SitLight
A Wearable Intervention for Improving Sitting Behavior

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Abstract
Various studies have taken different approaches to persuade users into adopting a healthy sitting posture. In addition to the sedentary lifestyles we have come to adopt, the importance and reasoning of these studies stem from the adverse effects of poor posture on our health and mood. However, studies approaching this area with real-time visual modality integrated into clothing are rather sparse. Utilizing this integration might potentially fulfill the requirements of the ubiquitous computing era and inform the users in a calmer way. To evaluate various aspects of this concept, a mid-fidelity prototype was developed and tested with users. Semi-structured interviews were then conducted to obtain their thoughts and opinions on such an approach. In addition to the approval of the concept, further concerns, advantages and disadvantages were disclosed, and used to inform a design space for similar concepts. Although requiring more research, the results of this study outline a primary design space consisting of essential characteristics one needs to be aware of when designing a similar concept.

Keywords: Wearable technology, smart clothing, visual modality, posture improvement, persuasive technology, calm technology

1. Introduction and Research Question
Persuasive technology refers to a set of hardware and software devices that encourage behavior change (Fogg, 2002). Behavior as Fogg (2009) describes has three main aspects pertaining to motivation, ability and trigger. According to Fogg (2009), for a behavior change to occur, all three aspects must be present. With the advancements in personal and ubiquitous computing, we are able to design systems that can target either three aspects (Ploderer, Reitberger, Oinas-Kukkonen & Gemert-Pijnen, 2014). In this regard, various studies have targeted our sitting behavior.

Due to our modern lifestyles, we are now sitting more than ever in our workplaces in addition to our leisure time (Dunstan et al., 2013). However, what seems crucial is to not only pay attention to our sitting period and take breaks, but also to be aware of our sitting posture while we are seated. According to Hong, Song, Cho & Bianchi (2015b), poor posture and prolonged sitting are among the main causes of musculoskeletal disorders such as back pain. Additionally, posture also has a bidirectional relation with our mood and emotions (Carney, Cuddy & Yap, 2010; Riskind & Gotay, 1982).
Various studies have addressed this area through different approaches. Several studies have focused on alerting the user through screen-based notifications (e.g. Demmans, Subramanian & Titus, 2007; Khurana, Marinelli, Saraf & Li, 2014; Jaimes, 2005; Tanaka, Ishimaru, Kise, Kunze & Inami, 2015; Lee, Choi, Lee & Shim, 2013; Shin et al., 2016; Zhu, Fang & Ma, 2017; Duffy & Smeaton, 2013). However, due to the amount of notifications one receives a day, these notifications can be ignored or considered invasive (Haller et al., 2011). To prevent the obtrusiveness of the previous approach, another wave of studies have taken a more subtle approach to their design. The main concept of these studies originate from the notion of calm technology and ambient design (e.g. Obermair, Reitberger, Meschtscherjakov, Lankes & Tscheligi, 2008; Hong et al., 2015b; Jafarinaimi, Forlizzi, Hurst & Zimmerman, 2005; Mateevitsi, Reda, Leigh & Johnson, 2014). Although being informative while not intrusive, these designs are mostly static physical objects which limit the user’s mobility. Thus, to enable mobility, wearable solutions have also been pursued in this area. Focusing on clothing, a number of studies have used various modalities to inform users of their posture (Dunne, Walsh, Hermann, Smyth & Caulfield, 2008; Wang, 2016; Wong & Wong, 2008; Wang et al., 2015). The intention of these studies was more focused on measuring the effectiveness of the wearable on the user’s posture and less on the modality itself. However, the modality can be of essential importance in the acceptance of the wearable and thus worth researching. Although using visual modality for other purposes in clothing, to my knowledge, there has been only one study using this modality for providing real-time feedback for improving sitting behavior. Additionally, this modality might potentially fulfil the need of calm technology in the ubiquitous computing era:

*The most potentially interesting, challenging, and profound change implied by the ubiquitous computing era is a focus on calm. If computers are everywhere they better stay out of the way, and that means designing them so that the people being shared by the computers remain serene and in control.* (Weiser & Brown, 1997, p. 77)

Furthermore, according to Mann (1996, p. 24), clothing can enhance “our capabilities without requiring any conscious thought or effort”. Thus, the integration of visual feedback into clothing could potentially unobtrusively inform the user. Therefore, the aim of this study is to contribute to this research gap, and investigate the advantages, disadvantages and challenges of integrating real-time visual feedback into clothing for improving sitting behavior. This leads to the following research question:

> How is a wearable clothing utilizing visual modality perceived for improving sitting behavior, and how can this concept aid us in defining the design space for similar design concepts?

To answer this research question, the following approach was taken: first, a workshop was conducted to inform the design concept, which later was visualized into a prototype and tested with potential users. This led to obtaining an in-depth understanding of the prototype and its concept. Based on these insights, a design space was developed to clarify the most essential characteristics one needs to be aware of when developing a prototype based on a similar design
concept. Clarifying such design spaces which are based on users’ insights, can increase the acceptance of these technologies in the near future (Buenaflor & Kim, 2013). By this study, I hope to contribute to the understanding and potential benefits and challenges of integrating visual feedback into clothing for improving sitting behavior.

2. Background

In the following section, I will first elaborate on the adverse effects of poor sitting behavior, and then present the facts and standards defining healthy behavior in this regard. The standards described are used as the grounding knowledge of posture in this study.

Posture and Well-being

Coming to adapt sedentary lifestyles, both at work and our leisure time has led many studies researching the health risks associated with poor sitting behavior. Sitting behavior is defined as: “the postures and positions of body segments held by a subject when sitting, that is the person’s postural range and movement frequencies” (Delleman, Haslegrave & Chaffin, 2004, p. 144). According to Van der Ploeg, Chey, Korda, Banks & Bauman (2012) and Dunstan et al. (2013), prolonged sitting is detrimental to health which could lead to chronic diseases, increased risk of obesity, cardiovascular disease, type 2 diabetes and certain types of cancer. Additionally, this sedentariness also brings attention to seated posture and the health risks associated with poor sitting habits. Defined by Kvålseth (1983), postural efforts are static efforts which reduce the blood irrigation to the muscles under pressure, which in short term cause a decrease in performance and productivity, and in the long run affect the health and well-being. Where the body can adopt, it will lead to physical distortion and when not possible it usually leads to diseases affecting the joints and tendons (Kvålseth, 1983). In relation to poor seated posture, musculoskeletal disorders such as back pain are common (Haller et al., 2011). However, when it comes to seated posture, there is a lack of consensus on the definition of a good sitting posture. Derived from postural fixity studies: “the optimum sitting behavior involves regular changes in position”, and thus “no seated position should be maintained for a prolonged period” (Delleman et al., 2004, p. 153; Graf, Guggenbühl & Krueger, 1995). This concept originates from the principles of “dynamic sitting” or “posture variation”. According to Delleman et al. (2004, p. 153), posture variation refers to: “achieving regular changes in posture, also through job enlargement, active breaks, and design of tasks or layout of equipment to enforce some standing and walking”. However, to my knowledge, there is no dispute over the adverse effects of slouching and having a forward inclined posture (Dul & Delleman, 2007; Delleman et al., 2004).

For this thesis, I have chosen to focus on two main aspects of seated posture: preventing slouching; and encouraging regular microbreaks to acknowledge the principles of posture variation. In this regard, some standards have provided specifications. According to Dul & Delleman (2007), 60 degrees of trunk inclination is the absolute limit to prevent the health risks associated with slouching; and for trunk inclination of 20 to 60 degrees, a maximum acceptable holding time is noted when there is no external back support. However, to allow posture variation and the movements needed for conducting a task, there is no limitation on
0 to 20 degrees of trunk inclination (Dul & Delleman, 2007). Additionally, according to the E-Facts-45 (2008), a microbreak of 10 to 30 seconds is necessary after each 30 minutes of being seated. In this regard, the United States Department of Labor has provided four referenced postures that all put the body in a neutral positioning, and also acknowledge the notion of posture variation (Computer Workstations eTool, n.d.).

According to (Haller et al., 2011), the average office worker spends about 50,000 hours seated throughout their working career. This sedentary behavior leads to estimations of back-related pain and discomfort among 40% of them (Haller et al., 2011). As students spend a long amount of time studying, this might also be a relevant problem to them. In addition to the effects of poor posture on our health, studies have also shown the effect of posture on our mood and emotions (Riskind & Gotay, 1982; Carney et al., 2010). The main objectives of these studies are to prove the bidirectional relation among posture and our mood and emotions, meaning that not only we express our emotions and overall mood through our posture, but also that our posture can stimulate those emotions and moods. These facts all highlight the importance of raising one’s awareness towards their adverse sitting behavior, and thus hope this awareness can potentially lead to a behavior change.

In ergonomics, posture is studied in relation to the well-being and effective performance of people (Kvålseth, 1983). From an ergonomist perspective, to avoid postural efforts, would be to design the workplace so that it would match the user, rather than the user adopting itself to the bad conditions of work (Kvålseth, 1983). However, having the workplace, machines and tools best designed to match the user is certainly a necessary step towards the well-being of the user and can help in decreasing postural efforts, but what also is essential is to raise one’s awareness towards their posture and sitting habits, which potentially could lead to an overall positive effect.

3. Related Research

This section will present the current state of literature and studies in relation to this thesis.

3.1 Persuasion, Reflection and Behavior Change

The advancements in personal and ubiquitous computing provide various advantages for systems encouraging behavior change. They enable capturing a wide variety of data, whilst being embedded and woven into everyday objects, materials and textiles (Ploderer et al., 2014). Additionally, people have always been interested in obtaining self-knowledge, with the aim to understand oneself better, and potentially alter or improve a behavior. In the health domain, among other usages, these systems have been used to encourage people in adopting healthy diets, increasing physical activity or to cease smoking (Ploderer et al., 2014). Sustainability is also another application area where these systems have been used in encouraging people to reduce their water and electricity consumption, waste and recycling and to increase the use of public transportation (Ploderer et al., 2014). In this study, I focus on the wellness sector to raise one’s awareness towards their sitting behavior to specifically prevent poor sitting posture (slouching) and encouraging regular breaks.
The underlying concept of the studies above originate from theories in persuasive technology and behavior change support systems (BCSS). Established by Fogg, persuasive technologies are defined as “any interactive computing system designed to change people’s attitudes or behaviors” (Fogg, 2002, p. 1). In this regard, Fogg coined the term “Captology” which covers the intersection of computing technology and persuasion, and is concerned with the “design, research, and analysis of interactive computing products created for the purpose of changing people’s attitudes or behaviors” (Fogg, 2002, p. 5). Technological advancements in the field of ubiquitous computing have provided persuasive technologies with a great possibility in overcoming the limitations of traditional media and human persuaders by providing interactivity and persistency amongst other benefits (Fogg, 2002). BCSS were first defined by Oinas-Kukkonen, being persuasive in their essence, and thus built upon the concept of persuasive technology (Fogg, 2002; Oinas-Kukkonen, 2013). Compared to persuasive technologies, BCSS puts a greater emphasis on people’s needs and goals; the intended outcome; and the user experience of the system in order to engage the user, and motivate them to achieve their goal (Oinas-Kukkonen, 2013). According to Oinas-Kukkonen (2013), persuasion through these systems should be unobtrusive to the main task, transparent and useful and easy to use.

These systems can particularly be beneficial in the health domain. Raising awareness for poor posture and the need for taking regular breaks have been persuaded using these systems. A number of studies have approached poor sitting posture by providing screen-based notifications to alert the user (e.g. Demmans et al., 2007; Khurana et al., 2014; Jaimes, 2005; Tanaka et al., 2015; Lee et al., 2013; Shin et al., 2016; Zhu et al., 2017; Duffy & Smeaton, 2013). Gamification concepts have also been utilized for this purpose. In a study conducted by Hong, Koo, Ban, Cho & Bianchi (2015), a flower avatar indicated the user’s posture aiming to create a cause and effect relationship between the user’s posture and the flower’s freshness. However, as each user might receive a handful of notifications every day, these notifications could easily be ignored or considered invasive (Haller et al., 2011). Moreover, dependent on the interrupted task, these notifications (irrespective of their intention) can be perceived disruptive, causing stress, which eventually leads to frustration (Hong et al., 2015b). In another study Haller et al. (2011) found vibrotactile feedbacks to be intrusive in the long run when compared to graphical and physical feedbacks.

Due to the reasons above, more subtle approaches have been taken by borrowing concepts from ambient media and calm technology. According to Weiser & Brown (1997, p. 78): “calm technology engages both the center and the periphery of our attention, and in fact moves back and forth between the two”. Thus, they are informing without being intrusive (Weiser & Brown, 1997), as they allow the user to initiate the interaction rather than the technology (Jafarinaimi et al., 2005). One such design is an interactive picture frame that would give feedback based on the user’s sitting posture (Obermair et al., 2008). Placed in the peripheral vision of the user, although they were aware of the changes in the frame, they were not distracted by it. In another study a physical flower avatar was developed to provide feedback based on the user’s back posture, sitting time, proximity to the screen and posture changes (Hong et al., 2015b). The flower reacted to each of the factors through a change in color, sound or motion. However, this study needs to be evaluated in order to assess its goal which was
informing users through subtle feedbacks. This approach has also been used to encourage regular breaks. Breakaway is an ambient display in the form of a human body which encourages users to take frequent breaks through changing its shape (Jafarinaimi et al., 2005). The findings revealed that the evaluatee appreciated the unobtrusive feedback design, so that she could ignore it if she decided to. The Health Bar, is another ambient display aiming to inform users to take short breaks by altering the color and reducing the illumination of the bar (Mateevitsi et al., 2014). However, these designs limit the user’s mobility. According to Hong et al. (2015b), wearables could also potentially inform users in subtle ways. In this study, the concept of smart clothing is used to not only inform the users in a subtle way, but also to prevent limiting them to a specific location.

Personal informatics systems or the Quantified Self movement also enable collecting information about oneself for the purpose of self-reflection and obtaining selfknowledge (Li, Dey & Forlizzi, 2010). The stage-based model of Personal Informatics systems consist of five main steps: preparation, collection, integration, reflection and action. However, these systems are more in favor of quantifying the self, whilst the approach of this thesis is to raise awareness by presenting the data in a ‘calm way’, and not overburden the user with numbers.

Gaining insight on one’s behavior through reflection can also lead to behavior change (Ploderer et al., 2014). Schön (1983) distinguishes between different forms of reflection based on their “temporal relation to the activity at hand” (Ploderer et al., 2014, p. 1671). These are reflection-on-action and reflection-in-action. In this study, a reflection-in-action approach was applied to intervene at the right moment and provide feedback at the time of action. If the intervention is provided at the right timing, this approach could have a high possibility of success (Fogg, 2002). However, as the feedback is intervening the user’s primary task, unobtrusiveness remains a challenge (Ploderer et al., 2014).

3.2 Wearable Technology

Wearable technologies have been used for encouraging behavior change in various domains. Particularly in relation to sitting posture, various commercial products such as FysioPal\(^1\), AiraWear\(^2\), TruPosture\(^3\), Prana\(^4\), Lumo Lift\(^5\) and Upright\(^6\) have been developed. On the other hand, there has also been various studies researching the use of wearables in this context. According to Buenaflor & Kim (2013, p. 104): “wearable computers are electronic devices that function as a computer and can be worn, carried, or attached to the body. They are designed to be context aware, always on, and continuously worn in an unobtrusive manner”. They are developed to: “enhance performance by increasing ease, productivity, and efficiency, and to satisfy and fill people’s needs” (Buenaflor & Kim, 2013, p. 105). The main advantage of wearable systems over static devices is their mobility (Buenaflor & Kim, 2013; Wang, 2016). Moreover, unlike portable devices, wearable systems do not require muscular effort to carry them around, remain attached to the body and can operate while being attached (Knight et al.,

\(^1\) http://www.paulinevandongen.nl/project/fysiopal/
\(^2\) https://airawear.com
\(^3\) https://www.truposture.com
\(^4\) http://prana.co
\(^5\) https://www.lumobodytech.com/lumo-lift/
\(^6\) https://www.uprightpose.com
It is this “operational and interactional constancy” which sets them apart from portable devices (Billinghurst & Starner, 1999, p. 57). According to Buenaflor & Kim (2013) and Spagnolli, Guardigli, Orso, Varotto & Gamberini (2014), specifically, wearable clothing overcome the obtrusiveness of many devices, allowing users to perform their everyday activities effortlessly, while being comfortable (Rossi et al., 2003). Moreover, factors such as weight and the degree of their integration assembling natural and usual clothing is essential in their unobtrusiveness (Buenaflor & Kim, 2013). Focusing on smart clothing, the convergence of electrochemistry and textiles is crucial in producing smart textiles, and thus wearables that are truly integrated (Baurley, 2004; Cho, Lee & Cho, 2009). A comprehensive report by Berglin (2013) provides an overview on projects combining smart textiles and wearable technology.

Prior to adopting and utilizing wearable technologies, it must first gain acceptance from its intended users. Therefore, a rich understanding on these factors is essential in designing such technologies (Buenaflor & Kim, 2013). Buenaflor & Kim (2013), identified and evaluated six key human factors influencing the acceptance or rejection of wearable computing systems. These factors consist of: fundamental needs, cognitive attitudes, social aspect, physical aspect, demographic characteristics, and technical experience (Buenaflor & Kim, 2013). The social and physical aspects are of relevance in evaluating the concept of SitLight in this study. Factors affecting the social aspect of wearables are personal privacy, social influence and culture. These factors address the effect of the wearable device on the individual’s social interactions, and thus, leads to an acceptance or rejection of the wearable (Buenaflor & Kim, 2013). As wearables are attached or worn on the human body, physical aspects such as comfort and safety, appearance and mobility become vital in their acceptance. In this regard Gemperle, Kasabach, Stivoric, Bauer & Martin (1998) defines thirteen design guidelines for wearability that concerns the physical shape of the wearables and their active relation with the human body.

Wearable technologies have been utilized in various application areas including: healthcare, emergency services, wellness, sports, fashion and entertainment (Buenaflor & Kim, 2013). Furthermore, several studies have utilized wearables for posture assessment. The common theme across these studies is to detect poor posture and provide an intervention that could potentially alter this adverse behavior (Duffy & Smeaton, 2013). To monitor body posture in an unobtrusive manner, several studies have approached their research through integrating wearable systems into clothing (e.g. Kang et al., 2017; Dunne et al., 2008; Mattmann, Amft, Harms, Troster & Clemens, 2007; Rossi et al., 2003). However, most of these systems are difficult to use in a daily routine either due to bulky electronics, or limitations in data measurement (Kang et al., 2017). However, there has also been attempts in converging the boundaries of electronics and textiles by naturally integrating the electronics into clothing and avoiding the aforementioned limitations (e.g. Kang, et al., 2017; Sardini, Serpelloni & Pasqui, 2015; Huang, et al., 2018). This integration leads to producing reliable and comfortable monitoring systems (Wang et al., 2015).

Various studies have utilized different modalities to provide real-time feedback and raise the user's awareness towards their sitting posture. The results indicate a positive effect in raising awareness and changing this adverse behavior. According to Wang et al. (2015),
sensing technology enables the users to be aware of their posture and correct it when necessary. In a study conducted by O'Brien & Azrin (1970), the effect of real-time informational feedback was studied on slouching. The feedback was in the form of a mild vibrotactile in the shoulder area which resulted in less slouching. Overall, they found that this reduction was due to the informational aspect of the feedback and not the aversive properties of it. Furthermore, the vibrotactile feedback was preferred to an auditory stimulus due to its private and less intrusive nature.

In a similar study (O'Sullivan, O'Sullivan, O'Sullivan & Dankaerts, 2013), the effect of real-time postural biofeedback in the form of vibration was measured. When slouching over an individualized threshold, the participants received the feedback from a BodyGuard device to change their sitting behavior. Spanning over a single session, the results revealed a significant reduction in low back discomfort. However, additional research is required to measure the long-term effectiveness of the feedback.

Wong & Wong (2008), took a different approach by utilizing acoustic modality to prevent poor posture of the spine. The prototype was a smart garment that would produce a tone from a buzzer for 5 times (each lasting 2 seconds) in case of detecting poor posture. The results indicated a 40% of time reduction in poor posture of the lumbar spine.

In another study, a smart garment for rehabilitation purposes has been developed for mainly arm-hand training scenarios to prevent compensatory movements, and shoulder training scenarios to prevent slouching. The smart garment works in combination with a smartphone application which gives visual and auditory feedback, and coaching for sustaining a correct posture (Wang et al., 2015). The garment itself also provides vibrotactile feedback. However, it was clear to the researchers that different modalities are useful in different stages or different training tasks (Wang, 2016).

Although there have been few studies integrating visual feedback into clothing for different purposes such as detecting motion sickness (Nojima, et al., 2015) and visualizing muscle activity (Kanebako, Oishi, Ishigami, & Uchiyama, 2013), closest to this study, is an interactive outwear which provides real-time visual feedback to both the user and a third person (Nishida & Tsukada, 2017). In case of detecting poor posture the LEDs on the sleeves will lighten up, and inform the user and a third person of poor posture. Although not as explicitly as other studies (e.g. locking the third person’s phone in case of detecting poor posture), this study also focuses on the eye of others as their main strategy.

Various feedback modalities have been used in the studies above to raise awareness regarding poor posture. According to Billinghurst & Starner (1999, p. 62): “the desired input and output modalities depend on the nature of the task and the information to be managed”. Thus, there is a need for exploring various modalities in this domain, and figure an optimum solution. Although visual feedback integrated into clothing has been used in mostly fashion and entertainment domains, to my knowledge, there has been only one study evaluating this modality in the context of poor posture prevention.
4. Research Methodology

In this section, I will elaborate on the methodology used for conducting this study. To clarify the process, first I will explain the approach of this study, and then present an overview of the research process and elaborate on each step. Concerning the exploratory nature of this study, a qualitative approach was chosen. According to Deniz & Lincoln (2005) and Lewis & Ritchie (2003), qualitative research has the potential to discover the phenomena under study in great detail and thus provide the researcher with a rich understanding of the problem. Due to the reasons above, it was appropriate to choose qualitative methods in order to gain an in-depth understanding on the participants’ feedbacks. This approach produced data that is rich in detail, and concerned with the quality rather than the quantity and the statistics of the data. Detailed explanation on the methods selected for each step will be described in the following.

4.1 Overview

The research process conducted in this thesis is as follows:

1. **Semi-sprint Workshop**: To widen my perspective, this first step was conducted to diverge and develop different ideas.
2. **Concept Development**: In addition to the researcher’s exploration, the findings from the previous step informed the concept of the prototype. After which, a low fidelity prototype was made to convey the concept, and facilitate the transformation of building the medium fidelity prototype.
3. **Prototype Development**: To be able to evaluate the concept of the prototype, a medium fidelity prototype was developed.
4. **Prototype Evaluation**: The last step was to deploy and evaluate the prototype with potential users and gain an in-depth understanding of their thoughts.

A thorough explanation of each step is explained in the following.

4.2 Semi-sprint Workshop

**The Design Sprint**

Originally the sprint is a design process developed by Google Ventures which includes various steps in order to reach a potential idea and test it. This process spans over 5 days and includes a predefined schedule for each day. The steps consist of: choosing a target problem to focus on, sketching competing solutions, deciding on the best solution, prototyping it and finally testing it with target customers (figure 1, Knapp, 2014). This approach is somewhat similar to other practices in design such as participatory design (Muller & Druin, 2012).
In its original state, the first step is to pick a problem and identify a focus for the team. The next step is to sketch competing solutions to solve the challenge at hand. The core of this step is to generate and sketch rough ideas through The Four-Step Sketch approach consisting of: Notes, gathering information on useful sources that can inform their ideas; Ideas, individually sketching rough ideas; Crazy 8s, sketching 8 different variations of the same idea to reach new perspectives; and Solution sketch, creating a self-explanatory storyboard of their most promising idea (Knapp, 2014). The sketching allows the participants to make their ideas concrete rather than talking in abstract forms. According to Knapp (2014), this process emphasizes on critical thinking rather than being artistic. The third step of the design sprint, consists of 5 steps which are: Art museum, where all the sketches are taped to the wall; Heatmap, where each participant picks the ideas they like; Speed Critique, where the highlights, standout ideas and objections of each idea are reviewed; Straw poll, where each person individually votes for their favorite idea; and Supervote, where the decider makes the final decision (Knapp, 2014). The last steps of the sprint are to create a high-fidelity prototype and test it with target users.

This method was used as an inspiration in this study. The main reason of choosing this method was its potential in diverging on various ideas and solutions, and being able to converge and reach a conclusion on the best. This step was an advantage to the research process as it could involve various perspectives before developing the final concept. It will be referred to this workshop as the semi-sprint workshop. The process is explained in detail in the following.

Participants
Convenience sampling was used to recruit the participants for this workshop. According to Lewis & Ritchie (2003), this approach lacks a clear sampling strategy and the participants are chosen based on ease of access. The workshop consisted of four students aged 24 to 27 all having a background in HCI. The participants were directly contacted by the researcher. Although it was initially planned to conduct a second workshop with a more diverse group including office workers, due to time limitations it was not possible to do so. An additional workshop consisting of people from different backgrounds might have yielded more diverse perspectives into the design process.
Workshop Process and Data Gathering
The workshop started by giving a brief introduction on the purpose of the thesis. Using a timeline for clarification, the participants were then introduced to the process of the workshop. Afterwards, ethical considerations were mentioned thoroughly and the participants gave their consent for audio recording. The session started with background questions about the participant’s awareness on their sitting behavior (see Appendix D). All questions were open-ended and although not intentionally, sometimes led to small discussions in between the participants. This step was an advantage to not only gain information on existing sitting habits and causes of posture awareness among the participants, but also to help them relate better to the challenge of the workshop. In the following, each step of the workshop will be explained and elaborated in detail. Pictures of the workshop can be found in Appendix A.

Step 1. Problem framing and reaching a common understanding: For every sprint, there is a question to be answered and a problem to focus on. To reach a common understanding on the problem, and convey the main focus of the workshop to the participants, the problem was conveyed through a scenario (Appendix D). For context, a brief explanation of the scenario is as follows:

Due to the prolonged sitting that Alex’s job and studies requires, his main problem is back pain. After visiting the doctor, his advice was to prevent himself from slouching in front of the computer, and also to take regular microbreaks throughout the day.

The challenge of the workshop was to design something that would help Alex in following his doctor’s recommendations. The challenge was stated explicitly to not only prevent different interpretations on the problem, but also to convey the main characteristics of the design that were important for the focus of this thesis. These consist of: useful and relevant information, intuitivity of design, unobtrusiveness and aesthetics.

Step 2. Sketching Solutions: After reaching a common understanding on the challenge at hand, it was time to diverge and generate various ideas. The following approach was conducted for this step:

Putting down ideas: In this step, the participants individually wrote down any rough ideas that could solve the challenge at hand. The instructions were to take an idea per paper and demonstrate it with words, drawings, diagrams or any other way they found suitable. Different variations of the same idea were drawn on the same paper. The participants had no limitation on the amount of ideas, but a time limitation spanning over 20 minutes to complete this step.

Voting: This step was to pick the ideas that had the greatest potential for solving the problem. After explaining the ideas to the group, voting was done through color stickers. Overall, 5 ideas proceeded to the next step.

Rapid variations: The aim of this step was to build upon the selected ideas from the previous step and generate variations by asking: “What would be another good way to do this?”.
The step was to encourage the participants to look at the ideas from different angles and build upon each other’s ideas. A time limitation of 20 minutes was given for this step.

**What should I sketch:** After the team had a good understanding on all the generated ideas, voting was done through color stickers. The participants would then each choose their final idea to demonstrate as a three-panel storyboard.

**Solution sketch:** Each participant would then sketch their selected idea in detail. The instructions were to sketch or make the idea as a storyboard consisting of what the persona would see while interacting with the solution. The participants were free in choosing the material they wanted to visualize their idea, whether it being sticky notes consisting of drawings, words and stick figures, or cardboard and playdoh. The only requirement was to make it in detail and self-explanatory. A time limitation of 20 minutes was given for this step.

**Step 3. Deciding Phase:** Having the final solutions sketched as storyboards, this step was to critically discuss the solutions and identify those that have the greatest potential for solving the challenge. In contrast to the original approach of this step where the focus is on picking one final solution to prototype, the aim of this step for this thesis was to discuss the ideas with a critical perspective to extract the highlights, advantages and disadvantages of each idea. The process started by each participant explaining their storyboard in order to give a final detailed explanation on their idea. The team was then encouraged to think critically towards each solution and discuss them thoroughly to extract their advantages and disadvantages. To get a final clear understanding of the participant’s views, each participant would then vote on their final decision and explain their reasoning.

**Data Analysis**
A loose qualitative content analysis was used to analyze the results of the workshop (Braun & Clarke, 2006). Conducting a loose approach was due to time limitations. The process is as follows: After transcribing and looking thoroughly at the data, a first level of abstraction was completed. Two different data sections were identified: one being the background questions and the other containing all the discussions around the ideas. Each data set was then analyzed and color coded based on different categories. The dataset resulted in two main themes. The advantage of this approach over only analyzing the final results was to recognize all the details the participants mentioned throughout the entire session. Doing so enabled me to be aware of all the discussions upon the ideas.

**Workshop Findings**
Regarding the background questions, the participants mostly recognized their bad posture due to pain, breaking from being immersed, or being informed by a third person. Their strategies for preventing bad posture were mostly in regards to adjusting their chair and furniture, which mostly were found unsuccessful.

Two main themes were discovered among the results of the workshop. One theme was mainly focused on ideas around furniture in an office, and the other consisted of different wearable solutions. In regards to the first theme, the ideas were designed around a computer, a speaker, chairs and a cup holder, all utilizing different modalities. Among these ideas was a
computer that had an attachable light bar on the top, and in case of slouching or notifying for a break, the light bar would blink in different colors. Another idea was based on a chair that would detect the user’s center of mass and give notifications at a certain period of time to inform the user of their sitting behavior. The latter idea was picked as the final idea of one of the participants.

The other theme consisted of wearable solutions. The ideas consisted of an upgraded fitbit, an anti-slouch necklace, an elbow support and an ankle choker. The idea of the anti-slouch necklace was based on vibration and constriction. In case of slouching the necklace would become tighter, and to notify a break it would vibrate. The concept of the elbow support was a bit more indirect to slouching. It was based on relating slouching to the angle of the elbow, and in case of detecting an angle less than 90 degrees, a light pressure would be applied. The other three participants chose the anti-slouch necklace as their final idea.

The persona for this workshop was intentionally designed so that it would identify a person who works and studies at the same time. The results of the workshop revealed that the participants were more inclined towards the anti-slouch necklace, and thus the wearability of this idea was taken as the main inspiration for developing the concept. However, rather than approaching the design with the current state of wearables (i.e. watches, wristbands, clips, etc.), a futuristic vision was applied and clothing was chosen as the wearable. The main reason of choosing clothing was to be able to take advantage of its mobility while not adding another device in the user’s ecology. The concept of SitLight will be further elaborated in the following section.

4.3 Concept Development

Developing concepts that function as the underlying abstract idea of physical designs is a common practice in HCI. According to Benyon (2014, p. 188), “Conceptual design is concerned with arriving at an abstract description of the system [...] but not with how the structure and functions are to be physically realized”. Multiple approaches have been introduced for developing concepts (e.g. Höök & Löwgren, 2012; Stolterman & Wiberg, 2010). A goal of this study was to expand the range of users, and thus develop a concept which could fulfil this need. In this regard, the results of the workshop indicated an importance of a design concept of a wearable technology. Additionally, being inspired by the new fashion industry integrating electronics into textiles, further supported the choice of clothing as the wearable. In regards to the feedback modality of the design, the aim was to choose a modality which would be effective but at the same time as unobtrusive as possible. According to Weiser & Brown (1997, p. 75): “ubiquitous computing will require a new approach to fitting technology to our lives, an approach we call calm technology”. Due to the reasons above, I decided to choose visual modality, and evaluate if this modality can be informing while being unobtrusive. Implicit in the first and second concept of the design, the third aspect of the concept was to acknowledge the principles of calm technology and design an unobtrusive system. As mentioned previously, a reflection-in-action approach was taken to provide the user with real-time feedback in the time of action. What seems crucial and remains a challenge in this form of feedback is unobtrusiveness. To summarize, the concept of SitLight is a wearable technology providing
real-time visual feedback to unobtrusively inform the user of their sitting behavior (figure 2). The concept was visualized through a development process described below.

4.4 Prototype Development
In this section, I will elaborate on the process of visualizing the concept, the prototype description, and the making process. According to Benyon (2014), prototyping can be used for different intentions throughout the design process to explore an idea. The reason to build a prototype in this study was to explore the concept and see how it would be perceived in the context of use. The process started by sketching multiple patterns to find one that would be both visible and intuitive at the same time (Appendix B, figure 1). After reaching a decision, a lo-fi prototype (Appendix B, figure 2) was made in order to convey the concept to others, and conduct small informal brainstorming sessions. This step was mostly done to gain inspiration from others and prevent small design problems in the early stages of the prototype. However, the lo-fi prototype also facilitated making the final version of the prototype. In the following the prototype will be explained in detail.

SitLight
SitLight refers to sitting lightly, and the use of lights in the prototype. It is a shirt that gives real-time visual feedback based on the user’s sitting behavior. The sitting behavior which this prototype aims at improving, is to prevent slouching and encouraging regular breaks throughout the day. The sleeves of the shirt were used to indicate a break, and the front to indicate slouching. To encourage the user to take a break, the fabric of the sleeves would turn blue after 30 minutes to indicate that a microbreak is needed. If the user reacts to the feedback and stands up, the sleeves would act as a timer and turn off gradually to indicate the necessary time of taking a break. Otherwise, the color builds up gradually on the sleeves. In this regard, the specifications of the prototype were that after 30 minutes, one fourth of the sleeve would turn blue, and after that, every 10 minutes the sleeve builds up gradually were in one hour half of the sleeve is lightened up. The blue color was chosen as to resemble low blood circulation in the body. It will be referred to this feedback as the break notification (figure 3).

In regards to the slouching feedback, the embedded LEDs in front of the shirt would lighten depending on the degree to which the user slouches. A forward inclination of 20 to 60 degrees would lighten up half of the strip in red, whereas more than 60 degrees would lighten up the entire strip. Moreover, to prevent giving feedback on wrong instances (e.g. reaching
something), in both cases a delay of 15 seconds was considered before giving feedback. It will be referred to this feedback as the *slouching* notification (figure 4).

![Fig. 3: Break notification](image)

![Fig. 4: Slouching notification](image)

**Making Process and Technical Specifications**

Here I will explain the details of developing the prototype as well as the technical specifications used in regards to the components and code of the prototype.

The first step in making the prototype was to figure out the combination of electronic components which would be suitable for a wearable. Finding this combination was somewhat difficult due to a lack of proper components. For creating the visual effect, Neopixel LED strips were used for both the sleeves and front of the shirt. The LED strips used in the sleeves were powered by three AA batteries providing a voltage of 4.5 to 24 LEDs. To program the LED strip, a Lilypad Arduino Simple was used. The Lilypad Arduino was then separately soldered to a bluetooth module (i.e. Adafruit Bluefruit LE UART Friend-BLE) which enabled controlling the lights through a smartphone app developed by Adafruit (Bluefruit). The Lilypad Arduino was powered separately using a li-po battery. For the front of the shirt, two LED strips each containing 30 LEDs were first soldered to each other by their voltage, ground and data pins. Both strips were powered by four AA batteries providing a voltage of 4.8 to 60 LEDs. The LED strips were programmed using an Adafruit Feather 32u4 Bluefruit LE which has a built-in bluetooth module that also enabled controlling the LEDs using the same application mentioned above. Similar to the Lilypad Arduino, this Arduino was also powered using a li-po battery providing a voltage of 3.6. Afterwards, two different codes were written for both functionalities of the shirt.

The next step after figuring the electronic components was to find the right combination of fabrics that would diffuse the lighting. For this purpose, for both the sleeve and front of the shirt separate layers of fabric were sewed together and then sewed to the led strips. A long-
sleeved shirt was then bought and cut from the back so that it would be an easy way of wearing
the shirt as well as fitting multiple people. Multiple velcro strips were then sewed to back of
the shirt for adjusting the size. Two pockets were also sewed to the shirt for holding the
electronic components. Afterwards, the three fabric strips (one for the sleeve and two for the
front of the shirt) were sewed to the shirt. Having only used the right sleeve was due to a lack
of suitable components. After sewing all the pieces together, the last step was to solder all the
wires in between. Prior to the evaluation and throughout the process, the safety aspects of the
prototype were also confirmed by the HCI lab assistant. Pictures of the making process can be
found in Appendix C.

4.5 Prototype Evaluation
In this study, evaluation was done in the form of user testing. The aim was to gain an in-depth
understanding of how the participants perceived the concept and the prototype. Semi-
structured interviews and observation were chosen as the two main methods. Three of the
evaluations were conducted in public settings to not only provoke the feeling of a natural
setting for the participants, but also to be able to evaluate the social aspect the prototype
triggers. The fourth evaluation was conducted in the participant’s office where they usually
work. All sessions lasted for about two hours.

Participants
Similar to the previous approach, convenience sampling was used to recruit the participants
for this evaluation. Four participants were recruited all being students, having different
backgrounds in IT Management, Cognitive Science, Human-Computer Interaction and
Software Engineering. The participants consisted of three females and one male between 23
to 27 years old. All participants were directly contacted by the researcher. Although evaluating
the prototype with one PHD student working in his office, it would have been optimal if time
allowed for more participants in this category and more participants in general. The
participants will all be referred with anonymous random female names.

Data Gathering
A combination of two different qualitative approaches were used for evaluating the prototype.
The two methods consist of semi-structured interviews and observations. According to Lewis
& Ritchie (2003), this approach has the advantage of gaining different insights stemming from
the different methods applied. Additionally, the mix of observations and interviews gives a
perspective to not only understand the events and behaviors in their natural setting, but also
to gain “a reconstructed perspective on their occurrence” (Lewis & Ritchie, 2003, p. 38).

Both the preceding and follow up interviews were semi-structured. The main advantage of
semi-structured interviews is that they are free-form and allow the researcher to ask follow-up
questions if necessary (Benyon, 2014). This method was especially useful in the case of this
study were the aim was to gain an in-depth understanding of how the participants perceived
the prototype. The sessions started by informing the participants about the process and getting
their consent for participating in the study as well as recording the session. Afterwards, some
background questions were asked to understand the main activity of the participants during
the week and whether it requires them to be seated for prolonged hours. The participants were
then given a brief explanation on the context of the prototype and the recommendations promoted by the standards regarding healthy sitting behavior. When asking the participants whether they needed more information on the specifics of the standards, all of them mentioned that they understood everything and did not need more information. However, it was planned to do so if any of the participants did request more information.

The next step was to evaluate the prototype. After setting up the prototype, the users wore the prototype and were asked to work with their computer as they usually would for about one hour. While doing so, the prototype was controlled using the Wizard of Oz technique. This technique is especially useful to explore a design concept far earlier than it is possible in the design process (Buxton, 2007). According to Buxton (2007), it enables users to have a real and valid experience of the system without being aware that some functionalities are not fully implemented. While controlling the prototype, I also observed the participants and took notes in order to refer back to them in the follow up interview. The notes were mostly in regards to the participant’s reactions towards the prototype’s feedbacks. According to Benyon (2014), as people naturally tend to become self-conscious when they are under observation, it should be conducted as unobtrusively as possible. One way of decreasing this effect could be to increase the observation time (Benyon, 2014). Although extending the observation time would have yielded better results, in the case of this study it would have been too demanding to do so. However, both the participants conducting an activity that requires their attention, or the observer simultaneously doing another activity while taking notes, could also help in decreasing this effect (Benyon, 2014). In this regard, the participants were asked to pursue their normal activities and work with their computer as a way to drag their attention to their own work and less to the observer. Moreover, to show that I am not explicitly taking notes, I used my computer to do so.

The follow up interview consisted of some general questions about the prototype, the intuitivity of the design, the persuasive potential of it, the feedback modality, the shirt being the wearable, the context and intentions of use and finally background questions about the participant’s sitting behavior (see Appendix E).

**Data Analysis**

The data of this study was analyzed using the qualitative content analysis approach. According to Braun & Clarke (2006), this method is used to identify, analyze and report patterns within the data. Essential to this approach is to structure the data while recognizing both the content and context of the text (Lewis & Ritchie, 2003). In this approach, the first step is to identify the *unit of analysis*. In the case of this study, the *unit of analysis* are the transcribed interviews. Then, the interviews are read through several times to gain a holistic perspective over the data. Through this step, *content areas* could be identified which are parts of the text that refer to the same topic in the *unit of analysis*. The data is then divided into *meaning units* which consist data that are related through their content and context. The *meaning units* are then condensed in order to shorten the text while preserving its core. After which the *condensed meaning unit* are abstracted to create *codes*. Essential to the previous step is to consider the context of the data while abstracting it. The codes are then sorted based on their similarities and differences which lead to the formation of *subcategories* and *categories*. The previous steps contain an analysis on the *manifest content* which deals with the content of the
text, being the obvious and visible components. On the other hand, an analysis on the relationship among the data and extracting the underlying meaning refers to latent content. The latent content is extracted through analyzing the underlying meaning of the categories and formulating themes, which are more interpretative in nature. As mentioned by Braun & Clarke (2006), qualitative analysis guidelines are not rules and should be configured to fit the data and research question at hand.

In the following I will explain the details of how this process was carried out in this study. The first step was to transcribe the interviews verbatim. The transcribed interviews were then read to familiarize myself with the gathered data and gain a holistic perspective. This step led to the recognition of content areas among the transcriptions and thus color-coding was chosen as an approach for indicating them. After the first round of color-coding, the data was analyzed once more in order to discover new content areas.

The next step to the analysis was transforming the data into an excel sheet and dividing it into meaning units. The data was then condensed, formulating condensed meaning units, and abstracted into codes. The excel sheet was also color-coded based on the previous content areas. As some participants had varying opinions throughout the session, it was also helpful to make short notes on how their opinions evolved on the concept as well as their final opinion. The codes were then printed and sorted based on their similarities and differences leading to the formulation of sub-categories. As the content areas were well thought through, the codes were sorted under the same content area, but also having the potential to be sorted otherwise. At this stage of the analysis, the content areas were recognized as categories. However, the potential for recognizing new categories was possible throughout the entire process. To extract and link the underlying meaning of the categories themes were then identified. An example of this approach can be seen in Appendix F.

An inductive analysis was performed throughout the entire process. According to Braun & Clarke (2006), this approach is an inductive or bottom-up approach where the analysis is data-driven rather than analyst-driven. Therefore, there is no pre-existing coding frame prior to the analysis. In relation to this study, this approach was chosen as it had the potential of recognizing the data in free form.

4.6 Limitations and Ethical Considerations

Qualitative research must be assessed with the broadest meaning of reliability and validity, which respectively pertain to the sustainability and well grounded nature of the study (Lewis & Ritchie, 2003). A thorough explanation of the methods used and how they were applied, as well as reflecting on the findings and limitations of the results can lead to assessing such measures in qualitative research (Lewis & Ritchie, 2003). Therefore, the aforementioned factors were made transparent in this study.

However, no study is without limitations. Regarding the participants of the workshop, this study could have yielded more perspectives by including participants from different backgrounds. Moreover, a different perspective could have been obtained by evaluating the prototype with an older group of people as well as more participants.

Another limitation of this study is the short-term evaluation of the prototype. This led to a short-term qualitative study which leaves less room for reflection and obtaining deeper
insights. This limitation mainly stemmed from the state of the design which required the presence of the researcher to control the prototype. By designing a higher fidelity prototype, the participants could have used the shirt for a period of few days or weeks. Doing so, would have allowed for a long-term qualitative study and thus obtaining deeper insights on the concept of the prototype, and the effectiveness of such a design on sitting behavior. Regarding the methods used, observing the users could have biased their behavior to some extent. Although increasing the observation time could have led to decreasing the effects of observation and gaining more valid results, for the scope of this study and the state of the design, this would have been too demanding to request. Furthermore, the study could have advantaged by being two researchers conducting the content analysis to confirm each other and reduce probable bias.

The main requirements outlined by Vetenskapsrådet were applied in either stage of including participants in this study (Vetenskapsrådet, n.d.). Before obtaining consent, the participants were informed thoroughly of the process and any information that would prevent them from participating in the study (i.e. the tasks included in the process, how long they will take). They were further informed that all the collected data will be anonymized, used only for the purpose of this study, and represented anonymously. At last, the participants were informed that their participation is voluntary and can be cancelled at any time they wished to.

5. Results

This section will present the findings of this study. In general, all the participants liked the idea of the prototype. One participant (Agneta) particularly mentioned that as bad posture is not recognizable right away, it is good to be aware of it. Other than the arm battery pack which felt a bit heavy and unbalanced for some participants (Karin, Emma), they all noted that the shirt was comfortable to wear. Regarding their sitting behavior, they all mentioned that they sit for about 6 to 9 hours a day. While some took breaks every hour to stand up (Agneta, Lina) others were less active. Other than one participant who overall had a good posture (Agneta), others noticed their bad posture through a pain trigger (Karin, Emma, Lina). Overall, the participants had no particular strategy for maintaining a good sitting behavior.

Two main themes were identified among the results; One refers to the main characteristics of the concept behind the design, and the second set of the results focus on the physical characteristics of the SitLight prototype (i.e. how the concept was visualized). The identified categories and subcategories are:

Intuitivity of Design: intuitiveness, feedback color;
Feedback Modality: light as the modality, visibility, obtrusiveness;
Clothing as the Wearable;
Intentions/Context of use: intentions of use, context of use;
Persuasive Potential, and Future Characteristics and Application areas;

The figure below demonstrates the layout of the subcategories among the themes (figure 5). Additionally, two categories (i.e. Intentions/Context of Use and Persuasive Potential) were related to the domain of the concept being sitting behavior.
Prior to explaining the results, it is worth noting that all four participants received the break notification, while Karin being the only one who received the slouching notification. As some participants did not receive this notification, the idea of the design was discussed with them at some point in the interview where it did not affect their answers. However, the small data set of this study, and only one user experiencing the slouching notification are the main limitations of the data set. Thus, one way to avoid this is extending the evaluation time which might have eventually helped the participants to understand the break notification and given them more time to receive the slouching notification. Moreover, a small data set could prevent recognizing various perspectives of a design. Regarding this study, including more office workers could have represented a more diverse data set.

5.1 Intuitivity of Design
The first category reflects on the participants’ understanding of the SitLight prototype.

Intuitiveness
First, I will explain the participants’ thoughts on the intuitiveness of each notification. The intention of the break notification was not clear for three of the participants (Agneta, Emma, Lina), and thus, they did not react to it accordingly. However, although being confused at first, one participant (Karin) understood the intention of this feedback and reacted in the intended way. The participants made different connections to this notification. For Karin, the color of the notification and the context given beforehand helped in making the right connection. However, the other three participants, perceived this feedback to be difficult to understand. They made different connections such as wrist and arm positioning (Agneta, Emma, Lina), sitting posture (Emma, Lina), or some configuration in the shirt (Agneta, Emma). The participants (Agneta, Lina) further mentioned that the lights alone were not enough to understand the intention of the feedback, and a more straightforward notification (e.g. up arrow) would have clarified its intention (Lina). However, Lina also mentioned that if she knew what the notification meant beforehand, she would have preferred the lights as they were. Additionally, she also noted that the building up lights signified a warning for her. Regarding the slouching notification, Karin understood its intention and noted its intuitivity. Although the other participants did not receive this notification, when asked afterwards about its intention, they all mentioned it correctly, which could be due to the appropriate placing of the light tubes. Lina further explicitly mentioned the intuitivity of this feedback. Furthermore,
Emma noted that having separate parts on the shirt for the two notifications makes them more understandable.

**Feedback Color**
Overall, neither of the participants understood the intention of using a blue color for the break notification. They (Emma, Agneta, Lina) mentioned that if it had been designed using a red color, it would have warned them more and they were less able to ignore it:

*Emma: I was thinking like just because it was blue light, I thought it was like okay, whatever, but if it would be lighting in red, then I would think more of a warning.*

On the other hand, Karin being the only participants who received the slouching notification, mentioned that the red color did associate a warning for her.

**5.2 Feedback Modality**
The second category of data deals with the participants’ perception on the use of light as the modality, its visibility and its obtrusiveness.

**Light as the Modality**
In one way or another, all four participants liked the idea of visual feedback. However, Karin and Agneta were more skeptical towards the idea at first. Karin showed more concerns towards the appearance of light as the modality, whilst Agneta was more concerned with visibility aspects. Although Agneta mentioned the visibility benefits of visual feedback in a display object, she eventually tilted towards the use of this modality for some parts of the SitLight prototype:

*Agneta: visual light can be nice if it’s a display object, but if it’s something you are wearing it’s a bit harder to notice it.*

Another limitation of this modality was recognized for people required to work in dark environments (Karin). However, the other two participants (Emma, Lina) approved the use of visual feedback in this context. Emma found this modality as one of the best solutions since you can see it instantly and it is less disturbing compared to haptic or auditory feedback:

*Emma: I think it doesn’t disturb you as much as like a feeling would do, I think that like vibrations on your body would disturb you more than a light, so I think it’s a good solution.*

Another important characteristic of visual feedback is its social aspect. Karin saw both sides, that while it could be annoying at times, it could also be a motivation to react. She further mentioned that depending on your intention this characteristic could also be helpful:

*Karin: [...] I mean people around you can see it as well, that’s what I said I wouldn’t like but at the same time it would be good because then some people would be even maybe your dad and say you are sitting wrong especially if you want to change your sitting behavior.*
Lina overall liked the social aspect of the shirt and perceived it as an advantage. However, she also mentioned that depending on your personality it might either be an advantage or a disadvantage in the design.

In the following I will explain the participant’s thoughts on utilizing this modality for each notification. In regards to the break notification, all participants approved the use of visual feedback. However, both Karin and Agneta had alternative suggestions for this feedback, but eventually both came to the conclusion that they would prefer visual modality for this purpose. Karin further mentioned that she would like the lighting area to be a bit smaller than how it was currently designed.

Multiple suggestions were made for the slouching notification. Karin and Agneta both preferred replacing the visual feedback with a light vibration. Agneta’s reasoning was in regards to improving the noticeability, while Karin did not like her entire shirt to light up. The other two participants (Emma, Lina) perceived visual feedback as the best modality for this purpose. Lina additionally saw the potential of a slight vibration as a further push in case of ignoring the visual feedback.

**Visibility**

This section is in regards to the visibility of the feedbacks. All four participants noted that the break notification was visible and dragged their attention. Other than Karin that reacted to the notification, the LEDs started building up for the other participants. Although noticing the final state of the notification, and the fact that more lights were on, the gradual change of the LEDs was not noticeable to either of the three participants. In this regard, Emma mentioned that a moving light would have been more noticeable. Either implicitly or explicitly, all participants mentioned that the feedbacks were in their peripheral vision:

*Lina: [...] like having it on my right arm, because like when you’re moving the mouse cursor or something, it’s always kind of there, it’s always in your peripheral vision [...].*

Karin being the only participant who experienced the slouching notification approved its visibility. Wearing the shirt again, Emma noted that although this notification is visible while working with the computer, it could be more problematic depending on the activity you are doing and the field of vision it requires.

**Obtrusiveness**

The results show that not only neither of the participants found this modality distracting, but also some (Emma, Lina) acknowledged this modality over others. One participant (Karin) made a comparison in between the two notifications and mentioned that the break notification was a bit more distracting as it required her to stand up. Another participant (Lina) further mentioned that the first break notification was somewhat distracting due to a lack of knowledge on its intention, but gradually this decreased, and although knowing the light was on, it was not bothering. She further mentions the advantage of utilizing visual feedback in this regard:
Lina: I think it’s good [referring to lighting as a form of feedback], because it’s noticeable in a sense that you know if something lights up it kind of draws your attention to it, and it’s non-intrusive enough to like ignore as well. So, I felt like it was a good mix [referring to the current design] between letting me know and not really like a flashing light or something that would have driven me crazy.

5.3 Clothing as the Wearable
This category reflects on the participants’ thoughts on the use of clothing as the wearable.

All participants liked the idea of using clothing as the wearable. Although some participants (Karin, Agneta) had other suggestions, they also eventually preferred the idea of clothing for this purpose. In the following, I will elaborate on the participant’s thoughts in this regard.

While developing her ideas, Karin concluded that clothing could be much more comfortable than using other wearables:

Karin: I think it would work better [referring to the use of clothing], because I always get annoyed of, I’m never having wristbands or something, yeah so, I don’t know maybe I would get annoyed of it, and if it’s the clothing, you already have it on you and its soft material so that’s quite nice.

As an additional idea for the shirt, she suggested using stronger material for the fabric so that it would be harder to slouch. Like Karin, Agneta also had varying ideas throughout the session. Irrespective of the futuristic vision of the prototype, i.e. having the same functionality on different shirts, she preferred wearing a shirt underneath the main clothing. This participant eventually developed her ideas into using a computer as a complimentary device to the shirt, so that among other things, she would be able to personalize and customize where she would receive the notification:

Agneta: I said that the focus could be on the computer but I think it can be a nice compilation, that your computer would tell you okay, now time to stand up and then you can walk around and you can escape a bit from the computer and just the time that the blue light goes off, so I think that these two could work well together.

The additional device could also be used for obtaining more information on sitting behavior (Agneta). Both Emma and Lina mentioned the advantages of clothing over receiving notifications from external devices. The main advantage in their point of view was that as clothing is always there, it would not require you to distract yourself from other devices:

Lina: [...] I think it would be really nice [referring to the shirt as the platform] because it doesn’t really require me to do any additional things or focus on any additional stuff because I’m already wearing it so it’s already around.

Emma further mentioned the feeling of the shirt being part of you compared to an external device:
Emma: [...] you get the feedback right away and it feels like it’s a part of you and it’s not like a device that you have to look at [...].

However, neither of the participants mentioned the mobility advantage they would gain in using wearables compared to static devices.

### 5.4 Intentions/Context of Use

This category reflects on the participant’s intention of using such a prototype, and the context of use surrounding it.

**Intentions of Use**

All participants responded positively to continue wearing a shirt similar to the concept of the prototype. However, Karin mentioned that she would do so if only it looked normal and modern. Most of the participants mentioned the potential use of the shirt due to bad sitting behavior (Karin), prolonged sitting (Karin, Emma), importance of posture in the long-term (Emma), and for recognizing times when they have to be more careful with their posture (Agneta). One participant recognized the comfortability of this solution over previous approaches she has tried (Karin).

**Context of Use**

Although the participants noted using the shirt while working and studying (Karin, Emma, Lina), one also mentioned the functionality of the shirt in other contexts they tend to have a poor posture such as standing and running (Emma). On the other hand, one participant (Agneta) noted wearing the shirt only at times when she tends to have a poor posture. Some participants further noted the necessity of turning off the shirt in busy and formal occasions.

### 5.5 Persuasive Potential

The fifth category of data deals with the participants’ reflections on the potential persuasiveness of the SitLight concept.

In this regard, the participants (Karin, Emma, Agneta) mentioned that the prototype can potentially raise their awareness towards their sitting habits, and thus lead to a change in their sitting behavior:

*Karin: [...] I already get aware of that I’m sitting wrong, and that’s something I’m not always aware of.*

As Karin was the only participant who received both notifications, she noted that the shirt did influence her sitting behavior. However, the other participants mentioned they would have reacted to the feedbacks if they knew its intention. Lina further stated how the shirt could potentially be helpful for less active office workers.

### 5.6 Future Characteristics and Application Areas

The last category of data presents the participants’ thoughts on potential characteristics and application areas for the prototype.
The participants envisioned a futuristic version of the prototype and the features and characteristics such a shirt should have. Karin mentioned that having one shirt with this functionality would not be convenient, and she would envision a future where we can program our clothing and add different functionalities to them. Emma also stated that the shirt should be seamless, embedding the lighting and electronics so that you would not notice the difference from any other shirt. For Agneta it was important that the shirt was connected to external devices so that it would not only create the possibility to configure different settings and customize the notifications, but also to have the data flow through different devices for different functionalities (IOT). She further noted that the shirt needs to be completed with professional advice.

Further application areas were also mentioned by the participants. One participant (Agneta) acknowledged the usage of the shirt in everyday activities (e.g. washing the dishes, cleaning, etc.) where posture is also important, but there are no external devices around. Her idea was a multi-functional shirt that dependent on the activity would change its functionality and modality to adapt to that specific context for improving the user’s posture. Another useful application area was for rehabilitation purposes so that chiropractors would be able to see how their patients behave and improve their postures over time.

6. Discussion

Most studies assessing wearable clothing for improving sitting behavior have mainly focused on developing effective and accurate sensing technologies, and testing it in order to assess its accuracy and effectiveness on the user’s posture (Wang, 2016). Although it can be argued that these studies influence the user experience and acceptance of the wearable, but there is also a need into looking at these interventions merely from the user’s perspective in the intended context. Although there have been studies providing guidelines for designing suitable wearables (e.g. Gemperle et al., 1998) and identifying factors that play an essential role in accepting (e.g. Buenafior & Kim, 2013) and assessing a wearable design (e.g. Knight et al., 2006), studies assessing wearables in combination to its modality and context of use from a user’s perspective are rather sparse in the area of sitting behavior (Wang, 2016). By doing so, we can gain a holistic perspective, and recognize the essential characteristics that influence the concept as a whole. The aim of this study was to make such a contribution.

For each design, there is two set of different characteristics; one referring to the main characteristics of the concept behind the design, and the other targets the physical characteristics of the design and how the concept is visualized. The “SitLight Concept” is developed upon three main core aspects consisting of: being a wearable in the form of a smart clothing, providing visual feedback as the modality, and unobtrusiveness as the principle of calm technology. This core concept was more or less approved by all the participants. Based on developing a prototype and the results obtained from the evaluations, I identified aspects which mostly target the physical characteristics of the design. These aspects are directly related to the concept of the design meaning that altering each of them could directly affect the concept. Based on these aspects, I define a design space useful for designing similar wearable concepts targeting at raising awareness towards sitting behavior (figure 6). In the following,
the design space will be elaborated by discussing the core elements of the “SitLight Concept” in relation to the physical characteristics of the prototype. However, as some characteristics overlap between the different aspects of the concept, they will be explained in the most relevant section.

![Figure 6: The design space](image)

One of the first core characteristics of the “SitLight Concept” is utilizing clothing as the wearable. While supporting earlier research (Mann, 1996; Buenaflor & Kim, 2013), the main advantage was its comfortability, while requiring less attention and effort from the user. In regards to this core concept, the design space identifies three main aspects when considering clothing as the wearable: the layer which the cloth is worn, the fabric used, and its connectivity to other devices (IOT). All, but the latter aspect (i.e. IOT), are targeting the physical characteristics of the design. In regards to the layer of clothing, what seems crucial is to further investigate the acceptance, advantages and disadvantages of using a shirt over an underneath layer of clothing. As it can be seen from the diagram above, this aspect is closely related to the second core concept of the design (i.e. visual feedback), meaning that if an underneath layer of clothing is found more advantageous, visual feedback will most likely not be a suitable modality anymore. In regards to the fabric of the clothing, if seen as a suitable choice, a textile can be chosen that helps in making slouching more difficult. In regards to connectivity to other devices (IOT), what is most important to consider is the advantages and disadvantages this connection can bring. However, this aspect is closely tied to the third core concept of the design being unobtrusiveness. Although connecting more and more devices in the user’s ecology can enrich the data and enable the user to obtain value added information, it can also lead to overburdening the user. This connectivity can also raise privacy issues where the data expands into other ecologies than the user’s. Therefore, in foreseeing a future where smart clothing becomes prevalent, personal data security becomes of essential importance (Spagnolli et al., 2014; Mann, 1996). This raises privacy issues which could lead to the collection of sensitive data and identification of users (Spagnolli et al., 2014). Therefore, further studies are needed.
in order to assess such aspects that have direct impacts on the acceptance of the wearable in the first place (Wölfel, 2017).

The second core characteristic of the “SitLight Concept”, is utilizing visual feedback as the modality. The potential advantage of this modality is being informative while staying in the peripheral. In regards to this core concept, the design space identifies six main aspects when considering this modality: the placement of the notifications; personal appearance preferences (PAP); design of motions with light; the color used; the context of use, and finally its social aspect. All but social aspect, target the physical characteristics of the design. In regards to the first aspect, the placement of the notification has a direct relation to the intuitiveness and visibility of the design. This importance of this aspect will be clarified through the results of the SitLight prototype. First, the relation of the placement of the notification will be assessed to its visibility. In regards to the prototype, it can be said that placing the lights on the front of the shirt raised more visibility concerns compared to the other notification which was placed on the arm and visible for all participants. The placement of the notification also has a direct effect to its intuitiveness. In this regard, it can be said that placing the break notification on the sleeves was not as intuitive as the slouching notification placed on the front of the shirt. However, in regards to this aspect, what is clear from the results and most challenging in utilizing this modality, is figuring the optimum relation among the placement of the feedback to its intuitiveness and visibility, while recognizing the aesthetics of the design. While supported by earlier research (Buenaflor & Kim, 2013), the second aspect (i.e. personal appearance preferences) can directly affect in choosing or rejecting a smart clothing utilizing visual feedback. As there is not one optimum solution for all, this aspect necessitates the need for customization. This leads us to foreseeing a future where we can program our clothing, and thus personalize them to our taste. However, looking at the new fashion industry producing smart clothing by utilizing digital fabrication tools such as additive manufacturing, and then seamlessly integrating electronics into textiles, this future is not one far away. Moving on to the following aspects, it should be clarified that all have an overlapping area with the third core concept of the design being unobtrusiveness. The third aspect is related to designing any motion when utilizing visual feedback. The importance of this aspect can be identified through the results of this study were neither of the participants recognized the gradual change of the LED lights in the break notification. The challenging point with this aspect is that although utilizing a more intense motion might lead to a better visibility, it can also increase the intrusiveness of the design, and thus, an optimum balance should be identified. The fourth aspect touches upon the color of the modality. As it was clear from the results of this study, some colors identify with more warning colors as others can be easily ignored. Thus, the intention of the designer should be clear when choosing the color of a notification to prevent warning the user with more intense colors when not needed and vice versa. When not used appropriately, this aspect can identify a design as intrusive. The next aspect is related to recognizing the working conditions and the context of use. What can be said in regards to this aspect is to be aware of the requirements of the working environment prior to designing for that context. One such example is people whose work requires them to have dark environments. A visual modality used in this context can lead to an intrusive design, and thus, a rejection of use. This aspect can directly alter the chosen modality. Finally,
last is the social aspect of visual modality. According to the results of this study, this characteristic can motivate as much as it can prevent the user from adopting it. Previous research has also identified this aspect crucial in the acceptance of wearable technologies (Buenaflor & Kim, 2013). If recognized as a disadvantage of the design, this aspect can identify a design as intrusive due to various reasons such as visualizing the user's information.

The domain of SitLight was to target sitting behavior. As the results indicated, the prototype does have the potential in raising the user's awareness towards their sitting behavior and potentially a behavior change. However, the results only indicate a persuasive potential of the prototype and not a persuasive effect. Additionally, other suitable application areas were identified which the shirt was considered useful in. In my opinion, this mostly originated from the wearability of the concept and the mobility it provides.

In a study conducted on wearable coaching in the context of fitness, the authors found a relation in between intrusiveness and the future use of a system, demonstrating that only systems that are not intrusive will be adopted for future use (Asselin, Ortiz, Pui, Smailagic & Kissling, 2005). Although the previous study is not related to the context of this thesis, the results can be relevant for any wearable technology. As seen from the design space above, the first and second aspects of the concept (i.e. smart clothing and modality), play an essential role in labeling a system as intrusive or not. However, if designed properly, the findings of this study indicate a potential combination of clothing and visual modality whilst being unobtrusive. This indicates a potential calmness of the design, which is necessary in the ubiquitous computing era (Weiser & Brown, 1997). However, the main challenge is designing the physical characteristics of the design, and figuring the best way to visualize the concept whilst preventing an intrusive design. This study has only outlined a set of primary characteristics that need to be considered when designing similar concepts. By taking a research through design approach, the following design space will further be enriched and contain research which can inform the HCI practice community among other benefits (Zimmerman, Forlizzi, & Evenson, 2007). To reach an optimum design, further research is required to study each characteristic of the design space thoroughly; and to obtain reliable and valid results, long-term in situ deployment of the prototype including more participants is necessary. Doing so would lead to a better understanding of the prototype, an opportunity to reflect on the design, gaining deeper insights, and also its effectiveness on sitting behavior.

7. Conclusion

The purpose of this thesis was to investigate the potential advantages, disadvantages and challenges of the integration of visual feedback into clothing for improving sitting behavior; and further explore and clarify the possibilities and limitations of the concept from a user's perspective. The following research question was pursued in this thesis: How is a wearable clothing utilizing visual modality perceived for improving sitting behavior, and how can this concept aid us in defining the design space for similar design concepts?

In order to answer the research question, a workshop was first conducted to develop the concept further. The concept was then visualized by a mid-fidelity prototype and deployed and tested with four users coming from different backgrounds. In addition to some concerns,
the results revealed an approval of the concept, and further disclosed the potential advantages and disadvantages of the design. The results further informed a design space molded around the concept, clarifying the essential characteristics, challenges and opportunities one needs to be aware of when developing a similar design concept. The design space demonstrates how closely the characteristics influence the concept of the design and thus provides a holistic perspective when approaching such designs. However, as this concept is rather sparse in the research area, the aim of this thesis was to outline the primary characteristics of its design space and act as a building block for further research to recognize other crucial characteristics, and research each in-depth. Doing so will give us a thorough understanding of the concept and clarify its potential advantages and limitations in this domain.

“The only way to engineer the future tomorrow is to have lived in it yesterday”

(Buxton, 2007, p. 37)
Acknowledgements

Finally, I’m writing the last words of this thesis. The most important thing I’ve learned throughout this thesis and will take on with me is to enjoy, embrace and feel every second of the process, rather than waiting for the end.

I would like to thank all the people who have helped me throughout these past months. First and foremost, my supervisor, Fatemeh Moradi, honestly, I can’t thank you enough, not only for all the thoughtful and inspiring meetings we had, but for all the amazing discussions we had from the first day I met you. You are truly an inspiring person, and I can’t imagine what these two years would have been without you being here. Just so you know: “dast az saret barnemidaram azizam” (bache famil, kolah ghermezi, norooz 97).

Secondly, Mikael Hansson, thank you so much for helping me in every process of making this prototype and all the time you have put although having a thesis yourself. I would like to further thank all the participants of this study for their time and valuable contribution.

To all my course mates in the Human-Computer Interaction and Social Media program, thank you for 2 amazing years, all those HCI lab days, all those amazing discussions, never going to forget them.

Last but not least, to my family, it’s all because of you and your support that I am where I am today. Thank you for everything.
References


Appendix A: Workshop Pictures

Fig. 1: Step 2: Sketching solutions

Fig. 2: Step 3: Deciding phase
Appendix B: Prototype Development

**Fig. 1: Sketching patterns**

**Fig. 2: Lo-fi prototype**
Appendix C: Making Process

Fig. 1: Layering different fabrics
Fig. 2: Sewing different layers

Fig. 3: Sewed LED strips
Fig. 4: Final light tubes
Fig. 5: Electronic components used for the break notification

Fig. 6: Electronic components used for the slouching notification
Appendix D: Workshop Scenario and Background Questions

Background Questions

- Have you ever been in the middle of a task, stopped and thought about your posture? If yes, what led to this action?
  - Have you made any sort of effort in keeping a good posture and do you have any kind of strategy or trigger for doing that?
  - If Yes:
    - Do you think the trigger worked well?

Scenario

Who’s Alex?
He’s 28, part-time programmer at “The best company” and student at Umeå University studying the Interaction Design program. Due to working and studying he sits a lot!

His story:
After a long day coming back from work, Alex feels it again, right in his back, neck and shoulders. Thinking of it he realizes he has been having this pain for a while now and every day it doesn’t get better but worse. On the way back home, instead of ignoring it, this time he calls his doctor to book an appointment for tomorrow afternoon after his class at university. Reflecting back to a couple months ago where he was only studying, he notices maybe it’s all the sitting that his new job requires as a programmer. Whatever it was, he sleeps with the pain and hopes he can figure out the cause tomorrow visiting the doctor.

Rushing from his class to the doctor, he makes it, and goes in on time. Answering the doctor’s questions, he starts explaining and showing where he feels the pain in his back and how long he has been having it:

“Right here in my lower back mostly. I always felt a slight pain in my back usually at the end of the day when I was coming back from university, but lately, I guess with this job that I have, it has become much more intense and I’m thinking it might be related to the amount of time I sit throughout the day, as it was a problem back when I only studied, but now it’s much more intense”.

The Doctor gets it right away and asks: “Can you show me how you usually sit behind your desk?”

Alex comes to show the good upright posture he always aims for, but then realizes that’s only him the first few minutes he reminds himself to sit correctly and almost always after a few minutes he starts to slouch his back deep into his computer.
Showing the doctor how he usually sits, the doctor replies: “There’s the answer to your pain” and starts giving him a simple solution to his problem:

“There’s a simple solution to your problem, but one that’s hard to remember as you have already noticed. First of all, as you can see in these pictures, the body has 3 neutral seated postures: Upright, Reclined and Declined. As you know already, you’re not following either 3 although you aimed for it. Where your problem lies is not knowing how to keep a good neutral posture, but that you just forget about it throughout the day and instead adopt a slouched back. What’s also important for you to know is that regardless of how good your posture is, sitting in the same posture or sitting for a long time is not healthy, so you not only have to remember to keep a good posture but also to change your working posture frequently throughout the day by making small adjustments to your chair, stretching your fingers, hands, arms and torso and most importantly to stand up every 30 minutes and walk around for as short as 10-30 seconds to a few minutes if you have the time, as sitting still and prolonged sitting bring a lot of health risks.”

Alex exactly understood what the doctor told him, but the challenge remained the same: Remembering not only to slouch his back but also to take breaks every 30 minutes and stretch. Going back all the way on the bus, he tries to figure out what is the best way he can remind himself without it being annoying so he wouldn’t quit using it. He wished there was just something that could give him feedback whenever he slouched and also reminded him to get up every 30 minutes while not attracting too much attention from him as he knew he wouldn’t use it otherwise.
Our Challenge:
Solving Alex’s problem!

By now you might already be relating to Alex’s problem. To help him keep up with his doctor’s recommendations, how might we solve his problem by designing something that provides just enough and useful information for him, its intuitive and easy to use, doesn’t attract too much attention from him, and also looks good!
# Appendix E: Interview Questions

## Introduction
- Overview of the session
- Ethical considerations
- Consent

## Background questions
- How old are you?
- What is the main activity you do during the day/week?
- Does it require you to sit for long hours?
- On average how long do you think you sit throughout the day?

## Brief explanation on the context of the prototype & specifications of healthy sitting behavior

### Setting up the prototype, testing for 1 hour and observing the participant

## General questions
- Overall, what do you think about the prototype?
  - Were you comfortable in it?
  - Was there anything in particular that stood out to you?

## Intuitiveness
- What do you think about the feedbacks in general?
- How did you interpret the feedback that you got from your arm?
  - Did you make any sort of connections to it?
- How did you interpret the feedback you got on the front of the shirt?
  - Did you make any sort of connections to it?
- How did you perceive the feedbacks (were they intuitive)?
- Were they easy or difficult to understand?
- How can the feedbacks become more visible or effective?

## Persuasive Potential
- Ask questions based on the notes I have taken from observing the users.
- Did the feedbacks have an effect on your sitting behavior?

## Modality and Clothing
Discuss the concept of the shirt with the participants.
- In general, what do you think of lighting as a form of feedback?
  - How do you think lighting worked as a feedback in this context?
- Do you have any other thoughts or ideas for alternative ways of giving feedback?
- How do you think the shirt itself worked for giving you feedback?
  - Do you think anything else would have worked better? (existing devices, items in your surroundings...)
- Were the feedbacks distracting you from your work?
- If you could, what would you change, keep or improve?

## Intentions and context of use
- Would you continue wearing a shirt similar to the concept of this shirt for improving your sitting behavior?
  - If yes, what are your reasons?
  - If not, could you please explain the main reason?
- In which situations and places do you think you will use (turn on)/not use (turn off) this shirt?

## Suggestions/background questions
- Imagine this being your own shirt, what would you like to keep or change in it? Why?
- During the time you are seated, do you usually take short breaks?
<table>
<thead>
<tr>
<th>Appendix E: Interview Questions</th>
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<tbody>
<tr>
<td>o  Do you have any strategy for reminding you to do so?</td>
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<td>o  If yes, has this strategy been working for you?</td>
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<tr>
<td>•  While sitting throughout the day, have you ever been in the middle of a task, stopped and thought about your posture? If yes, what led to this action?</td>
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<td>•  Have you made any sort of effort in keeping a good posture and do you have any kind of strategy or trigger for doing that?</td>
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<td>o  If yes, do you think it has worked well?</td>
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<td>•  Anything you would want to add?</td>
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## Appendix F: Example of Qualitative Content Analysis

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<tr>
<th>Meaning unit</th>
<th>Condensed Meaning unit</th>
<th>Codes</th>
<th>Subcategory</th>
<th>Category</th>
<th>Theme</th>
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<tr>
<td>yeah, I thought, it didn’t look like a warning, because it was blue, so I</td>
<td>The blue color did not resemble a warning for her</td>
<td>Blue color does not resemble a warning</td>
<td>Feedback Color</td>
<td>Intuitivity of Design</td>
<td>Physical characteristics</td>
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<td>thought okay and you said like, talked about the research thing before and</td>
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<td>I thought like oh it’s a prototype about behavior, and I thought like so maybe</td>
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<td>it’s moving, because I did not know how my arm should change, it’s not nothing</td>
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<td>with the positioning in the arm.</td>
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<td>it looked like more like a warning, it seemed for me like a warning, and at</td>
<td>The slouching notification resembled as a warning</td>
<td>The red color resembled a warning</td>
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<td>the same time when it blinked lightened up, I realized at the same time that</td>
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<td>I’m bending my back to the front, and I was like oh, okay</td>
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<td>I was thinking like just because it was blue light I thought it was like okay</td>
<td>The break notification was not warning due to its color</td>
<td>A red color would have been more warning and less able to ignore it</td>
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<td>whatever, but if it would be lighting in red, then I would think more of a</td>
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<td>I guess if I’m to think about it now I can retrospect I would think blue is</td>
<td>interpreted blue as a better color whilst red would have meant something worse is</td>
<td>A red color would have indicated something worse is happening that a blue color</td>
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<td>probably better than if it would have turned red or something like I would</td>
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<td>interpret blue as a better color whereas red would probably mean that</td>
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<td>something even worse was happening</td>
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<td>I didn’t know what it meant I tried to move a bit my wrist because maybe I’m</td>
<td>Did not understand what the break notification meant, and associating it with other</td>
<td>The break notification was not intuitive</td>
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<td>doing something wrong but then the light was still on so I didn’t know</td>
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<td>I didn’t really understand, I don’t think I understand, I was thinking like</td>
<td>Did not understand the break notification, and associating it with other things</td>
<td>The break notification was not intuitive</td>
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<td>oh was this supposed to be like from the beginning and it started now the</td>
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<td>lights, but then, I wasn’t thinking about it so</td>
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much but I thought maybe I’m sitting in a bad position or something

| I think like, it could like analyze how straight like the posture | Although not receiving the slouching notification throughout the session, it was understood | The slouching notification is intuitive |
| I guess they kind of measure like how you are sitting like some sort of gyroscope-ish | Although not receiving the slouching notification throughout the session, it was understood | The slouching notification is intuitive |
| Maybe some sort of like up arrow or something, something that kind of points me in the direction, I need to be told what to do | The lights alone were not enough for understanding the break notification | A more straightforward feedback was needed |
| I couldn’t really understand what the connection was, why was the light on for? was it because of my back? was it because of my wrist? so it was a bit hard to reach a conclusion just with the light so I just went on the way I was doing so far | The lights alone were not enough for making a connection for the break notification | A more straightforward feedback was needed |
| Yes, because how I said with my way of sitting at this moment and suddenly it lightens up and I was like oh, okay! And the blue one, I was first at the beginning a little bit confused, what should I do? I was like not sure if I can shake it off or something, and then I thought maybe it’s “moving”, and then when I stand up and it went away, I was like okay… its working, so this was fine. | The slouching notification was easily understood due to the context, and the break notification although confusing at first, the intention was understood eventually | The slouching notification was intuitive while the break notification was a bit more confusing |