Q.in: Cues to Balance Posture Habits

Figure 1. Q.in lets the user visualize their posture habits. A pie chart in the center displays activity as a ratio of available time in the whole day. Below that, a timeline gives the user an idea of when in the day they are engaged in specific postures.

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CHI 2013 Extended Abstracts, April 26–May 1, 2014, Toronto, Canada.
ACM ###-#-####-####-#/##/##.

Abstract

New technology has improved our understanding of the effects of lifestyle choices on our health, but it is often difficult for us to monitor our own personal habits and modify negative patterns of behavior. With a common household technology (the smartphone) we provide a framework called *Q.in* ["Cue In"] that helps users understand whether they are too sedentary or too active throughout the day. The solution monitors the posture of the user and suggests actions to mitigate negative effects of prolonged time in the posture. Results are presented through participant research and trials with a functional prototype.

Author Keywords

Posture; sitting; standing; lifestyle change; mobile application; smartphone; body data; quantified self.

ACM Classification Keywords

H.5.2 [User Interfaces]: User-centered design; H.5.m Miscellaneous; J.3 [Life and Medical Sciences] Health.

Introduction

Current research shows that individuals who maintain a sedentary lifestyle over a number of years may have an increased risk for heart disease, type 2 diabetes, a higher body-mass index (BMI), and a number of other negative effects related to a reduced metabolic rate

[13]. Time spent exercising or being active do little to offset the negative effects of a sedentary lifestyle [7], [14]. Prolonged periods of sitting or other inactive postures are known to increase obesity, disease, and mortality in adults [4]. Conversely, individuals who spend prolonged periods of time on their feet or engaged in ambulation are also at risk. This behavior is associated with venous and arterial diseases [5], [12], fatigue [11], and may increase the chance of musculoskeletal disorders [10], [15]. Remaining static in either posture for prolonged periods of time can detrimentally affect any person's health.

The severity of the health risks associated with both lifestyles cannot be ignored. Unfortunately, restrictions or habits in and out of the workplace can often impose or reinforce extreme sitting and standing behavior. While most workers have to adhere to the posture expectations, medical experts suggest counteractive measures that comply with workplace requirements. Brief periods utilized as a time to switch postures can go a long way in improving one's long-term health. A short walk could help people who sit down for long hours. Resting in a chair can benefit those who remain on their feet for long hours.

To encourage these breaks and raise awareness of these health risks, our team proposes *Q.in* ["Cue In"], a smartphone application that monitors a user's posture state throughout the day using the phone's accelerometer's orientation data. The application periodically offers the user an alternative activity to counteract the negative effects outlined above. *Q.in* helps individuals make informed decisions in and out of the workplace based on the quantity of time they spend in one posture. The design helps user's find a healthful balance between sitting and standing all day.

Approach

The team focused its approach using the user-centered design framework outlined in Garrett's *Elements of User Experience* [2]. Using this framework, the team looked to define the *strategy* (what the team wants), *scope* (what the users need), and *structure* (how those needs fit into real user contexts) of the design. The team asked and answered many questions all mapped neatly to Garrett's theoretical framework.

Garrett's robust process helped the team develop *Q.in* through ideation sessions, literature reviews, and user research in the problem space, as described below. The ideation sessions kept the team open to many possible solutions. The literature reviews informed team decisions. Finally, user research provided real-world context and a foundation for *Q.in*'s core functionality.

Literature Review

After defining a *strategy* roughly concentrating on the quantities of user posture states, the team conducted a review of products that seemed to target similar goals (e.g., devices such as Nike+, Nike+ Fuelband, and Fitbit). In defining a unique *scope*, the team also conducted a review of academic publications.

The teams' findings suggested that commercial solutions mainly monitored large-scale physical goals of the person (reaching a certain foot-travel distance goal). These existing products attached to the end of the user's appendages. The team's *strategy* centered on the state of the person's posture (sitting, standing, or actively moving), and thus found these existing products unsuited to measure small posture changes. The team ultimately deviated from the design *scope* of the commercial products.

Promising research from academic publications revealed effective ways to modify related behavior:

1. *TripleBeat* is a smartphone application that successfully encourages runners to meet exercise goals through an emphasis on performance awareness and competition among other runners [8]. The performance awareness is achieved with a glanceable interface and unobtrusive prompts to modify behavior, while competing users compare heart rates instead of pace or total distance.
2. *Breakaway* measures the amount of time a user has spent sitting down and displays this information through the position of a sculpture placed in the user's workspace [3]. *Breakaway* does not prompt the user for action, instead relying on the passive articulation of the sculpture to relay information to the user. Initial tests showed that a user did modify her behavior and take a break when the sculpture displayed a "too sedentary" state, and she enjoyed how this technology did not interrupt her focus during busy periods at work.

Overall, the review of commercial products encouraged the team to consider alternative hardware solutions while the academic research inspired user interaction methods and behavior modification techniques.

User Research

To validate the *strategy*, *scope*, and *structure* of the design, the team distributed an electronic survey through social media, email, and word-of-mouth. Questions addressed issues like daily activities, postures, habits, overall smartphone use, awareness of sitting and standing behavior, knowledge of health effects, and willingness to modify behavior using a smartphone application. In addition to the survey, face-to-face interviews were used to gather more personal accounts not easily gathered by an online survey. The interviews covered the same topics as the survey, but the interview protocol adapted the questions to facilitate a more conversational engagement between interviewer and interviewee. Both procedures were approved by the Institutional Review Board of Iowa State University.

SURVEY RESPONDENTS

The survey received 16 complete responses out of 25 attempts. Ages ranged 20–53 (mean=28.56, median=26); there were 13 Female. Five respondents had completed a Master's degree and 9 a Bachelor's degree. Only six respondents reported being students. Based on timestamps, it was determined that 5 respondents were located outside of the USA, namely: 3 in South America, 1 in Central Europe and 1 in India.

INTERVIEWEES

Three females and one male aged 19, 26, 48, and 54, respectively, participated in face-to-face interviews. Three of them were students (Bachelor's, Master's and Doctoral), but had a parallel job; their jobs were of particular interest, since two spent most work hours standing (a mechanic and a waitress), one spent most work hours sitting (an administrator) and one spent about 50% sitting and standing (a chemist).

Results
Participants provided rich data regarding their habits, awareness, and needs. The team found high variances in reported posture states. Roughly two-thirds of the respondents (*n*=11) reported spending at least two-thirds of their work time sitting down, while the remaining third (*n*=5) reported at least two-thirds of their work time standing up. In comparison, more respondents reported 50% of their time sitting down when not working (*n*=6 vs. *n*=0), although almost half of the respondents (*n*=7) still reported at least two-thirds of their off-work time sitting down. In essence, user research suggested our design, to be successful, needed to address the needs of two primary user segments: those that stood up a majority of their day and users that sat down a majority of their day.

The team validated the design's scope by assessing user knowledge, awareness, and concerns regarding their sitting and standing behavior. Before introducing an educational infographic on the effects of sitting and standing for prolonged periods of time, the survey and interview gauged user knowledge on the subject matter. More than half of the respondents (*n*=10) agreed that sitting **and** standing for long periods of time could be bad for their health, but didn't report a high motivation to change their posture behavior.

After the infographics were presented respondents reported their interest in adjusting their current behavior. The most popular strategies were, in order, adjusting the way they worked, adjusting their posture every hour, and using technology that would track their current postural behaviors. These results revealed a need to modify current user posture behavior, and a concrete solution strategy through the use of technology, in this case a phone application.

To assess the interaction with the application, respondents also rated two ways they could use this application, either by wearing their phone in their pocket to allow the application to accurately track their posture, or by manually input their approximate sitting and standing times. There former received mixed-to-negative opinions, while the latter received mixed opinions. The interviews showed that the aversion for wearing a phone may come from either aesthetic and comfort reasons, or simply by work restrictions. Nevertheless, the only reported phone placement that was consistent when sitting, walking and standing was the front pocket.

Finally, six possible motivation features were rated, namely, using social media to share their data, have an alarm to remind users to sit or move around, earn points for completing sitting–standing challenges, and, integrating their behaviors in a fictional story[1]. Only social media received negative opinions.

Solution
Most Americans own a cell phone and the majority of cell phone owners in America use a smartphone [9]. In an effort to be accessible to a wide audience, *Q.in* harnesses the computational power and sensors found in today's mobile technology as a standalone smartphone application. *Q.in* gathers sensor data from

[1] The underlying story was left open to participants' imaginations. Interviewees described theirs as having a "Tamagotchi" whose health depended on their posture.

the phone with the intent to provide meaningful information of the user's postures throughout the day.

To operate *Q.in*, users load it onto their smartphone and provide their age, gender, and posture goals. To gather the most accurate data, the phone needs to be stored in the user's front pant pocket. Once in place, *Q.in* automatically monitors the orientation and position of the phone with the accelerometer and GPS systems found in nearly all smartphones to determine the user's overall activity level. If *Q.in* detects the user has exceeded a defined duration at a certain posture, it prompts the user to take a break and suggests an activity for the break. For example, it may suggest that a secretary who has been sitting for too long take a short walk around the office, or suggest a sit-down break for a tradesperson who has been working on their feet all day.

Users who prefer not carrying their smartphone can self-report their activity levels. Self-reported activity data is known to be less accurate than measured data [1] and the user may not benefit from the prompts for action if their phone is not nearby.

In addition to immediate prompts for user action, *Q.in* lets users review precisely how much time is spent sitting, standing, and engaged in active behavior over time. Figure 1 shows the main posture review screen for the user. *Q.in* reminds users of the time remaining in the day with a progress bar at the top. In the center, a chart view that shows a ratio of the daily posture helps users monitor their overall progress. The application shows the user the ideal ratio of postures to maintain so they can see whether they are meeting the defined goals. Below the chart, a graph of detected postures over time shows the user how they spend their day. Together, these tools allow users to see the effects of their actions as they seek a healthful balance between rest and activity. The data visualization afforded to the user operates on the basis of the goal setting theory, where individuals attempting to meet a defined goal will be more successful than individuals who have no defined goal and are simply encouraged to do their best [6]. Over time, users are able to compare their current activity level to personal activity level trends and verify the results gained from adherence to *Q.in*'s advice.

Validation

Although the demand of the service from the users' perspective was verified by user research, the design team needed to determine whether a smartphone could accurately monitor the activity level of a user. To accomplish this, a prototype version of Q.in was developed for the Android OS version 4.2 and deployed on a Samsung Galaxy S3. The team built a barebones application that recorded the phone's orientation based on accelerometer output – it did not feature the advanced analysis and data visualization functionality of the final solution. The current prototype features a rudimentary version of the posture ratio pie chart seen in Figure 1. – it shows real-time information from the phone sensors and visualizes the sit-stand ratio on the pie chart. Iterative testing and design helped the team design the application to appropriately categorize a user's posture. Testing of this prototype was limited to test sessions for individuals on the design team. Overall, the results of the prototype are promising. The team was able to verify the sensor output in real-time and confirmed that a phone application can detect and categorize the posture of a user.

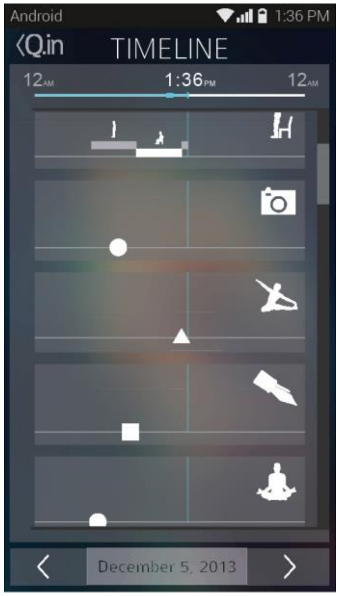

Figure 2. A possible future interface for *Q.in* that informs the user of a number of activities with data gathered from multiple sources.

Future Work

Through the ideation sessions, literature review, user research, and prototype testing, the team has laid the groundwork for a service that helps users monitor and understand the effects of their own posture throughout the day. In the future, the team would like to expand the utility of *Q.in* to gather and quantify new personal data streams. This goal is shown in Figure 2, a timeline view of multiple activities. *Q.in* becomes a hub used to quantify and monitor one's behavior and motivates individuals to make conscious decisions about their every day.

Acknowledgements

The design team would like to thank our faculty advisor, Stephen Gilbert, as well as our research participants for their contribution to this project.

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