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# B-ePain: A Wearable Interface to Self-Report Pain and Emotions

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**Abstract**

Chronic pain reduces quality of life and affects patients' emotional well-being. When technologies for monitoring and reporting emotions are applied to people suffering from chronic pain, mental health problems may be detected, allowing health professionals to improve patients' treatments and understand their patients in real contexts. However, older patients with chronic pain are limited by their knowledge about technology. Our work aims to understand how to design wearable devices that allow older adults to input complex information such as pain levels and emotional states.

**Author Keywords**

Chronic pain, self-report, emotions, wearable.

**ACM Classification Keywords**

J.3 [Computer Applications]: Life and Medical Sciences

**Introduction**

Pain is defined as an unpleasant sensory and emotional experience [7]. Chronic pain lasts more than 3 months, reduces quality of life and affects patients' emotional well-being [12, 2, 16]. Patients usually report their pain to physicians through self-reports on paper, causing data to seldom be analyzed or correlated with other data e.g. emotional states, social support, sleep patterns [15].

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Emotions are an important element of human life, with an important influence in our decision-making process and quality of life [6]. Recent research on emotional health proposes several approaches that support technological monitoring of emotions, e.g. computerized cognitive-behavioral therapy, mobile systems, computer games, and social networks [5]. When technologies for monitoring and reporting emotions are applied to people suffering from chronic pain, mental health problems may be detected, allowing health professionals to improve patients' treatments [12, 9].

Remote monitoring of patients using technologies can therefore improve treatment and help physicians understand their patients in real contexts, outside of their doctor's appointment. Although pain is generally correlated with negative emotions, patients suffering from chronic pain may become depressed, continuing with negative emotions even when pain symptoms decrease, so it is important to monitor both. However, older patients with chronic pain are limited by their knowledge and apprehensions about technology, and adoption of mobile or desktop applications for monitoring complex information that needs their input (e.g. emotions) may fail. Specifically in Chile, 17.4% of adults report no experience with computers, and 57.9% of older adults report no experience or fail a technology test (both numbers are significantly higher than in the rest of the OECD) [1]. Therefore, we propose that, to monitor complex information, such as pain levels and emotions, a simple wearable device may have higher acceptance, adoption rates and provide more useful data to physicians than alternatives (such as paper or mobile applications). The research question guiding this work is, *How should wearable devices to monitor complex information be designed, for older adults with low digital skills?*

We propose the preliminary design of a wearable device

that allows patients with chronic pain to self-report their pain and emotional state. Our device, called *B-ePain*, should allow both closer monitoring by physicians and self-reflection by patients. This paper is organized as follows. First, we discuss related work, considering technologies to report pain and emotions. Second, we describe our initial design, the characteristics of our prototype, and the results of a small user study. Then, we discuss our conclusions, limitations and future work.

### Related work

There are several types of technologies to report pain levels: on-line interfaces, mobile applications, ad-hoc solutions and pervasive systems. BodyDiagrams [10] is an online interface that allows users to indicate the specific affected area using a drawing. PainDroid [15], a mobile application to report pain, uses virtual reality technology to increase accuracy when assessing pain. Boormans et.al [4] proposed an ad-hoc solution in which pain is measured with a slider, allowing pain levels to be measured continuously. However, existing technologies for self-reporting pain are burdensome [13], present portability problems, and are usually not designed specifically for users with low digital skills.

Interfaces to report emotions have used a variety of technologies, e.g. mobile devices [14], web applications and tangible interfaces [8, 3]. These interfaces have used several input mechanisms, e.g. images, text, colors, scales, options, and color maps [14]. Some of these visualization tools allow physicians to intervene quickly, but are not designed to allow users to self-reflect and gain self-knowledge, as proposed by Li et al. (2010) [11].

Our proposal focuses specifically on users with low digital skills, trying to improve user satisfaction and adoption, since self-reporting devices require users to voluntarily input their

information.

### **B-ePain: a system to combine emotions and pain**

We interviewed 5 spinal surgeons to understand opportunities and needs in remote pain monitoring. The interviewees were enthusiastic about this idea, remarking that “self-report of pain may help decrease memory bias” (M1), and that “since pain is subjective [...] it is relevant to do an analysis within each patient, focusing on his/her individual behavior” (M2). Another surgeon (M3) was interested in finding correlations and remotely monitoring medication efficacy.

Existing multi-purpose wearable devices, such as the Apple watch and Android-based smartwatches, are flexible and allow users to receive notifications and perform several types of actions. Domain-specific wearable devices, such as the FitBit and Mi Band, monitor users but generally do not allow them to input information that can be used to understand users’ scenarios of use or moods. We propose a wearable device that incorporates benefits of existing wearable devices (e.g. by wearing it, the user is reminded to use it) but allows users to perform simple actions to record information. This information may then be correlated with information that is sensed by the device (e.g. physical activity levels) or available elsewhere (e.g. temperature and humidity). The overall goal of this research is to design a system to monitor the level of pain and positive/negative emotions in older patients with chronic pain and low digital skills.

With these inputs, we created a plastic (non-functional) prototype of *B-ePain*, a bracelet that allows users to report their pain levels (low, medium or high) as well as emotional information (positive or negative). *B-ePain* is designed as a wearable device to allow users to report pain and emotions at any time, providing a continuum of data that can be used

to improve their medical treatment. Figure 1 shows our preliminary design of a bracelet to self-report level of pain and emotions. Also, this design includes a touchscreen with a summary of self-reported information, as a feedback mechanism.

Then, we recruited 3 potential adult users (patients suffering from pain) to show them the prototype and gather insights for the design of a wearable device for adult users with chronic pain and low digital skills. We conducted semi-structured interviews with each participant. Each interview was about 10 minutes long. Our participants were 3 women (average age: 54, standard deviation: 2.6), who we identify as E1, E2 and E3. E1 and E2 suffer from fibromyalgia and E3 has rheumatoid arthritis.

Each interview had the following structure. First, one researcher gave a brief introduction about the study and its purpose. Then, we explained the prototype and gave the participants time to interact with it. Finally, the researcher asked questions about the prototype, using a predefined question set to guide the discussion.

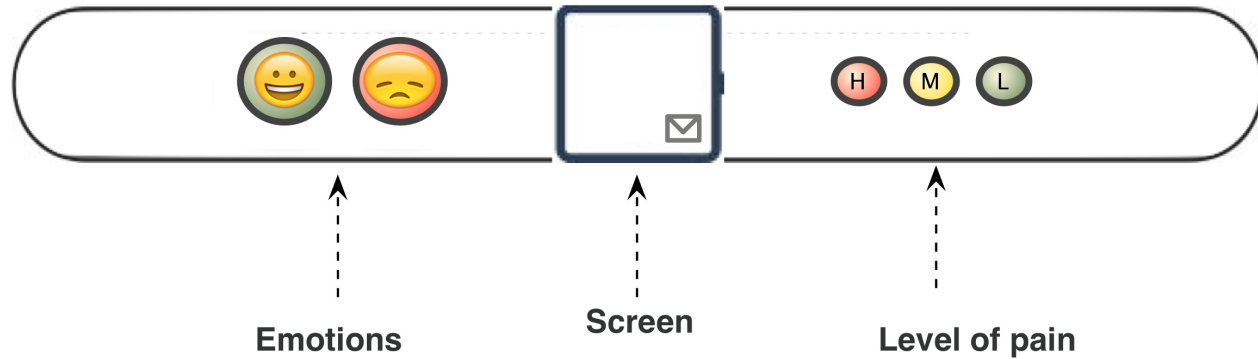
#### *Interview results*

This section discusses some of the points raised by our interviewees. Some quotes are provided (translated from Spanish).

Participants felt that a device such as *B-ePain* would be useful to report their pain to the doctor, and help him/her understand it (and them) more deeply. E3 said “I think that this is for reporting to the doctor, because when I go to my appointment he asks, “*How have you felt?*” and he sees I look fine so he doesn’t give it any importance. It would be good to have a report for the doctor when you go to your appointment”. E1 stated “You take a pill and the pain goes away. And when the doctor asks me how much it hurts,



**Figure 2:** preliminary version of bracelet B-ePain



**Figure 1:** Preliminary design of *B-ePain* with its main functionalities

I say, it hurts on some days, and it doesn't hurt on other days. Then, this bracelet could help me tell the doctor how much pain I really felt". E2 also agreed with this - she said "I explain this to the doctor and he pays no attention, maybe if he could see this information he would give it more importance".

One participant felt that this device would allow her to better understand her own emotional states. E1 stated: "when you have pain, you do things to forget it [...], I used to get angry with everyone and everyone told me I was getting angry for no reason, but I only realized it when I went to the doctor and he asked me how I felt". E3 had been suffering from pain for 13 years, so she felt she had more self-awareness about her pain.

Participants felt that B-ePain allowed them to express enough information to the doctors, without causing cognitive overload. They were concerned about being able to wear it with their clothes, mentioning that it should be *elegant* and

adapt to their wrist size, and they were also concerned with it fitting into their everyday life, mentioning that it should be waterproof and resistant to e.g. soap.

### Conclusions

We believe a device such as B-ePain may help patients gain self-knowledge and physicians improve treatment, by providing understanding about two types of subjective data of people suffering chronic pain: pain level and emotion. Our focus is specifically on how to design wearable devices that allow the input of information for users with low digital skills, who may not be able to use more complex technologies such as mobile applications or webpages.

This paper presents our initial prototype, which has not been implemented yet, and a small user study in which we talked to 3 patients suffering from chronic pain. The next steps in this research will be to incorporate patients into the

co-design of a new prototype of B-ePain, and implementing the device to begin testing it with users.

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