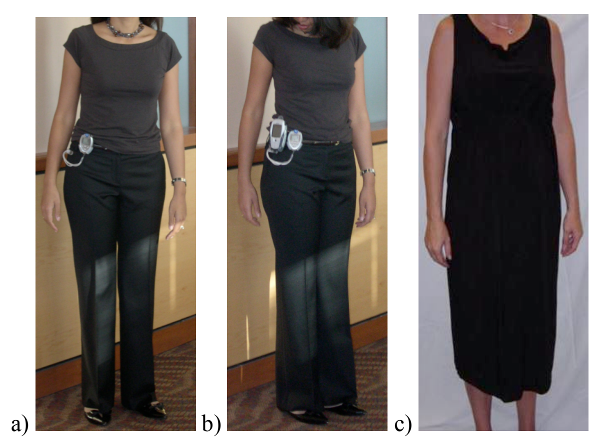

Figure 4. Casual business attire with a) the Omron HJ-112 pedometer, and b) the pedometer & Nokia 6600. c) A dress often has no practical or aesthetic place to put the pedometer.

An additional challenge for future designs

Another important challenge that emerged from our results that needs to be addressed in future systems regards how the system should determine *reasonable* goals that *encourage* a sustainable increase in step count.

There are two main approaches to setting daily step count goals with participants in a group: *one-size-fits-all* (*e.g.*, 10k steps/day programs) and *individual* (*e.g.*, based on current activity level). While there was consensus amongst our colleagues that individual goals were the right approach, we could not find a generally agreed-upon method for how to calculate them (so we chose what seemed to be an appropriate calculation from the literature). However, during the exit interviews, it became clear that there were two issues with the goals we set: what the actual number should be, and more broadly, whether to use individual or one-size-fits-all goals.

In the case of individual goals, participants with high goals tended to feel that the goal was usually unreachable. One participant reflected on her goal, *"I felt like my goal was impossible a lot of the time. ...I couldn't walk everywhere one day or if I didn't have time to take a big long walk, then there's just no way and then it became sort of like, well, it's too frustrating."* Another explained, *"I disliked the goal that was set. I felt it was too high...well, the first time I got it, I felt defeated. Like oh man, I'm never gonna be able to make that. And then the days I did – I did meet it, I was like wow, well I was super active today, that's why."* Participants with those high goals were often already doing planned exercise a couple of days per week (that involved a pedometer-recognized activity, *e.g.,* running or fitness walking), which is how they ended up with such high goals. However, most participants did not intend to do that activity on a daily basis (*e.g.,* going for a 6-mile run every day).

Regarding the choice of individual or one-size-fits-all goals, for Groups 1 & 3, individual goals seemed to work well (assuming the actual goal was reasonable). However, the participants in Group 2 (friends in their late 20s/early 30s who were all classified in the *maintenance* stage of change) would have preferred a one-size-fits-all approach, as they were more motivated by competing with each other.

Our results show that more work is needed to understand how to set reasonable goals that encourage a sustainable increase in physical activity for women who are already moderately active.

In general, participants found Houston to be fun and often motivating, but different people were motivated by different aspects. We feel the design guidelines we developed from our results can be of value to designers who are developing technologies that encourage physical activity. Next, we offer a discussion of several relevant technologies from research and industry.

RELATED WORK

There are numerous projects in research and industry that are exploring technology to support fitness and physical activity. We discuss a mere sample of relevant projects in the areas of virtual exercise advisors, fitness plans / journaling, monitoring devices, and games.

Virtual exercise advisor

"Laura" is an animated conversational agent – a virtual exercise advisor designed to encourage increased daily step count among older adults [1]. In a two-month *in situ* pilot study with eight females, participants wore a pedometer and were prompted to enter their daily step count into a computer system in their homes when they interacted with Laura. Laura used various mechanisms, *e.g.,* social dialogue and empathy exchange to provide feedback on progress and negotiate goal setting. Similar to Houston, this project investigated using technology to increase the step counts of female adults. However, Laura used an animated conversational agent as encouragement, while Houston uses personal awareness and social influence via the members of one's social network.

Fitness Plans / Journaling

A growing number of commercially available mobile phones help users keep track of their fitness activities and plans while on the go. *NEC's 232E Fitness Phone* [www.nechdm.com/232/232.asp] gives users access to a customized fitness plan and caloric expenditure calculator. More similar to Houston's *personal* version is the *Nokia 5140* [europe.nokia.com/nokia/0,8764,48662,00.html], which works with the user to customize a training plan, has a journaling feature to track progress and change the plan, and a digital compass for way-finding. *Bones in Motion* [www.bonesinmotion.com] is a location-aware mobile phone application that estimates activity level using timing and distance traveled. It allows users to record workouts, measure activity, and compare themselves to others using a web-based journal interface.

We see the investment these companies are putting into fitness as a sign that mobile technologies to encourage physical activity show real promise and hope that our research can inform future offerings.

Monitoring devices

Many devices attempt to monitor physical activity to provide personal awareness to users. For example, *BodyMedia's BodyBugg* [www.bodymedia.com] is a device worn on the user's upper arm that uses physiological sensors and data modeling to monitor health routines. It claims to infer states such as energy expenditure, physical activity, lying down, sleep versus awake, and driving. Data is uploaded to a computer via a wireless interface. BodyBugg tracks caloric expenditure and is coupled with a web interface where users log food intake. Like the pedometer, the BodyBugg raises user awareness of activity level. However, while it detects a greater range of activities than the pedometer, it is a larger, more noticeable, and arguably more uncomfortable device, and therefore may be better suited for planned exercise rather than everyday life. Additionally, it does not support social influence or sufficient feedback throughout the day as suggested by our design requirements.

SportBrain pedometers [www.sportbrain.com] enable users to upload their step counts to a web site where they can view past step counts, set goals, and share information with others, however they can only do this while at a computer. Furthermore, they can only upload information when they are at a computer with the proper USB cable. The web site promotes activity journaling and offers reward programs where users can win prizes. In our informal pedometer testing, all testers had significant data loss problems with SportBrain's *iStep X*, which made it unusable for our work.

A challenge for monitoring devices is to provide proper credit for physical activity with a device that people find acceptable to wear in various circumstances and address the other design requirements we found.

Games

A popular area of technologies to encourage physical activity in research and industry is games. *Nintendo's Pocket Pikachu* [6, p.90] is a pedometer with a virtual character that responds to step count. Marketed to children, Pikachu encourages physical activity by learning new tricks and becoming happier as the step count increases. *Get up move* [www.getupmove.com] is a program to encourage weight loss using *Dance Dance Revolution*, a video game where users physically move in a pattern on a special floor mat. The *TAXC Fortius training bike* [www.taxc.com] is a stationary bike that uses a virtual training course on a screen and generates electricity using heat from the bike's brakes. These 'exergaming' technologies are designed to encourage physical activity by making exercise fun.

Research projects in physical exertion interfaces have enabled users to play sports remotely using a synchronous computer connection [11] and move through a virtual world by the act of physically cycling [10].

Despite the myriad of products available today, the number of overweight and obese people is growing. None of these products incorporates all of the key design requirements that we discovered from our pilot study, therefore we feel that it is important to continue exploring the space of technologies to encourage physical activity so that effective tools for combating overweight and obesity may be created.

DISCUSSION / FUTURE WORK

In this section, we discuss our plans for this project and suggest directions for future work in the area of technology to encourage physical activity.

We plan to incorporate the design guidelines presented in this paper into the next version of our system. With the new system, we intend to team with colleagues from the medical community to perform a longitudinal study investigating the technology's effect on sustained behavior change. One outstanding issue is whether or not the pedometer is the correct monitoring device to use moving forward. In our study, we showed that the pedometer does not necessarily provide a good measurement of overall physical activity, as common activities such as cycling, weight lifting, swimming, walking / running up stairs or hills, vigorous house-cleaning and gardening are not adequately detected. To improve this, future work may involve using more sophisticated sensors (perhaps the Intel Multi-sensor board [9]) to provide measurements of more types of activities to help solve the problem of proper credit.

We would also like to explore the issue of manual versus automatic journaling. Previous work [16] suggests that the act of manually journaling one's activities can positively affect levels of physical activity, and it also gives users control over what data is recorded and potentially shared with others. However, automatic updating could provide a continuous record of activity and take the burden of having to remember to log activity away from the user (something asked for by several pilot study participants). Yet, automatic logging has the potential to *reduce* awareness and introduce deceptive data. We are interested in exploring how auto-logging compares to manual logging of physical activity, or if a combination is most effective.

Other interesting areas for future research include developing a deeper understanding of the various *barriers that prevent physical activity* and the more general topic of *motivating behavior change.* For example, a barrier identified by several pilot study participants was the negative effect of inclement weather conditions on people's routines. Additionally, future work could explore the more broad space of technology to motivate physical activity beyond technology-mediated social influence, *e.g.,* reward/punishment systems and team competitions.

CONCLUSION

In this paper, we presented *Houston*, a mobile phone-based fitness journal that encourages physical activity by providing personal awareness of activity level and mediating physical activity-related social interaction among friends. We described a three-week long *in situ* pilot study of Houston that we conducted with three groups of women from which we identified *four key design requirements* for technologies that encourage physical activity:

1. Give users proper credit for activities,
2. Provide personal awareness of activity level,
3. Support social influence, and
4. Consider the practical constraints of users' lifestyles.

We were encouraged by our work with Houston and are continuing our investigation of technology to encourage physical activity and fitness.

ACKNOWLEDGMENTS

Thanks to David McDonald, Cherie Fenner, Ken Smith, Huong Nguyen, Anthony LaMarca, Tanzeem Choudhury, Gaetano Borriello, the pilot study participants, and our friends and colleagues who provided guidance and helped test pedometers. The pilot study was covered by University of Washington Human Subjects Division application #05-7008-E/C 01.

REFERENCES

1. T.W. Bickmore, L. Caruso, K. Clough-Gorr, "Acceptance and usability of a relational agent interface by urban older adults," *In CHI '05 Extended Abstracts*, ACM Press, Portland, OR, (Apr 2005), pp. 1212-5.
2. Centers for Disease Control and Prevention, *Behavior Risk Factor Surveillance System Survey Questionnaire (BRFSS)*, Atlanta, GA, (Feb 2004).
3. Centers for Disease Control and Prevention, U.S. Dept of Health & Human Svcs, "Preventing Obesity and Chronic Diseases Through Good Nutrition and Physical Activity," *Preventing Chronic Diseases: Investing Wisely in Health*, (Jul 2003).
4. C.B. Chan, E. Spangler, J. Valcour, C. Tudor-Locke, "Cross-sectional Relationship of Pedometer-Determined Ambulatory Activity to Indicators of Health," *Obesity Research*, Vol.11, No. 12, (Dec 2003).
5. Consumer Reports, "Pedometers: Walking by the numbers," *Consumer Reports*, 69(10), (2004), pp.30-2.
6. B.J. Fogg, *Persuasive Technology: Using Computers to Change What We Think and Do*, San Francisco, CA: Morgan Kaufmann Publishers, (2003).
7. G. Iachello, I. Smith, S. Consolvo, G.D. Abowd, J. Hughes, J. Howard, F. Potter, J. Scott, T. Sohn, J. Hightower, A. LaMarca, "Control, Deception, and Communication: Evaluating the Deployment of a Location-Enhanced Messaging Service," Proceedings of UbiComp '05, Tokyo, Japan (Sep 2005), pp. 213-31.
8. *International Physical Activity Questionnaire (IPAQ): Long Last 7 Days Self-Administered Format*, (Oct 2002). http://www.ipaq.ki.se/ {verified 4 Jan 2006}
9. J. Lester, T. Choudhury, G. Borriello, "A Practical Approach to Recognizing Physical Activities," *Proc. of Pervasive '06*, Dublin, Ireland (May 2006—*to appear*).
10. S. Mokka, A. Väätänen, J. Heinilä, P. Välkkynen, "Fitness computer game with a bodily user interface," *Proc ICEC '03,* Pittsburgh, PA, (May 2003), pp. 1-3.
11. F. Mueller, S. Agamanolis, R. Picard, "Exertion interfaces: sports over a distance for social bonding and fun," *Proceedings of CHI '03*, Fort Lauderdale, FL, ACM Press (Apr 2003), pp.561-8.
12. National Institutes of Health, *The Practical Guide: Identification, Evaluation, & Treatment of Overweight & Obesity in Adults*, NIH Pub No. 00-4084, (Oct 2000).
13. President's Council on Physical Fitness and Sports, *Walking Works: The Blue Program for a Healthier America*, (Jul 2004).
14. J.O. Prochaska, C.C. DiClemente, J.C. Norcross, "In search of how people change: Applications to addictive behaviors," *Amer Psych*, 47(9), (Sep 1992), pp.1102-14.
15. I. Smith, S. Consolvo, J. Hightower, J. Hughes, G. Iachello, A. LaMarca, J. Scott, T. Sohn, G. Abowd, "Social Disclosure Of Place: From Location Technology to Communication Practice," *Proceedings of Pervasive '05*, Munich, Germany (May 2005), pp.134-51.
16. B.J. Speck, S.W. Looney, "Effects of minimal intervention to increase physical activity in women: daily activity records," *Nursing Research*, 50(6), (Nov 2001), pp.374-8.
17. F.A. Treiber, T. Baranowski, D.S. Braden, W.B. Strong, M. Levy, W. Knox, "Social Support for Exercise: Relationship to Physical Activity in Young Adults," *Preventative Medicine*, Vol. 20, (1991), pp.737-50.
18. C. Tudor-Locke, "Taking Steps Toward Increased Physical Activity: Using Pedometers to Measure and Motivate," *President's Council on Physical Fitness and Sports: Research Digest*, Series 3, No. 17, (June 2002).
19. U.S. Department of Health & Human Services, *Physical Activity and Health: A Report of the Surgeon General*, Atlanta, GA: U.S. Department of Health & Human Services, Centers for Disease Control & Prevention, National Center for Chronic Disease Prevention & Health Promotion, (1996).
20. U.S. Department of Health & Human Services, *The Surgeon General's call to action to prevent and decrease overweight and obesity*, Rockville, MD: U.S. Dept of Health & Human Services, Public Health Svc, Office of the Surgeon General, (2001).
21. U.S. Department of Health & Human Services, Public Health Service, Centers for Disease Control & Prevention, National Center for Chronic Disease Prevention & Health Promotion, Division of Nutrition & Physical Activity, *Promoting Physical Activity: A Guide for Community Action*, Champaign, IL: Human Kinetics, (1999).
22. Weight-control Information Network, "Statistics Related to Overweight and Obesity" http://win.niddk.nih.gov/statistics/ {ver. 4 Jan 2006}
23. World Health Organization, "Obesity and Overweight," Chronic Disease Information Sheet, http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/index.html {verified 4 Jan 2006}