Changing the perception of pain

An interactive experience using heat and guided meditation

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ABSTRACT
Chronic pain is a common condition that people struggle with on a daily basis and many strive to find ways to relieve their pain. With the development of wearables and smart garments we are now moving from designing an object to be used, to an object to be worn. Technology is an extension of the body and the interaction in itself also becomes part of our body. This development enables different kinds of treatments to be implemented in a wearable. Accordingly, this study have investigated if an interactive experience using heat and guided meditation with a wearable can support individuals living with chronic pain, and to what extent the experience can change the perception of pain. The results indicate that an interactive experience including these modalities can have the ability to change perception of pain. The study also suggests implications for design by presenting design qualities that become important in such a design, which resulted in; distraction and immersion, familiarity and practice, personalization and flexibility.

Author Keywords
Bodily interaction; Interactive experience; Wearable; Pain; Thermal stimuli; Guided meditation; Body awareness.

INTRODUCTION
Chronic pain is a common condition that can lead to great suffering for the individuals living with this condition. Globally, it has been estimated that 20 percent of adults suffer from pain [11]. In Sweden about 40–50 percent of the population suffer from chronic pain and at least a quarter of these individuals have difficulties living with their pain [32 pp.26,51]. This can cause a variety of disabilities e.g. being unable to perform daily activities as desired. Ageing has shown to be associated with an increased likelihood of chronic pain [23] and as the world population is ageing [5] the number of people living with pain might be even more common in the future. Pain is also the most common cause for seeking medical consultation, which leads to tangible social costs and consequences for the society [32 pp.47,41].

Previous research states that there is a negative correlation between pain and quality of life, meaning that reduced pain can enhance perceived quality of life [32 p.19]. People living with chronic pain thus often strive to find ways to relieve their pain, both by pharmaceuticals or non-pharmaceutical treatments [2, 32 p.26]. Even though a multimodal treatment, including therapies from multiple disciplines, have shown to be effective in reducing pain on a long-term basis [32 p.37], pain has primarily been regarded as a medical problem [11]. This is starting to change and an overall trend within the healthcare field is to make it more personalized. The growing development with wearables, smart garments and electronic textiles thus offers potential for implementing different kinds of treatments to make it more personalized, which makes this subject a hot topic for further research [13, 40].

Self-treatment of pain and improving a sense of control by being part of one’s own care, e.g. using non-pharmaceutical therapies, has shown to have a positive effect on pain [6,7,12,26,41]. Heat is a common method often used and several previous studies on heat have shown to effectively relieve pain [6,15,19,27,39]. Body awareness, as well as meditation and mindfulness are other non-pharmaceutical therapies shown to have a positive effect on pain [41]. A study that aim to investigate how an interactive experience for self-treatment can support individuals living with chronic pain can thus have a considerable impact on a person’s quality of life, as well as an economical impact on society [32 pp.19,42,53]. This study thus aims to investigate this further by using heat and guided meditation to enhance body awareness in an interactive experience.

The interaction with an artifact have played a big role when designing a mobile application or a website that the users should interact with. New technology like wearables opens up for new types of interactions that are grounded in the body and thereby extend the domain of interaction design. The HCI community has recently also turned to aesthetics as a way to create a better experience in design [18]. As new technologies are more involved in our daily lives, technology is an extension of the body and the interaction in itself also becomes part of our body [25,36]. Accordingly, the human body and bodily experiences is increasing its role in interaction design as we are now moving from designing an object to be used, to an object to be worn [28,34].

Research on wearables has neglected human factors like body and mind in the past [10]. Turning to Somaesthetics when designing an interactive experience means designing for a bodily experience [14,17,30], where the interaction takes place within the own body rather than in a visual interface. As technology gets closer to our most intimate
interactions with our body and mind [21], a study that focus on investigate an interactive experience involving body and mind is thus of utmost interest. Accordingly, this paper aim to investigate if an interactive experience with a wearable using heat and guided meditation can support individuals living with chronic pain, and to what extent the experience can change the perception of pain. The paper also aims to offer implications for design by investigate what design qualities that become important in such a design. An important notice is that the research performed is not a medical study, thus the focus has been on the interactive experience.

BACKGROUND

The perception of pain

Pain is complex and subjective condition and a result of extensive processes in the central nervous system. It consists of a number of dimensions like intensity, quality, duration, effect and personal perceptions that is unique to every individual [33 pp.31,34]. The definition of pain according to The International Association for the Study of Pain (IASP) is: “An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.” [35]

There are different types of pain (e.g. acute and chronic pain) that can be of different character (e.g. musculoskeletal or neuropathic). Acute pain is one of our body’s protection systems and an important part for human survival. When pain becomes chronic there is an unbalance between inhibitory and stimulating factors in the brain. For the pain to be characterized as chronic it must be recurrent or long lasting for at least three to six months [32 p.23]. With a longer duration the perception also changes as it can lead to an increased sensitivity to pain [33 pp.29,33].

Hansen & Streltzer’s [12] review on psychology aspects of pain highlight findings from previous research and state that the perception of pain involves far more than a sensation. This means that it is not merely a sensation of an on and off mode, or a state of pain or no pain. Hansen & Streltzer’s [12] explains that there are also psychological and emotional aspects especially when it comes to individuals living with chronic pain. Pain can also be a learned response and in some cases it can be entirely “in the mind” [23], which opens up for new therapies to tackle the challenge of changing perception of pain and not only see pain as a medical condition.

There are several factors that can improve or worsen pain. Stress [23] or focusing one’s attention on pain has shown to worsen, whereas distraction on the other hand has shown to be highly effective in reducing pain. There is also the aspect of a vicious cycle in which pain in itself causes disability and stress, which in turn worsens the perception of pain [6,7,12,26,41]. Even though pain primarily has been regarded as a medical problem [11] the importance of the body and mind has started to increase its role when treating pain. Previous research have for example shown that heat or body awareness alone can be helpful therapies to relieve pain as well as improving a sense of control and being part of one’s own care [6,7,12,26,41].

So if we want to change perception of pain, how can we measure the subjective experience of pain? Self-estimation by rating pain on a scale is common when assessing pain. A frequently used scale is the Visual analogue scale (VAS-scale), which measures the intensity of the pain by asking a person to rate how s/he perceive their pain on a scale from 0-10. Self-estimations like the VAS-scale offer several advantages such as brief and simple administration, easy scoring and understandable to most people. Though, the measures are also limiting since it is considered one-dimensional, not being able to capture the subjective and multidimensional aspects of pain. A body map is thus often used as a complement to bring other aspects of pain to the fore and making the pain experience easier to articulate. On a body map the participant can explain where and how they experience their pain or bodily sensations by drawing and making marks on a body sheet. Describing words are sometimes also used to describe the character of the pain on different body parts [15,32,38]. Accordingly, this study has chosen to include both the VAS-scale and body maps to capture a broader spectrum of the participant’s pain experiences and bodily sensations.

Technology and modalities for pain relief

As technological components are developing, there is an increased potential of implementing different kind of treatments with wearables and smart clothing. There are several products focusing on health and wellbeing entering the wearable market [40]. One example is TruPosture [1], a smart shirt designed to reduce back pain. By measuring the shape of the spine the device remind the user to straighten the back when the posture changes by sending gentle vibrations and giving the user feedback on ideal postures in a mobile application. Another example is Spire [31], a breath and activity tracker intended to decrease stress. By tracking the user’s breathing through a device attached to the users clothing it gives feedback through a mobile application reminding the user to slow down their breathing and offer guided meditations.

Heat is a common method that has shown to effectively relieve pain in several previous studies [6,15,19,27,39] and there are a lot of different electrical heating products embedding heating elements on the market. Applying electrical heating in clothing is nothing new, though most products are intended for outdoor use; prevent from getting cold; are often bulky and thus limiting body movements or not specifically designed for treating pain [39].

Mindfulness and meditation by increasing body awareness have also shown to decrease pain through mechanisms including enhanced cognitive and emotional control and altering the contextual evaluation of sensory event [41]. There are also studies on Virtual reality (VR) showing that getting immersed in a VR experience can reduce the level
of pain. Through a combination of technologies, VR distract the users attention and allow the user to shift focus by being engaged in an immersive experience [22].

Based on these findings one could argue that designing for pain and pain relief is about breaking the pain signals going from the nerves to the brain, distracting the mind and/or reprogramming the brain to learn new behaviour and give attention to bodily sensations. An interactive experience that focuses on getting the user immersed using different modalities can thus be further investigated as a way to change perception of pain. Even though heat and body awareness have been researched separately for pain relief, at the time of this study no research have been found that combines the two modalities. A study focusing on this could thus be interested for further research as it could bring new knowledge regarding designing for pain and changing perception of pain with technology.

**Bodily experiences and interaction design**

The human body and bodily experiences is increasing its role in interaction design as we are now moving towards designing for technology to be worn [34]. Klemmer et al. [20] states that the physical human body is a central part of shaping human experiences, which include our interactions. As technology is an extension of the body, the interaction in itself also becomes part of our body [36]. Arvola [3] refers to interaction qualities as “the experienced attributes of artifact-in-use”, often also referred to as use qualities or experiential qualities that can be used as guidelines for designers. Löwgren [24] states that interaction design is about creating the right conditions for the user, so that the user can make good use of a digital design. He continues by saying that use qualities are certain properties of a digital design that are experienced in its use. Both authors also suggest different qualities to guide designers, though with new types of interactions involving body and mind there might be new interaction qualities that become important in such design. To be able to design for these new bodily interactions, highlighting design qualities that become important in such a design can offer implications for design in the future. Turning our attention to Somaesthetics can be one step in that direction.

The Somaesthetic Theory, grounded by the philosopher Richard Shusterman [40], focus on the body (soma) and our sensory appreciation (aesthetic). He argues that our body is an essential part of our humanity, it is our “tool of tools” and should thus be recognized as an important part of all human performance, our perception, action and thought. The body have been taken for granted in the past and Somaesthetics aim to enrich our bodily experience and performance by recognizing that body, mind and culture are co-dependent of one another. In the end this affect our living body, our perception, our actions and ultimately how we interact with ourselves, others and objects. Höök et al. [14] state that Somaesthetic theory helps us direct attention toward our bodies, so when designing a Somaesthetic experience the experiential quality of turning inwards becomes an important factor. Nunez-Pacheco and Loke [28] also state that if we develop our bodily self-awareness we also develop our powers of perception and action in the world. Though, as any other skill Höök et al. [14] also mentions that body awareness is a mastery that takes time to train. To support designers engaging in Somaesthetics Höök et al. [14] also suggest a strong concept called The Somaesthetic Appreciation Concept (SA-concept). The concept state that a design following Somaesthetic Appreciation will involve certain interactions such as; timing (the system has to be right there when you turn your attention to something in your experience), modalities (allowing felt and subtle inward looking experiences are key), aesthetics (producing a welcoming somatic response, opening our mind to the sensations rather than being crude or invasive) and intensity of feedback (e.g. not too hot, too subtle and or too strong).

Combining these outlooks on the body when designing an interactive experience to support individuals living with chronic pain, turning our focus inward by being aware of the own body and getting immersed in an interactive experience by following the SA-concept, might enable our mind to change perception of pain. As a complement to this previous research, this study aim to investigate if there are other design qualities that become important in such a design as well.

**Body awareness for pain relief**

As the name body awareness implies it is about being aware of the own body and its sensations by turning attention inward and listening to bodily signs and signals. There are several ways to increase body awareness that have shown a positive effect on pain. Some of these methods are; meditation, mindfulness, Basic BAT and Feldenkrais.

Feldenkrais is aimed to improve function in activities in our daily lives by increased body awareness [9, 42]. In a typical Feldenkrais lesson an instructor ask the participants probing questions to guide attention to different parts of the body and bodily processes. The participants are also asked to think about their experiences in certain terms such as; hot or cold, heavy or flat [14]. Basic BAT takes a holistic approach, working with the resources of the body as a whole. By including body function, behaviour and interaction with self and others as well as free breathing, the method is about restore balance with awareness and regain contact with the own body. The breathing is especially important, as it connects the body and emotional life [9].

Meditation and mindfulness have been described as a non-elaborative and non-judgmental awareness of the present moment and its experiences. There are different styles and techniques; e.g. being present in the moment, maintaining focus on a specific object and the changing sensation or flow of the breath; or engagement in a non-directed acknowledgement of sensory, emotional or cognitive events that might arise in the mind [29]. Mindfulness based stress
Therapy – the experience of heat
Therapy is the therapeutic application of topical heat applied on the skin. Continuous low-level heat therapy have shown to be a safe method with a low side-effect profile and often used to relieve different kind of musculoskeletal pain conditions [6,26]. Heat treatment of moderate temperature has shown to increase the temperature in deep muscle tissue and increase blood flow [26] and these mechanisms have been shown to reduce both pain [7,26] and malfunction [26]. Cramer et al.’s [6] study on self-treatment for neck pain using heat therapy showed that heat pads self-applied during a period of 14 days seemed to effectively relieve pain and improved somatosensory functions. Crowe et al.’s [7] study on self-management and chronic low back pain showed that medication, exercise and application of heat were the most common strategies used by the participants to manage their chronic low back pain since it provide relief and prevent exacerbation.

Designing with heat
When designing with heat, thermal comfort has to be taken in consideration. Thermal sensation for a human is mainly related to the thermal balance of the body as a whole, due to physical activity, clothing and environmental parameters like air temperature, mean radiant temperature, air velocity and air humidity. Unwanted local cooling or heating of the body can also cause thermal discomfort why this has to be taken in consideration as well [16]. Fanger [8] defines thermal comfort as: “that condition of mind which expresses satisfaction with the thermal environment”. He also address that each person is unique and to be able to satisfy everyone at the same time one must aim at creating optimal thermal comfort for the group.

Designing with heat as a modality and using it as a way of communication, Jonsson et al. [17] state that the aesthetics aspects of heat makes the experience more complex and goes beyond the physical sensation. It is not just the sensation in the moment of heating up the body; it is rather a felt experience from within the own body.

Jonsson et al.’s [17] study on heat and body awareness showed that heat is subtle but efficient in directing attention inwards and can affect how one perceives the own body. The subtle quality of heat also worked well with the Feldenkrais experience they explored. To achieve the subtness with heat, slowness was key in the interaction. This was accomplished by include slow temperature changes and letting the heat lingering on after the stimuli and taking surrounding material in consideration. As things take time to heat up, transferring heat is a process and the inertia of heat was also shown to be an important factor. The authors also state that recognizing that the experiential and aesthetic aspects of heat interaction can be part of creating a certain atmosphere or aesthetic experience that enables further explorations of slow and reflective forms of interactions and extend the domain of interaction design.

THE SOMAVEST
The SomaVest is a wearable prototype and the result of a design exploration that has extended from previous research with the SomaMat by Jonsson et al. [17]. The SomaVest focus on heat and body awareness by taking existing technology from the SomaMat and bringing it into a new context and a new design. The prototype consists of a vest including a combination of heat and a guided meditation and was used in the user test of this study (see Figure 1).

The prototype is part of an interactive experience where the aim is to direct the user’s attention inwards through guided meditation and heat impulses activated on different body parts and thus create body awareness. The heat impulses follow an audio script telling the user to direct attention to different body parts and together with breathing exercises reinforce the bodily experience, giving the opportunity to change perception of pain. It is about letting go of the pain by being present in the moment and focus on different sensations that emerge in the body through self-awareness. The SomaVest thus helps the user to shift focus from their pain by being immersed in an interactive experience.

Figure 1. The design of the SomaVest; adjustable on each side with Velcro and a bag to store the electronics.
Through the design explorations different locations of the heat stimuli on the body and different designs solutions was tested. Since the prototype was going to be a wearable, thus worn by participants with different body sizes, one design challenge was to meet the criteria of one-size-fits-all. After design iterations and prototyping with-, on- and through the body, a decision was made to design a vest that could be adjustable to different body sizes. Consequently, the prototype only includes the upper body and automatically excludes other body parts the users might experience pain in. One possibility that emerged through this design decision was the ability to investigate if heat had the ability to travel to other body parts not included in the prototype.

The body parts that the SomaVest include are; shoulders, lower back, stomach and collarbone (see Figure 2). DC powered heating pads (11x7cm), made out of polyester filament and conductive metal fibre covered by protective polyimide film, provide the thermal stimuli in the prototype. As Jonsson et al. [17] stated with the design of the SomaMat, the heat from a single heat pad can be hard to detect, thus the heat pads were arranged in cluster of three (one cluster each were placed on the left-and right shoulder, two clusters each on the stomach and lower back and one cluster each on the left-and right collarbone). The heat intervals increase gradually when activated in the same time being in the temperature span as Jonsson et al’s [17] study. This is also in line with Höök et al’s [14] SA-concept of e.g. finding the right intensity of feedback with heat as a modality. The heat pads are regulated by an Arduino micro-controller connected via Bluetooth to a mobile application. The guided meditation was provided through closed-back headphones to eliminate any external distractions.

The vest is made out of a stretch cotton fabric and Velcro attached on each side, which makes is adjustable to different body sizes. Each heat pad clusters are placed inside a protecting cotton pocket, attached on the inside of the vest in order to be close to body. On the inner rear of each pocket (the side away from the body) two extra layers, a thin synthetic wadding called Vlieseline [37] and a protecting cotton fabric, was added to store heat and to prevent any melting of other fabrics as well as making the pockets more rigid and easier to work with [17].

The prototype also consists of a 15 minute guided meditation that can be divided into three parts: i). The first part lets the user get in the right mood by focusing on breathing exercises by following a guided voice. ii). The second part guides the user to different body parts by using heat impulses together with a guiding voice. To prevent the user form feeling overwhelmed by the heat and to get a pause, there is a short break with probing questions without any heat stimuli added a few minutes into the session. iii). The third part only consists of heat impulses directing attention to different body parts and excludes the guided voice to allow the user create their own experiences and enclosed space.

The complete guided meditation also follows the rhythm of an ambient background sound throughout the whole session. This was added to enhance the immersion and help the user create an enclosed space. Since focusing on pain can increase the perception of pain [12], the guided mediation has thus excluded any focus on the pain and for example the probing questions included in the guided instructions have focused on other bodily sensations. When designing the interactive experience used in this study, interaction qualities suggested by Höök et al’s [14] concept of Somaesthetic Appreciation (timing, modalities, aesthetics and intensity of feedback) have also been taken in consideration in the design process with the prototype. For example the heat impulses are timed with the guided instructions; the heat increase in intensity and disappear slowly; the heat as a modality have been adjusted and tested to suite a majority of the users and different body parts; the aesthetic of heat are subtle and in combination with probing questions it enable bodily sensations to emerge.

STUDY

The research performed in this study is qualitative. To gain empathy for the user and gather participants for the user tests, a pre-study were initially performed through an online survey that was sent out to a closed online-group for people living with chronic pain. User tests were later performed and followed by semi-structured interviews, consisting of predefined questions that worked as a base and allowed for follow up questions. To analyse the data, the interviews were transcribed and a thematic analysis were conducted wherein the dataset was reviewed to identify initial themes or patterns [4].

The inclusion criteria for participation were that the participant considered themselves as having what can be defined as chronic pain, pain that have been continuously or recurrent for at least three to six months. This was later controlled via a survey that took place before the session with the user tests. A total of five participants, four women and one male between the ages 56-68, participated in the user study. 4 out of 5 were retired and one person reported to be self-employed. All respondents had continuously or
recurrent pain for several years and 3 out of 5 state that they experience pain all the time. Two participants stated experiencing pain now and then several times a week. 4 out of 5 have tried heat to relieve their pain and only one participant had tried mindfulness or meditation specifically to cope with pain.

Each participant tested the SomaVest three times on three different occasions, resulting in a total of 15 sessions (3x5). Each session lasted about one hour and took place in the participant’s own home. All sessions took place over a period of two weeks; each session was performed several days in a row or with one- or a few days in-between, depending on the participant’s availability. To see any changes over time and before and after a specific session, the sessions were divided into before, during and after.

Before: the user answered an initial survey on the first session with basic questions regarding age, pain experience and experience with heat and guided mediation. To make sure that every participant felt comfortable with the heat stimuli and to get a sense for how it works, each participant tested the heat level before the actual test with the prototype worn on the body. The participants were asked to place a hand on one of the pocket’s the heat clusters were placed in as the heat was activated. To be comfortable wearing the prototype as well as with the heat stimuli activated on the body, the participants tested the prototype as the heat stimuli was activated manually on each body part included in the SomaVest. An instruction of the guided meditation and its three different parts was included to give the user a sense of the whole session.

Before the actual user test, the participants were asked to reflect on their pain experience as well as bodily experience by drawing where and how they experienced their pain on a body map by using different colours and using describing words. To be able to measure the intensity of the pain the participants were also asked to rate their pain on a VAS-scale. The scale ranged from 0-10 where 0 = “no pain at all” and 10= “worst possible pain”. The scale consists of a 10 cm horizontal line where one centimetre equals 1 point on the scale [32 pp.121-122]. The body map and the VAS-scale was performed by the participants both before and after each of the three sessions and used as a means for further discussion during the follow up interview taking place after each session. By comparing the rating of the VAS-scale before and after each session any change in their pain could be identified. Rating pain on a scale like the VAS-scale is a snapshot at that given time and can thus not give any further details of the pain experience. The body map complemented the VAS-scale by also looking at locating the pain on the body as well as describing and identifying the pain and any other bodily experiences.

During: the user tests took place in a 15-minute session. The sessions were performed while sitting up and since the test took place in each participant’s home they got to choose a comfortable seating of their own. For hygienic reasons the user was asked to wear thin clothing underneath the vest. When the participant felt ready the session started and to feel comfortable and able to relax as well as prevent any external distractions (e.g. family members or the researcher) the participant were alone in the room during the user tests.

After: the user filled out a body map and pain rating on the VAS-scale; followed by an interview. The interviews gave a deeper knowledge about the participant’s experiences and consisted of a set of basic questions on each of the three sessions. On the second and third session the interviews also included questions related to the previous session to detect any possible effects in-between sessions. The questions related to the different stimuli that the interactive experience included, e.g. heat and guided meditation, as well as the bodily experience and the perception of pain.

Ethical considerations have been taken into account and participants obtained information about the aim of the study and terms of participation. The participants were informed that their participation was voluntary and could be cancelled at any time, their identity would be strictly confidential and results from the study would be published and presented in a manner that protects their anonymity.

RESULTS
Pain assessment
Participants rated their pain on a 0-10 point VAS-scale before and after every session (see Figure 3 and Table 3). In 14 out of the 15 sessions the participants rated a decrease of their pain on the VAS-scale and the best improvement for a participant was reported on the second session were the pain was rated to 4,90 before and 0, no pain at all after the session. Looking at all three sessions and all participants the mean before each sessions took place were set to 2,67 and the mean after all three sessions was set to 1,48, which shows an improvement of 1,19 points (see Table 1).

The standard deviation (SD) for all sessions and all participants are within the range of a normal distribution being 1,84 before and 1,50 after (see Table 1). Looking at all participants before session 1 the SD is 1,59 and after session 3 the SD is 1,60, also within the range of a normal distribution (see Table 2).

<table>
<thead>
<tr>
<th>Mean</th>
<th>Standard deviation (SD)</th>
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<tr>
<td>Before</td>
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<tr>
<td>After</td>
<td>1.48</td>
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<tr>
<td>Difference</td>
<td>1.19</td>
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<tr>
<td>P-level</td>
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</tbody>
</table>

Table 1. Mean value, Standard deviation (SD) and Significant level (P-level) for all participants and all three sessions. Significant differences are indicated if: 0.01 < p < 0.05 = *; 0.001 < p < 0.01 = **; p < 0.001 =***
To see any further progression over time, looking at the mean before session 1 with a value of 3.66 and after session 3 with a value of 1.2, an improvement of 2.46 points can be identified (see Table 2). Over all, the values reported in the pain assessment (see Table 3) could be considered low and the changes between sessions are in many cases minor. The subjective experience of pain do not necessary have to be present all the time and one participant (P2) mentioned often experiencing pain in the evenings, while the user tests in most cases took place during daytime. Other external factors that might have taken place before or after the sessions (e.g. concurrent treatments, physical activity, emotional state etc.) have not been taken in consideration and cannot be excluded from the result.

One participant (P5) reported degradation on the third session with a value set to 3.8 before and 4 after. Since the values on the scale, between 0 and 10, are not visible it can be difficult to rate the same value if the participant do not experience any difference before and after. Since 0,2 is a small degradation it is not clear whether or not the participant actually felt worse or if there were no difference at all. Looking at the body maps before and after on the third session the participant reported feeling pain in the same body parts before and after and degradation might thus not be the case.

As this study has investigated any possible effects before and after trying the SomaVest, the null hypothesis is that there is no change before and after. The alternative hypothesis is that there is a change. To be able to reject or confirm this, a paired two-sample t-test was performed with a significance level of 0.05 (5%). The p-value was 0.0062 and thus smaller than 5% (see Table 1) and the null hypothesis can be rejected and the alternative hypothesis is the most likely.

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<tr>
<td>Before S1</td>
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<tr>
<td>After S3</td>
<td>1.2</td>
<td>1.60</td>
</tr>
<tr>
<td>Difference</td>
<td>2.46</td>
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Table 2. Mean value, Standard deviation (SD) for all participants before session 1 (S1) and after session 3 (S3).

<table>
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<th></th>
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<td>1.1</td>
<td>1.8</td>
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</table>

Table 3. Pain assessment value on the VAS-scale for each participant (P) and each session (a= before, b=after).

Figure 3. Progression over time showing pain assessment value on the VAS-scale for each participant (P) and each session (S) (a= before, b=after).
Interview

Effect on pain

After the first session one participant (P1) mentioned that the aching pain disappeared in the hands and shoulders, though at the same time felt a little hesitant if the sensation would last or not since s/he had not moved around yet. The participant did not experience any sensation in the lower parts of the body, e.g. the legs, and thus mentioned that with practice it might be easier to let the heat travel to other body parts if you learn how to master the ability. Another participant (P5) mentioned feeling safe during the session because of the pleasurable heat and calming voice and a pleasant sense of feeling softer in the body as well as cooler and lighter afterwards when the heat was no longer present.

After the second session a majority of the participants reported that the pain felt slightly better after than before the session. One participant (P4) reported feeling stiff in the body and having aching pain in the back before the session and even though the aching pain still occurred afterward it felt less than before and the stiffness disappeared. Another participant (P2) reported even feeling better in his/her feet. Participants were also asked if they had experienced any difference in their pain or any other bodily sensations between the sessions, one person (P2) stated feeling great and not experiencing any pain on the night after the first session as s/he usually otherwise does. Another participant (P5) stated not remembering due to being busy and not having the time to either feel or think about it.

After the third and last session a majority reported having a positive change in their perception of pain due to feeling less pain and other bodily sensations like getting a better night sleep, feeling more relaxed and calm. The participants reported having this experience between both the second and third session and right after the third session. As one participant (P4) stated; “It has been reduced, though I always feel the pain it gets milder and milder.” 4 out of 5 reported to be able to forget about their pain during the first session. The one person (P5) that reported not being able to forget about the pain also reported to have difficulties to relax in general and felt the need to try the session multiple times. Though not all participants reported a high rating on their pain scale, a majority was still able to forget about their pain during the second and third session or experienced less pain after or in-between sessions. One participant (P1) felt the session affecting the tension in the body in a positive way helping to relax and heat up the body resulting in pain relief. Another person (P3) stated; “it gives a relaxed feeling that you for a moment forget about your pain”.

All participants reported that they would like to continue using the SomaVest. One participant (P1) mentioned wanting it to be a bodysuit and include the whole body. Another participant (P5) mentioned wanting to owning a vest and be able to use it on a regular basis e.g. at least once a day, especially in the morning as that could have a positive impact on the pain during the rest of the day, but also use the SomaVest in the evening to fully relax. This was also expressed by one of the participants:

“If you were to perform this on your own by moving around heating pads that would be disturbing since you would have to move it every time and that would not give the same pleasurable treatment….If you had to leave the house for this kind of treatment every day it would immediately cause inconvenience, so you should be able to have one of your own and be able to decide for yourself when it best suits you. It would be an easy task to put it on and sit for a while. I am so grateful that I got to try this”. (P1)

Progression over time between sessions

All the participants mentioned a positive progression over time as the different sessions were performed (see Figure 3). They experienced it being easier to relax, calm down and to get into the meditation on the second and third time compared to the first session. One reason mentioned for this was familiarity and practice; they got more and more familiar with the whole session and the guided meditation on the second and third session. Since they felt more familiar they also felt that they did not have to concentrate as much, thus it became easier to relax and calm down their breathing as well as getting into the right mood faster. With time they also expressed a sense of ease when it came to their ability to follow instructions, being able to feel and experience different bodily sensations as well as letting the heat travel to different body parts (e.g. arms, hands, legs and feet) that were not included in the SomaVest.

Heat

All participants expressed a positive experience with the heat. Several of the participants reported that they did not feel their pain especially when the heat was activated. One participant (P5) reported not feeling the heat as much on the first session due to the choice of seating and bodily position. With another seating and position on the second and third session the same participant reported a better experience with the heat.

Three of the participants (P1,P3,P4) felt the heat being a bit warmer on the second or third session even though no changes had been made. Regarding the heat intervals one participant (P1) expressed wanting more heat, though at the same time stating that the heat intervals was good and if they are too long it might be more difficult to feel its movement between different body parts. Another participant (P4) expressed wanting the heat intervals to be longer especially on the area were the pain was located.

None of the participants reported experiencing any difference in their pain on the front or the back of the body, though they seemed to have different experiences of the heat. One participant (P4) felt more heat on the lower back
due to the pain being located at this area. Others stated that
the heat had a surprisingly comfortable feeling on the
stomach and reported feeling more heat on this area as well
as feeling a flow of heat beaming down to the toes when
activated on the stomach.

The guided meditation’s effect on pain

The guided meditation is of different character throughout
the session. Only one person (P3) reported the different
parts of the session having an effect on the perception of
pain. The participant felt some pain at the end of the third
session when there were no guided instructions and having
to change position in the chair, and at the same time
reported not thinking about the pain in the beginning when
listening to the guided voice.

A majority stated an appreciation for the whole session,
though feeling more relaxed at the end. To be able to get to
that relaxed state in the end of the session, one reason
mentioned was the importance of the guided instructions in
the beginning. Another reason mentioned was the ability to
disconnect your self when being relaxed. Two of the
participants (P3, P5) especially mentioned the combination
of heat and meditation is what makes the experience good,
since it makes you very relaxed and able to unwind in a
different way when the two modalities work together. One
person stated (P1) that the guided voice was calm and nice
in a way that you felt safe and when you reach the end of
the session, with the music and heat, you are at a certain
stage that you almost feel like you are lifting from the
ground. Another person stated;

“...when someone is talking you are always listening
and following what is about to happen, compared to the
end when your thoughts are somewhere else. But at the
same time both are nice in their own way” (P3)

Familiarity and practice also showed to be connected to
concentration, the level of immersion and distraction. 4 out
of 5 participants reported that the second and third session
over all felt better and that it was easier to keep
concentration since they recognized the session and the
meditation. They also stated it being easier to concentrate
right away due to familiarity. When distraction occurred it
was due to thoughts wandering away; focusing on locating
the pain; hearing a telephone ringing in the background or
the emotional state e.g. being stressed out before the session
started. Due to distraction it took some time before they
could fully relax and concentrate. One person stated (P5);
“...at one point the thoughts wandered away, but the voice
then said to focus on the breathing if that happened”.

Bodily experiences and sensations

Except describing their perception of pain, the participants
also described bodily experiences and sensations using
body maps. Even if some of the bodily experiences that was
reported before a session (e.g. feeling stiff or aching pain)
also remained after the session, in most cases they also felt
a positive change in their body afterwards (e.g. still feeling
some aching pain though instead of feeling stiff, feeling soft
and light; or still feeling aching pain but feeling less pain).
An example of this is illustrated in a comparing pair of
body maps shown in Figure 4a and 4b.

Other bodily experiences mentioned was the feeling of
being more relaxed and calm especially at the end of the
session. One participant described (P1): “Almost like I’m
laying on a cloud”. Several participants also reported
having a warm and comfortable feeling in the body, a
calmer breathing and being able to turn the focus inwards.
Two participants (P2, P3) reported to have slept better the night after the sessions. One of these (P3) also reported not having the normal migraine. The other one (P2) mentioned getting a pedicure with massage on the day of one of the sessions and that usually have a positive affect on the sleep the same night. The same participant (P2) also stated being stressed out before one of the sessions due some problem with the microwave that same morning. This made it more difficult for the participant to relax, unwind and concentrate during the 15-minute session thus wanted a longer session.

Another participant (P1) reported not having to take one of the pain medications for two days while taking part of this study and also stated; “I will probably think of this with heat and to relax, because I’m probably so tense in my body that I don’t even notice it”. A majority of the participant also reported being able to transfer and feel the heat in body parts not included in the SomaVest as it got the blood flow running or as one person stated;

“I could feel the heat there as well. I think it was when she told you to focus on that area”…”…when the heat was activated on the stomach I could feel how it beamed down to the feet. When it was here [points at the shoulders] I felt how it went down to the elbows” (P2)

Body parts mentioned regarding transferring the heat were; arms, hands, fingers, feet and legs. These are body part that the guided meditation tells the user to focus on letting the heat travel to. There also seemed to be a progression over time transferring the heat to other body parts. One person stated (P1) being able to feel the heat in her hands but not in the legs on the first session and on the third session reported to feel the heat in the legs as well because s(he) now was familiar with the session and could more easily focused on getting the heat to these other areas. The same person also stated; “It is like you have the same body temperature in the whole body even though the heat is just added at times”.

All participants could see benefits of performing and using the SomaVest on a daily basis to be able to relax and thus change perception of pain and have a positive bodily experience. One participant (P3) compared the experience of using the SomaVest to a journey while stating that s(he) would take a journey everyday if s(he) had access to this kind of meditation vest. Another participant (P1) compared the experience to the sensation you feel at the end of a massage. Others stated (P1, P4) that to become warm in the body without the SomaVest you have to stay active and do movements that hurt if not taking pain medication. Another participant (P2) compared the bodily experience and the effect with the SomaVest to painting and weaving;

“When I’m painting I feel this good. Then I’m able to forget everything…You forget everything!…the same goes for when I’m weaving even though I’m active, at that point I don’t think of my pain…You forget and unwind…and I think that is healthy for people because I believe that a lot of pain comes from stress” (P2)

**DISCUSSION**

In the following the findings from the user tests are discussed in terms of effect on pain and implications for design, by presenting design qualities that become important in a wearable that aim to support individuals living with chronic pain.

Even if the pain is considered chronic it do not necessarily have to be present all the time and this was clear as several of the participant did not report a very high pain rate on the VAS-scale at the time of the sessions. Investigating pain can thus be a challenging task. However, the findings from this study indicates that an interactive experience with a wearable aimed to support individuals living with chronic pain, using heat and guided meditation, can have an impact on both perception of pain and bodily experiences.

All participants could see benefits of performing and using the SomaVest on a daily basis to be able to relax and thus change perception of pain and have a positive bodily experience. Since previous research has stated that stress can cause or worsen pain [23], the relaxed sensation the SomaVest gives the user seems to be an important aspect in the experience. The findings indicate that the relaxed state is accomplished best if a combination of guided instructions and heat stimuli are used. The result also indicates that it gets easier to relax, turn inward and get in to the right mood with time and practice by performing several sessions. It was also clear that with time and practice or depending on the emotional state the user might be in, the requirements might not be the same for everyone. Being able to make personalization’s regarding length of the session and heat intervals can thus be important design features.

The interactive experience the user had with the SomaVest was compared to every thing from taking a journey, to giving the same bodily experience being able to forget about the pain as when being immersed in an activity like painting or weaving. Some participants also mentioned that to become warm in the body without the SomaVest, they had to be physically active and sometimes perform movements that are painful - if not taking pain medications.

One could argue that the SomaVest thus offers an alternative way to increase body temperature and get a relaxed sensation in the body, which in turn might change the perception of pain and enable the user to be more physical active. However, to be able draw such final conclusions further studies have to be conducted.

The experience with heat showed a positive effect on changing the perception of pain especially when activated on areas where the participants experienced their pain. The participants also reported being able to make the heat travel to other body part not included in the SomaVest. Indications showed that transferring heat became easier when the guided voice in the meditation actively told the user to let the heat travel to other body parts. The result also showed that this became easier with time and practice by performing several sessions and thus being familiar. Some
participants also experienced a surprisingly comfortable feeling with the heat on the stomach, getting a sense of the heat beaming down the legs all the way to the toes. Accordingly, the heat seemed to have both a direct affect on the area where it was activated; as well as an indirect affect on body parts where the heat was not actively present.

The participants expressed the experience with the SomaVest having an effect both during and after as well as in-between session, both regarding perception of pain and bodily sensations. By being immersed and relaxed, indications show that it was possible to forget about the pain during the session. In some cases the pain was still current afterward though being experienced somewhat milder. In most cases the participants also stated feeling a positive bodily experiences as well, e.g. giving a sensation of feeling lighter, cooler or softer.

In 14 out of the 15 sessions the result showed a decrease in the participants pain (see Table 3). Due to being familiar with the session and practice by performing several sessions, the findings also showed a progression over time (see Figure 3). Familiarity and practice also showed a connection to immersion and distraction. When being familiar with the session through practice, the participants felt safe and relaxed thus finding it easier to concentrate and getting immersed in the experience and not being as easily distracted by external factors that occurred. Even though some participants expressed feeling more relaxed at the end of the session, the guided meditation in the beginning also indicated having an effect on the level of immersion the participant’s experienced at the end of the session. External distractions like emotional state and bodily position during the session were also factors shown to affect the level of immersion, thus being able to make personalization’s and offer a flexible experience can be beneficial.

The findings in this study are relevant to designers, researchers and practitioners working in the domain of pain, wearable technology, interaction design, and for stakeholders interested in creating interactive experiences to support individuals living with chronic pain. The following sections suggest implications for design by presenting a set of design qualities that can work as guidelines for future work. The design qualities suggested are distraction and immersion, familiarity and practice, personalization and flexibility.

Distraction and immersion
The findings from this study suggest that distraction and being immersed in an interactive experience can have the ability to change the perception of pain and bodily experiences.

Being immersed and distracted in a VR-experience have shown to affect the perception of pain [22] and thus the findings reported in this paper are in line with previous research. However, distractions can be both positive and negative to the experience. Positive distractions could be about disconnecting your thoughts from your pain or being immersed in a experience, whereas negative distractions are the one’s that take you out of the situation that leads to an unwanted loss of focus or not being able to concentrate, e.g. the heat level or the comfort of the artifact. The result indicates that guided instructions could be a positive distraction. Include a guided voice and probing questions that guide the users attention can distract the user in a positive way by shifting focus from the pain. This way the user is able to turn the focus inward and listening to other bodily sensations then the pain that might occur. Being able to distract the mind and keep thoughts away from the pain is also in line with what Hansen and Strøltzer [12] states about giving the pain attention actually can worsen the experience of pain.

The results also showed that it could be beneficial to use guided instructions specifically in the beginning of the meditation, since it can affect the level of immersion and relaxation one will have at the end of the session. Following guided instructions can get the user into the right mind-set and catch the users attention right away, thus disconnects the user from any disturbing thoughts. The guided meditation used in this study consisted of three different parts. As the meditation proceed during the session the user gradually gets immersed and are able to forget about the pain or change the perception of pain. Thus this gradually immersion might bee a key to fully relax and disconnect your thoughts from your pain, especially for beginners engaging in meditation.

Several of the participants also reported not feeling their pain especially when the heat was activated. Thus, when heat and guided meditation are used as modalities together it might be the most effective and determine the level of immersion. This might be due to the modalities together are able to calm down the user, create a safe and relaxed enclosed space and distract the user and thus make it possible to change the perception of pain. The combination of both heat and guided meditation was also specifically mentioned by two participants (P3,P5) as one reason that made the experience pleasant.

With an initial guided instruction explaining that it is ok to lose focus and let the user know what to do to get back on track if that happens, did also show to benefit some participants that lost focus during the session. One person (P1) also stated that the guided voice was calm and nice in a way that you felt safe, thus when you reached the end of the session with the music and heat you are at a certain stage that you almost feel that you are lifting from the ground. The guided instructors voice as well as any added background music could thus affect the experience. Accordingly, the design and the different components included in the guided meditation can be either a positive or negative distraction if not tested and applied carefully. The bodily position during the session can also be an unwanted negative distraction affecting the outcome. This was clear
when a participant expressed not feeling the heat due to being in an uncomfortable position. It is only when you are relaxed and comfortable that you can fully get in the right mood, assimilating the guided mediation and can be able to change perception of pain.

**Familiarity and practice**

Through user test performed in three different sessions with each participant, the results from the pain assessment showed a progression over time (see Figure 3). These findings suggest that *familiarity and practice* are important to be able to change the perception of pain.

Familiarity is about being familiar and recognizing what is about to happen and feel calm and safe due to this. Practice is about performing several sessions through repetition. To become successful in something you often need practice. A professional football player does not become a professional player over night - it takes time and effort.

With familiarity and practice the results also showed that it became easier to make the heat travel to different body parts, even to body parts not included in the SomaVest. The result from this study showed that it became easier to relax, unwind with time by being familiar with the session. Turning inwards and getting in the right mood was also reported to get easier with time and practice, and it was also possible to do it faster. This type of familiarity is also what Höök et al. [14] states about being able to master the ability of turning inward. Like any other skill, body awareness is a mastery that takes time to train and thus familiarity will have an impact on perception of pain when designing an interactive experienced including heat and guided meditation to support individuals living with chronic pain. One could argue that this is comparable with fitness and physical condition; you have to gradually exercise and practice to gain a good physical condition.

All participants could see benefits of performing and using the SomaVest on a daily basis. Even though not all participants reported a high rating on their pain scale before the sessions, a majority was still able to forget about their pain during the second and third session or experienced less pain during and after and between the sessions, and reported that this was due to familiarity and practice. In some cases participants reported the pain still being current after a session, though some experienced a milder perception of pain or a different positive bodily sensation (e.g. feeling stiff before and softer afterward). Even if the pain does not completely disappear, relief or even the smallest change in the body can be positive for an individual living with chronic pain.

By practice and being familiar with the session they were able to relax more when feeling calm, comfortable, safe and recognizing what was about to happen. This is in line with what Loeser and Melzack [23] state about stress, that it can worsen the pain experience. Accordingly, if the user feel relaxed and calm rather the being stressed it can have a positive effect on their perception of pain and bodily experience.

Feeling safe was also an important factor due to familiarity mentioned by the participants. By feeling comfortable and safe by recognizing the situation they were able to generally be more adoptive towards the session. Several participants stated that the calm guided voice and pleasurable heat contributed to that safe feeling. One person (P1) mentioned almost having an out of body experience feeling like the body left the ground at the end of the session. Another person (P5) also stated that there was a pleasant feeling of being softer in the body during the session and a sense of feeling cooler and lighter afterwards. This sensation can almost be compared to the heat giving the comfortable feeling of being physically touched during the session since the session lead to feeling lighter, softer relaxed and having a cooler body temperature after the session.

Even though several of the participants reported not feeling their pain especially when the heat was activated, they also stated that the guided meditation and its different parts helped them get to a relaxed state that increased with practice and familiarity. This can be an indication that when the two modalities work together and are familiar to the user, they are the most effective as they are then able to calm down the user, create a safe, relaxed and enclosed space. This in turn will helps the user to disconnect the thoughts and let other bodily experiences emerge and thus shift focus and change the perception of pain.

With practice and familiarity the experience can also change over time. Participants reported that the heat felt differently and especially warmer due to familiarity and practice as you are more relaxed and are able to more easily turn inwards and thus are able to experience things differently. Though there could be several external factors explaining this experience and these single statements are just an indication of what can be further explored with heat.

Familiarity and practice also showed to be connected to the level of immersion, concentration and distraction. When the participants were familiar with the session through practice they were able to keep concentration more easily and ignore external distractions that occurred. Practice together with familiarity are thus important design qualities that this study advocates to consider when designing an interactive experience that aim to change perception of pain. An interesting aspect of this would though be to investigate what possibilities any further use of the SomaVest could have on perception of pain. Can regular usage over a longer period of time have even more effect on pain? Or does the user get too familiar with practice that it will lose its effect? It is also possible that with familiarity and practice the user might be able to turn inward, let the heat travel and feel the presence of heat and change the perception of pain - without any actual heat stimuli or guided instructions being present.
Personalization and flexibility

Pain is a subjective experience that can change over time. To be fully adoptive to modalities like heat and guided mediation included in a wearable like the SomaVest, this study showed that personalization and flexibility are important qualities in such a design.

Personalization involves being able to make personal choices (e.g. adjustment in length of the session or heat intervals to suit your own pain experience). Flexibility could be about being able to use the SomaVest when it best suits your individual needs (e.g. owning a vest of your own and perform a session whenever it suits your personal needs - in the morning, evening, once a day, several times a day, when you pain experience are the most- or least present).

The results from this study showed that personalization can be beneficial due to the emotional state the user might be in. One participant (P2) mentioned being stressed out before one of the sessions and consequently had difficulties to relax and unwind in only 15-minutes. The emotional state can thus affect the outcome and personalization’s regarding e.g. the length of the session may be beneficial to implement.

One person (P3) reported that the different parts of the session had an effect on the perception of pain. The participant stated that the pain was more present in the end of the session when there was no guided voice, whereas not thinking of the pain in the beginning of the session when there was a guided instruction. Since only one participant reported this on one of the three sessions, it can be difficult to draw any conclusions from this single event. Though, it can be an indication that guided instructions can be helpful for some users to be able to shift focus from their pain. This is also in line with what Hansen and Streltzer [12] state about focusing on pain can worsen the pain experience.

With time the user might not have the same requirement or need for a certain component, e.g. a guided instruction. To include the ability to make personalization by being able to choose from different meditation tracks the design also enables flexibility that might be helpful to maintain a frequent use. Since the result showed a progression over time regarding the perception of pain, designing for frequent use in an interactive experience aimed to support individuals with chronic pain, might have the best effect on their pain. Being able to use it on a regular basis and adapt it to your own lifestyle and your individual pain experience might be important to be able to use this kind of wearable as a self-treatment for pain. This was also expressed by one of the participants (P1); it would become an inconvenient if you had to leave your home for this kind of treatment and not choose for your self when and how to use it.

Since every pain is unique, personalization and flexibility becomes even more important. Adjusting the length and the temperature of the heat intervals as well as the length of the whole session can be implications for future designs. To include different kind of meditation tracks, e.g. mediations with and/or without guided instructions could be other solutions towards such a design.

Taking personalization and flexibility into account in an interactive experience such as the one created in the SomaVest, it can allow the user to take control of one’s own care. This is in line with previous studies stating that self-treatment and taking control and being part of one’s own care has shown to be beneficial when treating pain [6,7,12,26,41].

CONCLUSIONS

This study have investigated if an interactive experience using heat and guided meditation with a wearable can support individuals living with chronic pain, and to what extent the experience can change the perception of pain. The study has resulted in implications for design by presenting design qualities that become important in such a design. The findings indicate that an interactive experience including these modalities can have the ability to change perception of pain.

The most prominent results showed: a progression over time regarding changing the perception of pain and bodily experiences. With practice and familiarity, the heat resulted in different experiences (e.g. feeling warmer due to familiarity). The heat experience showed a direct effect on the pain (e.g. the pain felt less or not at all when the heat was activated directly on the location of the pain). The heat experience also showed an indirect effect (e.g. following guided instructions and/or with practice it was possible to transfer the heat to other body parts). The participants felt over all better in their pain during and after then before a session. In cases were the pain still occurred after a session the pain was milder or resulted in a different bodily sensation (e.g. feeling soft rather then stiff). The interactive experience can result in other bodily sensations that can have an indirect effect on pain (e.g. getting a better night sleep, release tension and feel more relaxed and calm). The construction of the guided meditation is important (e.g. instructions in the beginning can have a positive effect on concentration and the level of immersion). Personal settings (e.g. regarding length of the session or heat intervals) could be beneficial for a more regular use. Flexibility (e.g. perform the session in your own home and adapt it to you own personal lifestyle and pain experience) seems to be key for regular usage. Based on these findings, familiarity and practice, distraction and immersion and personalization and flexibility are design qualities suggested to be considering in an interactive experience when using heat and guided mediation to support individuals with chronic pain.

FUTURE WORK

The research performed in this study is not a medical study. The placebo effect is difficult to eliminate from these types
of studies, and is thus one of the limitations with this study and a challenge for future research to consider. Further research is needed to underpin these results by performing more rigorous studies, investigate the long-term effectiveness and explore the effects of heat and guided meditation in more severely affected participants. Other evaluation methods or self-estimations for pain and quality of life could also be included in future research. Allowing participants to keep the prototype in their home and perform long-term studies could also be investigated further.

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