Supporting Anxiety Patients' Self-Reflection through Visualization of Physiological Data.

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ABSTRACT

Anxiety patients are often constrained in daily life to an extent where they experience severe difficulties in keeping a job or being with family, hereby leading to a decreased quality of life. Self-reflecting on emotional reactions during daily life activities is a critical part of anxiety treatment, and can lead to increased self-awareness and eventually behavior change to cope with the disorders. mHealth technologies have emerged as a means to improve effectiveness of treatment for mental disorders, yet few studies have utilized real-time data from physiological sensors to support self-reflection on emotions. We conducted a study with two anxiety patients and their psychiatrists to explore their experiences of using GSR sensor data as visual cues to support daily self-reflection on anxiety episodes. We contribute with findings indicating that GSR visualization as part of anxiety treatment can support patients in confirming episodes. Furthermore, we present design considerations for such visualizations.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Field studies; User studies;.

KEYWORDS

mHealth, Anxiety, Field Study, GSR, Sensor, Visualization

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1 INTRODUCTION

Mental disorders lead to a tremendous personal and financial burden worldwide and are thus a major global health concern [48]. Anxiety disorders are some of the most frequent mental disorders [48], and often linked to a high comorbidity with other mental disorders [28] and a reduced quality of life [10]. There are several kinds of anxiety disorders but common for all are the general symptoms during episodes. These includes physical reactions such as increased heart rate and sweating, referred to as arousal, and caused by worrisome thoughts and rumination [43]. Cognitive Behavioral Therapy (CBT) is an effective and well-documented treatment program for anxiety disorders [45], which focuses on altering negative thought patterns. Elements of treatment include both sessions between a therapist and a patient as well as reflections on anxiety episodes between sessions [2]. The patient typically reflects on their anxiety by writing episodes down in a diary or questionnaire related to the context and emotions surrounding an episode [35]. Not only does self-reflection have a positive impact on mental health in itself; the process of tracking health has also shown to be effective in terms of changing behaviors as well as improving understanding and awareness of health patterns [26]. Studies have likewise shown that when patients reflect between sessions in CBT it yields better outcomes in terms of decreasing the anxiety and the fear of anxiety [24].

While the use of self-reflection in CBT is beneficial, it poses challenges for anxiety patients as they tend to either reflect too much leading to increased rumination [11] or too little, leading to a neglect of the perceived need for treatment [34]. Anxiety patients' perception of physical reactions and thoughts is often misaligned making it difficult to interpret and understand their own emotions and thus, their disorder [12]. Anxiety patients experience difficulties in identifying when and where the state of the body changes and even if it changed at all during the day. This reduced sense of the body leads to difficulties in interpreting thoughts that become unrealistic and further accelerate the presence of overwhelming negative emotions [12, 41].

Visualizing data from physiological sensors might support anxiety patients in their self-reflections and better align thoughts and physical reactions, which could lead to an improved understanding of why they are experiencing negative emotions. Mobile health (mHealth) tools have emerged as a means to support self-reflection on mental health [26] but current tools do not take sufficient advantage of physiological sensors [10]. Recent developments in wearable sensor technology have made this more feasible, see e.g. [18, 33, 47] and Galvanic Skin Response (GSR) sensors have shown to effectively measure increased emotional arousal [40]. Previous work has emphasized the use of such sensors for suicidal adolescent inpatients [27], stress in general [19, 31, 42], stress related to autism [37] and surveys on peoples' perception towards sensor use [36]. Research on using visualization of physiological states has mostly been employed on healthy individuals to increase well-being through life-logging [3, 9, 32, 44, 46]. Anxiety studies have utilized sensors to either detect isolation (through GPS) [1], predict social anxiety (through GPS, accelerometers and texting activity) [4, 21] or detect physiological states (through GSR and HR) to determine effectiveness of treatment programs [5, 30]. We have not been able to identify any previous studies with a focus of aligning anxiety

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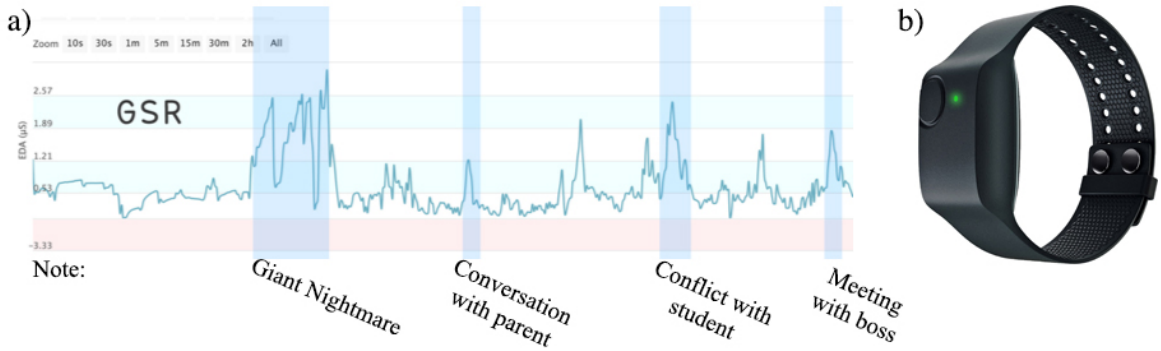

Figure 1: a) GSR graph from E4 manager from one participant along self-reflection notes, b) Empatica E4 wristband

patients' thoughts and physical reactions through visualization of physiological sensor data.

The aim of this study is to explore anxiety patients' experience and acceptability of using visualization of physiological data to support self-reflections as part of their CBT treatment. We conducted a qualitative field study with two anxiety patients and their respective psychiatrists. The patients wore the Empatica E4 wristband sensor for a period of time and used a corresponding PC application for visualization of objective data to increase their understanding and interpretation of emotions and physical reactions to gain a more unbiased view on their anxiety. We conducted interviews with both patients and psychiatrists.

2 STUDY DESIGN

In the following we give an in-depth description the study design including the system the patients used during the study, the study procedure including ethical considerations, a description of the people participating in the study, data collection methods and data analysis.

2.1 The GSR System

We asked the anxiety patients to use a system consisting of the Empatica E4 GSR wristband sensor (see figure 1b) to gather physiological data and a corresponding desktop application [14] for visualization to help them reflect on their anxiety episodes at the end of each day. We chose GSR due to the simplicity over e.g. EMG, and because different independent studies show high correlations between GSR data and subjective ratings related to arousal [7, 15, 16, 25, 29]. Related work from HCI suggest using recollection cues from contextual data sources can complement physiological data [32, 44]. However, given the personal vulnerability of our study participants we chose to simplify the technical setup by exclusively emphasizing GSR data, not to provoke a sense of being under surveillance.

To visualize the GSR data, we asked the participants to use the E4 manager software, shown in figure 1a. This study setup was designed on the basis of the Day Reconstruction Method (DRM) [22] and Cued-Recall Debriefing (CRD) [7, 8, 39]. In DRM, participants are asked to reconstruct their day using fill-out sheets similar to the ones used in CBT. To support this reconstruction the CRD method suggest using cues collected passively in real-time to support recollection in retrospect [39]. Inspired by CRD, we used GSR data as cues in our study to support the patients in recalling their anxiety episodes. The cues were used to fill out sheets based on the DRM questionnaires presented in [23] each day. The E4 wristband includes a button, which a patient can press during the day to place a marker in the data as a cue, when they feel their anxiety increasing.

2.2 Ethical Considerations

We had a number of ethical considerations on methodology before we started the study. Firstly, we obtained ethical approval to conduct our study by the ethical committee of the [Blind review]. Secondly, we chose to present the purpose and design of the study at a meeting with 15 psychiatrists at the psychiatric ward of Aalborg University Hospital, with whom we collaborated closely with throughout the study. They provided input on developing the study design. Thirdly, since anxiety patients can be in a fragile mental state we needed to ensure to include sufficiently "robust" patients, i.e. patients that did not suffer from too severe anxiety episodes. To deal with this issue, the psychiatrists involved in the study asked patients whom they assessed to be able to cope with such participation.

2.3 Participants

The four participants, two patients and two psychiatrists, have been given pseudo names for the remainder of this paper to ensure their anonymity. Patients were recruited through the psychiatric ward at [Blind review] University Hospital. The two patient participants (Caroline and Mathilda) were asked by their psychiatrists (Anna and Camilla) if they wanted to participate in the field study before we contacted the patients. This procedure, along with the novelty of our study (which caused some skepticism in an already emotionally exposed patient group) meant that we did not obtain more participants. However, it was crucial for us that participants felt that participation was optional given their fragile mental states.

2.3.1 Patient 1: Caroline, 23 and Psychiatrist 1: Camilla. Caroline is a 23-year old student, who has not been diagnosed with an anxiety disorder but have strong physical reactions during anxiety episodes. She does not always remember episodes and can be unsure whether it is anxiety or something else. She had been in CBT at the psychiatric ward for six months at the time of our study. As part of her CBT, her psychiatrist provided her with fill-out sheets to note

anxiety related episodes, but she did not find these useful. She is not eager to use technology and does not own a smartphone. Caroline's psychiatrist at the psychiatric ward is Camilla, who also participated in our study.

2.3.2 Patient 2: Mathilda, 29 and Psychiatrist 2: Anna. Mathilda is a 29-year old math teacher suffering from panic disorder and Obsessive-Compulsive Disorder (OCD). She is in CBT at the psychiatric ward, and is also medicated for her disorders. While it is simple to remember intense anxiety episodes, she often does not recall the less intense. Sometimes she writes her episodes down and brings them to therapy sessions. She is keen on monitoring her anxiety through technology and already wears a smartwatch for tracking body signals, primarily to gain insights on her sleep patterns. Mathilda's psychiatrist at the psychiatric ward is Anna, who also participated in our study.

2.4 Study Procedure

Based on collaboration with the psychiatric ward, we designed the study procedure to be divided into two parts: 1) Participation period of 14 days and 2) Individual interviews with psychiatrists. In the following we describe the first part, which included an initial interview with patients, daily self-reflections in the patients' natural setting and a concluding interview. Afterwards, we describe the interview with psychiatrists.

2.4.1 First part: 14-day study with patients. The first part started with an initial interview with the aim of getting to know the patients, their anxiety, treatment and their attitudes towards technology. Patients were introduced to and given the E4 wristband, the embedded GSR sensor, desktop software for visualization and the fill-out sheets for daily self-reflections.

As previously mentioned, the procedure for daily self-reflection was based on DRM and CRD. Patients wore the E4 sensor during their everyday activities where it gathered GSR data continuously. At the end of each day, patients transferred the data from the wristband to the E4 desktop application after which sensor data was visualized through graphs. Only the individual patients and three researchers had access to the uploaded data. Patients were instructed to look for peaks (cues) in the GSR data that stood out from the rest of the data. This is similar to the manual GSR analysis approach followed by non-experts in [6]. For each of the more extreme peaks, patients used the provided fill-out sheets to report what happened, where it happened, if they were alone or with others and how they felt at a timestamp.

After the home period, we conducted a concluding interview with the purpose of exploring patients' experiences with the system. The interview guide was designed on the basis of User Experience Questions (UEQ) from [20] and technology acceptance in healthcare questions presented in [17]. Both [20] and [17] are designed as questionnaires where the person is rating statements on a scale. Therefore, the questions were reformulated for qualitative purposes allowing for further elaboration depending on the participants' answers.

2.4.2 Second part: Interviews with psychiatrists. Upon completion of the first part of the study, we conducted individual semi-structured interviews with psychiatrists Anna and Camilla. This was done to further explore and elaborate on their professional views on the technology and visualizations of GSR data. The interview guide was formulated based on the results from the field study and included questions of current treatments, if and how they had used the GSR data during the CBT treatments with the participating patients, their thoughts on how and when the system could be introduced in treatment and to whom as well as whether or not they saw any challenges with the introduction of such a system in current CBT treatment.

3 FINDINGS

In this section we present the findings from the field study with patients and insights from the psychiatrists. While the first part of the study was planned to last for 14 days, Caroline only participated for two days due to concerns regarding constant monitoring. Mathilda participated for 27 days as she wished to extend the 14-day study period. Reasons for either discontinuation and extension are elaborated in the following sections. None of the participants used the button on the wristband, and only Mathilda used the fill-out sheets.

3.1 Aligning Thoughts with Physical Reactions

A recurring subject among both psychiatrists and patients was explained as a disconnection of what anxiety patients experience happening physiologically in their body and psychologically in their mind. Our study showed a potential in using visualization of physiological data to support patients in re-establishing this connection by aligning thoughts and physical reactions. Having access to physiological sensor data in the field study, both participating patients reflected that they sometimes experience uncertainty related to their physical reaction, but found it comforting to be able to see the visualization graphs in the GSR system. The patients explained that they now could use this information to get confirmation that something had happened in their body and not only in the mind. The patient Caroline said: *"... sometimes I can be unsure if it is anxiety and then it might be a help I think"* and the other patient Mathilda explained:

> *"It's both terrifying and supportive at the same time. Once it's shown in front of you it becomes more real, and when you then get such numbers, and if you like numbers, it becomes even more real." Mathilda, patient*

An example of Mathilda's data is shown in figure 1a along the notes from the fill-out sheets. This figure illustrates the correlations of her thoughts and the GSR peaks showing her physical reactions. Furthermore, Mathilda, explained that using the GSR system for a month facilitated new reflections on her anxiety and associated physical reactions in terms of how it affected her:

> *"It's actually pretty good for when you are about to spaz out over why you are so tired or why you don't want to do anything when you get home, and then I can actually see, it's not only right there and there, it is actually also some time after or, there is a reason why I just feel spent." Mathilda, patient*

The data visualizations were also actively used in the CBT sessions as they brought new reflections on the kinds of experiences

that occurred during a day. The patient Mathilda had noticed patterns in the GSR data that led to a change in her perception of when she experiences anxiety. The data showed clear distinctions between periods when at work and when having time off. The impact of work on her anxiety was, however, something she and her psychiatrist had discussed previously during their sessions. Having data visualizations of physical reactions meant that she now could use these data actively to reflect upon her daily activities and better understand her anxiety in relation to these and her treatment:

> *"I think it's interesting that I try really hard to convince myself that work is so healthy for me, and my psychiatrist tries really hard to convince me that it's not. It is a little annoying that I have now borrowed a device that does not speak my case [smiles]" Mathilda, patient*

The psychiatrist to Mathilda, Anna, said based on the experience with the field study: *"It can take a while for a patient to see that some things are not appropriate, so it would be fine to have a tool that measures it, then the patient might more clearly see [the triggers]. It becomes more tangible".*

3.2 Constant Monitoring

While the patient Mathilda found it highly useful how the system collected data constantly, the other patient, Caroline, had a different feeling about the constant monitoring of physical reactions. Caroline had to opt out of the study after two days as she became too aware of the device measuring her symptoms: *"I have only worn it [E4 wristband] for a day and a half because I felt like I was being monitored and was very aware that it constantly measured my body signals. I found it uncomfortable".*

Related to constant monitoring was also the physical design of the wristband, which the patients both found too large and clumsy, drawing attention towards it by others in their surroundings. The patient Caroline had experienced being asked multiple times about the purpose of the device and felt uncomfortable answering.

The psychiatrists explained how monitoring was important and how they use fill-out sheets for this purpose in current CBT treatment, but also noted how it could have a negative effect. For instance, the psychiatrist Camilla said: *". . . sometimes it becomes difficult to write down all the time, and it becomes a bit against the intention as the patient might get an enormously big focus on the anxiety".* In relation to being overly focused on the anxiety, Camilla also mentioned, based on the experience with Caroline in the field study, that:

> *"I believe that rumination is also connected to feeling monitored, that you think like someone is watching all the time and all data is relevant. The patient may lose focus and what you should pay attention to becomes blurry. They may also be worried about what will be payed attention to when we look at the data together" Camilla, psychiatrist*

The psychiatrist Anna mentioned how constant monitoring through the device could be used to nuance the patients' perception of their anxiety: *"It could be a nice nuancing, because they [the patients] see very black and white: either it is fantastic or very bad".*

3.3 Opportunities as Seen by the Psychiatrists

Even though patients had mixed experiences using the system as part of their treatment, the psychiatrists saw great potential in introducing visualization of physiological data in CBT treatment. For example, the psychiatrist Anna said: "It could make sense to many. No doubt about it". Both psychiatrists saw different potential purposes depending on each individual patient, as the psychiatrist Camilla said:

> *". . . something to do with the degree of self-awareness . . . it might have different purposes . . . They [the patients] think they have anxiety all the time and knows what it is and so and so, so it could be kind of a disconfirmation, and opposite; is the patient really bad at noticing the things and you [as their psychiatrist] could have a suspicion that there are many situations the patient doesn't notice or understand too well, then it could be something else" Camilla, psychiatrist*

The other psychiatrist Anna saw a great potential in using the system for preventing anxiety episodes by discovering the triggers: "This technology could help identify the triggering factors to make crisis plans".

Both psychiatrists agreed that using visualization of physiological data should be an integrated part of current CBT treatment and not a stand-alone solution, as it was beneficial that they could help the patients in interpreting the data. This would also allow the psychiatrists to support the patients if they found the device uncomfortable as Caroline did in the field study.

4 DISCUSSION

People suffering from anxiety can have difficulty aligning thoughts and physical reactions affecting their ability to reflect on their mental health [12]. We extend previous research with findings indicating the value of visualizing physiological sensor data to anxiety patients, hereby lending support in reflecting on their disorder.

4.1 The Comfort of Confirmation

We found that patients could be unsure whether they experienced an anxiety episode or not, an observation supported in [34]. They therefore found it comforting to see a spike on the graph to know that something happened in the body and not only in their mind. This was comforting as it became clear that an anxiety episode emerged compared to ruminating on it, which, as one of our patients said, could make her "spaz out". Confirming episodes through data helped patients uncover patterns to learn more about themselves and their anxiety, e.g. that Mathilda's work increased her anxiety. Given the impact in terms of patients learning more about their anxiety, it is critical for future work to explore the level of accuracy with which GSR spikes can reveal anxiety episodes. However, the study presented in [27] support our findings by suggesting that physiological sensors can help participants self-monitor and manage their own distress more explicitly.

4.2 When to Introduce Visualizations and to Whom

mHealth interventions are beneficial when it comes to making treatment more accessible to a wider population [10, 13, 38], but as every person is unique, both physiologically and behaviorally, mHealth interventions will not work for all [18]. This became apparent from our interviews with psychiatrists and in the field study where one patient perceived the system as very useful, while one decided to opt out early. The psychiatrists said some patients are highly sensitive to the body's signals, which enhances their anxiety. These might not benefit from using physiological visualization as it is a constant reminder of their condition. As noted by [13], many factors affect a patient's mental disorder, e.g. physical illness, cultural and social factors, previous and present life events and genetics. This is in line with the opinion of the psychiatrists in our study, who would prefer to assess patients' suitability for using the system before introducing it. They also emphasized that the proposed system should be an integrated part of CBT and not a stand-alone solution. However, more studies are needed in order to more accurately point towards particular groups of anxiety patients that could benefit by such visualizations or which patients that should not view these.

4.3 Future Design Considerations

The design of the visualization of GSR data should be carefully considered to allow it to change anxiety patients' perception of their mental health. Based on our findings, we suggest designing sensor data visualizations in a way opening for patient interpretation. This is in line with related work in HCI, which has shown that participants prefer visualizations of emotional data that does not suggest or label specific emotional reactions, cf. [44] and [9]. Thus, design considerations in this regard should draw on knowledge gained from HCI studies on emotion reflection where GSR data is used to measure arousal in combination with contextual and visual information to support users in reflection of their affective states, e.g. [32, 44]. The patients in our study considered it a benefit and not a burden to be able to confirm episodes through their own interpretations of the GSR data. Psychiatrists also supported this by highlighting the benefit of patients viewing their own GSR data in order to provide a sense of agency during the treatment. Also, we suggest using a wearable having a somewhat smaller device, e.g. the Empatica Embrace, which has a 30% smaller form factor. Kleiman et al.'s [27] experiences with the size of the E4 wristband are similar to ours.

5 CONCLUSIONS

This study examined patient experiences using visualization of continuously measured physiological data to support self-reflection on anxiety episodes. This has not been studied in previous work and we contribute with an explorative study on the matter. Patients used GSR data as visual cues to support recollection and self-reflection on anxiety episodes. Visualizations can confirm anxiety episodes, making it clear if one emerged rather than having to keep ruminating about it. Visualizations also increased understanding of the disorder and associated physical reactions. However, some anxiety patients may react intensely towards being monitored, and introducing such visualizations needs careful considerations by health professionals.

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