



Therapist-Informed Design Directions for Mobile Assistive Technologies for Anxiety

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Abstract. Anxiety is increasingly becoming a global burden. Although several mobile anxiety assistive technologies have been designed and developed aiming to support the increasing demands, it is not well understood how the design can be improved to aid better regulation outcomes for patients while providing therapists with useful and timely data to make better clinical decisions in assessments and treatments. We explore this area through fifteen interviews with specialist therapists treating anxiety disorders. The uniqueness of this exploration lies in its special attention to therapists' knowledge on inter-and intra- patient differences in anxiety. This focus enabled the identification of novel therapist-informed, therefore, clinically meaningful customization approaches that could be automated and integrated into the future assistive technologies for anxiety. The therapists' notion of unintended adverse consequences of envisioned technologies is also revealed and discussed. Overall, this paper contributes to the future design of in-the-moment digital interventions and digital diaries for anxiety, an understudied area in the literature.

Keywords: Anxiety · Digital diaries · Digital interventions · Mobile assistive technologies · Personalization · Temporal adaptations

1 Introduction

Designing mobile mental health technologies is a rapidly emerging branch of interest for human-computer interaction (HCI) researchers [54]. Research in this area increasingly collaborates with mental healthcare professionals to understand the prerequisites for future design [29, 38, 52]. The aim is to aid the development of mobile technologies with improved effectiveness and accessibility in the treatment of several mental health conditions. Anxiety is one such condition that has gained attention recently, as COVID and its related quarantines have almost doubled the prevalence of anxiety disorders and imposed barriers for traditional face-to-face therapy [59].

Anxiety is a set of physiological, behavioral, and cognitive responses to a perceived threat that is usually future-oriented and uncertain [11, 16, 17]. Pathological anxiety leads to a variety of anxiety disorders, impairing the daily functioning of affected people and contributing significantly to global non-fatal health loss [50, 60]. Although the prevalence of anxiety disorders is increasing at a rate of 14.9% per year [2, 60], only one-fourth of the affected are estimated to receive any treatment [2]. To remedy this situation, rethinking and improving the design of mobile assistive technologies for anxiety is important, given the great potentials associated with these technologies (e.g., access to patients outside therapy).

Existing mobile technologies that assist anxiety mainly act either as digital interventions (e.g., [21, 45]) or digital diaries (e.g., [30, 39]), whereas some have overlapping roles (e.g., [7, 49, 53]). Existing digital interventions aim to facilitate the self-regulation of anxiety, and digital diaries collect mostly subjective data related to anxiety experiences aiming to support later reflections by patients or with therapists. Three of the compelling limitations of these technologies can be related to lack of (1) inclusion of evidence-based interventions [19], (2) customization to accommodate patient-specific (inter-individual) differences, and (3) adaptations to temporal (intra-individual) differences in anxiety [25]. Research has not adequately investigated how to address these limitations motivated by traditional therapy practices. Further, other areas for improvement targeting mobile usage are yet under-explored. Examples include capturing useful information about in-the-moment anxiety experiences without burdening patients and accommodating common concerns around stigmatizing mobile interactions.

To expand this limited knowledge, this paper attempts to (1) explore challenges arising due to limitations of current mobile assistive digital technologies for anxiety and (2) identify design directions to overcome such challenges and potentially improve treatment effectiveness, based on therapists' expertise. A special focus has been laid on challenges related to adapting to inter- and inpatient differences in anxiety, capturing useful information on anxiety experiences outside the therapy, and mitigating unintended adverse consequences that assistive technology can raise. We explored the above areas, with a focus on five common anxiety presentations. We initiated this exploration by reviewing HCI, psychology, and psychiatric literature. Then we conducted fifteen interviews with therapists specialized in anxiety disorders to explore further and refine the high-level concepts recognized in reviewing related work.

2 Background and Related Work

Anxiety disorders often begin in early adolescence or young adulthood [22]. Some common DSM-5 classified anxiety disorders that are prevalent in these populations are social anxiety disorder (i.e., excessive anxiety about social interactions and situations), specific phobia (i.e., excessive anxiety about a specific object or situation), generalized anxiety disorder (i.e., excessive anxiety and worry about numerous events or activities perceived to be difficult to control), panic disorder

(i.e., excessive anxiety about having additional panic attacks), and agoraphobia (i.e., excessive anxiety about a range of situations where escape is difficult) [4, 20]. Therapists use diverse pharmacological and psycho-social interventions to treat them, depending on their educational background, practice and judgments.

According to a meta-analysis conducted on clinical randomized control trials of psychosocial interventions, mindfulness, relaxation and cognitive-behavior therapy approaches are found to be the three most effective interventions for anxiety disorders [6]. Cognitive-behavior therapy (CBT) is a widely accepted and practiced treatment for anxiety due to its extensive evidence base [24, 44]. Some primary treatment components of these approaches include psychoeducation (i.e., educating about anxiety, including etiology, progression, consequences, prognosis, and treatment), relaxation (i.e., training to achieve a state of decreased arousal), mindfulness (i.e., regulating attention and orienting towards the present moment), exposure (i.e., encouraging to confront triggers), cognitive restructuring strategies (i.e., reframing anxious thoughts to have positive emotional impacts), and later reflection (i.e., after-thinking about anxiety experience and learning from them) [32]. However, a recent review suggests that most freely available mobile apps marketed toward assisting anxiety and highly rated by users were largely inconsistent with such components [19].

2.1 Design Approaches for Anxiety Mobile Assistive Technologies

The approaches taken to design currently highly available commercial mobile apps for anxiety are not clear. Existing HCI or psychology research-based mobile technologies, on the other hand, often attempt to base them on traditional evidence-based psychosocial approaches [25, 45, 53, 58]. While many of them are designed with a focus on promoting general mental health, only a few have been designed with specific attention to anxiety [39, 53]. Mental health professionals have often been involved in the design process of research-based technologies. Examples include using their expertise to translate the content of training manuals of psychotherapy approaches to mobile or online app formats [45, 53, 58] and receiving their feedback on initial prototypes of technologies such that the designers can refine them before presenting to patients [25].

A few designs are also implemented or envisioned considering the literature evidence on advances of physiological and behavioral analytics that provide means to detect anxiety. Some technologies are designed as wearable or hand-held devices that can record heart rate like signals continuously or as needed, so patients can visualize representations of those signals and attempt to regulate anxiety to reach a relaxed state (i.e., biofeedback technique) [14, 21]. Some are envisioned (but not implemented) as wearables that can continuously record physiological signals, request users' subjective inputs, and trigger other objective recordings (e.g., audio-visual and location data) when an anxious state is detected, so recorded data can support patients and clinicians in identifying actual triggers later on [39].

The existing design approaches that involve therapists have not attempted to explore areas such as how to make the assistive technologies adaptive for inter-individual and temporal differences in anxiety. Therapists' extensive experiences

with a range of patients can potentially be useful in understanding such under-explored areas. Further, the design that incorporates literature-based knowledge of objective anxiety analytics lacks therapists' perspectives and expectations.

2.2 Underexplored Design Directions

Accommodating Individual Differences in Anxiety Regulation. Different patients (and even the same patient) respond to different interventions depending on various factors related to their in-the-moment anxiety experiences. However, only a very few technologies provide several options of interventions [45, 53, 58]. Other technologies usually offer only a couple of treatment components [3, 5, 13, 25, 30, 37], sometimes supporting limited anxiety presentations [39, 43, 56], leading patients to rely on multiple technologies. Further, due to limitations in clinically meaningful adaptations within interventions, diverse regulation outcomes occur from one patient to another (e.g., [25]). Although it is not evaluated for regulation outcomes of one particular patient at different times of use, closely similar regulation outcomes at each time point are unlikely to expect.

Intending to improve interventions' effectiveness for a variety of patients, related technologies often allow a level of customizability [7, 25, 45, 53]. One such approach is interface-specific customizations, for example, allowing users to choose a color to incorporate in a relaxation exercise [7], or a surface-material of a biofeedback device [25]. However, these superficial interface changes of generic nature have little or no clinical impact compared to customizing actual interventions. Limited technologies use the customization approach of providing choices of interventions to choose from [45, 49, 53] and the option to adjust some therapy-specific parameters within an intervention (e.g., adjusting breathing-in/out duration within a relaxation exercise [53]). Such approaches have a better clinical validity, as they closely align with tailoring techniques used in clinics [44, 48].

Guiding Suitable Interventions. The technologies that provide customizations in interventions rely on patients' judgments and make patients decide which intervention to use, when, and with what adjustments. On the other hand, people with anxiety often face challenges in making the right decisions, as they are prone to avoidant decision making [8]. Also, they usually find it challenging to generate insights about their own anxiety experience (e.g., whether they are anxious, what is triggering anxiety) due to poor emotional awareness [51]. Therefore, relying only on their judgment to customize cannot be counted on to improve regulation outcomes. Very few technologies attempt to understand how the user is feeling based on subjective inputs and then suggest some interventions [5, 13]. However, their criteria for suggesting an intervention are not clear. Further, they can only guide an intervention if the user initiates the technology use or has set up reminders for regular check-ins, so patients still need to determine when to use an intervention. Therefore, before any detailed design, it is vital to explore clinically meaningful adaptation techniques to be incorporated.

Psychology or psychiatric literature has not yet derived establishments on how to match patients to suitable treatments for anxiety. In fact, personalized psychotherapy is still a growing body of interest that explores which interventions work for whom, considering various mental health conditions [12,44]. Related work in the anxiety domain mainly involves analyzing randomized controlled trials to understand the pre-treatment characteristics of patients that are influencing the treatment outcomes [10,33,44]. The characteristics that are under consideration for moderating treatments vary and can be categorized into classes such as clinical factors (e.g., symptom severity, anxiety presentations, treatment history), cognitive and behavioral factors (e.g., stigma of treatment, capacity for participation, avoidance tendency), non-cognitive traits (e.g., personality, motivation), sociodemographic factors, and biological factors.

There is some emerging evidence of treatment components that are suitable for different anxiety presentations [18]. Further, patient-centered baseline severity of symptoms is identified to be correlated with treatment outcomes in some clinical studies [33]. These two factors, i.e., anxiety presentations and baseline severities, have a clear relation to anxiety experiences, vary considerably among different patients, and could also change within the same patient from time to time. Hence, it would be useful to explore whether (and how) therapists tailor the interventions depending on these factors while exploring other potential factors. Such exploration would support deriving potential criteria to guide interventions within mobile assistive technologies.

Capturing In-the-Moment Anxiety Experiences. The existing digital diaries for anxiety either provide a platform to manually enter subjective anxiety levels from time to time with or without notes on triggers and thoughts (as in [30,49]). Subjective recordings within these technologies need to be initiated by the user, which would be problematic for those facing challenges in developing insights on their anxiety experience. As detailed earlier, a few technologies have envisioned triggering subjective recordings through objective anxiety detection [39]. While this approach can potentially address this limitation, relying on indicative metrics for objective detection of anxiety is vital. Otherwise, many false positives may occur, resulting in unwanted interruptions for patients (e.g., elevated heart rates may also trigger instances of high-intense physical activities). On the other hand, triggering patients on the detection of brief and common high-anxious states is not meaningful (e.g., increase of anxiety level in a driver for a short duration due to an unexpected crossing of a pedestrian).

The knowledge on user's anxiety experience based on objective metrics could support technologies to understand when a user requires intervention, and then to guide a suitable intervention, as envisioned for assistive technologies for other mental health conditions [9]. For this purpose, relying on rapidly fluctuating levels of anxiety would not be suitable. A more realistic approach would be guiding interventions based on momentary but somewhat prolonged phases. The psychology literature points to some phases specific to social anxiety (e.g., anticipation, confrontation, and termination in social anxiety disorder) [31]. However, there is

a limited understanding of regular temporal phases encountered by patients in daily field contexts, maybe because of the lack of attention paid to symptom variations that occur in between therapy sessions. Some recent analytic research has shown the interest in objectively exploring anxiety patterns that arise relating to certain anxiety presentations such as panic disorder without providing interpretations or benefits of any observable patterns [28,40,41]. Exploration with therapists could be helpful in this area, as they can support identifying a set of phases that could potentially contribute to the future design of in-the-moment interventions for anxiety, given their broad experience with patients.

Unintended Adverse Consequences of Assistive Technologies. A major challenge faced by users of any kind of assistive technologies is stigmas around using mobile technology in public settings [36]. This issue is more prominent when it comes to anxiety due to stigmas surrounding mental health issues [27], and can lead to obsessive preoccupation, inducing anxiety further. Current technologies seem to have paid limited attention to these types of sensitive concerns in their designs. For example, although tangible interface-based digital interventions and diaries [7,21,49] can produce rich interactions, it is unclear whether users would tend to use them in mobile settings due to their high tendency to draw others' attention. Further, limited attention has been paid to privacy concerns for sensitive information that these technologies collect and long-term effects of usage (e.g., effects resulting from high reliance on devices [36]). Attention to these areas before the detailed design is vital, and it can support mitigating unintended adverse consequences that new technologies can raise.

Overall, the above-identified gaps of related work point to some high-level design directions for future assistive technologies for anxiety. Those are the needs for (1) delivering a set of carefully-chosen interventions based on evidence-based psychosocial approaches, (2) facilitating clinically meaningful customizations (e.g., guiding suitable interventions based on patients' anxiety experience), (3) incorporating appropriate mechanisms to identify factors that would support deciding suitable customizations, and (4) careful consideration of unintended adverse consequences that new technologies can raise and plan to mitigate them.

3 Method

To further investigate the design directions identified through gaps in related work, we interviewed therapists who are specialized in treating anxiety disorders based on a few reasons. We realized that approaching therapists prior to patients is appropriate because: (1) therapists are more likely to offer rich insights on patients' differences in anxiety based on their broad experiences, which individual patients are not able to provide [51,57], (2) although the therapists' knowledge on anxiety experiences in between therapy sessions is limited, they are likely to have a reconstructed knowledge based on patients' retrospective reports, and (3) therapists' expertise in psychotherapy can support identifying suitable intervention based customizations. Further, similar studies conducted in

other mental health domains have demonstrated the discovery of well-grounded design directions through involving high-level informants like therapists [38, 45].

3.1 Participants

Fifteen therapists volunteered for this study (female = 9; years of experience: [M = 14.13 (2–40)]; practicing hours per week: [M = 23.80 (2–50)]), in response to email invitations that we distributed to publicly available email addresses of therapists who were identified to be treating anxiety disorders in a major city of Australia. Twelve were psychologists, and others were a psychiatrist (P6), counselor (P8), or social worker (P1). Seven held doctoral degrees (P2–5, P11, P13, P15), six held master’s degrees (P1, P6–7, P9, P12, P14), one a graduate diploma (P10), and one was studying for the master’s (P8). All used cognitive behavioral therapy (CBT) to treat anxiety. Other approaches used in treating anxiety are relaxation-based therapies (P1–2, P5–10, P12–14), mindfulness-based therapies (P1–2, P4, P7–9, P11, P13), acceptance and commitment therapy (P4–5, P7, P9–10, P12), and dialectical behavior therapy (P2, P12, P14).

3.2 Data Collection

The principal researcher (first author) conducted face-to-face hour-long semi-structured interviews over three months in compliance with the institutional ethical requirements. Each interview was conducted in person, except for one as a remote video interview. This highly interactive setting allowed us to ask follow-up questions to improve the clarity of responses. All the interviews were audio-recorded. We also used an online questionnaire prior to interviews to collect therapists’ professional demographics. Based on the review of related work, we used five questions to primarily guide the interviews:

- Q1. Which treatment components have you identified as the most effective for anxiety disorders in general?
- Q2. How do you customize treatments depending on patients’ anxiety presentation (social anxiety, specific phobic anxiety, panic-inducing anxiety, agoraphobic anxiety and generalized anxiety) and severity?
- Q3. Can you identify different temporal phases of anxiety experienced by patients?
- Q4. What are your preferred treatment components to be used during those phases?
- Q5. What are the challenges you and your patients face due to the limitations of digital or non-digital assistive tools used, and how can those be improved?

These broader questions (without specifics) were used to minimize biasing the responses. However, we provided some examples whenever a clarification was needed. For instance, the concept of general anxiety phases in Q3 was often clarified by providing an example from the literature [31]: “*literature on social anxiety shows that patients go through phases related to anticipation, confrontation, and termination. Have you identified any phases that are applicable for different anxiety presentations?*”. This clarification was always presented as an example for social anxiety not to influence participants’ insights on general phases.

Follow-up questions and some visual prompts were used as interview probes. The researcher asked follow-up questions when clinicians did not relate to some insights extracted from literature (e.g., “*Do your patients share that they stigmatize usage of mobile apps for anxiety in public?*”). Further, clinicians were presented with some images of recent research-based assistive tools as prompts to extract more insights on Q5 (e.g., the researcher presented those images, briefly explained those and asked “*what modifications would you like to have before recommending these technologies to your clients?*”).

3.3 Analysis

The fully transcribed interviews were analyzed using a thematic analysis method similar to the one suggested by Nowell et al. [34]. This method is recognized as useful for examining various perspectives while capturing similarities and differences and generating unanticipated insights. Using the NVivo software, coding was started with a deductive approach focusing on the themes around the main question areas. As the familiarization with the data improved, coding was performed, taking an inductive approach, resulting in novel themes. One researcher performed the analysis; others engaged in verification and revisions during weekly team meetings. During the analysis stages, we further utilized a design process framework, which focuses on generating prerequisites for personalized mobile mental health technologies, as a guide for deriving design directions [46]. The results and discussions are categorized into final codes.

4 Results and Discussions

4.1 Supporting a Variety of Effective Treatment Components

As responses to Q1, the therapists suggested psychoeducation (13/15), exposure (13/15), mindfulness (12/15), relaxation (11/15), cognitive restructuring (9/15), cognitive defusion (4/15) (i.e., encouraging to defuse thinking related to false or irrational beliefs), self-soothing or distraction strategies (2/15) (i.e., coping behaviors which provide a sense of safety), and later-reflection (1/15), as the most effective treatment components for anxiety in general. Note that each therapist pointed to more than one component. The components suggested by more than half of the therapists echoed the core components of cognitive-behavioral therapy [32], except for the later reflection, which seemed to be ignored as a treatment component because it is a common exercise practiced in every therapy session.

One-third of therapists preferred cognitive defusion over cognitive restructuring strategy, saying that it is “*more suitable for patients who are not ready to directly accept that their thoughts are not valid*” (P5). Similarly, although about two-thirds of therapists discouraged self-soothing and distraction components, as they do not contribute to developing skills in overcoming fears, others who work with vulnerable populations (e.g., P2: “*autism*”, P14: “*self-harm tendencies*”) claimed that those are useful to calm down patients. They provided options

to interact with fidgeting devices, carry around soothing items, and play with therapy dogs. However, since “*high-demand for comfort is a common anxiety symptom that needs to be overcome*” (P15), all the therapists agreed that these strategies should only be provided through technologies for highly vulnerable patients or as a last option for less vulnerable patients.

The above results point to the need for different interventions by different patients. Although therapists agreed that technology needs to support a range of interventions, they also raised the concern that technology should not overwhelm patients with too many options. They suggested implementing a digital “*toolbox of interventions*” with add or remove capabilities (P6, P9, P14) (as in [53]), providing a “*default set of interventions at set-up*” (P11), and “*sorting*” mechanism to categorize interventions (P6, P13).

4.2 Anxiety Condition Specific Customizations of Interventions

Baseline Severity Based Customizations. Aligned to the customization suggested above for highly vulnerable patients, in responding to Q2, three therapists stated that they start therapy with direct and easy-to-follow components for people with higher baseline anxiety severities. Since they are “*anxious most of the time*” (P12), therapists used mindfulness-like components prior to complex cognitive restructuring strategies. Further, those therapists claimed not using interoceptive exposure (i.e., engage in activities that deliberately bring on the feared physical sensations [32]) component with emotionally sensitive patients, as “*it require skills to control reactions to bodily sensations*” (P14).

These results point out that patients’ severity level-based customizations (related to the order of interventions and interventions to filter out) need to be incorporated into technology design to enhance engagement and mitigate risks.

Anxiety Presentations Based Customizations. Related to Q2, almost all therapists suggested that psychoeducation, exposure, and cognitive restructuring interventions are effective for all types of anxiety. Psychoeducation on “*what anxiety is*” (P3), “*what common symptoms are*” (P6), and “*how therapy can be supportive*” (P15), is identified as an early preparation step for treatment by all therapists. Many therapists preferred the combination of cognitive restructuring and exposure, as those contribute directly to “*addressing the underlying problems*” (P8) of avoidant behavior [8] and maladaptive thoughts (i.e., thinking related to false or irrational beliefs) [55]. For all anxiety types except generalized anxiety, many therapists indicate that much focus should be on exposure compared to cognitive strategies. However, practicing exposure component for generalized anxiety is identified to be not straightforward as “*intentional creation of triggers is difficult*” (P12), as they closely relate to the “*uncertainty of various situations*” (P15) and “*frequent worry*” (P3).

Therapists also related to specific customizations within treatment components. For example, many therapists claimed to alter the content of psychotherapy according to patients’ anxiety “*triggers*” (P9, P12, P15) and “*reactions*”

(P7, P9, P14). Some therapists also provided examples of using customized experiments that combine exposure and cognitive restructuring interventions. For example, P3 explained an experiment involved in asking a patient to hold a fully filled glass of water while delivering a speech, intending to invalidate the patient’s particular belief of shaking a lot when anxious. Further, the type of exposure techniques used by therapists also varied for different anxiety types. For social anxiety and specific phobia, imaginal exposure (i.e., vividly imagine being in the presence of feared circumstances), stimulated exposure (e.g., using virtual reality or video), in-vivo exposure (i.e., real-life confrontation with triggers) were commonly used. For generalized anxiety, some therapists claimed to use uncertainty-based in-vivo exposure. For panic and agoraphobic anxiety, imaginal exposure was used to reduce sensitivity before interoceptive exposure.

Based on these results, we can hypothesize that the regulation outcomes would be more effective if future technologies could be designed to guide the most appropriate interventions with customized content considering patients’ anxiety presentations. Some of the above results also point to customizations required in order of interventions to reduce risks to the users.

4.3 A Conceptual Framework for Regular Phases of Anxiety

In responding to Q3, many therapists required clarifications such as whether the researcher is referring to phases that are “cyclic” (P4), occurring “across the life span” (P13), or “related to therapy work” (P3). This result confirmed that the concept of anxiety phases is less established in clinical practice. However, given an example from literature [31] and conveying that we are interested in phases recurrently occurring in daily context during anxiety experiences and generic to different anxiety presentations, everyone provided useful insights, leading to tentative classes of regular and generic phases of anxiety. Figure 1 illustrates a conceptual framework of temporal phases of anxiety that we derived based on therapists’ responses to this question.

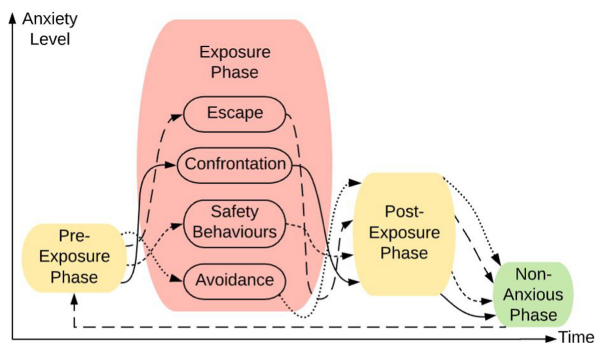


Fig. 1. Conceptual illustration of cyclic class of regular anxiety phases

We named the four identified phases as pre-exposure phase (i.e., occurs when anticipating negative outcomes before exposing to a trigger), exposure phase (i.e., occurs when or closer to exposing to a trigger), post-exposure phase (i.e., occurs after exposing to a trigger), and non-anxious phase (i.e., occurs when the maladaptive thoughts are inactive) aligned to terms used by some therapists. While the exposure phase was assumed to reflect a confrontation response to the trigger, some alternative phases were also identified: avoidance (i.e., when decided not to face the trigger at all), escape (i.e., fleeing from the trigger), safety behaviors (i.e., facing the trigger with the support that provides a sense of safety). These three alternative phases can potentially contribute to creating vicious cycles of anxiety [1], which are discerned to bring short-term relief and reinforce anxiety in the long term.

Overall, this class of phases can be better explained using an example given by P3: “*A person who has a fear of driving will anticipate well in advance if they need to drive somewhere (pre-exposure). Deciding not to drive and use an alternative transport mode can give them short-term relief (avoidance). However, later on, there is a chance that they will ruminate about their inability (post-exposure with increasing anxiety levels). Choosing to drive on their own can make them feel extremely anxious once they start driving (confrontation). Afterward, their success will give them a sense of confidence (post-exposure with decreasing anxiety levels)*”. Similarly, one can imagine the outcomes of driving by having a supporter nearby (safety behavior) or deciding to stop halfway through and return without completing the trip (escape).

Rough approximates of anxiety level fluctuations across the phases, which are based on the examples given by therapists, are represented with arrows in Fig. 1. The duration of phases is not illustrated, as it was identified as highly subject to inter- and intra-patient differences; “*people with severe conditions quickly get into anxious phases, and stay most of the time in anxious phases*” (P11). An example provided by P2 clarifies this: “*a patient who only used to get anxious during lectures [...] felt anxious once got to the university, eventually became anxious while driving to the university, then started to become anxious as soon as got in the car, then got anxious as soon as woke up in the morning*”. Similarly, anxiety levels and frequency of phases were also identified to vary depending on patients’ triggers and baseline severity (P12, P15). Further, the four phases were identified to be occurring mostly in order for many anxiety experiences that include an apparent trigger. However, when no anticipation is involved (e.g., uncued panic attacks), therapists presumed that the pre-exposure phase is likely to be “*skipped*” (P2, P11). Also, distinguishing these phases for generalized anxiety was identified to be difficult as anxiety itself is the trigger (i.e., “*worrying that they are worrying too much*”) (P5), “*anticipation is a habit*” (P7); and “*thought switching*” happens quickly and frequently (P7, P9, P11).

4.4 Anxiety Phases Based Customizations of Interventions

In response to Q4, therapists acknowledged that they “do not usually ask patients to involve particular interventions in certain phases of anxiety” (P3).

However, almost every therapist indicated their preferred components for identified phases with some rationale. Many therapists recommended using relaxation during the pre-exposure phase to minimize the increase in anxiety levels. Relaxation, self-soothe or distraction, and mindfulness were perceived to support the confrontation in the exposure phase (P3, P9, P14–15). However, all therapists agreed that priority should be given to “*ride out fear*” (P15) without using those strategies when direct confrontation is not highly risky. No preferences were suggested for alternative phases, as those phases should not be the goal. Aligned to face-to-face therapy, many therapists suggested using later reflection during the post-exposure phase. Psychoeducation and cognitive restructuring components, which require high concentration levels, were preferred for the non-anxious phase. Moreover, a majority of therapists suggested using mindfulness, relaxation and cognitive restructuring components regularly, regardless of patients’ anxious state. Those components were assumed to promote disorders “*prevention*” (P3, P6, P8, P11–12, P15) and “*provide a chance to use interventions frequently for those who report being anxious most of the time*” (P11).

These results indicate that future assistive technologies can attempt to objectively detect identified phases and guide interventions as above criteria, without leaving patients to decide when to use which intervention.

4.5 Design Directions Motivated by Current Challenges

Through initiating discussions on Q5, we could collect therapists’ insights on (1) how the future assistive technologies can support overcoming common challenges, as well as (2) what unintended consequences can be introduced through these novel technologies and how we can plan to potentially mitigate them.

Practicing Environment Based Customizations. Many therapists identified stigmatization as a common challenge faced by their patients. They assumed that their patients’ lack of digital diary usage might have relations to their concerns about whether technology usage would reveal to others that they are experiencing a mental health condition and engaging in therapy. Therapists highlighted the need to customize interventions to users’ context; designing to minimize technology usage when in public by promoting non-technology activities, such as “*socializing with friends*” (P3) or “*mindfully eating a meal*” (P7), and designing the interventions to be practiced in public with “*hard-to-recognize*” (P4, P13) form factors and interactions may be by integrating them into “*everyday products*” (P14). “*Games*” (P6), “*mindful painting*” (P4), “*non-visual*” feedback (P13) were among suggested technology components.

Flexible Practicing Times. Our interviews also revealed a failed method used by current mobile technologies to involve users in interventions. The therapists, who often review existing mobile applications aiming to select ones to recommend for their patients, claimed that frequent reminders implemented to promote engagement in interventions often do not use “*gentle and encouraging language*” (e.g., “*you have not used it for three months*”) (P7, P9). Such reminders

were identified to “*induce patients’ anxiety*” (P7). They suggested facilitating patients’ autonomy by implementing “*flexible scheduling*” (P6) for interventions to be practiced regularly, considering patients’ “*anxiety states*” (P11) and “*other schedules*” (P3). Facilitating “*supporting for rescheduling*” was also identified to be important. Moreover, some therapists highlighted that technology needs to pace the frequency of interventions to avoid being over “*interruptive*” (P3, P12) and to discourage “*long-term reliance*” on technology (P4, 5). Their suggestion was to “*reduce the frequency of interventions*” (P3) as patients show progress.

Fostering Awareness and Insights on Anxiety Experience. Many therapists claimed to face the challenge of not receiving precise and sufficient information about the anxiety experiences of their patients that occur outside therapy through the recommended traditional thought and behavioral records or digital diaries. This was identified as affecting therapists’ decisions, therefore, effectiveness in treatments and assessments. Many therapists linked this challenge to patients’ lack of awareness and insights on their anxiety experiences. Improved awareness can support “*realizing anxiety triggers*” (P7) and also indirectly support “*understanding how much they are impaired due to anxiety*” (P1). Therefore, therapists showed their interest in digital diaries, which can (1) automatically record longitudinal behavioral analytic data related to anxiety for later reflection and (2) carefully trigger users in the real-time to record needed information based on experiencing anxiety phase.

Monitoring Progress. A majority of therapists reported spending a lot of time filling assessment questionnaires frequently with patients and comparing the results over time to understand patients’ progress because that information is imperative to decide the next steps for treatment. The absence of objective evaluation metrics in current therapy was identified to “*waste a lot of time that could have been used for deep therapy work*” (P10). Therapists agreed that if future technology could at least roughly estimate and keep track of regular phases experienced by patients, those estimated could support detecting the direction and rate of progress. Some patterns that were identified as indicative of positive progress are: “*reduced frequency*” of phases corresponding to avoidance, escape and safety behavior responses (demonstrating greater “*tendency to confront*”) (P2, P4, P6, P10); “*reduced duration*” of pre-exposure (demonstrating reduced resistance to exposure) and post-exposure (demonstrating ability to quickly settle down); and “*reduction in anxiety levels*” within phases (P6, P7). Recognition of these three patterns would be possible through longitudinal objective monitoring of anxiety phases. Further, some therapists pointed to subjective ways to estimate patients’ positive progress; improved ability to “*challenge negative or anxious thoughts*” (P4). This measure reflects the patient’s progress in developing new skills and needs to be supported by subjective data collected during repeated cognitive restructuring interventions over time (P8).

Selecting Interventions that Work Best. In selecting an intervention out of various options to suit patients' learning styles and other preferences, therapists claimed to “*collaborate with patients*” (P1) as they are the “*experts of themselves*” (P5). For this purpose and to validate the appropriateness of selected interventions, usage history on different interventions could support. Measures such as: (1) whether there was a significant anxiety level change from prior-to-after usage of an intervention, and (2) how much the user liked using an intervention were identified to be relevant to understand which interventions worked best in the past. Some therapists also shared experiences of patients who got bored and less reactive to certain intervention options that were used repeatedly. Based on this observation, clinicians suggested that future technologies can guide different intervention options at the detection of reduced progress.

Not Inducing Anxiety Through Careful Presentation. Despite the benefits of fostering awareness regarding anxiety, therapists presumed that presenting anxiety detection data too often or to a patient who is not ready for it could generate obsessive preoccupation. They suggested that technologies should not be designed to make users “*overattentive to their anxiety patterns*” (P7). They pointed that “*guidance from a therapist is important for sensitive users when reviewing such information*” (P5), as they may over-ruminate due to the “*lack the ability to process information*” (P12) and “*use it for their benefit*” (P10).

Therapists also provided insight into the idea that technologies can use carefully designed data presentation to find a balance between improving awareness and mitigating the related risks. One such mechanism is reflecting on areas that need improvement while emphasizing positive progress. For example, “*without presenting that the user had x number of panic attacks since beginning, present facts such as: earlier you had one attack every day, but now it is five days a week; and you do not stay in panic state for 15 min anymore, but only 10 min*” (P7). Another approach is not directly reporting detected adverse phases or negative progress without reconfirming, as algorithms are not always accurate. To gain further insights, a questioning approach can be used: “*for most people when they display a similar pattern, they feel quite anxious, and for some people, it might mean (involving in an intense physical activity) or (excitement), are any of these apply to you right now?*” (P11). Part of this strategy is to inform users that they are not the only ones with anxiety problems and not upset them when technology produces false anxiety reports. Further, technology can present neutral or negative progress “*with recommendations to act upon*” (P13); e.g., see a therapist. These strategies can reduce the risk for users who require additional support in interpreting information from technology. Therapists suggested that they can play a role in this process by communicating information to patients in appropriate forms while making important clinical decisions (e.g., modifying therapy or “*referring patients to new therapists that suit them better*”) (P13).

Overall, in order to convert therapist-guided customizations into automated adaptations envisioned in this section, the technologies need to gain the ability to detect the user-specific, context-specific, and time-specific factors that

rule those customizations. The potential factors that we discovered include patients' anxiety presentations, their baseline severity, the experiencing phase of anxiety, whether they have completed prerequisite interventions, and timeliness to practice interventions. Objective anxiety assessment research could potentially support automating the detection of these anxiety-related factors [15, 23, 26, 35, 42, 47]. Further, the technology can keep track of previously practiced interventions by the user and use that data to check whether the user has completed prerequisite interventions. Moreover, the technology can use anxiety phase detection data and subjective data from other applications like calendar apps to check the timeliness to practice interventions.

5 Limitations and Future Work

The validity of the reported results can be supported by the literature evidence, therapists' expertise, and the empirically validated interventions that they use. However, involving potential end-users (i.e., patient and general public populations) is vital to perform refinements in future work. The tentative phases and customizations suggested in this paper can be used as a starting point to investigate further and needs to be done through the collection and analysis of subjective and objective data from potential end-user populations in future research. An initial attempt towards this goal is presented in [47]. Further analysis of longitudinal data collected in the wild could yield more rigorous discoveries (e.g., modified phases, new measures to estimate patients' progress).

Achieving all the design directions indicated in this paper in a single design would not be straightforward because some of the suggested goals cannot be achieved without extensive research work. Examples include analytically detecting the factors that rule the suggested customizations; implementing various interventions, customization criteria and other design considerations; validating them through user studies over extended periods; and refining to accommodate individual differences of anxiety experience. Such efforts require collaborations in HCI, data-analytic, and psychology areas, encouraged in this paper to achieve envisioned benefits to the patient, therapists, and general public populations.

6 Conclusion

This paper contributes to a unique area of knowledge; design directions for more effective and personalized mobile assistive technologies for anxiety. As major contributions, it identifies a rich set of literature-driven and expert therapist-informed design directions for future digital intervention and digital diary technologies, including (1) a set of user's anxiety experience-specific and context-specific factors, which can be considered in guiding suitable interventions for a user, (2) preliminary directions for detecting those factors, including a conceptual framework for regular phases of anxiety; (3) potential intervention-based customizations considering those factors, which could accommodate inter- and intra-individual differences in anxiety; and (4) directions for overcoming current challenges faced by patients and therapists using proposed capabilities and for

mitigating unintended adverse consequences that new adaptive technology can raise. These contributions can draw the attention of human-computer interaction researchers to critical design directions, which incorporate clinical knowledge and analytic capabilities beyond the traditional user-interface design.

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