EmoBall: a study on a tangible interface to self-report emotional information considering digital competences

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Abstract. Monitoring emotional information is highly complex: it is difficult to accurately register it due to subjectivity and technical complexities; and it is difficult to provide reliability and incorporate contextual information. However, it is an important problem in healthcare, since it is useful to monitor people, especially if they are at a high risk of depression or other mental illnesses. Research in affective computing seeks to generate new methodologies to help store, analyze and share this information. Several techniques have been proposed to monitor emotions. One of them is *self-report*, which is a subjective method of measuring emotions from the perspective of the individual. This work presents a new tangible interface to self-report emotions, called EmoBall, specifically designed for people with low digital competences, since it requires practically no previous knowledge of technology. We evaluated this interface and analyze the results of the evaluation, considering the digital skills of the interviewed users. We found EmoBall to be a promising first step towards a tangible interface to self-report emotions; however, we did not find evidence of digital competences affecting user perceptions of the device. This paper discusses our insights regarding the resasons for these results, as well as directions for future research.

1 Introduction

Emotional well-being is an important element in people's quality of life because emotions are part of human intelligence and they are related with different types of behaviors. Monitoring emotional information is highly complex: it is difficult to accurately register emotional information due to subjectivity and technical complexities; and it is difficult to provide reliability and incorporate contextual information. Research in affective computing seeks to generate new methodologies to help store, analyze and share this information. Several techniques have been proposed to monitor emotions. One of them is *self-report*, which is a subjective method of measuring emotions from the perspective of the individual.

The evolution of user interfaces has allowed new ways of interacting with technology. Tangible User Interfaces (TUI) allow manipulating digital information by taking advantage of human abilities to handle physical (tangible) objects [**?**], taking advantage of physical interaction to improve collaboration, communication, learning and decision making [?]. We think that TUIs could be appropriate for populations with low digital competences.

This work is a first attempt to study emotion self-reporting considering digital competences from users. For this, we created a prototype tangible interface called EmoBall that allows easy self-reporting of emotions (by pressing a ball), sharing this information with social networks and providing feedback to users through simple images that show them their registered emotions. The contributions of this work are the following ones:

1. We identify the benefits and challenges of using a TUI to self-report emotions in users with different digital competences.
2. We provide insights regarding how digital competences could affect the usability of a TUI to self-report emotions; and
3. We provide design guidelines for interfaces for self-reporting emotions.

This paper is organized as follows. First, we discuss related work, considering studies about digital skills and competences, and tangible interfaces for emotion self-reporting. Then, we describe the design and characteristics of our prototype, EmoBall. Section 4 describes our experiment, then section 5 describes the results and their discussion. Finally, section 6 presents our conclusions and discusses possible avenues of future work.

2 Related Work

This section presents related work: first, we review literature about digital skills and then we discuss tangible, wearable and ambient interfaces to express, view, or share human emotions.

2.1 Digital Skills

Digital skills, competences, and digital literacy are concepts that aim to identify the skills or knowledge regarding technology that users have. Technology is constantly changing, causing the skills needed to use it to become a "moving target". The concept of digital competence also involves social and emotional aspects that allow users to understand the use of digital devices [?]. Digital competences have been defined as involving "the confident and critical use of information Society technology (IST) for work, leisure, learning and communication", and requiring knowledge about computer and internet use [?].

The DIGCOMP project began in 2011 with the purpose of developing a standardized instrument to measure digital competences [?]. This instrument evaluates four relevant areas of competences: information, communication, content creation and problem solving. Four final categories of users are defined, their digital competences may either be: *no*, *low*, *basic*, or *above basic*. This proposal has been applied in a wide sample of at least 15 countries in the European community [?]. We use this instrument for our work.

2.2 Interfaces for emotions

Tangible interfaces incorporate physical interaction into digital data manipulation [?]. This type of interface has been used to express emotions, e.g. with SubtleStone in classroom settings [?]. In this case, the device allowed students to be more aware of their own emotions during class [?]. Another use of this type of interface is for people to communicate remotely, allowing awareness of the presence and availability of others [?]. Mood Squeezer is a ball that allows users to reflect on their mood, with the goal of providing a wider range of conversations in an office environment [?].

The term Ambient Intelligence refers to a digital environment that is sensitive, adaptive and responsive to the presence of people [?]. This may encourage reflection processes that may result in better work practices and behavioral change. For example, a rabbit figure was used to provide mood visualization through its ears [?]. Results showed that different interfaces are appropriate in different situations, and that mood is affected by context. Common household objects have also been used as ambient intelligence interfaces. For example, EmotoCouch is a couch that changes color depending on user emotions, either to reinforce those emotions, comfort the user, or give feedback [?]. MoodLight [?] is another example, changing color depending on the degree of user excitement.

Wearable computing integrates computational capabilities to body-worn devices, such as clothes or accessories. A scarf was used as a wearable interface to visualize five emotions (stressed, happy, sad, excited and quiet), giving feedback through heat, vibration, and music [?].

The presented devices and systems aim to display, detect or share emotions for several purposes. However, to the best of our knowledge, there have been no studies that present tangible, wearable, ubiquitous systems that deal with emotions and study them from the perspective of users with different levels of digital competences. This is the focus of our work: to present a new interface to report and share emotions, and to understand whether a tangible interface for emotions is more appropriate for users with low levels of digital competences.

3 Design of EmoBall

The main motivation to develop Emoball was to design a simple and tangible object to report emotions. Our design was inspired in part by SubtleStone [?] as an element to register emotions in ball form. We used a LED matrix to represent positive and negative emotions with “faces” as shown in Figure 1. To provide an interactive feedback to users EmoBall has two mechanisms: first, the ball vibrates when an emotion is registered and saved in memory to let the user know when he/she recorded data; second, self-reported emotions may be viewed in summary form or shared through Twitter when the ball is connected to a base with a touchscreen.

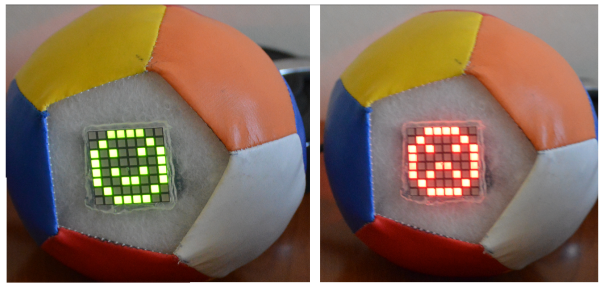

Fig. 1. EmoBall emotion faces: (a) Happy (b) Sad

3.1 System description

The EmoBall system has two main interfaces: the ball TUI and a base with a touchscreen. Each time the user presses the ball, a LED matrix on the ball displays a face depicting a specific emotion. When the ball is pressed twice, the emotion is selected and saved, and the ball vibrates. When the ball is placed on its base, the user can see the information he/she has registered on a touchscreen. The screen has three options: a graph visualization of the latest emotions the user has reported, a text visualization in which each emotion is represented by an adjective and the total number of reported emotions of each kind, and an option to share the emotions via Twitter (a popular social microblogging site). Figure 2 illustrates the system architecture.

We implemented EmoBall using a Microsoft Gadgeteer FEZSpider Kit with .NET Framework 4.0, .NET Micro Framework 4.2, GHI Electronics SDK and Visual Studio 2012. This kit was incorporated into a toy ball (Figure 2). The following Gadgeteer modules were used for our implementation.

- **Information storage:** Information is stored in a SD card.
- **Emotion representation:** Emotions are represented with an 8x8 matrix.
- **User interaction:** EmoBall uses pressure sensors to allow users to change emotions on the ball. If the ball is pressed twice, the selected emotion is stored in memory and haptic feedback is provided through vibrations to let the user know the emotion was recorded.
- **Base:** The base was implemented with a second Gadgeteer FEZSpider Kit and a T35 touchscreen that allows visualizing the registered information.

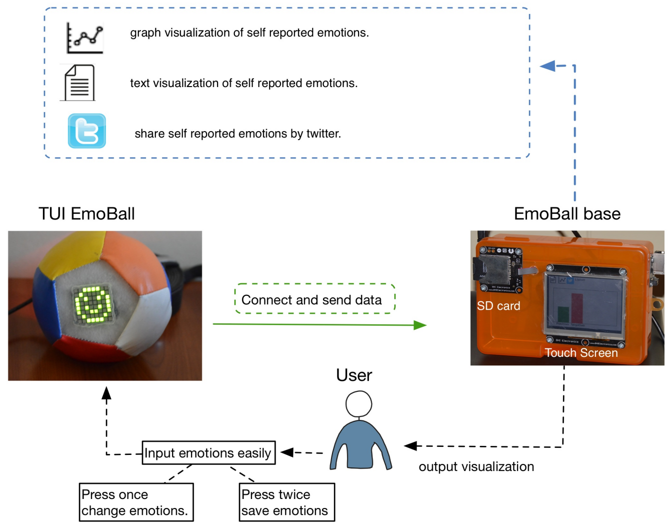

Fig. 2. General architecture of the EmoBall system.

4 Methodology

Our goal was to evaluate our interface considering the digital competences, or skills, of the potential users. To accomplish this goal, we evaluated EmoBall through focus groups, allowing users to interact with the system and collecting three types of information:

- Questionnaire results regarding digital skills (based on DIGCOMP [**?**]).
- Results from a usability evaluation using SUS (System Usability Scale) [**?**].
- Audio recordings from the focus group.

Then, we analyzed our results, to see whether our system is considered useful and usable, and how the results relate to the participants' digital skills.

4.1 Participants

Our participants were 14 women and 2 men. 6 had low digital skills, 7 had basic digital skills, and 3 had above basic digital skills. The average age of participants was 53. We conducted three focus groups: the first had 7 participants, average age: 65, the second had 6 participants, average age: 56, and the third had 3 participants, average age: 18. In our study the age of participants and the level of digital skills was correlated (higher age participants had lower digital skills).

4.2 Assessment tools

We used the DIGCOMP instrument to measure digital competences [?], and the system usability scale (SUS) as a quick way to measure the overall usability of the system [?]. In this scale, scores below 60 indicate poor usability, while scores over 80 indicate very good usability [?]. The discussion within the focus groups was recorded and transcribed. We used thematic analysis to identify and analyze themes within the data [?].

4.3 Experiment

To evaluate the prototype and see whether results from the evaluation correlated with digital skill levels, we performed three focus groups (with 16 participants in total) during January 2015. Each focus group had the following structure:

1. One researcher gave a brief introduction about the EmoBall prototype, describing its purpose and its mode of use.
2. Participants were given time to interact with the prototype.
3. We encouraged semi-structured discussion (using questions from a guide) about the prototype.
4. Participants completed the DIGCOMP survey and the SUS questionnaire.

5 Results

This section presents our analysis of the obtained results. We discuss the usability results and the qualitative analysis of the focus group discussion.

5.1 System Usability Results

The average usability score from the SUS questionnaire was 68.5. This means that general usability of EmoBall is good. Section 5.3 discusses these results when divided into groups considering digital skills.

5.2 Analysis of focus groups

Two researchers transcribed the comments from the focus groups, and built a theme map (Figure 3). We also used the transcription to build a word cloud, to see common topics emerging. We programmed a python script to remove all conjunctions, prepositions, articles, pronouns and adverbs from the transcription (in spanish), translated the remaining text, and used the WordItOut [?] service to build the word cloud (4). We can see that the main discussed topics are emotions, people, and types of emotions (happy, sad, angry).

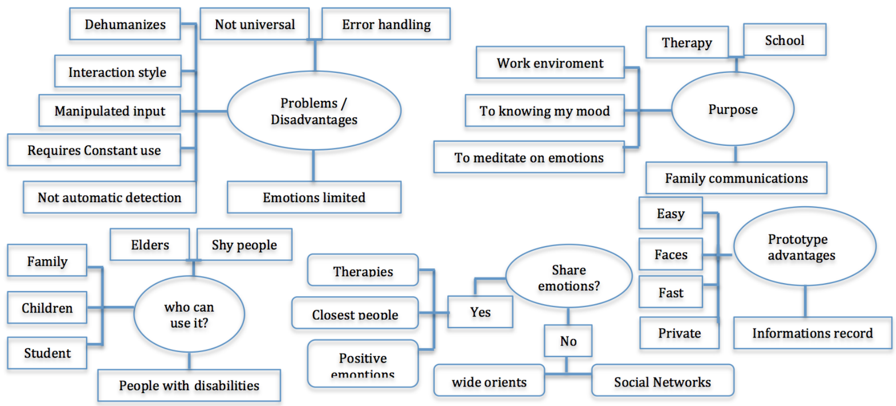

Fig. 3. Thematic map from focus group discussions

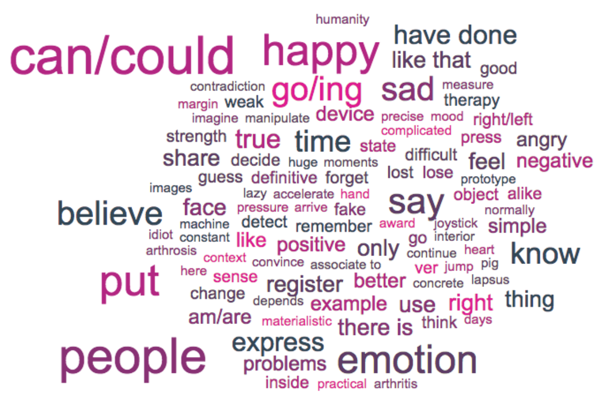

Fig. 4. Word cloud from transcription of focus group discussions

The thematic map allowed us to see the following topics emerge from the focus group discussions. We include some quotes (translated from spanish) from the participants.

1. **Potential users:** The focus group participants identified who they believed can benefit from using the prototype, e.g.: patients caregivers, shy people, students, people with disabilities. For example, some users believed this type of interface to be ideal for children who do not yet know how to read or express themselves clearly: *"it would be great for young children [...] to know whether the child had a normal day, a happy day or it was stressful or sad"*.

2. **Purpose:** The participants identified potential scenarios of use: at school, in the workplace, in therapy sessions, and for self-reflection: *"it helps to you to know how you're feeling, it allows you to think and analyze it and say "Oh!, I feel this way", and by end of week I can see summaries of how I felt"*
3. **Problems and Limitations:** Participants discussed interesting problems, related to ethics, privacy and ease and comfort of use. One participant was concerned with losing human abilities to express emotions. Another wanted the device to automatically detect his/her emotions, even at the risk of losing accuracy, like a "mood ring". There was also some discussion about not being able to correct errors in expressed emotions, and in having to express emotions as an additional chore to be done. The range of emotions in EmoBall is limited, which some users found to be a constraint *"You could have other faces, like intermediate options, the ball only has sad and happy moods"*. One participant commented that people with some disabilities, e.g. arthritis, would find it difficult to use the ball (as it requires physical force).
4. **Sharing and Privacy:** Sharing emotions is a privacy issue. Users do not share emotions with anyone: they share emotions with their closest family members and with therapy professionals. Some participants only want to share their positive emotions, keeping their negative emotions private *"I do not like to share in social networks, because it is like publicly exposing myself. I feel this information is personal..."*
5. **Advantages or Benefits:** Participants mentioned that the prototype has several advantages, especially its ease of use and how quickly it can be used. It also records information privately and it is easy to see (through the displayed emoticons) which information is being saved. 60% of participants commented on advantages or benefits that they found in EmoBall.

5.3 Usability evaluation concerning to digital competences

To understand how digital competences could affect the usability evaluation of a TUI to self-report emotions [**?**], our study reflects evidence of *Good* usability evaluation for participants with low digital competences ($SUS_{Low} = 64$ $Average_{age} = 63$) and basic digital competences ($SUS_{Basic=} = 64$ $Average_{age} = 53$). The group with high level of digital competences found the usability to be *very good* with scores ($SUS_{AboveBasic=} = 88$ $Average_{age} = 34$). Figure 5 show the SUS results for each focus group. We show the scores for each focus group since the format of discussion in which one participant's opinion may influence another's may explain some homogeneization within each group.

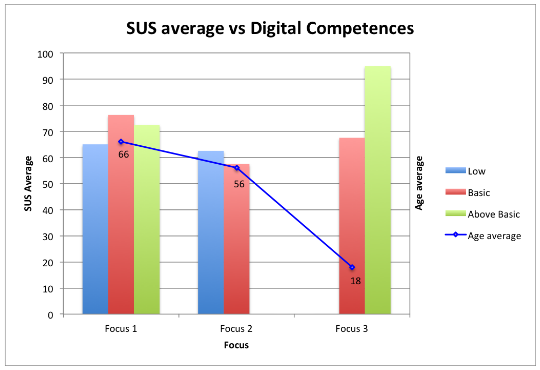

Fig. 5. SUS evaluation for each focus group

These results are counter-intuitive to our initial hypothesis, since users with higher digital competences found EmoBall to be better than users with low and basic digital competences. Although this was an unexpected result, we believe there are some possible explanations for this phenomenon: first, users with higher digital competences were younger, and more open to trying new types of devices. Future experiments should consider a homogeneous age group with different digital competences. Second, users generally found this interface to be useful, but not necessarily *for themselves*: they believed, as previously discussed, that this interface is ideal for e.g. children, people with disabilities, caregivers, or in a context of therapy or self-reflection. People with higher digital skills could perhaps more easily understand uses for the technology that did not immediately concern themselves, and thus were more positive about it. Further experiments are needed to confirm these hypotheses.

5.4 Design insights

The analysis of the focus group discussions led us to a set of design insights to consider when designing tangible user interfaces considering digital competence of users. These are discussed below.

- *The context of use may define the interaction style* EmoBall was implemented as a general-purpose emotion self-reporting device, based on previous works (e.g. [**?**]). However, we did not specify a clear context of use or target population, and this was a cross-cutting concern for all digital competence groups we interviewed. Our results agree with Edge and Blackwell's proposal [**?**] on methodologies for the design of tangible interfaces: an important aspect of TUI design is a clear identification of context of use, how the user will benefit, and which properties of the interface will support the activities it was designed for. We believe that a second iteration of EmoBall, designed for a specific context, may need to have additional characteristics and a different interaction style, which will help it become more successful and accepted for the specific target population.

- *Privacy concerns: Selective sharing* A device to register and report emotions was found to be beneficial by our study participants, because they beleived it is positive to reflect about their emotions, and review them afterwards. However, sharing this information has many privacy concerns. It is important to allow the user to clearly identify whether he/she wants to share this type of information, who to share it with, and which types of emotions to share (e.g. only share positive emotions).
- *Motivate users to self-report emotions and self-reflect by showing benefits of this practice* The study participants perceived storing emotional information to be a positive aspect of EmoBall. This is similar to the results from the SubtleStone study [**?**], as well as other studies that have shown that TUIs for children promote participation and produce emotions in their users [**?**]. It is important to consider during TUI design how to encourage the user to actually use the device and clearly display the benefits of doing so. One measure of the motivation for using an interface is the Intrinsic Motivation Inventory [**?**], which may be used to measure an activity and how it relates to interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice. We believe further generating spaces to self-reflect in interfaces for emotions may motivate users to actively use a device such as EmoBall.

6 Conclusions and Future Work

This work presented a proposal of a tangible interface to self-report emotions, called EmoBall. Comparing EmoBall with tangible interfaces like Mood Squeezer [**?**] and SubtleStone [**?**], there are evident similarities in the benefits and disadvantages that these devices deliver to users, e.g. they help users be more conscious about their moods, but it is difficult to incorporate a large range of emotions. EmoBall and Squeezer Mood [**?**] participants revealed that they did not feel comfortable with sharing their moods on social networks. On the other hand, the Squeezer Mood [**?**] and SubtleStone [**?**] studies both specify the context of use and target user, which were not available in our study. However, the study presented in this paper focuses on whether digital skills affect user experience when studying interactions with a tangible interface.

We evaluated EmoBall, finding an overall *good* level of usability evaluation (even for participants with low and basic digital competences). We also found several insights about interfaces for reporting emotions. First, users indicated they would not share this kind of information through social networks and prefer to register emotions privately. Second, our study participants suggested that the ideal scenario for this type of device may be a concrete one that can benefit from emotional information, e.g. education or mental health. Third, the device must consider all types of users in order to create a universal design.

We did not find evidence of digital competences affecting user perceptions of the device. Our experimental study had some limitations. First, we only involved

16 users, and as any study dealing with humans, the variability within these users may explain the variability of the results (or lack thereof). For example, we controlled digital competences, but we did not measure willingness to try new technologies. Second, EmoBall was a fully-implemented working device, however, it is a prototype (that e.g. requires researchers to charge it and fix any problems after use), so we could not send it to participants to use for days or weeks and analyze their experiences and activity logs afterwards. Instead, they had a short experience with the prototype before giving us their opinions. Therefore, a more extensive (and perhaps, lengthy) study, with a greater number of users, is needed to obtain more precise statistics.

As future work, it is important to study whether another type of interaction is better to report emotions, e.g. changing the squeeze interaction to touch interaction. Given the small sample size of our study, it is difficult to speak of generalizable results, so further evaluation is required. We will also apply this evaluation in specific contexts, e.g. informal caregivers, or young children.

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