Exploring a Multifaceted Framework to Support the Design of Mobile Apps for Self-Regulating Anxiety

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ABSTRACT

The ubiquity of mobile devices gives rise to mobile applications designed for self-regulating anxiety, yet empirical evidence of the efficacy and safety that these apps provide is lacking. An in-depth understanding of mobile app-based support for anxiety can provide guidelines to improve future designs, including their accessibility and user experience. Our research takes one step toward filling this gap by exploring individual experiences of anxiety through semi-structured interviews with eight participants with varying anxiety experiences. Our findings indicate that mobile apps have the potential to be a supplemental tool for anxiety regulation through user-level customization, and naturalistic and trustworthy communication. We propose a framework that integrates top-down (e.g., Cognitive Behavioral Therapy) and bottom-up (e.g., Body Psychotherapy, Polyvagal Theory) therapy approaches, and Norman's Three Levels of Emotional Design to contribute to the design of mobile apps for self-regulating anxiety.

CCS CONCEPTS

• **Applied computing → Health care information systems**.

KEYWORDS

Anxiety, self-regulation, mobile apps, design

1 INTRODUCTION

Anxiety is a chronic and fluctuating state of mind causing individuals to deal with excessive worry and tension from internal and external triggers [15]; it is prevalent worldwide [23], takes many forms [13–15], results in increased need for medical services [9], and it can be very costly due to a lack of human and structural resources [1].

Mobile health apps could help to address the previously noted issues by offering an accessible support system for access to therapy [12]. For example, Pocket Skills is an app based upon solid research that provides a conversational agent designed to guide the user in learning the Dialectical Behavior Therapy method [21]. Despite increases in the development of assistive mobile technology for self-regulating anxiety and managing its prevalence, accredited research on the efficacy and safety level of mobile apps is lacking [17]. The skills and training of mobile app designers and healthcare practitioners do not often overlap, resulting in situations where appealing mobile apps for anxiety could be built without sufficient direction to ensure they offer support in a safe way. Ideally, the two professions should collaborate when creating an app, but they may not have a clear understanding of each others' views. Our work aims to establish clear guidance that acknowledges both the requirements of good interface design and therapeutic practices.

We conducted interviews with eight participants who have experienced anxiety to investigate: **RQ1** *What techniques or resources do people use to prevent, alleviate, manage or overcome their anxiety?* and **RQ2** *How can a self-regulated anxiety mobile application help prevent, alleviate or regulate anxiety?* We found that individual experiences of anxiety apply to triggers, symptoms, intervention, and regulation, which can be identified in three phases, visceral, behavioral and reflective. We found mobile apps have the potential to offer self-regulation for anxiety if they allow user-level customization that supports naturalistic and trustworthy social engagement.

Paper contribution: a novel framework to guide the design of mobile apps for self-regulating anxiety. Our framework is built upon well-known models of anxiety, therapeutic approaches, Norman's Three Levels of Emotional Design, and informed by an interview study with eight participants.

2 RELATED WORK

The design and development of **e-mental health services** has gained traction to support the self-regulation of mental health conditions, including anxiety. The term **e-mental health** refers to "*mental health services and information delivered or enhanced through the Internet and related technologies*" [5]. A literature review in this area finds that e-mental health addresses four main sections of the mental health care service: "*information provision; screening, assessment, and monitoring; intervention; and social support*" [12]. These initiatives have the potential to close the gap between the shortage of mental health services offered and the volume of those who need it. Based on 59 empirical studies, the above review reveals that most interventions primarily treat depression and anxiety [12]. Researchers believe in the potential of e-mental health (i.e., making it more accessible, convenient, and cheaper for under-served or rural populations). Yet, concerns have arisen for the research, design, development, and evaluation cost of e-mental health products. There may be a lack of quality control and standards established for the creation of these products. Furthermore, experts worry about the lack of personalization an individual may receive, potentially leading to inadequate care [12].

Mobile Health (mHealth) lies on the e-mental health spectrum of care. Prior to the mental health movement, mobile applications developed for health monitoring have been popular. In recent years, popular anxiety related mHealth mobile apps such as Calm, HeadSpace, and Relax Melodies, have been downloaded more than 10 million times each on the Google Play Store. The usage of mobile apps is more cost-effective and convenient compared to a desktop app or going to see a physician [12]. A smartphone always allows for direct access because of its computing power, connectivity, and portability. Even with the benefits mHealth apps offer, due to the lack of published information, the efficacy of mHealth apps is a concern. Much of what is available to consumers has not been rigorously evaluated [23] or incorporated the expertise of health care professionals in their design and development processes [24].

Our work seeks to address this need for improved design of mobile health apps for anxiety by drawing on four main areas: two approaches to treatment for anxiety disorders (one top-down and one bottom-up), as well as two relevant theories: the Polyvagal Theory (physiological) and Don Norman's Three Levels of Emotional Design (user experience).

Cognitive Behavioral Therapy (CBT) is a top-down approach that has strong empirical support for treating anxiety disorders [7, 10, 26]. A top-down approach focuses on the top portions of the brain (e.g., neocortex, frontal lobes and prefrontal lobes) that regulate emotion, thoughts and behavior. This model hypothesizes that individual thoughts and behaviors are based on their perception of an event rather than the event itself [10]. CBT's cognitive model has three levels (1) core beliefs: absolute beliefs developed during childhood or any other significant formative experience relating to the self, others and the world, (2) assumptions: dysfunctional rules that people live by, and (3) automatic thoughts: negative involuntary thoughts pertaining to a situation [6, 25]. In practice, the CBT model identifies present maladaptive thinking and behavior patterns, tests their validity, and works to change and manage them [7]. Acquisition of adaptive skills for this goal derives from

collaborative sessions between patient and therapist. Goal-oriented sessions are focused on 'SMART', i.e., specific, measurable, achievable, realistic and time-limited [22] techniques. These include both cognitive and behavioral techniques [19].

Body Psychotherapy is another anxiety treatment approach. This bottom-up therapy approach works with parts located at the base of the brain (e.g., brain stem) that deal with reflexes, memories, and automatic survival responses. Psychophysiology has links to two branches of the autonomic nervous system (ANS); the sympathetic nervous system (SNS), which relates to fear and arousal that can trigger the fight and flight responses, and the parasympathetic nervous system (PNS), which relates to rest, digest and sleep processes [3]. Body Psychotherapy applies the Polyvagal Theory to further explain the underlying physical mechanisms of anxiety.

Porge's **Polyvagal Theory** claims that adaptive evolution of the ANS provides adaptive behavior strategies. The nervous system picks cues from the environment to determine safety, risk, or danger factors. Based on the assessment, the nervous system puts the body into three hierarchical states used to support different behaviors; safe social engagement (the myelinated ventral branch of the vagus nerve, part of the PNS), mobilization (part of the SNS) and immobilization (the unmyelinated dorsal branch of the vagus nerve, part of the PNS) [18].

In practice, Body Psychotherapy applies the Polyvagal Theory in different modalities, such as: Bioenergetic Analysis (techniques include exercising and breathing to break down SNS tensions), Biodynamic Psychotherapy (utilizes body massage and sound for PNS stimulation), and Rubenfeld Synergy Method (combines touch with talk therapy to release tension so the body and mind can connect for ANS regulation) [3]. With ANS regulation, the Polyvagal Theory can be related to the interactions between people, artifacts in the environment, and anxiety triggers through Norman's Three Levels of Emotional Design.

Norman's **Three Levels of Emotional Design** [16], which is motivated by the human emotional system, can further be used to explain the interactions with anxiety triggers and human body. In summary, Norman suggests that an emotional system can be visualized and designed for at three levels: visceral, behavioral and reflective. In his framework, he has suggested that interface design can be improved by focusing on these components, considering how these components react to interactions with interfaces. Visceral reactions are the first level of the perception of the user experience based on attitude, belief, and feeling, which are unconscious. The behavioral level refers to controlled aspects of action in response to a product. Hence, this level concerns the usability of a product, and if the user's goals are carried out quickly, accurately, pleasurably, and requiring minimal cognitive load, emotions elicited are likely to be positive. The third level is reflective, which occurs at a more conscious state, compared to visceral and behavioral states. Reflecting is an act of rationalization and generalization applied to the evaluation of a design. All three levels of emotional design are interconnected to form the full user experience.

3 METHODS

Our review of the literature highlighted that mobile apps supporting people with anxiety have potential but the design of such services

requires more regulation. Insufficient evidence of the efficacy of mobile app usage for anxiety poses the concern about how the lack of personalization could lead to inadequate care. We conducted interviews to gain a deeper understanding of the needs of people who have experienced anxiety to inform our development of a framework (see section 5) that will offer guidance during the design process of such apps.

3.1 Data Collection and Analysis

To identify the extent that mobile apps could support self-regulating anxiety, we conducted semi-structured interviews (see Appendix A for the main questions used to guide the interviews). Our study collected contextual knowledge of participants' personal experiences of anxiety (questions 1-5) and evaluated users' perspectives on mobile app use for anxiety (questions 6-11). Our study was authorized by the Rochester Institute of Technology's Institutional Review Board and was conducted before the start of the COVID-19 pandemic.

We recruited participants who self-identified as having experienced impairments due to anxiety at some point in their life. Participants were briefed about the purpose and procedure of the study. We also provided the participants with a list of resources in case they wanted to seek additional information and counseling support for anxiety.

All eight participants (four male and four female) were based in the US. Our participants were aged 19-30. Four of eight participants (P1, P4, P5, P6) had a diagnosis of a mental health disorder from a healthcare professional. In addition, P4 and P5 reported issues relating to Obsessive-Compulsive Disorder (OCD), and P6 and P7 reported seeking assistance from a therapist. Our interviews lasted approximately 40 minutes.

To fully understand, analyze and interpret the results of the qualitative data obtained from the interviews, the first author followed Braun and Clarke's thematic analysis [4]. Furthermore, inter-rater reliability is not part of their checklist of criteria for good thematic analysis [4]. The first five phases carried out by lead author were: 1) familiarization with the data by listening to the interview audio recordings prior to transcribing them in Google Word; 2) generating initial codes by reading the transcripts line-by-line and applying codes to sections of text; 3) searching for themes by moving codes into Miro and categorizing them; 4) reviewing themes through a process of organizing them into multiple categories of codes that share common meaning to determine if they formed any patterns; 5) the themes were then defined and given descriptive names. Refinement of final themes was done with members of the research team through iterative discussions. A final sixth phase involved writing a narrative for each theme with important quotes from participants that validates the themes.

4 RESULTS

Three main themes were identified from our thematic analysis of the interviews; 1) mobile apps have the potential to be a supplemental tool for anxiety regulation, 2) anxiety is an individualized experience that requires user level customization, and 3) naturalistic and trustworthy communication provides relief.

4.1 Mobile Apps Have the Potential to be a Supplemental Tool for Anxiety Regulation

Benefits offered by mobile apps should be considered as shared by P3: *"It's probably far cheaper than having to go through a therapist and it might be more accessible and might be able to reach more people."* During this study, Calm is the only app participants (P6 and P7) mentioned using extensively for their anxiety, and those participants had the most positive view towards the benefits an app can have towards helping with anxiety.

Even though there may be many advantages with the utilization of mobile apps, it may not be appropriate for all situations, since anxiety is experienced differently by individuals. Sometimes, technology can also be a trigger and cause anxiety, as shared by P1: *"I've been trying to limit, I guess, my like, use of my phone and like stuff like that, because I think that my phone stresses me out more than anything."* Participants expressed that there are limitations to what a mobile application can offer them, as expressed by P6: *"You can't really expect an app to just fix things for you. I mean, a lot of it I think has to come internally, from yourself but that requires special knowledge on understanding human physiology, and yourself, and I think that's why a therapist is so good because you can learn those tools, but I think at the end of the day, the most important thing is it's coming from within. The app is a supplement to help with that."* For the majority, most used their phone indirectly to help them alleviate their anxiety. For example, using it as a distraction by watching YouTube videos or reading Reddit. Most did not specifically seek out anxiety related apps to help them. The majority are open to the use of an app but shared that they would not really use it.

Even though there may be potential benefits to using a mobile app to help alleviate or manage anxiety, *"there's only so much an app can do"* (P4). Participants shared that an app may be useful, but it should be a supplement, *"in the short term, it might be a great solution."* (P3), and not something they want to rely on for an extended amount of time.

4.2 Anxiety Is An Individualized Experience That Requires User-Level Customization

Mobile apps *"wouldn't relieve as much stress maybe, unless it's totally personalized and tailor to you somehow"* (P3). Varying anxiety triggers were identified; finding a job, performing well in school, attending social events, spiraling negative personal thoughts and more. Even though there were overlaps in triggers, there were still slight differences. For example, related to work, One participant dealt with the prospect of being hired while another was overwhelmed by the workload that was assigned. Differences in triggers also caused varying *"physiological symptoms"* (P1), emotional pain, and *"it's just an out of control spiral where you have like one negative thought that influences like a billion more."* (P1). Hence, participants expressed a wide range of methods of prevention and regulation for their anxiety; communication with a trusted individual, obtaining validation or reassurance, detaching from and repressing the problem, relaxation, mindfulness, meditation, focusing, re-centering, self-therapy, thought blocking, medication, or being distracted by some form of entertainment. The method of coping also tied with the severity of their expressed anxiety. For someone who experienced anxiety at a severe level, seeking help from a doctor and being

prescribed medication was helpful. Whereas for others, in the case that anxiety was accepted as a normal part of their life, sleeping it off and letting time pass alleviated it. Furthermore, even though some participants were unwilling to use a mobile application, they mentioned that it would be useful for others who may be more severe on the anxiety spectrum. Depending on the severity and hindrance to everyday functioning that anxiety can cause, cognitive overload on an app is also a concern. While the level of support needed from an application can be seen as a customization, it is also agreed that each individual needs to personally work on their anxiety at an intrinsic level.

The trade-off between privacy and a better user experience was also mentioned. For some, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) gave them reassurance when it came to the privacy of their health information. Others dismissed it due to preconceived views of corporations as evil, and mining personal data and selling it for profit is already happening. Most were weary of *"who's using the data?"* (P2), but they are willing to offer pertinent information relating to their health, and if it was managed by a trusted source with *"credibility"* (P8). P6 mentioned: *"There's a trade-off between privacy and a better experience for the user, yeah, if they track everything you did, they'd probably have the best experience, but who knows what they're doing with your data."* To help self-regulate their anxiety, participants are willing to provide pertinent information regarding their health to mobile apps.

Due to the *"wide spectrum"* (P5) of anxiety triggers, *"everybody else probably has their own thing to help alleviate the symptoms* (P5) and *"everyone has a different process"* (P6) for regulating their anxiety. Therefore, user level customization can be considered as having four stages: identifying triggers, symptoms, regulation, and intervention, which would help to guide the design process.

4.3 Naturalistic And Trustworthy Communication Provides Relief

Human interaction, primarily in person and from someone close, was preferred by the majority of participants, as mentioned by P3: *"Human interaction is usually the first one I go to. Direct human interaction, not like indirect, like through a phone or text."* This was because someone close offered a sense of comfort, as trust is already established. Trust came in the form of not being judged and understanding the individual to the point where they can be vulnerable in sharing their anxiety. Hence, validation, reassurance and acceptance from those that are close offered much value to participants.

There are circumstances where having someone to talk to, and listen to their concerns can alleviate the anxiety. The listening person does not have to be someone close, but someone who has similar experiences. The majority of participants (6/8) mentioned that talking to someone that has experience with anxiety offered some form of reassurance and validation of their situation. Although participants had individual anxiety experiences, some had preconceived ideas of what others may experience based on their own experiences. P5 mentioned that hearing from someone who also had OCD reassured him more because they are going through similar experiences, and

P4 shared: *"still [be] able to reach their goals with anxiety, I think that will give people with anxiety more confidence in like their ability"* to overcome their own struggles.

Even though communication was important, participants did not express the use of a formal support group. At times, *"people aren't always gonna be available"* (P8), so utilizing an alternative option is more acceptable. For desperate times, communication with a chatbot or artificial intelligence is acceptable. Chatbot features can *"provide that semblance of comfort"* (P8). Being heard and, *"knowing that at least something is there, just kinda listen to you, I feel like that'd be something pretty decent for a lot of people"* (P8). Social engagement, in-person or digitally, through naturalistic and trustworthy communication can help alleviate anxiety.

5 PROPOSED FRAMEWORK

Our thematic analysis indicates that mobile apps have the potential to help self-regulate anxiety with user-level customization. Therefore, we take direction from our interview data and related work to establish a framework that integrates Norman's Three Level of Design, the Polyvagal Theory, and the CBT model to guide the design of anxiety self-regulating apps. Norman's Three Level of Emotional Design not only provides an in-depth and iterative cycle to understanding and evaluating an individual's anxiety, but also recognize the influence that our technology can have on our state of mind. Our findings indicated that mobile apps can both trigger anxiety and help individuals self-regulate. Furthermore, naturalistic and trustworthy communication was also identified to be a method that can help alleviate anxiety. Therefore, we applied the Polyvagal Theory's support for safe social engagement as a behavioral category to better explain how social communication can affect anxiety and vice versa.

Our framework is a multifaceted approach. All three models contributing to this framework depict external or internal triggers affecting behavioral outcomes. The framework highlights how contextual knowledge of an individual's psychology, physiology and environment can provide insight into three phases in which anxiety manifests; visceral, behavioral and reflective. The first phase in our framework is reflective, where maladaptive behavioral patterns are identified. To uncover the cause of the negative patterns, identification of what state the body is in (e.g., safe engagement, mobilization, and immobilization) requires understanding the nervous system at the visceral level. Anxiety has been linked to the dysregulation of the ANS [2], especially the over-arousal of the sympathetic nervous system [20]. Recognizing SNS over-arousal and PNS under-arousal can help monitor anxiety [11]. Once we identify how the body has reacted to cues from the environment and manifested in a specific type of behavior, a comprehensive and customized intervention system can be created to improve a more adaptive outcome. The framework cycles through the three levels of emotional design to evaluate and understand the state of the body and mind to formulate user-level adaptive techniques for intervention of anxiety. Our framework can be used to support the design process when determining the interface and user experience of mobile apps for self-regulating anxiety.
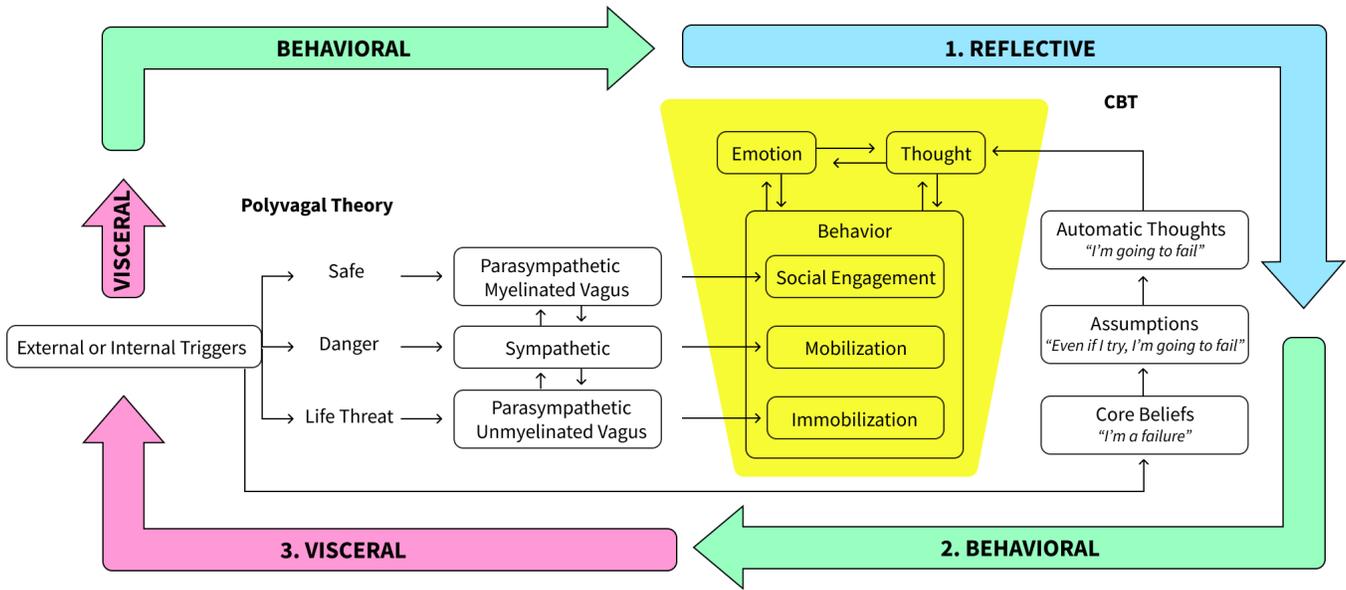
Figure 1: A multifaceted framework based on the Polyvagal Theory, Cognitive Behavioral Therapy and Norman's 3 Levels of Emotional Design.

6 DISCUSSION

6.1 A Holistic Approach

There are many approaches used to treat anxiety. CBT is a popular treatment. Unlike CBT that works to change maladaptive cognitive patterns stemming from an individual's misconstrued perception of their environment [19], the Polyvagal Theory states that the nervous system is choosing for the individual what cues from the environment may trigger danger. According to Deb Dana, a leader in applying the Polyvagal Theory as a platform in clinical work, using a top-down modality (such as CBT) will only be successful if the nervous system supports it [8]. Hence, combining both models' perspectives help form a holistic approach to better understand anxiety on a psychological and physiological level. Incorporating Norman's Three Level of Emotional Design provides guidance to how the CBT model and Polyvagal Theory can be applied to design well-thought-out interfaces and interactions.

6.2 The Design Guidance

Implementation of our framework consists of many touch points. We anticipate that our framework can be applied as a discovery phase of understanding anxiety, by helping to explain anxiety's triggers and symptoms based on three phases, visceral, behavioral, and reflective. Relating to anxiety, cues that trigger certain anxiety responses are often unknown to the individual. These cues can be viewed at a visceral phase, as the processing of information from triggers in the autonomous nervous system occurs outside of consciousness. At the behavioral phase, controllable actions such as mobilizations and engagement with or avoidance of social activities occur in response to anxiety triggers. At a reflective phase, ideation such as "I am a failure" short-circuits planned action. The regulation of anxiety can be related to the modification of visceral, behavioral

and reflective reactions from maladaptive forms to positive forms. Due to the vicious cycle of anxiety, our framework is an iterative cycle that takes into account regulation of contextual changes in triggers and symptoms. These changes will affect feature design and considerations such as language, lighting setting, sound effects, notifications, color usage and other design factors. Therefore, data aggregation pertaining to the three phases can guide interface and experience design to build user-level customized features. Features can consist of CBT and BP techniques for cognitive and behavioral goals. The app has the potential to offer well-informed features based on aggregated data from the user and integrated applications on their phone (e.g., fitness and calendar apps).

Besides features, aspects such as language should be considered. Our analysis shows that human-like natural and trustworthy communications were preferred by P5: *"To alleviate the symptoms I think the best thing you can possibly do is have someone that knows what having severe anxiety feels like and talk to you about it."* Hence, there is much room for improvement for future technologies such as chatbots, artificial intelligence and voice assistance in natural language processing. Features can be built around fostering social engagement and connection between those that have similar experiences of anxiety. Even so, promoting in-person interaction should be considered since our findings indicate that it is preferred compared to digital ones. To decrease mobile app reliance and fatigue, smart devices can be integrated. The app can connect to smart devices to track biomarkers of anxiety. A comprehensive approach can use mobile apps as a mediator between the therapist (e.g., features customized for specific goals a therapist assigns) and ANS tracking through smart wearables (e.g., utilizing biomarkers such as EEG, heart rate variability tracking to identify the ANS through a sympathetic (SNS) over-arousal and parasympathetic (PNS) underarousal state), and extrapolating that information during therapy sessions.

Our framework offers initial guidance on how the understanding of individualized anxiety experiences can be applied to design a well-informed mobile app.

6.3 Limitations and Future Work

Due to the sensitive topic of mental health, particularly anxiety, it was challenging to recruit participants. This study lays the groundwork for future research to **1)** identify optimal situational usage of mobile apps as a supplemental tool for self-regulating anxiety; **2)** validate the framework by obtaining feedback from healthcare providers; **3)** apply the framework to evaluate existing anxiety related mobile app features; and **4)** use the framework to lead research for designing anxiety related mHealth apps. We hope mHealth apps will be seen as a part of a larger system that contributes to the improvement of care and well-being for those with anxiety.

7 CONCLUSION

Our preliminary work provides insights on the potential of mobile apps in aiding self-regulation of anxiety. The importance of human engagement, naturalistic and trustworthy communication as methods to help alleviate anxiety contributes to a broader discussion for further collaboration with healthcare providers. As the field of psychotherapy becomes more integrated towards the assimilation of techniques and theories, it is crucial to apply the most up-to-date practices in a multifaceted manner. To design better mHealth apps, our framework applies Norman's Three Levels of Design, the Polyvagal Theory and the CBT Model to form a holistic approach to understanding and designing for anxiety. Our research identified a cycle of experienced anxiety through triggers, symptoms, intervention, and regulation. Based on this cycle, we offer a framework that gives guidance to identify triggers and symptoms of anxiety based on three phases, visceral, behavioral and reflective, which can be used to design for intervention and regulation.

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A INTERVIEW QUESTIONS

- Q1: *Can you describe what your anxiety experience was like?*
- Q2: *Can you recall how you felt?*
- Q3: *Did it have any negative effects on your everyday life?*
- Q4: *If yes, can you describe in what ways?*
- Q5: *How were you able to overcome or manage that experience?*
- Q6: *Have you ever used any anxiety related mobile applications before?*
- Q7: *Can you recall what it's called?*
- Q8: *Can you recall how the application helped you in any way?*
- Q9: *Were there any features that stood out for you?*

- Q10: *What desired features and capabilities for a self-regulating anxiety mobile application would you need and/or want?*

- Q11: *How much autonomy are you comfortable with the application having?*