Designing Efficacious Mobile Technologies for Anxiety Self-Regulation

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ABSTRACT

This paper presents a step-by-step process that was developed primarily to extract design pre-requisites for personalized mobile technologies assisting anxiety self-regulation. This process, which is recognized as a preliminary framework, was developed, refined, and tested based on a multidisciplinary literature review and an exploratory study conducted with mental health professionals who treat anxiety disorders. The step-by-step nature of this framework draws from multiple disciplinary and stakeholder perspectives, integrates knowledge about efficacious psychological interventions, considers individual differences and specific challenges faced by patients, and realizes contextual needs. It also includes incremental and iterative refinements based on multidisciplinary sources to foster more evidence-based interface designs. Once reached its maturity, this framework can potentially be applied for

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designing efficacious technologies for a range of mental health conditions. The expected future contributions and limitations of the framework are also discussed.

KEYWORDS

Anxiety; Design Framework; Mobile Technologies; Personalized; Self-Regulation

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INTRODUCTION

The interest in personalized intervention is growing in the psychology field to further improve the efficacy of established interventions [12]. In parallel, there is a proliferation of mobile technologies to make the interventions more accessible [11]. These two areas have encouraged human-computer interaction (HCI) researchers to design personalized mobile technologies (PMTs) to improve mental health by leveraging wearables, smartphone applications, and affective computing techniques.

Anxiety disorders (ADs) is a group of mental disorders with a high prevalence (see Sidebar 1). If well-informed, personalized mobile technologies that assist anxiety self-regulation (PMTs-ASR) can be developed, those will be beneficial for the affected people with or without access to the interventions. Also, such technologies can support the people who are at risk of ADs to reduce the risk of escalating their anxiety into a full-blown anxiety disorder.

HCI researchers have attempted to achieve personalization by providing different treatment components in one package [3, 13, 15], along with occasional user-level customizability [3, 13]. Also, the importance of user adaptation for PMTs-ASR is envisioned [5]. Less focus has been paid on providing suitable empirically-validated treatment components to an end-user considering the symptoms and experiencing phases of ADs (e.g., anticipation, confrontation, and termination phases for social anxiety disorder [8]). This research-in-progress focuses on deriving design considerations for PMTs-ASR through the aforementioned focus, while considering five common ADs and young adults as the targeted end-user population (see Sidebar 1). A similar focus has demonstrated the potential of deriving in-depth design considerations for PMTs in bipolar disorder domain as well [6].

The existing attempts in guiding the designs of PMTs-ASR involve presenting design considerations as actionable guidelines [2, 13, 15]. The processes that integrate knowledge on empirically-validated interventions [13] and data from multidisciplinary, multi-stakeholders inputs [15], have demonstrated promising outcomes in deriving rigorous design considerations for PMTs in bipolar disorder domain [6, 9]. Inspired by such processes, in this paper we present a simple, yet powerful systematic process,

Anxiety involves a set of cognitive, behavioral, and physiological responses. Contrary to fear and stress, the responses are often anticipated and dislocated from the external stimulus [4]. The current prevalence of anxiety disorders (ADs) is estimated at 7.3% worldwide, and only 27.6% of the affected are estimated to receive any treatment [1].

Anxiety Disorders Considered [7]:
Social Anxiety Disorder - Excessive anxiety about social interactions and situations.
Agoraphobia - Excessive anxiety about a range of situations where the escape is difficult.
Specific Phobia - Excessive anxiety about a specific object or situation (e.g., heights, animals).
Panic Disorder - Excessive anxiety about having additional panic attacks.
Generalized Anxiety Disorder - Excessive anxiety and worry about numerous events or activities that are perceived to be difficult to control.

Young adults, who are more likely to experience the symptoms of the considered ADs, are considered as the targeted population [7].

Sidebar 1: Anxiety Definition, Considered Disorders, and Target Population

Study Design: The exploratory study consisted of a short online questionnaire and a one-hour face-to-face semi-structured interview around the treatments for anxiety disorders. The questions focused on following themes guided by an initial literature review:
Questionnaire: Demographic Information

- Experience in the field of mental health.
- Practicing treatment approaches.
- Treating patient populations.

Interview: Insights for Design Considerations

- Treatment strategies and components.
- Homework and observed difficulties.
- Identifiable phases and stages of anxiety.
- Treatment component mapping to different symptoms, phases, and individuals.
- Opinions on existing interfaces and suggestions for future interfaces.
- Individual differences in manipulating and regulating anxiety.

Sidebar 2: Study Design

Table 1: Participants' Demographics.

Role	Counselor	1
	Psychologist	5
	Social Worker	1
Highest Level of Education	Bachelor's Degree/ Graduate Certificate/ Graduate Diploma	4
	Doctoral Degree	3
Area of Specialty	Social Anxiety	7
	Generalized Anxiety	7
	Panic Disorder	7
	Agoraphobia	5
	Specific Phobia	4
	Other	3

as a preliminary design framework, that reinforces establishing in-depth and rigorous design pre-requisites for PMTs-ASR. A few interesting early level design considerations derived through this suggested process are presented, to provide with an example of the framework's application.

METHODOLOGY

After conducting a literature review in HCI and psychology domains to extract pre-requisites for PMTs-ASR, the authors generated initial insights for a design framework. It was discerned that cognitive, behavioral and physiological symptoms and characteristics of different phases of anxiety are important factors to be considered in designing PMTs-ASR, as the aim is to regulate them [6, 12]. These were identified as potential treatment moderators (see Sidebar 3). To ensure the effectiveness of technologies, considering the implications from evidence-based effective interventions is identified to be essential [6]. Also, in personalizing such technologies, allowing flexibility for individual differences in regulation and different contextual uses was recognized to be vital [14]. Further, inputs from multidisciplinary sources were identified to increase the credibility of designs. Those insights were confirmed through an exploratory study, and then developed into a design framework.

The exploratory study was conducted with mental health professionals treating ADs (MHPs-ADs) to refine the design considerations derived through the literature review and exploring new ones. Reasons for selecting MHPs-ADs as the initial group of contact over the patients include: anxious patients usually find it difficult to identify their anxiety symptoms and what strategies work for them [16], and MHPs-ADs are more likely to identify the individual differences in anxiety based on the wide range of experiences with different types of anxiety patients. Sidebar 2 presents further details on study design. However, input from patients are perceived to be necessary and is planned for future work. For this late-breaking work, data collected from 7 MHPs-ADs (male=2, female=5; # of years of experience: (M=14.86; SD=13.03); # of hours of practicing per week: (M=21.29; SD=14.43)) were considered. These participants were volunteered in response to 621 direct email invitations distributed among publicly accessible MHPs-ADs contacts practicing in Melbourne, Australia. Table 1 presents demographic information relating to their practice. The conducted interviews were audio-recorded, fully transcribed, and then qualitatively analyzed using a thematic analysis approach [10]. The analysis was assisted with NVivo software program. The coding was started with a deductive approach focusing the design considerations derived from the initial literature review. As familiarization improved with data, coding was performed inductively. The generated themes and codes of interest were used to test the framework. The next sections present the preliminary design framework and some results.

THE PRELIMINARY DESIGN FRAMEWORK

Since the presented framework (see Figure 1) is foreseen to be useful for those who design personalized technologies for a range of mental disorders, it is presented as a generic framework. An example usage

Treatment Moderators: The variables associated with better response to an intervention.
Maladaptive Thinking: The thinking related to a false or irrational belief.
Cognitive Reappraisal: Reinterpret thoughts to change an emotional response trajectory.
Psychoeducation: Educating about anxiety, including neurological and physiological reactions, cognitive symptoms, and emotional reactions.
Decatastrophizing: Asking how bad some event would be, so the patient realizes that even the worst case scenario would be manageable.
Rational thinking: Asking how frequent an event is likely to be, prompting the patient to realize that the chances of it happening are low.
Thought Defusion: Encouraging patients to defuse their maladaptive patterns of thinking.

Sidebar 3: Clinical Terminology

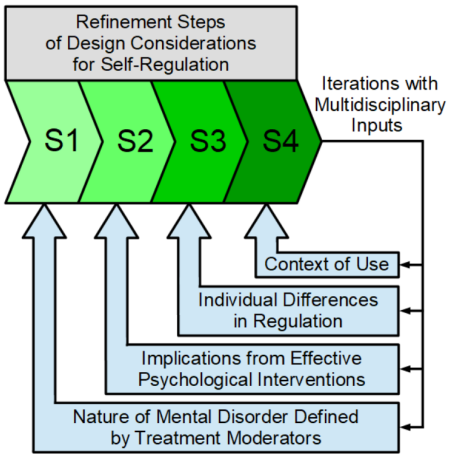

Figure 1: Preliminary Design Framework

of the framework is presented in *Preliminary Results* section. Through the presented framework, the authors suggest a step-by-step refinement process for literature-based design considerations. It is further proposed to refine such design considerations through multiple iterations that are based on multidisciplinary multi-stakeholder input (e.g., mental health professional, patients, patients' support networks, HCI experts). Within an iteration, it is recommended to follow four steps (S1, S2, S3, and S4) incrementally by feeding data collected from literature or multidisciplinary multi-stakeholders.

During the initial iteration (iter.1), the designer needs to decide the factors to be considered in personalizing the mental health technology. It is recommended to choose these factors considering the potential treatment moderators that define the nature of the mental disorder (e.g., the research-in-progress considers cognitive, behavioral and physiological symptoms and characteristics of phases of anxiety). During iter.1, it is also recommended to go through all the four steps to derive (in S1) and refine (in S2, S3, and S4) initial design considerations solely based on literature evidence. Although iter.1 will be time-consuming, it allows generating more evidence-based designs in the long term.

In each iteration, new insights can be generated based on the data collected, relating to treatment moderators, effective psychological interventions, individual differences in regulation of mental disorder, and the context of using the technology. Here, the context of use is not only referred to the situated environment, but also can refer to engaging activities (attention levels varies), contexts related to anxious thoughts, etc. Based on the insights relating to those four categories, it is suggested to refine the design considerations within each of the four steps.

In S1, the design considerations for regulation of mental disorder can be derived or refined considering different dimensions of each of the treatment moderator categories (e.g., avoidance, escape, fidgeting as behavioral dimensions). In S2, those can be refined based on the data associated with the implications of effective psychological interventions. During S3, refinements are based on the individual differences in regulating mental health condition. Finally, in S4 of an iteration, further refinements can be done based on the data related to the contexts of designed technology use.

PRELIMINARY RESULTS

To test the validity of that framework, the findings from the literature review (iter.1) and interviews with MHPs-ADs (iter.2) were fed as inputs to the suggested four steps. The initial testing indicated that the proposed preliminary design framework could lead to generating in-depth and rigorous design considerations for PMTs-ASR. The following subsection illustrates an example built upon a cognitive symptom to demonstrate how the framework can be used in generating design considerations.

The Design Framework in Action. As a common cognitive symptom, *maladaptive thinking* was recognized. Hence, assisting in overcoming such thinking was identified as a primary design consideration (iter.1, S1). Maladaptive thinking, which influences the feelings, physiological reactions and behaviors

(1) "If a patient believes that something happening will cause her husband to die, then asking how likely it is would be considered an appropriate question. But, asking how bad that would be is insulting."
(2) "If a patient believes he has social anxiety, and that if he leaves the house he will run into someone, then asking how bad that would be is appropriate. However, asking how likely it is would not be effective since it is very likely."

Sidebar 4: A Participant's Example - Contextual Appropriateness for Thought Challenging Strategies

Table 2: Application of Framework: One Iteration Relating to Avoidance Behavior

S1	Behavior of Avoidance
S2	Facilitate to create a *progressive exposure plan**, with the support from an MHP (to enforce safety) and suggestions from the mobile interface
S3	The suggestions provided by the interface should be based on the *end-user's level of anxiety* (need for integrating anxiety detection mechanisms to assist with a better understanding of the user's state)
S4	Also, the suggestions should be based on the context of the fear

* e.g., if the user's anxiety level is extremely high of spiders: a possible progressive plan would be exposing to images, videos and virtual reality experience of spiders, stuffed spiders, and finally to real spiders.

of anxious patients, were identified to be treated through treatment components like *cognitive reappraisal techniques*. Hence, the need to provide exercises focusing such techniques became a refined design consideration (iter.1, S2). At that stage, S3 was skipped with the intention of exploring more on individual differences in regulation of maladaptive thoughts in the next iteration. Based on the literature advising to reduce interface distractions in mobile contexts, the need for suggesting the type of self-regulation exercise depending on the user's level of attention was recognized to be important. Therefore, this requirement was considered as a refinement to suggested exercises (iter.1, S4). The data used in iter.2 indicated that catastrophizing and anticipating the worst case scenarios are the two most common maladaptive anxious thoughts (7/7). That finding led towards providing two different types of exercises for changing those types of thoughts (iter.2, S1). Some common techniques used by the MHPs-ADs to address this problem are *psychoeducation* (7/7), challenging the thoughts through *decatastrophizing* or/and *rational thinking* (6/7), and *thought defusion* (3/7). Hence, new insights emerged regarding the previously identified exercises (iter.2, S2). It was also recognized that different individuals respond to above mentioned different treatment components and delivering methods (e.g., psychoeducation assisted through verbal conversations, white-board drawings or biofeedback of heart rate) (7/7). Hence, providing different exercises assisted in different delivering methods (i.e., visual, auditory, and haptic modalities) and providing the support and configurability to choose the strategies that work for an individual was identified as a potential design consideration (iter.2, S3). One participant raised that sometimes it is not practical to question relating to decatastrophizing or rational thinking depending on the context of the thought (refer to Sidebar 4). Hence, the ability to decide which techniques to use was identified as another design consideration (iter.2, S4). Table 2 also presents another example of application around a behavioral symptom; avoidance.

DISCUSSION AND FUTURE DIRECTIONS

The preliminary use of the presented design framework has shown a promising validity, by assisting to ease the process of deriving well-informed, in-depth design considerations for PMTs-ASR. However, rigorous evaluation is needed and planned to be performed through further iterations involving young adults with ADs using functional prototypes produced through this research. One of the major areas that require attention is, handling the conflicts arising from the multidisciplinary multi-stakeholder data. Since the data collected in the presented study was strongly related to the targeted audience, a separate refinement step was not added to orient design considerations towards end-users. However, considering end-users, safety, and privacy like factors through additional steps is identified to be useful, depending on the focuses of the interface designs. Future work with populations linked to other mental health conditions should explore the potential utility of the presented design framework for designing PMTs targeting those conditions. Also, further work would potentially be able to extend this framework to be applied for various other health conditions. Sidebar 5 further illustrates some possible

This research expands the reach of the traditional CHI community to include working with multiple key stakeholders in digital health, in particular patients and MHPs. Some future possibilities for the CHI community to contribute to this field are:
(1) Work towards yielding more meaningful and efficacious mobile interfaces aligned with personalized interventions, by forging longer-term collaborative relations with mental health teams.
(2) The important movement toward developing end-user PMTs that promote self-regulation and proactive behavioral change, rather than overburdening the traditional medical community.

Sidebar 5: Possible Directions for the CHI Community to Contribute

future directions for the CHI community to contribute towards efficacious mobile technologies to assist with mental health conditions.

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