NeckGraffe: A Postural Awareness System

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Abstract
Common, complex, and burdensome to individuals and society alike, neck pain is estimated to affect more than 70% of the population at some point in life and between 12-34% of the population at a given time, with one study finding that 45.5% of office workers experienced neck pain in a 12-month period [1]. We plan to build a system that would give real time alert to the user, each time they maintain an unhealthy neck posture. The system would give a visual data analysis of the amount of time the user maintains an unhealthy neck posture and provide feedback to assume a healthy posture; and the threats involved with maintaining unhealthy posture over a long time.

Introduction
Technology has seen a rapid growth in the last decade. Smartphones, laptops, tablets, and the like are gradually shifting from a position of luxury to need. There is a strong tendency for people to use these devices for long hours, both at work and at home. Among other factors, however, frequent computer use is commonly associated with increased risk of neck pain [1,4,5].

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that 45.5% of office workers experienced neck pain in a 12-month period [1].

Healthy posture may be part of the solution to the widespread problem of neck pain. Improvements in posture are associated with decreased musculoskeletal symptoms [3,5]. Users have responded positively to personalized interventions that facilitate postural awareness using real-time data. While ergonomic education can provide short-term benefits, interventions involving ongoing feedback and instruction to reinforce the desired behavior have been shown to improve ergonomics and maintain those improvements over time [5].

Contextual Investigation

We framed our contextual investigation of the association between posture and cervical pain by focusing on pain associated with frequent technology use. As stated previously, frequent computer use is commonly associated with increased risk of neck pain [1,4,5]. An increasing number of people using computers for longer periods of time may therefore present worrisome implications for public health.

Posture, in addition to a variety of ergonomic, physical, psychosocial, and personal factors, is associated with work-related neck problems [1,2]. Among other variables, neck pain is significantly correlated with frequently sustaining a prolonged forward bent neck position, frequent prolonged sitting, and frequent repetitive motions [1]. Posture alone may not be determine whether or not an individual experiences neck pain. Edmunston et al. [6] found that, quantitatively, seated posture in subjects with postural neck pain was not significantly different from posture in asymptomatic control subjects, but the subjects with neck pain had a different perception of their posture than controls. The possibility that persons with neck pain may have impaired positional perception supports the value of a system that could help users improve their posture based on objective data.

Users have responded positively to personalized interventions that facilitate postural awareness using real-time data. One study of different ergonomic interventions for office workers included a photo training group in which workers received personalized office training on proper ergonomics and work area adjustments, a group that only received office training, and a control group [5]. Workers in the photo intervention group received self-modeling feedback at frequent random intervals throughout the workday in the form of a pop-up screen with a photo of the worker with correct posture and ergonomics shown side-by-side with a photo of the worker's current posture [5].

The photo intervention group demonstrated similar short-term benefits as the group that received only office training, but while postural improvements and reductions in pain for the group with office training alone deteriorated over the course of the intervention to baseline levels, the photo training group exhibited sustained postural gains and reported reduced pain [5]. Though both intervention groups reported reduced pain from baseline scores, the photo training group preserved postural gains as well as pain reduction.

Based on these findings, our system will be designed to provide users with accessible, personalized, quantitative postural feedback over a prolonged period of time. Explicitly and consistently alerting users to

unhealthy posture in real time, as well as educating users about the musculoskeletal elements of establishing and maintaining healthy posture, should facilitate sustained postural awareness and improvement.

Design Solution

Design Solution - Body Sensor Component

We propose designing a sensor to measure the different positions of the neck. The user will wear this sensor on the lower neck region with a body adhesive.

The sensor for our system will consist of an accelerometer augmented by a gyroscope to measure the different positions of the neck posture each day. The sensor continuously maps out the user's neck position. By default, it will vibrate to notify the users of their current unhealthy neck posture after every 10 minutes. The vibration feedback time is customizable through the phone interface. The sensor communicates with the mobile interface via Bluetooth where it communicates the information collected by the body sensor to the mobile interface for determining the mechanics of healthy vs. unhealthy posture. The message to vibrate the sensor is also relayed back to the body sensor via the Bluetooth channel.

Vibration feedback in an awareness system notifies users of unhealthy neck posture without them having to check their phone for an alert. The vibratory feedback is an intervention mechanism designed to intercede with the ongoing activity of the user to alert her of an unhealthy posture.

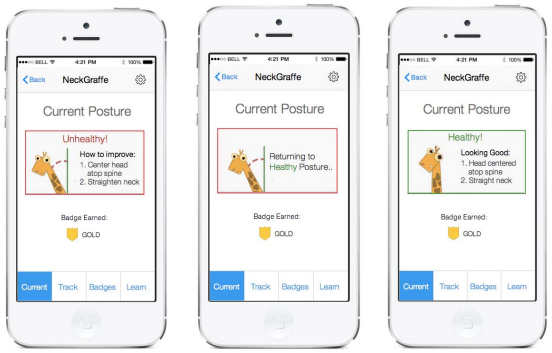
Design Solution – Mobile Interface Component

The mobile interface has several screens pertaining to the different available options, as described below.

HOME SCREEN: CURRENT POSTURE

"Current Posture" serves as the application's home screen. Here, the user can see whether or not they currently have healthy or unhealthy posture. If the user's current posture is unhealthy (C1), some tips are offered for improving one's posture. Below the tips is the "Badge Earned" section, which displays the user's current badge(s) and, if clicked, navigates to the "Badges" screen.

When the user assumes a healthy posture after having been in an unhealthy posture, a transition screen (C2) is shown briefly before the healthy posture screen (C3) appears. The screen for healthy posture is very similar to the unhealthy posture one, except that instead of a mournful giraffe with bad posture, a happy one with a straight neck appears.



C1: Unhealthy **C2:** Transition **C3:** Healthy

Figure 2: Different posture states on mobile interface

POSTURE TRACKING:

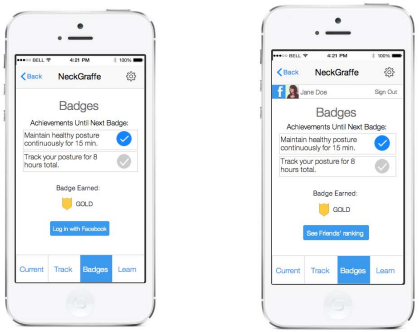
T1: Daily **T2:** Weekly **T3:** Monthly

Figure 3: Different data tracking options in mobile interface

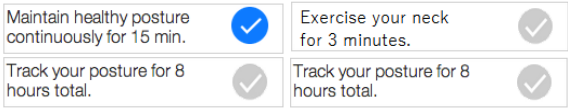
Tracked data about the user's posture, categorized as either healthy or unhealthy, can be displayed by day, by week, or by month. The daily (T1) postural breakdown is displayed as a pie chart, while weekly (T2) and monthly (T3) data are displayed as stacked bar graphs. The date ranges change when viewing daily, weekly, monthly data.

BADGES

The screen lists the badge that the user has currently earned as well as the achievements the user needs to meet, such as continuously maintaining a healthy posture for 15 minutes, before they earn the next badge. The missions could be updated after the user completed one mission on the list (B3->B4). From this page, the user can also choose to check in with Facebook (B2); once signed in, the user can press the "See Friends' Rankings button" to see the current leaderboard for their Facebook friends.



B1: Checked out **B2:** Checked-in



B3: Original Missions **B4:** Updated Missions

Figure 4: "Badges" screen on the mobile interface

LEARN:

The "Learn" screen shown in Figure 5, accessed by pressing the "Learn" button at the bottom of the screen, offers educational tips about posture, such as the amount of extra stress placed on one's spine when assuming forward head posture. The set of tips and facts being presented on this screen will be constructed from peer-reviewed published work. The user can navigate to the next or previous tip by pressing the back or forward arrow buttons.

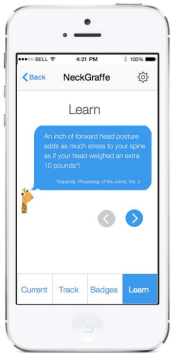


Figure 5: "Learn" screen on mobile interface

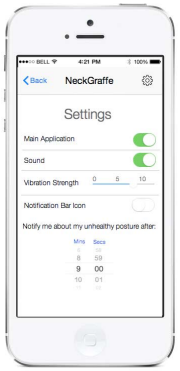


Figure 6: "Settings" screen for mobile interface

SETTINGS:
The user can navigate to the "Settings" screen as shown in Figure 6, at any time by selecting the gear icon located on the right hand side of the top logo banner. From the "Settings" menu, the user can set or calibrate different options. She can turn the main application on or off, which in turn switches posture tracking on or off, toggle vibration feedback from the body sensory on or off and select a preferred intensity, turn the notification/taskbar icon on or off to display an icon to keep track of her posture from outside of the app, and set how quickly she would like to be notified if she assumes an unhealthy posture.

Design Decisions

Five main functions define the interface:

Current, Track, Badges, Learn and Settings. The "Current" and "Track" screens are associated with collecting and presenting the data obtained from the sensor worn by the user. These two provide the basic functionality that helps the user in keeping track of their posture information. A review of existing posture awareness systems showed that every competitor system provides these basic functionalities.

The goal of our system is to make the user more aware of his or her posture. Since habit formation is a lengthy process, the user would likely need to wear our system regularly for long periods of time to establish greater postural awareness, which we hypothesize will eventually lead to maintenance of healthier posture. Therefore, we felt that there needed to be a mechanism for encouragement and positive reinforcement of desirable behaviors, such as wearing the system and improving one's posture. To achieve this, we decided to gamify the application and allow for a competitive system where the user earns high scores for posture-related accomplishments, such as wearing the system and maintaining healthy posture for increasingly longer periods of time. In the social component of the "Badges" section, users can share their accomplishments with friends who also use the system

and compete for the highest score in their social network, providing intrinsic and extrinsic motivation to use the system. In addition, the "Learn" section of the application promotes awareness through education by providing the user with tips and facts about the consequences of unhealthy neck posture and how to fix it. With these functions, our system truly educates and motivates users.

"Settings" is an important function for all applications. Customizability is a very important usability principle. The "Settings" function is specifically important in our design because we are intervening in the user's space by providing notifications such as vibration feedback from the body sensor.

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