THE DESIGN SPACE OF MOBILE MENTAL HEALTH INTERVENTIONS FOR ANXIETY MANAGEMENT

ANDREAS BALASKAS

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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
Declaration

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Signed: Andreas Balaskas  Date: 19/05/2023

COVID Impact Statement

As a consequence of the global pandemic, ethical approval for conducting studies with users of mental health apps was delayed by 2 months. This resulted in delays in recruitment procedures and data collection. Additional professional (converting teaching to remote settings) and personal responsibilities associated with the pandemic limited the time I had available for my research for 3 months.

Signed:  Andreas Balaskas  Date: 19/05/2023

Signed:  Gavin Doherty  Date: 19/05/2023
Abstract

Digital mental health is a rapidly growing area within Human-Computer Interaction. Mental health problems will affect one-third of the population worldwide during their lifetime. At the present moment, anxiety disorders are highly prevalent and are among the most common psychological disorders with an estimated 264 million adults experiencing anxiety worldwide. The significant effects of anxiety disorders make mental health a public health priority. One of the most evidence-based treatments for anxiety disorders is cognitive-behavioral therapy (CBT).

Technology advances have created the opportunity to deliver psychological interventions in daily life - a type of intervention described as “ecological momentary interventions” (EMI’s). In addition, such advances have opened up possibilities for the delivery of "just-in-time interventions" that adapt treatment delivery over time to provide interventions most likely to be effective, using information gathered through ecological momentary assessment (EMA) or sensing. The widespread availability of smartphones has led to a proliferation of mobile apps for anxiety. Such systems can be used in conjunction with therapy, as standalone treatments, or for use in the prevention of mental illness. As such, they provide an accessible solution to many barriers to care. Designing digital technologies for mental health requires navigating a complex design space, for which various design components have remained unexplored.

In addition, despite the potential benefits of using such technologies, the majority
of them fail to gain traction, the attrition rates of people using them are high, and sustained use is even rarer. Insights into consumer perspectives regarding how mobile health can best support anxiety disorder management, and how to design mobile technologies to provide an engaging experience for users are lacking. Personalizing intervention content to individual users could lead to sustained use. Yet, currently available technology-based interventions are not tailored to account for variability in different characteristics and we know little about the design options for such systems.

This thesis investigates the design of mobile interventions for mental health disorders and their potential to improve engagement for anxiety management apps. It unveils the different components that comprise such interventions, the enablers, and barriers to engagement with applications designed for that purpose, the desired features, and the possibilities of enhancing care by personalizing content to individual clients. It asks which are the technological and interaction possibilities of such systems, why users engage and disengage from mobile apps for anxiety management, and how health professionals might tailor intervention content for users of such systems. As a result, I developed a model of the various possibilities and explored the tailoring possibilities to address the issues and challenges faced by those populations.

This thesis contributes to knowledge concerning the design of mobile interventions for mental health, user engagement, and personalization. It provides insights into the design options available in those technologies and the experiences of users of mobile applications for anxiety management. First, the thesis starts with an exploration of the state of the art of EMIs by identifying the components that comprise mental health mobile interventions both in academic literature and consumer apps in practice, with a focus on the engagement and tailoring features offered through the use of these applications. This exploration allowed me to map out the different technological and
interaction possibilities of these interventions. A mixed-methods study reviewed app store reviews and interviewed app consumers to unveil the reasons for users engaging with and abandoning mobile apps targeted for anxiety disorders and provided suggestions for improvement. A user study explored daily perspectives and uncovered challenges and opportunities for the long-term engagement of participants with mobile applications of this kind. Lastly, I conducted interviews and ideation activities with mental health professionals in order to understand therapists’ current practices and identify new possibilities for delivering intervention content in between face-to-face CBT therapy sessions. Through collaboration with mental health professionals, I unveiled the possibilities for tailoring intervention content in between face-to-face CBT therapy sessions. The qualitative outcomes of these evaluations assert the potential of mobile technology to support the individual needs of people for anxiety management.

This thesis enriches the HCI field by providing a better understanding of the design space of ecological momentary interventions, including different options and perspectives on how to design engaging personalized mobile interventions in the context of digital mental health and anxiety management.
Περίληψη

Η ψηφιακή ψυχική υγεία είναι ένας ταχέως αναπτυσσόμενος τομέας του πεδίου της Αλληλεπίδρασης ανθρώπου-υπολογιστή. Τα προβλήματα ψυχικής υγείας θα επηρεάσουν το ένα τρίτο του πληθυσμού παγκοσμίως κατά τη διάρκεια της ζωής του. Οι αγχώδεις διαταραχές είναι ιδιαίτερα διαδεδομένες και συγκαταλέγονται στις πιο κοινές ψυχολογικές διαταραχές με περίπου 264 εκατομμύρια ενήλικες να βιώνουν άγχος παγκοσμίως. Οι σημαντικές επιπτώσεις των αγχωδών διαταραχών καθιστούν την ψυχική υγεία προτεραιότητα της δημόσιας υγείας. Η πιο κοινή θεραπεία για τις αγχώδεις διαταραχές είναι αυτή που βασίζεται στη γνωσιακή-συμπεριφορική θεραπεία (ΓΣΘ).

Η πρόοδος της τεχνολογίας έχει δημιουργήσει την ευκαιρία παροχής ψυχολογικών παρεμβάσεων στην καθημερινή ζωή. Επιπλέον, τεχνολογικές εξελίξεις έχουν ανοίξει δυνατότητες για την παροχή τους ακριβώς την ώρα που συμβαίνουν και προσαρμόζουν την παροχή θεραπείας με την πάροδο του χρόνου ώστε να παρέχουν παρεμβάσεις που είναι πιο πιθανό να είναι αποτελεσματικές, χρησιμοποιώντας πληροφορίες που συλλέγονται μέσω δεδομένων που παρέχει ο χρήστης ή με την συλλογή δεδομένων από αισθητήρες. Η ευρεία διαθεσιμότητα των κινητών τηλεφώνων έχει οδηγήσει στο πολλαπλασιασμό των εφαρμογών για κινητές συσκευές για το άγχος. Τέτοια συστήματα μπορούν να χρησιμοποιηθούν σε συνδυασμό με θεραπεία, ως αυτόνομες θεραπείες ή για χρήση στην πρόληψη ψυχικών ασθενειών. Ως εκ τούτου, παρέχουν μια προσβάσιμη λύση στη φροντίδα της ψυχικής υγείας. Ο σχεδιασμός ψηφιακών τεχνολογιών για την ψυχική υγεία απαιτεί την πλοήγηση σε έναν περίπλοκο
χώρο σχεδιασμού, για τον οποίο διάφορα στοιχεία σχεδιασμού έχουν παραμείνει ανεξερέ-
υντά.

Επιπλέον, παρά τα πιθανά οφέλη από τη χρήση τέτοιων τεχνολογιών, η πλειοψηφία τους
αποτυγχάνει να χρησιμοποιηθεί ετερόλειτο. Τα ποσοστά των ατόμων που σταματούν να τις χρησι-
μοποιούν είναι υψηλά και η συνεχής χρήση είναι ακόμη πιο σπάνια. Λείπουν πληροφορίες
χειρισμό με τις αποφυγής των χρηστών για τον τρόπο με τον οποίο οι εφαρμογές των κινητών
τηλεφώνων που αφορούν την ψυχική υγεία μπορεί να υποστηρίζουν καλύτερα τη διαχείριση
της αγχώδους διαταραχής και τον τρόπο σχεδίασης τεχνολογιών κινητής τηλεφωνίας για να
παρέχουν μια ελκυστική εμπειρία στους χρήστες. Η εξατομικεύση του περιεχομένου των ε-
φαρμογών σε μεμονωμένους χρήστες θα μπορούσε να οδηγήσει σε συνεχή χρήση. Ωστόσο,
οι επί του παρόντος διαλογισμοί θεραπείες βασιζόμενες στην τεχνολογία δεν είναι προσαρμο-
σμένες για να λάβουν υπόψη τη μεταβλητότητα σε διαφορετικά ανθρώπινα χαρακτηριστικά και
γνωρίζουμε ελάχιστα για τις επιλογές σχεδιασμού για τέτοια συστήματα.

Αυτή η διατριβή διερευνά περαιτέρω τον σχεδιασμό των εφαρμογών για δια-
tαραχές ψυχικής υγείας και κινητά τηλεφώνα για τη δια-
ταραχές ψυχικής υγείας και τις δυνατότητες τους να βελτιώσουν την ικανότητά τους για
παραχή αποτελεσματικής βοήθειας για την διαχείριση του άγχους. Παρεισχίζει τα διαφο-
ρετικά χαρακτηριστικά που περιλαμβάνουν τέτοιες εφαρμογές, τους λόγους που οδηγούν
σε χρήση, τα επιθυμητά χαρακτηριστικά, τα εμπόδια που αποτρέπουν την συνεχή χρήση
και τις δυνατότητες για βελτίωση της αποτελεσματικότητας της εξατομικεύσης στην
περιεχομένου σε μεμονωμένους χρήστες. Ερευνά ποιες είναι οι τεχνολογικές δυνατότητες και
tα χαρακτηριστικά τέτοιων εφαρμογών, γιατί οι χρήστες ψυχικών και σταματούν
να χρησιμοποιούν τέτοιες εφαρμογές στις χιλιάδες υστερείες για τη διαχείριση του άγχους
και πώς οι επαγγελματίες υγείας μπορούν να προσαρμόσουν να εξατομικεύσουν το
περιεχόμενο τους για τους χρήστες τέτοιων συστημάτων. Ως αποτέλεσμα, ανέπτυξε ένα
μοντέλο των διαφόρων δυνατότητας και διατριβή τις δυνατότητες εξατομικεύσης για την
αντιμετώπιση των ζητημάτων και των προκλήσεων που αντιμετωπίζουν αυτοί οι πληθυσμο-
Αυτή η διατριβή συμβάλλει στη γνώση σχετικά με το σχεδιασμό χινητών εφαρμογών για την ψυχική υγεία, την συμμετοχή των χρηστών και την εξατομίκευση. Παρέχει πληροφορίες που αφορούν τις επιλογές σχεδίασης οι οποίες είναι διαθέσιμες σε αυτές τις τεχνολογίες και τις εμπειρίες των χρηστών εφαρμογών για τη διαχείριση του άγχους. Αρχικά, η διατριβή ξεκινά με μια εξερεύνηση της τελευταίας τεχνολογίας των παρεμβάσεων ψυχικής υγείας με τον εντοπισμό των τεχνολογικών χαρακτηριστικών που περιλαμβάνουν αυτές οι εφαρμογές τόσο στην ακαδημαϊκή βιβλιογραφία όσο και στην αγορά, με εστίαση στις δυνατότητες χρήσης και εξατομίκευσης που προσφέρονται μέσω της χρήσης αυτών. Αυτή η εξερεύνησή μου επέτρεψε να χαρτογραφήσω τις διαφορετικές τεχνολογικές δυνατότητες αυτών των εφαρμογών. Με την χρήση μικτών μεθόδων εξέτασα τις κριτικές των χρηστών των εφαρμογών αυτών στην αγορά και διεξήγαγα συνεντεύξεις από χρήστες τέτοιων εφαρμογών για να αποκαλύψω τους λόγους για τους οποίους οι χρήστες χρησιμοποιούν και σταματούν να χρησιμοποιούν τέτοιες εφαρμογές που στοχεύουν σε αγχώδεις διαταραχές και παρέχει προτάσεις για βελτίωση. Επιπλέον, διεξήγαγα μια μελέτη δυο εβομάδων με χρήστες για να διερευνήσω τις καθημερινές απόψεις και χρήση με αυτές τις εφαρμογές και να αποκαλύψω πως παρακάτω παραδείγματα και ευκαιρίες για βελτίωση με σκοπό τη μονοπρόθεσμη ενασχόληση των χρηστών με εφαρμογές αυτών του είδους. Τέλος, πραγματοποιήσαμε συνεντεύξεις και δραστηριότητες με επαγγελματίες επικοινωνίας στην ΓΣΘ και θεραπευτές που παρέχουν πρόσωπο με πρόσωπο με πρόσωπο με πρόσωπο. Μέσω τους συνεργασιών με επαγγελματίες και επεξεργασίας της επικοινωνίας, αποκαλύβα της δυνατότητας εξατομίκευσης του συνεργατικού επικοινωνιακού περιβάλλοντος των ανθρώπων για τη διαχείριση του άγχους.
Αυτή η διατριβή εμπλουτίζει το πεδίο Αλλελιπίδρασης ανθρώπου-υπολογιστή παρέχοντας μια καλύτερη κατανόηση του χώρου σχεδιασμού των εφαρμογών για την ψυχική υγεία, συμπεριλαμβανομένων διαφορετικών επιλογών και προοπτικών για το πώς να σχεδιάζουμε εξατομικευμένες εφαρμογές που υιοθετούν τους χρήστες και οδηγούν σε μακρο-χρόνια χρήση στο πλαίσιο της ψηφιακής ψυχικής υγείας και του άγχους.
I would like to thank my principal supervisor, Prof. Gavin Doherty, and my external supervisors Anna L. Cox, and Stephen M. Schueller for their wisdom, precious guidance, and kindness throughout these four years. I am extremely grateful for the support I received for my research. It would not have been possible without their tenacity and insight. You all helped me develop professionally and become a better researcher.

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Andreas Balaskas,
University of Dublin, Trinity College
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Στην οικογένειά μου και στους υπέροχους παππούδες μου Ανδρέας και Ευδοξία, και Ανδρέας και Ελένη.
**Associated publications**

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Anxiety disorder

Anxiety disorder is a term used to describe a variety of different type of disorders. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) describes the different types of disorders including generalized anxiety disorder (GAD), panic disorder/agoraphobia (PAD), separation anxiety, social anxiety disorder (SAD), specific phobias, and selective mutism.

Customization

Customization is initiated by users and allows the modification of app features based on their preferences.

Cognitive Behavioural Therapy (CBT)

Cognitive Behavioural Therapy is a skills-based psychotherapy treatment that attempts to educate clients about the link between their thoughts, actions, and emotions and to provide skills to break this link. CBT is one of the most evidence-based treatments for anxiety disorders.
Computer-assisted therapy

Computer-assisted therapy is psychotherapy that utilizes a computer program to deliver a significant part of the therapy content or uses a computer program to assist the work of the therapist.

Ecological Momentary Assessment (EMA)

Ecological Momentary Assessment (EMA) is the repeated assessment of user experiences in real-world contexts, in real-time.

Ecological Momentary Interventions (EMI)

Ecological momentary interventions are treatments that are provided to people during their everyday lives (i.e. in real time) and in natural settings (i.e. real world). Treatment is delivered using mobile technology, and can be implemented standalone or as a supplement to existing treatment.

Human-Computer Interaction (HCI)

Human-computer interaction refers to the academic field and study of how people interact with computers and how technology is designed and used to successfully support peoples’ interactions within their everyday life.

Just-in-time Adaptive Interventions (JITAI)

A just-in-time adaptive intervention is an intervention design that adapts the provision of support (e.g., the type, timing, intensity) “over time to an individual’s changing status and contexts, ” with the goal to deliver support “at the moment and in the context that the person needs it most and is most likely to be receptive using information gathered through Ecological Momentary Assessment (EMA) or sensing.”
Mental Illness  Mental illness is a condition which causes serious disorder in a person’s mental health and refers all diagnosable mental disorders.

User Engagement  As the concept of engagement is broad and depends on the context that will be examined, we define engagement in each individual study by considering specifications (and definitions) for different subdomains examined in this thesis.

Personalization  Personalization is a process that aims to improve the relevance of an app to a user by changing its characteristics and content. Personalization is used to tailor the user’s experience based on their previous behaviors.

Tailoring  Tailoring in the context of technology-based interventions most often refers to the adjustment of technology-delivered self-help programs to suit the user’s needs, characteristics, and comorbidities of case formulation. In this thesis, we distinguish personalization and customization based on the nature of human involvement.
Introduction

1.1 Overview

Mental health disorders are highly prevalent and advances in technology open up new opportunities for supporting the delivery of mental health treatment. However, our understanding of the functionality and potential of such systems is incomplete. One of the most significant opportunities for improving mental health support with the use of apps is the provision of treatment in real-time and in natural settings to provide in-the-moment support, termed ecological momentary intervention. This thesis examines the characteristics of mobile mental health interventions, how to support the design for engagement, and personalize intervention content for mental health interventions for anxiety management. It reviews the set of technological and interaction possibilities of such systems, identifies reasons for and barriers to engagement, and attempts to understand the possibilities of tailoring intervention content. This section presents an overview of the field of mobile technologies for mental health and describes the associated challenges and opportunities which motivate this Ph.D.
work.

1.1.1 Mental Health & Anxiety Management

Mental health disorders are among the leading causes of disability. Psychological disorders are characterized by impairments in thoughts, feelings and behaviors (1). It is estimated that one-third of the population worldwide will be affected by a mental health disorder during their lifetime (2, 3, 4).

Anxiety disorders are among the most common class of mental health disorders. It is estimated that 264 million adults experience anxiety worldwide (5). Anxiety disorders affect functioning in daily life, and cause avoidance behaviors, excessive feelings of worry and fear, and a variety of physical symptoms such as sweating, and increased heart rate (6). It is optimal to target anxiety symptoms in real time since real-life situations impact anxiety symptoms in real-world natural settings. A possible solution to this is the delivery of psychological interventions while people are engaged in their typical routines in their everyday life, a class of systems called Ecological Momentary Interventions (EMIs).

The most common treatments for anxiety disorders are those based on cognitive-behavioral therapy (7, 8). Previous studies have shown that cognitive behavioral therapy (CBT) is an effective treatment for anxiety disorders (9, 10, 11, 12). CBT is a skills-based treatment that attempts to educate clients about the link between their thoughts, actions, and emotions and to provide skills to break this link. It is more common for CBT to be delivered in a clinical setting where the client and therapist work together to break a vicious circle of altered and unhelpful thinking and behavior patterns.

1 This thesis includes some work specifically related to EMIs, which are a particular form of mobile health app, as well as work more generally related to mobile mental health apps, but with a particular focus on the possibilities of EMIs in terms of personalization.
Technology advances have created new opportunities for the delivery of internet and mobile-based solutions for expanding treatment delivery methods to increase the reach of mental health care.

1.1.2 Smartphones & Mobile Applications for Mental Health

By 2023 the number of mobile broadband subscriptions is expected to reach 8.3 billion while the number of smartphone subscriptions is expected to equal about 70% of the world’s population (13). In the meantime, the proliferation of health apps, and mental health apps in particular, has increased the need for research on mental health interventions. It is estimated that more than 10,000 apps targeting mental health disorders are available (14, 15). Apps can be used to deliver a range of intervention strategies, provide information about mental health, and enable real-time communication with health care professionals. Mental health apps can be used in conjunction with therapy, as standalone treatments or for use in prevention of mental illness (16).

A core feature of smartphones is that they are used in a variety of situations throughout daily life, and thus provide broad reach for the delivery of interventions. Furthermore, the powerful computational capabilities of smartphones, the introduction of sensors, and the ability to connect other wearable devices provides the opportunity not only to give support at opportune or high-risk moments, but also to predict when they might occur.

Young adults are increasingly interested in seeking support since the pandemic began (17). Rates of mental health distress, including anxiety and loneliness, increased during the pandemic as closures and physical distancing disrupted school, work, and social activities (18, 19). Unfortunately, access to traditional face-to-face therapy for individuals with an anxiety disorder in many countries is limited by cost and availability (20, 21, 22, 23). There is an expanding need for mental health services among
students on college campuses in the past few years that has led to long waitlists for University counseling centers for students seeking treatment (24). The economic barriers to the delivery of treatment in traditional clinical settings are daunting (23). In light of these reasons, there is much interest in developing new forms of treatments for common mental health conditions, including anxiety disorders.

Clinicians and adults awaiting support for their mental health recognize the need for alternative forms of intervention such as the use of apps which hold the potential to address barriers in mental health service delivery (25, 26). Smartphone apps could fit within current models of mental health care, in which low-cost, easily accessible, and low-intensity interventions are offered as a first step in treatment, with more intensive resources reserved for those who fail to respond (27, 28). Anxiety is a common reason people search for mental health apps (29). The clinical symptoms of anxiety disorders raise some unique considerations for apps intended to support anxiety management. The symptoms of anxiety disorders might also impact one’s motivation and interest in using a mental health app to self-manage these symptoms. As such, the characteristics of anxiety disorders and the treatments that are effective at addressing them, might guide the features of apps intended to promote anxiety management. Although some research has examined users’ opinions of mental health apps for specific conditions and target groups, there is a need for a greater understanding of users’ burden and engagement with mobile apps for anxiety management.

1.1.3 Engaging Users with Mental Health Apps

Despite the proliferation of mental health apps, the majority of them fail to gain traction (30) and sustained use is rare (30, 31, 31, 32). Even though the number of mental health apps available is increasing, there are high attrition rates among all mobile applications (33, 34, 35, 36). Mobile apps are not often used daily nor for a long period
of time (30, 31, 32), with evidence suggesting that most mental health apps are rarely used after being downloaded and only opened a few times (37). Recent studies examining engagement with popular mental health apps from commercial marketplaces found that only 4% of users who downloaded a mental health app opened it again after 15 days (31), only a small number of apps have attracted a substantial number of active users, and 56% of anxiety apps had no monthly active users (30). These variations in app usage indicate that we need to understand more about the interactions of users with different app features. In order to facilitate sustained app usage, we need to get more insight into user experiences (30). In addition, mental health interventions that are empirically supported and tested are not necessarily widely used, and popular apps may not have been tested in credible ways (14, 38).

High attrition rates may be attributed to the lack of knowledge regarding the translation of treatment elements in CBT into engaging digital elements, the loss of a therapist-client relationship, the lack of individualized treatment, and the omission of important therapeutic components (e.g. opportunities for live exposure tasks) (39, 40, 41). Hence we need to understand not just the content in mental health apps from the viewpoint of evidence-based strategies, but also from the point of view of engagement elements and other features relevant to digital delivery. Effective use of mobile applications has the potential to increase access to evidence-based care and engage users actively in treatment (42).

Self-management is a critical component of many mental health interventions, this however places a burden upon the user. To design for engagement, it is crucial to understand users’ reasons for and the barriers they perceive to using these apps. This would provide researchers in digital health with a better understanding of users’ self-management practices with such apps, and of the different design aspects that affect user adoption and sustained use. This understanding will in turn facilitate develop-
ers in the development of apps that are usable and more effective.

User studies are valuable for understanding the underlying reasons why people may engage with some apps more than others (43). Alongside engagement in real-world settings, increasing client engagement in therapeutic activities between sessions is equally important. People with mental illnesses are faced with cognitive and motivational challenges and symptoms are often contingent on life events and social contexts, which are hard for systems to capture and predict (44). In these situations, the efficacy of technology-supported therapy may be bolstered by inviting therapists to contribute to the tailoring of apps based on their own circumstances and needs.

It has been found that personalized health interventions are more effective than the ones employing a one-size-fits all approach in depressive and anxiety disorders (45, 46). Systems that are adaptable and tailored to users’ needs can deliver more pertinent information, thus enhancing user engagement and clinical efficacy (47, 48). Yet, we currently know little as to how therapists’ input might be best integrated into the personalization of mobile technologies, how therapists view this possibility, and which features and content are perceived as worth shaping.

It is important to understand therapists’ perspectives on the delivery of tailored intervention content to users of mental health mobile technologies for anxiety management. Through this understanding, we can uncover a greater range of possibilities for the design of personalized mobile applications for therapist-supported CBT.

This thesis examines the design of mobile apps that operate both before and during therapeutic sessions. The focus outside of the clinical setting is on the design possibilities of mobile mental health interventions, both of research and consumer applications. The aim is to understand the set of technological and interaction possibilities of such systems, the enablers and barriers to engagement, and provide suggestions
for improvement. Inside the therapeutic sessions, the focus is on understanding how we can design personalized technologies to support user engagement.

To conclude, several gaps in mental health for anxiety management have been identified. First, the design options of mobile mental health interventions currently available for anxiety management are unknown. Second, users’ needs and perspectives regarding anxiety management have not been systematically addressed. In addition, there are no user studies in deployment settings that investigate the daily usage of such apps with a focus on understanding the reasons and barriers to engagement at particular time points. Third, the different strategies to personalize intervention content from therapists’ viewpoints have not been documented. This thesis aims to address these gaps to capitalize on the unique opportunity provided by advances in technology to support design for anxiety management. The specific objectives and the ways in which each gap is addressed are outlined in the following sections.

1.2 Understanding a Design Space

The notion of design space is a common concept in the design research literature. Even though many authors have used this term, few define it explicitly. The term has been used to refer to all design-relevant information that is available in the design process (49). Generally, the concept of design space is used to highlight that, during the initial stages of a process, there is the freedom to choose from many options and to explore alternatives (50, 51). Others have reconceptualized the concept of design space as the space of possibilities for realizing a design, which extends beyond the concept design stage into the design-in-use activities of people (52). In this thesis, we use Westerlund’s elaboration of the concept of design space, in terms of a conceptual tool to design and understand design processes (50). In this context, design
space refers to all possible design solutions. This concept suggests that it is actually the solutions that are actively used when designing instead of describing the process as it would start from a problem (50). Westerlund recognizes that in reality, the design space is an extremely complex multi-dimensional space containing an endless amount of solutions, but they are here only interested in it as a concept (50). The approach is to focus on understanding the available possibilities before deciding on a solution instead of talking about solutions in relation to problems. The author argues that "it is the artefact that does not yet exist that is in focus during the work. All these possible artefacts make the design space." Knowledge and experience of the design space are constructed during the design process by identifying all the possible solutions and by understanding what works and what does not (50). In this thesis, we will refer to the design space as the space/representation of the range or set of potential design options that can be used during the process of designing a system or solution. This will enable us to develop an up-to-date understanding of the different possibilities for the design of mental health technologies. Figure 1.1 shows illustrations representing the design space and how knowledge is gradually constructed based on findings from different studies.

HCI designers can choose to work with many different methods and techniques to approach problems that require a solution. Westerlund highlights the distinction between exploratory and experimental approaches. The emphasis of an experimental approach is on determining the adequacy of a proposed solution often resulting in yes or no answers. In this thesis, we took an exploratory approach which has the “emphasis on clarifying requirements and desirable features of the target system and where alternative possibilities for solutions are discussed” (53).

This thesis offers an understanding of the design space of mobile applications, with a particular focus on ecological momentary interventions for mental health. It brings
Figure 1.1: Illustrations showing how the design space evolves during research
together the set of technological and interaction possibilities that are evolvable over
time, an understanding of the design of mobile applications for anxiety management
to engage and support sustained use for end-users, and the design of personalized
mental health interventions to which users can relate.

1.2.1 Designing for Complexity

Design problems are complex in nature. Horst Rittel formulated the description of
wicked problems in an attempt to capture the nature of design problems (54). Wicked
problems are defined as a "class of social system problems which are ill-formulated,
where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing." (54). There are no definitive conditions or limits to design problems. Designers are tasked with complex problems that require a solution. There is a need to understand technologies on multiple levels simultaneously – as technological artifacts, social facts, and cultural narratives (55). Understanding the notion of "wicked problems" in design should help us to realize that design work is about focusing on the existing possibilities for each problem and not just focusing on the problems themselves. HCI emphasizes the importance of process in building user experiences through human-centered approaches (56).

### 1.3 Research Questions

This thesis aspires to support designers of mental health technologies in understanding the different possibilities of such technologies, and support engagement, and personalization across the different stages of the user journey. This thesis aims to understand how EMIs can be designed to provide appropriate tailoring of therapeutic content to engage users with an app (See Figure 1.2: Research flow for the investigation of the design space). Specifically, this thesis aims to answer the following questions:

1. How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?

2. What is the functionality of mobile mental health interventions for anxiety both in the academic literature and in practice?

3. What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?
4. What perspectives do therapists have on how to deliver tailored intervention content to users for anxiety management?

1.4 Contributions

This thesis contributes to the field of HCI, particularly the questions of design, user engagement, and personalization. The contributions of this PhD work include:

- A review of the definitions used across the literature to describe EMIs for mental health disorders, and to categorize the design options available for the deployment of these interventions. This thesis extends existing knowledge and contributes to the design of mental health interventions by (i) defining ecological momentary interventions for mental health (ii) identifying the set of technological and interaction possibilities of such systems. This work has been published in Plos ONE (Balaskas, Schueller, Cox, & Doherty, 2021).

- The exploration of the functionality of publicly available mobile mental health apps for anxiety management that integrate CBT, with a focus on engagement and tailoring systems. The thesis reviews how cognitive behavioral elements are delivered by anxiety apps and their functionalities to support user engagement. Additionally, the different strategies used to personalise treatment by tailoring intervention content to suit different groups and user needs are unveiled. This work has been published in JMIR mhealth and uhealth (Balaskas, Schueller, Cox, & Doherty, 2021).

- The investigation of the nature of user burden and engagement with mental health apps targeting anxiety management. This thesis also discusses ways to improve engagement with such apps. This thesis describes a mixed-methods study, by reviewing app store reviews of 5 CBT-based apps that present some
evidence of effectiveness for anxiety management and interviewing 15 users of consumer mental health apps. It extends the existing literature by highlighting and distinguishing barriers preventing adoption and sustained use, and by exploring users’ experiences with apps targeting anxiety management. This work has been published in Frontiers Digital Health (Balaskas, Schueller, Cox, & Doherty, 2022).

- The exploration of the daily perspectives on the usage of mental health apps for anxiety management that integrate CBT, with a focus on understanding reasons for and barriers to app use and engagement. This thesis describes a two-week user study exploring this objective by recruiting young adults on the waitlist to receive treatment. This work offered the opportunity to understand how apps are used in daily life and the reasons affecting user interactions at different time points. This work has been published in PLOS Digital Health (Balaskas, Schueller, Cox, Rashleigh & Doherty, 2022).

- Clinicians’ perspectives on the investigation of the different possibilities for personalizing intervention content. This work was developed with two aims. First, it intended to understand therapists’ practices relevant to the tailoring of therapy delivery to individuals, and client engagement with therapy. Second, it identified new possibilities for tailoring intervention content in-between face-to-face CBT therapy sessions. It provided an understanding of the different possibilities for the delivery of personalized content to meet individual needs. This work explores these objectives by conducting semi-structured interviews and ideation sessions with therapists experienced in providing CBT treatment to people with anxiety disorders. This work has been submitted for publication.

- This thesis advances our knowledge on the set of technological and interaction possibilities of digital mental health interventions, so far under-explored in the
field. It identifies a set of implications for designing mental health interventions for anxiety management on mobile applications with a focus on supporting engagement, and discusses the implications for designing personalized systems in clinical settings.

Overall, this thesis resulted in a new understanding of the design options for mobile technologies for anxiety management to support user engagement and personalization, informed by analysis of the state of the art, user perspectives and experience, and therapist perspectives.
<table>
<thead>
<tr>
<th>Investigation of EMI Design space</th>
<th>Chapter</th>
<th>Main Activities</th>
<th>Research Questions</th>
<th>Objectives</th>
</tr>
</thead>
</table>
| Understanding the functionality of mobile mental health applications | 3       | Study 1        | PhD RQ Answered   | 1. To provide an overview of the definitions given for “ecological momentary interventions” in the treatment of common mental health disorders  
2. To describe the set of technological and interaction possibilities which have been used in the design of these interventions. |
| Scoping Review Methodology      |         | RQ1. How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?  
RQ2. What is the functionality of mobile mental health interventions for anxiety both in the academic literature and in practice?  
RQ’s specific to study  
A. How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?  
B. What characterizes an ecological momentary intervention (EMI), and on what dimensions might we categorize EMIs?  
C. Are they defined consistently across different application areas, and to what extent have the potential features been explored in these application areas? | |
|                                  | 4       | Study 2        | PhD RQ Answered   | 1. To review how cognitive behavioral elements are delivered by anxiety apps  
2. To review their functionalities to support user engagement and tailoring based on user needs. |
| Systematic Review and Analysis  |         | RQ2. What is the functionality of mobile mental health interventions for anxiety both in the academic literature and in practice?  
RQ’s specific to study  
A. What is the functionality of publicly available mobile apps for anxiety that integrates CBT focusing on content delivery, including engagement and tailoring features? | |
| Understanding users’ perspectives on the functionality of apps | 5       | Study 3        | PhD RQ Answered   | 1. To understand the user burden of, and motivations for, engagement with mobile apps for anxiety management  
2. To identify ways to improve the design of the apps |
| Mixed-methods study (User review analysis & Semi-structured interviews) |         | RQ3. What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?  
RQ’s specific to study  
A. What are the views and perspectives of users on the functionality of mobile apps for anxiety?  
B. What are the main barriers to engagement  
C. How could the apps be improved to support user engagement | |
<table>
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<tr>
<th>6</th>
<th>Study 4</th>
<th>PhD RQ Answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>User study (Two-week study)</td>
<td></td>
<td>RQ3. What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?</td>
</tr>
</tbody>
</table>

**RQ’s specific to study**

A. How are mobile apps for anxiety management used in daily life?
B. What are the engagement problems occurring during app use at particular time points?

<table>
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<tr>
<th>7</th>
<th>Study 5</th>
<th>PhD RQ Answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed-methods study (Semi-structured interviews &amp; Ideation activities)</td>
<td></td>
<td>RQ4. What perspectives do therapists have on how to deliver tailored intervention content to users for anxiety management?</td>
</tr>
</tbody>
</table>

**RQ’s specific to study**

A. What are the current therapy practices relevant to the tailoring of therapy delivery to individuals, including strategies therapists use to engage clients with therapy?
B. What perspectives do therapists have on how to deliver customized intervention content to anxiety management users of mental health mobile technologies?

---

1. To explore the daily use of commercially-available mobile apps for anxiety that integrate CBT
2. To understand reasons for, and barriers to, engagement during app use

1. To understand therapists’ practices in regard to facilitating client engagement with therapy
2. Identify new possibilities for tailoring intervention content in between face-to-face CBT therapy sessions with therapists’ input

---

**Figure 1.2: Thesis outline**
1.5 Research Approach

The basic strategy draws on several methodological choices that are common to design research. Digital mental health is a highly complex context for research and design, combining the individual significance of engagement with mental health apps for anxiety management, the daily and long-term use of such technologies by this group, therapists’ diverse practices, and expectations for the personalization of the apps of this kind. HCI researchers are interested in establishing what works and why.

A distinction in research approach can be made between the research questions presented in the previous section. It is important that the methods of data collection and analysis fit the research question (57, 58). Traditional research methods can be characterised as either positivist (quantitative) or interpretivist (qualitative). Interpretivist approaches can provide knowledge to understand why systems work, the correlation between different systems, as well as insights required to support the action of design. It allows researchers to develop a deeper understanding of the data (59). In HCI research it is common to use qualitative methods to gain an understanding of the use of technology in context. While quantitative methods are often used in the evaluation of technologies and are useful for understanding large datasets, qualitative studies usually consist of smaller numbers of participants but provide rich, descriptive data (57). These methods allow understanding the design features that are appealing and relevant to users (57). The research topics formulated by the research questions were mostly exploratory seeking new insights and assessing phenomena in a new light. Therefore, this design investigation does not follow a single methodology but is underpinned by well-known perspectives and tools that support the research agenda.
The research design is a general plan for how to answer the research questions. A qualitative research design was selected as a type of research design since it focuses on understanding and interpreting human behavior, experiences, and social phenomena through the collection, analysis, and interpretation of non-numerical data. Qualitative research design is a plan for a qualitative research project, including the formulation of a research question and who to integrate in the research (sampling) (60). This type of research relies primarily on collecting qualitative data (i.e., non-numerical or categorical data such as words and pictures etc.), and can be either interactive or non-interactive (i.e. whether the researcher is personally immersed in the research or not) (61). Qualitative research seeks meaning and understandings about processes and phenomena, with attention to narratives, personal experiences, and language. The aim of qualitative research is not to find significance in numbers but rather in themes that emerge from narratives indicative of common human experiences (62, 63). It is often used when the research questions or objectives require an in-depth understanding of human experiences, perspectives, and meanings. We used a review methodology approach in the first two studies in order to unveil the different technological and interaction possibilities of mobile mental health apps. Qualitative studies- whether structured, semi-structured or ethnographic- most typically focus on understanding technology use, or future technology needs, in situated settings (58). A multiple-method qualitative research approach was applied for the rest of the thesis and was selected based on its ability to increase our understanding of the users’ needs from mental health technologies for anxiety management. In particular, we selected a methodology that was open to the discovery of new possibilities and that would enable us to delve deeper into users’ perspectives and needs.

Mixed methods research is the class of research where the researcher mixes or combines quantitative or qualitative research techniques, methods, approaches, concepts
or language into a single study (64, 65). The main purposes for conducting mixed methods research in this thesis include triangulation (i.e., seeking convergence and corroboration of results from different methods and designs studying the same phenomenon), complementarity (i.e., seeking elaboration, enhancement, illustration, and clarification of the results from one method with results from the other method), and development (i.e., using the findings from one method to help inform the other method). In a qualitative mixed method design, one component provides the theoretical base, while the other complements it. Mixed method qualitative design is used when qualitative data types, levels of analysis, or participant perspectives are different enough that it is necessary for the two methods to be handled differently and to be kept apart (65). Mixed methods enable qualitative researchers with the designs and principles to handle problems of increasing complexity, and these advances will move qualitative inquiry forward (65, 66). As previously discussed, this research project was split into five stages, each with its aims and objectives. This research also pursued the concept of ‘complementarity’ to inform the design of individual studies. In each study, the design was influenced by the previous one. The first two studies used a systematic approach to identify all the different components of mobile apps with a particular focus on ecological momentary interventions for mental health in academia and consumer apps in practice. Chapter 3 identified the different functionalities of mobile apps in academic settings. Taking the next step, in chapter 4 we explored further the functionalities of publicly mobile apps that are available to download and use. Having identified the existing app functionalities, we explored users’ reasons for and barriers to using these apps. This helped to inform the design of apps that are more usable and effective. Chapter 5 was a mixed-method study that collected qualitative data from different sources to counterbalance inherent biases in each method. The studies provided complementary insights that together provided a
more comprehensive understanding of users’ perspectives that would not have been achieved by either study alone. The study in Chapter 6 was designed as a sequential exploratory study because we aimed to explore further the view of users with mobile apps for anxiety management in daily life and to use as adjunct support for those on the waitlist to receive treatment. The goal was to extend the previous work by collecting qualitative and quantitative data to understand barriers and enablers to engagement at particular time points. To increase user engagement, the above studies demonstrated the need to enhance mobile app personalization. In response to this, a final study was designed.

In the last study, we conducted a qualitative analysis of semi-structured interviews and ideation activities with therapists to explore the possibilities of delivering tailored intervention content and using mobile apps as an adjustment in-between therapy sessions. Data were collected from therapists who have experience providing CBT therapy for people with anxiety disorders. As the work of this thesis employs multiple methodologies and has an exploratory character, each chapter provides its own methodological outline. Details of each study design, tools, participants, recruitment, and so on, are described in depth inside the chapter concerning the particular study. This organizational choice was made in order to make the content of this thesis more coherent, fluid and readable, given that it presents five unique studies, each with their own particularities.

1.5.1 Interdisciplinary Research

Interdisciplinary collaboration between the disciplines of HCI and psychology constituted much of the work in this thesis. In order to realize the potential of these technologies to improve service delivery, a collaboration between disciplines in health research is needed (67). Multi-disciplinary expertise in the areas of mental health and
Human–Computer Interaction are needed to identify user needs and develop and evaluate each intervention (68). The design of digital health interventions can benefit from the knowledge of users, health professionals, and HCI specialists.

In terms of developing and evaluating health technologies, HCI and health researchers take different approaches. The gold standard in health research to determine effectiveness of an intervention is the use of randomized controlled trials (RCT) (68). However, HCI research involves stakeholders from different disciplines to gain knowledge important for the design and development of such technologies. This ensures the design of future technologies that can improve engagement outside of study environments.

This thesis draw skills from both HCI and mental health domains in order to answer research questions and to best achieve the overall aims of the thesis. This was achieved by either interdisciplinary skills that the researcher has had to acquire or by interdisciplinary collaboration. This was especially necessary for Chapters 5 and 6 which involved interviews and a user study. The HCI researcher received guidance from a leading researcher in the field of psychology. Collaborations with therapists were valuable in Chapter 7. These studies were possible through collaboration between six co-authors, three from HCI (the researcher, Dr. Kevin Doherty, and Dr. Gavin Doherty), one from neuroscience (Prof. Anna L. Cox), and two from psychology (Dr. Stephen M. Schueller and Chuck Rashleigh).

1.6 Thesis Structure

The remainder of this thesis is organized as follows:
Chapter 2 – Literature Review
This chapter examines the notions of mental health, EMIs, user engagement, and personalization. It provides an introduction to mental health and anxiety disorders in particular. It reviews the concepts of ecological momentary interventions, user engagement, and personalization, including approaches to design such concepts in Human-Computer Interaction. Then, it examines the relevant literature on user engagement and personalization with mental health technologies.

Chapter 3 – Defining “Ecological Momentary Interventions” & exploring their functionality | Scoping Review
This chapter presents a scoping review of the literature by exploring how researchers involved in the creation of mental health technologies understand the notion of “ecological momentary interventions” and by categorizing the design options available for the deployment of these interventions. Informed by this analysis, we define “ecological momentary interventions” for mental health and unveil all the different technical characteristics of such systems.

Chapter 4 – Exploring the functionality of commercial mobile apps for anxiety management | Analysis of engagement and tailoring features
This chapter investigates the functionality of commercial mobile apps for anxiety management with a focus on content delivery, engagement, and tailoring features. We conducted a systematic search for anxiety apps described as being based on cognitive behavioral therapy (CBT) on Android and iPhone marketplaces. In this chapter, 36 mobile apps for anxiety management that integrate CBT are reviewed through direct use for their functionality features and different features that encourage regular use, enhance the appeal of app content, and help users remain engaged with therapy or the app in general. In addition, through regular direct use of such apps,
we revealed the existing strategies used for the tailoring of intervention content for a specific group of users.

Chapter 5 – Understanding users’ engagement with mobile apps for anxiety management | A mixed-method study

This chapter investigates the enablers and barriers to engagement with mobile apps for anxiety management. It first reviews 600 app store reviews from 5 publicly available mobile apps that integrate CBT and provide some evidence of effectiveness for anxiety management. This review analysis identified key factors contributing to the adoption of and sustained use of such apps, as well as barriers to engagement. Second, it provided the results from semi-structured interviews with 15 users of mobile apps for anxiety management to examine in more depth users’ perspectives on mobile apps and provide suggestions for improvement. This chapter finally discusses implications for design by combining the results of those distinct studies.

Chapter 6 – Exploring users’ daily perspectives on the usage and engagement of mobile apps for anxiety management | A user study

This chapter investigates the daily perspectives on the usage of mobile apps for anxiety management that integrate CBT by young adults, with a focus on understanding the reasons for and barriers to app use and engagement. We conducted a 2-week study in which 17 young adults on the waitlist to receive treatment were selected and instructed to use up to 2 of 3 apps; apps were selected based on different engagement metrics indicating regular use in real-world settings and some evidence of effectiveness for anxiety management. Qualitative and quantitative data were gathered through daily questionnaires to capture participants’ experiences with the mobile apps. In addition, 11 semi-structured interviews were conducted at the end of the study. The results of this study contribute to a deeper understanding of users’
Chapter 7 – Understanding clinicians’ perspectives on the design of personalized interventions for anxiety management | Ideation study

This chapter intends to understand current therapy practices including strategies employed by therapists for the engagement of clients with therapy and to explore what content can be tailored by therapists, how tailoring can be offered in different stages of treatment, and what tailoring needs should be taken into consideration. To achieve this, we conducted 10 semi-structured interviews and ideation sessions with 10 therapists. We recruited therapists with experience in providing CBT treatment to people with anxiety disorders. In this chapter, we uncovered the range of possibilities for the design of personalized mobile applications for therapist-supported CBT.

Chapter 8 – Discussion

This chapter concludes with the contributions brought by this thesis. It reflects on the contributions of this thesis to the research questions. Finally, this chapter concludes by calling for future research aiming to revise and advance the understanding of the design of engaging and personalized interventions and adopt longitudinal approaches to the investigation of user engagement within a human-centred design process.

Chapter 9 – Conclusion

This final chapter restated the contributions of this thesis to the field of Human-Computer Interaction.
Literature Review

2.1 Introduction

In order to build an understanding of technologies to support mental health and anxiety management, we conducted a narrative review of the literature. This chapter will give an introduction to anxiety disorders, their symptoms, and their treatment. We then provide a discussion of the different types of technological interventions used for the management or treatment of anxiety disorders and we examine current approaches to evaluating mental health apps. This will be followed by an overview of the concepts of "ecological momentary assessment" and "ecological momentary interventions" which constitute a special case of mental health technologies. We then review the concept of user engagement and personalization, including approaches to design and validate these systems. Finally, we describe the previous work summarising attempts to understand user engagement with mental health apps, as well as personalize treatment for users. The purpose of this section is to give the reader an understanding of the current knowledge concerning the design of mental health appli-
2.2 Method

This chapter aims to an understanding of the current knowledge concerning the design of mental health applications with a focus on anxiety management, engagement, and personalization. Given this interpretive aim and given the breadth of the literature, a narrative methodology was used. A narrative literature review was conducted to provide the state of knowledge on this particular topic. Such reviews provide useful overviews of an area and are valuable when one is attempting to link together many studies on different topics for purposes of interconnection (69). In order to identify relevant studies for inclusion, searches were conducted of the following databases: Google Scholar, PubMed, and PsycINFO. Multiple search terms were used, including ‘anxiety disorders’, ‘cognitive behavioral therapy’, ‘mental health’, ‘digital mental health’, ‘ecological momentary interventions’, ‘mobile mental health’, ‘anxiety’, ‘user engagement’, ‘tailoring’, and ‘personalization’. In addition, the related work of the identified papers was checked. For each identified direction, a handful of prominent papers were considered for inclusion.

2.3 Mental Health and Mental Illness

Mental health is an important part of how people function in their daily lives but there is no one specific definition of mental health and its understanding varies across cultures. Mentally healthy individuals experience both positive and negative feelings such as anger, frustration, disappointment, and sadness as appropriate emotional reactions to different life events. In this thesis, we use mental health as a term to denote a scale running from mental wellness to mental illness which can range from positive
to negative. Mental illness and mental health are two related but distinct concepts and ‘mental illness’ refers collectively to all diagnosable mental disorders. The Diagnostic and Statistical Manual of Mental Disorders (DMS-5) defines a mental health disorder as: "A mental disorder is a syndrome characterized by clinically significant disturbance in an individual’s cognition, emotion regulation, or behaviour that reflects a dysfunction in the psychological, biological, or develop mental processes underlying mental functioning. Mental disorders are usually associated with significant distress in social, occupational, or other important activities" (70). A clear definition of mental disorders plays an important role in knowing which diagnosis should or not be included in the classifications, proposing relevant treatment available to those who need it, and preventing the over-medicalization of everyday distress (71). The DSM is the handbook used by health care professionals as a guide to the diagnosis of mental disorders. It contains descriptions, symptoms, and other criteria for diagnosing mental disorders (70). Several mental health disorders exist with anxiety being one of the most common forms of mental illness.

2.3.1 An introduction to Anxiety disorders

Anxiety disorder is a term used to describe a variety of different type of disorders. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) describes the different types of disorders including generalized anxiety disorder (GAD), panic disorder/agoraphobia (PAD), separation anxiety, social anxiety disorder (SAD), specific phobias, and selective mutism (72). Obsessive-compulsive disorder (OCD) and post-traumatic stress disorder (PTSD) were formerly included in the anxiety disorders, but have now been placed in other chapters of this manual. Anxiety disorders are believed to be caused by a combination of psychosocial factors, such as childhood adversity, stress, or trauma, and genetic vulnerabilities (72, 73). The age of onset for
anxiety disorders differs among the disorders and they tend to run a chronic course, with symptoms fluctuating in severity between periods of relapse and remission (72). According to the American Psychiatric Association, women are more likely than men to receive a diagnosis of an anxiety disorder (70).

There is a high comorbidity between anxiety (especially generalized anxiety disorders or panic disorders) and depressive disorders, somatic symptom disorders, personality disorders, substance abuse disorders, or among anxiety disorders, which renders treatment more complex (73, 74). To determine the severity of anxiety disorders and to monitor treatment progress, there are commonly used rating scales that are usually be used, including the Hamilton Anxiety Scale (HAM-A)23 for GAD, the Panic and Agoraphobia Scale (PAS)24 for panic disorder/agoraphobia, and the Liebowitz Social Anxiety Scale (LSAS)25 for SAD (72).

Anxiety is a common feeling for individuals and it can be a normal emotional response to many stressful situations but it becomes a problem when there is no obvious reason for it or when anxious feelings persist for more than a couple of weeks. Anxiety disorders are characterized by an intense emotional response to a real, perceived (fear), or future (anxiety) threat and associated behavioral disturbances such as avoidance. These disorders differ from each other, however, in terms of the things that cause fear or anxiety (70). For example, fear of specific objects or situations is characteristic of specific phobias, fear of experiencing a panic attack leads to panic disorder, and fear or anxiety over various events or activities is characteristic of generalized anxiety disorders. The symptoms of anxiety differ between people and among disorders with the most common symptoms including anxious thoughts or beliefs that are difficult to control, restlessness, trouble concentrating, difficulty falling asleep, fatigue, irritability, or physical symptoms such as chest pain or shortness of breath. The most common treatment for anxiety disorders is psychotherapy, medication, or
a combination of the two (72). The term anxiety management is used throughout the thesis to describe people interested in the use of mental health apps to support their mental health in relation to anxiety symptoms.

2.3.2 Cognitive Behavioral Therapy Treatment for Anxiety

One of the most important and widely applied treatment approaches for mental health disorders and anxiety is psychotherapy. In psychology-based interventions, the person with a mental health disorder — in mental health contexts referred to as the client — engages in a collaborative relationship with a therapist, who employs different techniques to help the person understand, overcome and prevent the recurrence of harmful thought patterns, feelings or behaviours (75). Psychological treatment for anxiety disorders often includes some interventions aimed at increasing one’s ability to cope with anxiety at the moment, such as distress tolerance, and other interventions to build long-term skills to address anxiety such as cognitive-behavioral therapy, exposure therapy, or mindfulness meditation training (76). While there are a multitude of therapeutic techniques, cognitive behavioral therapy (CBT) is considered one of the most evidence-based treatments for anxiety disorders (7). CBT is defined as "An amalgam of behavioral and cognitive interventions guided by principles of applied science. The behavioral interventions aim to decrease maladaptive behaviors and increase adaptive ones by modifying their antecedents and consequences and by behavioral practices that result in new learning. The cognitive interventions aim to modify maladaptive cognitions, self-statements or beliefs. The hallmark features of CBT are problem-focused intervention strategies that are derived from learning theory [as well as] cognitive theory principles." (77, 78).

In CBT, therapy helps clients to eliminate exaggerated fears and the avoidance responses that help maintain anxiety disorders, and they are taught to bring atten-
tion to the relationship between their thoughts, feelings, and behaviors (79). CBT includes various combinations of the following therapeutic techniques: psychoeducation about the nature of fear, anxiety, and distorted cognitions, self-monitoring of symptoms, somatic exercises such as relaxation strategies, cognitive restructuring, imaginal and in vivo exposure to feared stimuli while weaning from safety signals, self-reliance training, whereby client learns to take more responsibility for daily routine and start gaining control over emotional reactions, and relapse prevention (7, 20). There are different models used for the treatment of different anxiety disorders with a common attempt to provide conditions where clients can relearn a sense of safety in relation to feared cues (79).

In clinical settings, therapeutic sessions take place weekly or on a fortnightly basis with sessions lasting about 50 minutes. The duration of treatment depends upon the type of treatment and complaint. CBT is typically used short-term and is considered a highly structured approach. CBT techniques are weighted differently during therapy depending on the specific anxiety disorder (7). In-between therapy sessions, the therapist develops a treatment plan to enable the client to change his or her thoughts and consequently behaviors. In order to meet the increasing demand for anxiety treatment, different technological approaches have been developed for supporting the delivery of CBT for anxiety disorders. The next section details the application of these capabilities for anxiety management.

### 2.4 Technology-delivered Cognitive Behavioral Therapy for Anxiety Management

CBT, due to its highly structured format, can be readily supported by digital technology and thus has become the most widely used approach for the design of comput-
erized and online-delivered therapy (80). Computer-assisted therapy can be defined as "psychotherapy that utilizes a computer program to deliver a significant part of the therapy content or uses a computer program to assist the work of the therapist" (81). Computer-assisted cognitive-behavioral therapy (CCBT) has been developed as a way of helping patients build core CBT knowledge and skills while reducing reliance on traditional face-to-face sessions (41). Most CCBT programs involve a sequence of modules or lessons to deliver evidence-based treatments via desktop computers, laptops, or tablets (41, 82). CCBT methods for anxiety are delivered either as self-help programs without therapist involvement or with limited assistance of a therapist—either by telephone, by email, or in person where the computer program is used as an adjunct to therapy (41, 82). These programs deliver different cognitive-behavioral principles and techniques including psychoeducation about CBT, cognitive restructuring, breathing training, relaxation techniques, graded exposure to feared stimuli, response prevention, and assertiveness training (82). Overall conclusions from several meta-analyses and systematic reviews show that CCBT is effective for anxiety, and has similar efficacy to face-to-face treatment (82). In addition, previous research has shown that CCBT supported by a therapist or other helping professionals had better outcomes and lower dropout rates (82).

Mobile technologies provide another promising avenue for delivering CBT. Mobile apps that integrate CBT are being some of the most empirically supported apps for anxiety (83). Typically, mobile apps deliver a specific component of CBT treatment, stress management, or skill (e.g., breathing exercises, relaxation, mindfulness, thought diaries, mood tracking) in contrast to CCBT which provides a full course of CBT (82).
2.5 Mobile apps for Anxiety Management

The widespread availability of smartphones has led to a proliferation of mobile apps for anxiety management. Apps can support individuals in managing their own mental health, and can be used privately and “on the go” (84). These self-help interventions can be delivered in a variety of different settings. The interventions can be used as partial replacement to face-to-face therapy, as unguided self-help, or as an independent intervention involving some support from a professional (85). The vast majority of those apps which target anxiety disorders do so by offering self-management techniques and exercises, providing supportive resources, and enabling real-time and asynchronous exchanges with mental health care specialists (86, 87, 88).

Several studies have examined the effectiveness and efficacy of delivering interventions with the use of mobile applications and showed preliminary evidence that psychological interventions delivered via smartphone devices can reduce symptoms of anxiety (38, 83, 89). A systematic review identified 15 RCTs and randomized trials of the effectiveness of EMIs for anxiety disorders with the majority of these studies targeted generalized anxiety. The findings indicate that EMIs have potential in treating both anxiety and stress (89). A meta-analysis was conducted to examine the efficacy of smartphone-supported psychological interventions for reducing symptoms of anxiety and to explore which types of smartphone interventions were most efficacious, and in what context. The results from 9 RCTs showed that psychological interventions delivered via smartphone devices can reduce anxiety. A random-effects meta-analysis found these interventions reduced total anxiety symptoms significantly more than control conditions, with no evidence of publication bias affecting results. The greatest benefits were observed among the RCTs which compared smartphone interventions to waitlist control conditions (38). In addition, similar to the
results from another study, the researchers found that smartphone-delivered interventions for anxiety have a greater effect when apps are paired with face-to-face or internet-based therapies (38, 90). However, less than half of the identified apps were currently available to the general population through the app stores (38). A most recent meta-analysis of 66 RCTs of app-supported smartphone interventions for mental health problems, with the majority of them published in 2019, found evidence that app-supported smartphone interventions are efficacious for several common mental health problems including anxiety symptoms (generalized anxiety and social anxiety) (83). Mobile apps that offered professional guidance (e.g., supportive text messages, personalized feedback, telephone calls) and reminders to engage produced larger effects on multiple outcomes (83).

As mentioned in chapter 1, the clinical symptoms of anxiety disorders raise some unique considerations for apps intended to support anxiety self-management. The characteristics of anxiety disorders and the treatments that are effective at addressing them might guide the features of apps intended to promote anxiety self-management.

### 2.6 Finding mental health applications

A common strategy to find a mobile mental health app is to search the app marketplaces (i.e., Google Play store or Apple iTunes) (84). Highly rated apps tend to be downloaded more frequently than those with lower ratings (91). Users also find apps through word of mouth, advertisements, or searches in social media (84, 92). In addition, clients attending mental health treatment, are more likely to use an app if their therapist recommends it (93). With the increasing availability of mental health apps and in order to understand the clinical usefulness or utility of such apps, researchers have developed guidelines for assessing such apps (94, 95, 96, 97), developed app
rating platforms (84), and reviewed a variety of such apps in the academic literature (86, 87, 88, 91, 98, 99, 100, 101, 102, 103, 104).

### 2.6.1 App Rating Guidelines

Several app rating guidelines have been created to understand the different characteristics that need to be considered when assessing a mobile mental health app and provide an understanding of what constitutes a quality app with regard to those characteristics (84). A five-stage app model has been proposed by the American Psychiatric Association, which includes (1) gathering background information; (2) determining risk, privacy, and security; (3) evaluating evidence; (4) assessing ease of use; and (5) considering interoperability. The hierarchical nature of this model determines that if an app is insufficient at one stage, one need not consider the app any further (94).

For researchers, professionals, and clinicians, the Mobile App Rating Scale (MARS) is the most widely used rating system for classifying and assessing the quality of mental health apps (95). This 23-item MARS provides a multidimensional measure of an app’s quality by providing a total mean score representing overall app quality and four subscales: engagement, functionality, aesthetics, information, and a subjective quality score based on raters’ own impression of the app, including its usability and perceived effectiveness. The MARS has demonstrated high levels of interrater reliability for evaluating the quality of mental health apps and has been used in several publications to understand a variety of different mental health apps such as mindfulness (105) and depression (95). To minimize the burden of use for end users, a user version of the Mobile App Rating Scale (uMARS) questionnaire became available a year later (106).

As a result of a systematic review of existing app rating methods, the Enlight rating
guidelines were created resulting in a series of quality assessments and checklists (97). There are 25 items in the quality assessment section, each with a likert-type scale divided into six core constructs: usability, visual design, user engagement, content, therapeutic persuasiveness, and therapeutic alliance. Raters identify specific aspects related to app use, including credibility, evidence base, privacy explanation, basic security, and complete a general subjective evaluation of the likelihood that the app could produce the intended clinical aim.

2.6.2 App Rating Platforms

In order to simplify the process of finding and reviewing mental health apps and reduce the burden for the end users, several app rating platforms have emerged. These include the for-profit Organization for the Review of Care & Health Applications (ORCHA), in addition to the Anxiety and Depression Association of America’s (ADAA) mental health app ratings, the Mobile Health App Database (mHAD) Germany, MindTools, PsyberGuide, and the Toolbox (84). The app rating platforms identify, provide clear information, and rate apps based on different criteria. For example, Psyberguide uses expert reviewers to review applications in terms of three criteria: credibility, user experience, and transparency (107).

2.6.3 Reviewing consumer mental health apps

The proliferation of mental health apps and the need to understand their utility has increased the research on mental health interventions available on the marketplaces. Several papers have recently reviewed apps targeting a variety of mental health conditions, including depression (98, 99, 100, 101), bipolar disorder (91), and anxiety disorders (86, 87, 88, 102, 103, 104). A review characterized the different types of mobile phone depression apps available in the marketplace. This review found that depres-
sion apps provided support on five different dimensions: therapeutic treatment, psychoeducation, medical assessment, supportive resources, and multipurpose. Most apps had a dynamic user interface and used text as the main type of media but the majority of apps failed to sufficiently describe their organizational affiliation (100). Another study showed that CBT apps for depression integrate a mix of features, including many that are not evidence-based. The apps offer limited CBT features focusing on mood tracking, recording thoughts and emotions, and dealing with negative thoughts—with their presence or absence not linked with expert involvement in app creation—and lack elements used in high-intensity interventions (98). Most of the top-rated apps for depression provide multiple functions with the most common including the provision of interventions, self-monitoring, and screening. In addition, the apps were found to lack a privacy policy consistent with their rating (99). Another study found that the utility of self-help CBT or behavioral activation apps for depression is questionable, and their usability is highly variable; furthermore, apps are rarely accompanied by privacy policies (101). Similarly, the content of apps targeting bipolar disorder is not in line with practice guidelines, and most apps lack citations and privacy policies (91).

Previous reviews targeting anxiety disorders have had aims for specific target groups or conditions such as youth anxiety or social anxiety (88, 102). A review study assessed the overall quality of 121 consumer-marketed apps for youth anxiety. The evidence-based components for the treatment of youth anxiety were quite scant with only a quarter of apps incorporating more than one evidence-based treatment component (102). Another study aimed to review social anxiety apps in order to characterize their purpose, and description and to review the evidence on their effectiveness. The majority of the 38 reviewed apps were exclusively focused on social anxiety and most apps used multimedia modalities for content delivery. Most apps did not provide in-
formation on their organizational affiliations or their content source and none of the apps provided published studies on effectiveness (88).

Other review papers targeted a variety of anxiety disorders (86, 87, 103). A study reviewed the degree to which current iPhone apps targeting symptoms of worry and anxiety incorporate content consistent with evidence-based cognitive-behavioral therapy interventions for anxiety and worry. After reviewing 361 apps, the authors concluded that the majority of these apps were largely inconsistent with evidence-based treatments for anxiety and worry. The majority of them did not contain any content from cognitive-behavioral therapies and of those with supported content, assessment/self-monitoring interventions were most common (86). Similarly, another study reviewed the quality, features, and content of 52 anxiety apps. The results showed that the majority of them do not offer evidence-based interventions, lack the involvement of health care professionals in their development, and very few of them have been rigorously tested. The reviewed apps targeted a variety of anxiety symptoms or conditions with a minority of them offering information about the information approach they used by adopting a cognitive behavioral approach, or a mix of approaches. The reviewed apps offered a variety of techniques (e.g., relaxation, reframing, meditation, exposure, hypnosis) without grounding them in a therapeutic rationale or providing information about efficacy data (87). A comprehensive review of the current state of the mental health app literature examined published reports of apps designed for DSM-5 anxiety and mood disorders, OCD, and PTSD. The results showed that an overwhelming majority of these empirically supported apps are not yet available for public download (103).

A study assessed the extent to which evidence-based treatment elements are present within popular smartphone apps for depression and anxiety, and examined the frequency of specific evidence-based elements within the apps (108). The results from 17
anxiety apps showed that some of these interventions are well-represented in mental health apps for anxiety management, including practice elements such as psychoeducation, relaxation, mindfulness, meditation, and self-monitoring. In contrast, other treatment elements commonly included in evidence-based protocols for anxiety such as exposure are rarely used (108). Mobile apps designed primarily for anxiety disorders can contain several elements of CBT (e.g., cognitive restructuring, relaxation, breathing exercises, exposure) and other treatments (e.g., acceptance, mindfulness, and hypnosis-guided imagery) (86). The examination of sensors used to collect data or provide support based on collected data has received little attention among these studies. Only 1 app review that we are aware of has investigated the use of sensors—in a review of apps targeting children and adolescents with anxiety disorders. The results showed that there were no apps that gathered data passively through sensors (102).

According to current research studies, the case for recommending available apps to users requires considerable attention since many apps do not meet evidence standards. Even though several studies have reviewed mental health apps available on the marketplaces, there is a need for a greater understanding of what these apps actually provide and what strategies they employ to engage and deliver treatment to users is needed. Thus, there is a need to examine both the provision of features that encourage regular use and tailoring of content delivery to provide interaction that is both engaging and effective for particular users.

2.7 Ecological momentary assessment and intervention

Technology advances have created new opportunities for the delivery of treatment. Support for real-time repeated monitoring and assessment of current states or symp-
toms and progress tracking through mobile phones has created opportunities for the observation of behaviors in people’s daily lives. Such advances have led to the development of a new type of mental health app that makes use of sensing technology to provide intervention content relevant to each user’s input. This section reviews the concepts of ecological momentary assessment and intervention (EMA/I) which constitute a special type of mobile mental health technology.

2.7.1 Ecological Momentary Assessment

Ecological Momentary Assessment (EMA) is the repeated assessment of user experiences in real-world contexts, in real-time (109). In the past, EMA-based studies have been mainly done via paper and pencil measures but technological advances allow researchers to develop EMA tools that take advantage of computational and sensing technologies. EMA allows for real-time repeated monitoring and assessment of current states or symptoms and progress tracking (109). There are three major benefits of using EMA technologies; the circumvention of retrospective bias, temporal and longitudinal validity, and ecological validity (109, 110). EMA ensures the ecological validity of collected data by collecting data in individuals’ real-world environments, reduces bias or error inherent in retrospective reporting, and enables tracking of experience across time and situations. EMA has more recently been employed by HCI researchers to facilitate insight into users’ experiences, and to support the design of health and wellbeing technologies (111). In recent years, there is an increased interest in the topic of EMA methods to topics related to mental health. With respect to mental health, for example, EMA is often seen as a means to ‘actively engage patients in the process of recovery’ and increase users’ insight with respect to their own mental health and wellbeing (111). EMA techniques have been widely used to study a wide range of psychological disorders, including among others, anxiety disorders.
Engagement is considered a key metric for many EMA technologies and yet users’ motivations for engaging in the practice of self-report, for example, have rarely been assessed in advance of system deployment (111). Narratives of use defined in terms of compliance alone may also neglect users’ autonomy and therefore a large part of the role of design (112).

### 2.7.2 Ecological Momentary Interventions

**Defining Ecological Momentary Interventions**

The term “ecological momentary intervention” was first coined in 2005 by Patrick et al. (113). The authors presented an ecological framework for cancer communication and discussed the possible contribution of ecological momentary assessments (EMA) to cancer communication. They envisioned delivering tailored interventions based on EMA responses (113). The capabilities of such an “ecological momentary intervention” should include the provision of personalized feedback based on real-time assessment responses and even environmental data or other contextual factors (113).

Heron and Smyth (114) provided a concise definition for the term ecological momentary interventions as "treatments that are provided to people during their everyday lives (i.e. in real time) and in natural settings (i.e. real world)” (114). Treatment is delivered using mobile technology, and can be implemented standalone or as a supplement to existing treatment (114).

The use of these systems has been described as a “therapist in your pocket” approach, and is widely viewed to possess “the potential to revolutionize clinical treatment” (109). The argument is that these systems provide the capability to deliver psychological intervention strategies at opportune moments, in real-world settings,
and in an accessible and scalable fashion. EMIs is a framework by which formal or unstructured treatments or interventions are delivered to people (114).

**Just-in-Time Interventions**

Over the past decade, the introduction of smartphones has enabled a truly new type of EMI. A new class of EMIs, referred to as “just-in-time interventions”, adapt treatment delivery over time to provide interventions most likely to be effective, using information gathered through Ecological Momentary Assessment (EMA) (111) or sensing (115, 116). This creates opportunities to enable delivery of deeply personalized interventions (117). Even though EMIs and JITAsIs share many of the same elements, JITAsIs entail the provision of opportunistic interventions by adaptively improving and tailoring the interventions over time, and thus can be seen as a subset of EMIs.

**Initial explorations**

An influential review by Heron and Smyth in 2010 synthesized and critiqued mobile technology-based EMIs delivered through the use of palmtop computers and mobile phones (114). Twenty-seven interventions were reviewed targeting a variety of psychological, behavioral, and physical issues. The review described the qualities of EMI including delivery methods, intervention components, the content of EMI and its tailoring. At that point in time, interventions were delivered using a variety of technologies including SMS, palmtop computers and mobile phone voice calling capabilities. The majority of the EMI systems they reviewed were provided in conjunction with interactive websites, or were used to supplement group or individual psychotherapy.

EMIs tailored intervention messages either with information obtained from pre-intervention assessments, or by delivering interventions at predefined times when in-
Individuals were in need of additional support. EMI prompting protocols differed between studies, and the prompts were delivered either at fixed times, at random times, or at tailored dates or times (114). The increasing development of internet and mobile-based solutions to expand the reach of mental health care over the last decade makes it a timely moment to examine the literature on EMIs.

2.8 Common Approaches and Challenges to Designing and Evaluating Mental Health Technologies

As mentioned in Chapter 1, HCI and health researchers have different approaches to the development and evaluation of health technologies. Previous research in clinical settings has focused primarily on examining the effectiveness and efficacy of an intervention as a whole (83, 118). Health researchers determine the effectiveness of an intervention with the use of randomized controlled trials (RCT) (68). In recent years, a new methodology called Microrandomized trials (MRTs) is used to optimize treatment and to compare interventions to each other and to no intervention (117). However, none of these methodologies reflect real-world use or engagement, which can negatively impact effectiveness once digital interventions are executed outside of a controlled environment (119, 120).

HCI can ensure the design of future technologies that can improve engagement outside of study environments. However, HCI researchers face several challenges in the design of digital mental health interventions such as regulated access to sensitive care settings or direct contact with highly vulnerable client populations and lack of clinical training or prior experience in therapeutic settings (121, 122). In order to design and develop digital mental health technologies, Human-Computer Interaction (HCI) research involves multidisciplinary research and stakeholders from different
disciplines to gain knowledge related to the topic.

The involvement of users with severe mental health difficulties in the design stage is extremely rare due to ethical considerations such as avoiding participants causing distress. Alternative approaches for HCI researchers to develop an understanding of their target group are by using knowledge derived from the academic literature on characteristics and theories of mental health problems as well as treatment manuals (123) or by involving mental health professionals during the design of digital mental health interventions in order to inform technology concepts (16, 124). In addition, testing digital mental health technologies in real-world settings is complex and time-consuming since research studies require ethical approval and mental health professionals should be involved to ensure participants’ safety (122). HCI research on digital mental health has focused primarily on examining factors that affect user experience by involving participants during the design process or by collecting retrospective data after app use by analyzing user reviews for mental health apps, conducting interviews, and focus groups (125, 126, 127, 128, 129, 130).

2.9 User Engagement with Mental Health Apps

2.9.1 Defining User Engagement with Mental Health Apps

User engagement is an important factor for the effectiveness of digital mental health apps and in supporting the sustained use of such apps. The concept of engagement is broad in nature as reflected in prior research reviewing and developing the concept of engagement across different contexts (112, 131, 132, 133). Engagement is predominantly conceptualized as a multidimensional construct with three common components (behavior, cognition, and affective) shared between domains with little shared consensus as to its conceptualization within and between domains (132).
User engagement in clinical research has been defined and associated with objective/behavioral metrics of use of or interactions with a mental health intervention, such as the number of log-ins or time spent using the technology (31, 134, 135), and popularity metrics such as the ratings and user reviews (136). ‘Low engagement’, in the context of health services refers to a lack of uptake and/or poor adherence to an intervention among service users (37). User engagement in mental health apps has been used to describe different user-centred outcomes, including usability, acceptability, feasibility, and satisfaction (137). However, engagement also entails users’ subjective experience which may be a mechanism for change in clinical outcomes (80, 134). Understanding the reasons why people use a technology might be more important in predicting effectiveness that the frequency or duration of use.

User engagement as a subjective experience in human-computer interface research has for example been characterized as feeling focused, attentive, and satisfied when using a digital technology (138). Human-computer interaction conceptualizes engagement not just as the quantity of use, but also the quality of use (112). A review on engagement in digital health interventions described engagement as the extent of usage and a subjective experience characterized by attention, interest, and affect (138). Doherty and Doherty state that it is more important to select the most useful interpretation and measurement of engagement based on the context that it will be used and the design questions being asked (112). The digital mental health domain is very broad encompassing interventions with or without care professionals, and various technologies used in various contexts. Therefore, it is important to define engagement for each individual study. As the concept of engagement is broad and depends on the context that will be examined (112), we define engagement in each individual study by considering specifications (and definitions) for different subdomains examined in this thesis. In Chapter 4, we reviewed engagement features of
consumer apps by recording features that "encourage regular use, help users to stay engaged with the app or therapy itself". The following three chapters examine user engagement by identifying factors that affect user behavior (usage), cognition, and affect with mental health apps for anxiety management. We view engagement as a process (getting and remaining engaged and/or disengaged) rather than a state (of being engaged).

2.9.2 Measuring User Engagement with Mental Health Apps

There are no standard metrics to compare app engagement across different published papers (37, 137). Many research papers on mental health apps continue to select only apps with high App Store star ratings or the highest number of downloads even though these metrics are not associated with app features, function, or evidence (139). The most downloaded apps are not necessarily the ones that are used daily and provoke sustained use (140). Recent research has offered additional stickiness metrics derived from two app parameters including the number of monthly active users (MAU) and total downloads. This metric, termed number of monthly active users per normalized total downloads, estimates the number of active app users per normalized download, with a higher number indicating greater stickiness (140). Similarly, recent studies have explored the reach of mental health apps by estimating the number of monthly active users (MAU) and daily active users (DAU) (141) to characterize the mobile health app marketspaces.

In response to the low uptake and low sustained use of mobile mental health apps, a recent review examined how studies have measured and reported on user engagement indicators for mental health apps and found that engagement was measured by using subjective and objective criteria. Studies reported using custom subjective scales and subjective criteria that were assessed with surveys, interviews, or both, and
objective criteria of usage data using indistinct measures. In addition, no identified study used the same combination of criteria or the same thresholds to evaluate an app (137). The inconsistencies illustrated in this study raise the possibility that no engagement indicators were designed to take into account the potentially unique cognitive, neurological, or motor needs arising from mental illnesses (137). This lack of consensus hinders understanding of what makes apps engaging for different users.

2.9.3 Previous work examining users’ engagement with mental health apps

A lack of engagement with mental health apps has been reported as a key limitation for realizing the potential of apps to broadly disseminate mental health treatments (37). Designing for longitudinal patient engagement is challenging (142, 143). Challenges of engagement may be associated with factors related to mental health conditions such as high variability in mood, often transient feelings of crisis, reduced motivation, the heterogeneity of symptoms experienced at the individual level, and low levels of app usability (apps being difficult or unenjoyable to use) (37). Previous research has shown that greater engagement with digital interventions is significantly associated with improvements in mental health (144), and technology-supported strategies ranging from reminders, coaching, personalized information, and peer support appear to increase engagement (145). However, there are no studies that systematically examine which app features or engagement metrics increase the sustained use of apps (144, 146) and the mechanism(s) through which such strategies promote engagement (145). A recent study reviewed current challenges surrounding user engagement with mental health interventions. The review paper discussed several potential theories associated with a lack of uptake and/or adherence to mental health interventions including poor usability, lack of user-centric design, privacy con-
cerns, lack of trust, and apps being unhelpful during crises or emergencies (37). Table 2.1 summarizes the challenges to user engagement with mental health apps.

Table 2.1: Challenges to user engagement with mental health apps

<table>
<thead>
<tr>
<th>Author</th>
<th>Target</th>
<th>Study Aim</th>
<th>Challenges with engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torous et. al. (2018)</td>
<td>Mental health apps</td>
<td>A narrative review of the literature to identify challenges surrounding user engagement with mental health smartphone apps</td>
<td>factors related to mental health conditions (e.g. high variability in mood, reduced motivation, heterogeneity of symptoms), poor usability, lack of user-centric design, privacy concerns, lack of trust, apps being unhelpful during crises or emergencies</td>
</tr>
<tr>
<td>Thach (2018)</td>
<td>CBT-based Mental health apps</td>
<td>User review analysis to identify features that engage users to use and continue using mental health apps</td>
<td>technical issues, lack of customer services, lack of clear security measures and privacy policy, complicated in design, and advertisement content</td>
</tr>
<tr>
<td>Oyebode et. al. (2020)</td>
<td>Mental health apps</td>
<td>User review analysis to identify themes representing various factors affecting the effectiveness of mental health apps positively and negatively</td>
<td>usability issues, content issues, ethical issues, customer support issues, and billing issues</td>
</tr>
<tr>
<td>Alqahtani and Orji (2020)</td>
<td>Mental health apps</td>
<td>User review analysis to uncover issues surrounding user engagement with mental health apps</td>
<td>poor usability, lack of content variety, lack of personalization, lack of customer service and trust, and security and privacy issues</td>
</tr>
<tr>
<td>Borghouts et. al. (2021)</td>
<td>Mental health apps</td>
<td>A systematic review of the literature to identify common barriers and facilitators that influence user engagement with mental health apps</td>
<td>severe mental health issues that hamper engagement, technical issues, and a lack of personalization.</td>
</tr>
</tbody>
</table>
Several studies have been published to provide an understanding of the reasons for and the barriers users perceive to using mental health apps. In this regard, research has mainly focused on analyzing user reviews to understand users’ opinions of mental health apps. Several efforts have been made for specific mental health disorders such as depression (98), bipolar disorder (147), and sleep disturbance (148), for specific types of app such as mood tracking (129, 149), or for specific types of psychological treatments such as computerised cognitive behavioral therapy (CCBT) (150) and mindfulness (151). Other studies have focused on gaining an understanding of specific target group users, such as exploring adolescents’ perspectives on mental health apps (130), and mood-tracking apps considered useful to young people (152).

Previous studies have aimed to better understand the physical and mental health apps people with symptoms of depression and anxiety use and for what purposes (92), and examined features young people like and dislike in smartphone apps for anxiety and depression (128). The results revealed that people use mental health apps specifically for training or habit-building purposes (92), and the features liked by young people include autonomy, simplicity, the ability to personalize experiences, and social features that allow connecting with others (128).

A number of studies have explored users’ opinions and expectations for mental health mobile apps in general (125, 126, 127, 153, 154). These studies provide knowledge regarding functionality and aspects that affect user experience with these apps. For instance, we know that users find mental health apps more often through social media, personal searches, or word of mouth as opposed to professional sources (153). Users value apps that are easy to use (126, 127, 153), offer an aesthetically pleasing interface (125, 126, 153), and low-cost subscriptions (125). Additionally, we know that users prefer apps that allow customization of the interface (125, 126, 127), offer high quality content, and adaptive functionalities to user needs (125, 126). Other features
often desired by users include tracking, the provision of reports and insights, ability to share data, and notifications (153). Users of CBT apps for mental health highly appreciate the ability to monitor and reflect on themselves, the ability to receive notifications, and apps that provide different interactions between them and therapists (155). Another study identified privacy, feedback, ease and speed of use, personalization, and control over the amount of information received as important features in mental health mobile technologies (156). Other facilitators that influence user engagement are social connectedness facilitated by the intervention, increased insight into health, and a feeling of being in control of one’s own health (43).

Prior research reveals that reasons for disengagement from mental health apps include usability issues, lack of content variety, lack of personalization and customization options, customer support issues, and data privacy issues (43, 125, 126, 155, 157). Another study reported that apps are not sufficiently able to emotionally support users, may distract users from real life, may create misinterpretation about themselves, and may discourage face to face interactions (154).

Designing for engagement in the digital mental health domain must place the emphasis on engagement with both the technology and the treatment in order to achieve the overall therapeutic objectives of each intervention. Engagement with self-management apps is critical for the continued use of apps; engagement however is also important to building client-therapist relationships and improving client self-efficacy. Successful technologies will achieve a balance, whereby an appropriate level of engagement with the technology enhances engagement with the overall therapeutic process (16, 122). Human-computer interaction research emphasizes that understanding user needs is the first step in designing these types of technology-based interventions (158). However, there is currently a lack of research exploring users’ needs and engagement from mental health mobile apps for anxiety management.
2.10 Personalization of mental health apps

2.10.1 Defining tailoring & personalization

Personalization, customization, and tailoring have numerous definitions and several disciplines study these topics. Classifications of health intervention tailoring found across the existing literature focus on the delivery of tailored messages (159, 160) and researchers proposing reporting standards for such interventions (161). However, tailoring in the context of technology-based interventions most often refers to the adjustment of technology-delivered self-help programs to suit the user’s needs, characteristics, and comorbidities of case formulation (28, 45). For some researchers, the difference between personalization and customization is not important, whereas others emphasize their differences (162). Another area of research has explored the use of adaptive UIs (User Interfaces) which is a type of interface design that tailors the user experience by leveraging a variety of techniques, such as responsive design, device detection, user profiling, contextual awareness, and machine learning algorithms (163). The adaptation is usually done automatically by the system, and the changes focus on improving usability, accessibility, and performance across different devices and platforms. The aim is to provide an optimized user experience by adjusting the interface based on the user’s context and device. Adaptive UIs aim to create a consistent experience for users regardless of the device or platform they are using. While adaptive UIs focus on adjusting the interface to fit the user’s context, personalization focuses on adjusting the content and features to fit the user’s preferences and interests (164, 165). Blom and Monk define personalization as "a process that changes the functionality, interface, information content, or distinctiveness of a system to increase its personal relevance to the individual" (166). Fan and Poole (2006) define personalization as "a process that changes a system to increase its personal relevance to an
individual or a category of individuals”. The researchers present a personalization framework, wherein personalization is conducted either by the system (implicit), or by the user (explicit). The object of personalization can be the content, user interface, functionality or channel. This framework furthermore makes a distinction between personalization as directed towards individuals (individuated) or groups of individuals (categorized) (167). Both definitions describe personalization as a process aiming to increase technological characteristics and content relevance to individual users. Therefore, in this thesis, we refer to personalization as ”a process that aims to improve the relevance of an app to a user by changing its characteristics and content”. Throughout this thesis, personalization and customization are distinguished based on the nature of user involvement. Personalization is used to tailor the user’s experience based on their previous behaviors, whereas customization is initiated by users and allows the modification of app features based on their preferences.

2.10.2 Previous work on personalizing digital mental health technologies

Despite prior research revealing the need to deliver more personalized technologies, there are only a few studies that have explored the delivery of such interventions. Previous studies have been conducted on tailored internet-based treatment for anxiety disorders with comorbid anxiety and depression (45) (168) and to treat symptoms of anxiety and depressive symptoms in the presence of panic attacks (46). A study aimed to tailor Internet-based treatment by the therapists according to interview data collected by the participants using the Structured Clinical Interview (SCID). The Structured Clinical Interview is a semi-structured interview guide for making the major diagnoses of mental health disorders. The modules and the order in them which a participant was prescribed were decided based on different participants’ profiles.
Treatment consisted of a number of individually-prescribed modules in conjunction with online therapist guidance. Therapists made accessible the selected modules to participants each week and sent weekly e-mail reminders to those who did not complete them. The conclusion drawn from these results is that tailoring an Internet-based therapy can be a feasible approach in the treatment of anxiety-related disorders (45). On the basis of this study, other authors explored user autonomy and allowed participants to choose which modules to use during the intervention. After giving a brief description of the modules, participants could choose which modules to use. The results of this study suggest that patient choice could be incorporated into Internet-delivered treatment packages suggesting further investigations (168). Another study investigated the effects of a tailored, therapist-guided, Internet-based treatment for individuals with reoccurring panic attacks, and examined whether people in different age groups (18–30 years and 31–45 years) would respond differently to the treatment. Similarly to the study mentioned above, each participant, based on the results of the SCID interview and based on a clinical impression from a telephone interview, was prescribed cognitive behavior therapy text modules. The results showed that tailoring an Internet-based treatment can be a feasible approach in the treatment of panic symptoms and comorbid anxiety and depressive symptoms. In addition, the authors found that age did not influence the outcome (46). A recent study explored both users’ preferences as well as how their engagement with an app are impacted by different ways of providing personalized recommendations by giving users more or less autonomy in choosing the app content, and different ways of sharing the data required for delivering personalization. Results revealed an asymmetry between what users declared as their preference for autonomy (versus guidance) and how they used the app in reality (169).
2.10.3 Understanding Personalization in Digital Mental Health Technologies Studies

As mentioned in this chapter, several studies mentioned the lack of personalization and customization options as a barrier to engagement with mental health apps. In order to gain an understanding of how these concepts are implemented in or requested in those studies, we examined their operationalization.

Previous studies analyzing user reviews of mental health apps have shown that users requested a variety of customization options including the interface and appearance of the app (such as background, theme, and sounds), customizing some app functionalities (such as breathing rate, meditation duration), and customizing reminders to fit individual daily routines (125, 126, 170). Other apps tailor the content based on certain user characteristics (such as adapting meditation based on user’s current emotion state) (170). Users have complained about some apps’ generic content which made it unsuitable and unhelpful for their condition (125) and requested personalized app functionalities that are tailored to them and with different techniques relevant to individual situations (126).

2.10.4 Understanding Users’ Perception on Personalizing Mental-Health Technologies

A few studies have captured users’ perceptions of personalized mental health technologies. A systematic review was carried out on qualitative studies on users’ perceptions of mobile health apps. Users requested providing options to customize an app’s interface, reminders, or treatment elements (e.g. the number of symptoms reported, the frequency of health tips) as a means of achieving greater personalization. In addition, they have suggested that apps should support more interactivity, and
allow to alter the type of language used (i.e., changing language that felt patronizing) (171). Another study aimed to gain the viewpoint of service users from a local mental health service in developing a mental health app. A significant theme of this study was the option to personalize apps by customizing different app functions (127). A systematic review identified, among other objectives, factors associated with engagement with digital mental health interventions for young people. Users believe that mental health apps should tailor modules to one’s own needs, and provide the ability to opt-in or opt-out of features, social features, or notifications (128).

While previous research has explored users’ suggestions, to the best of the authors’ knowledge, no study has to date explored therapists’ perceptions of personalization and their participation in the design of new possibilities in this regard.

2.11 Summary

This chapter has looked at the potential of technology to support mental health, the design possibilities of such systems which are under-explored, and the methodology for examining these apps. It provided us with an understanding of EMA/I, anxiety disorders, and their treatment. In addition, it provided us with knowledge concerning the different technological interventions for anxiety management and current approaches to finding and evaluating mental health apps for that purpose. It gives an overview of the concepts of user engagement and personalization and reviews previous attempts concerning such concepts for the design of mental health interventions for mental health. This chapter shows that even though there is a breadth of research studies in the field of digital mental health, the design space of such technologies is under-explored, users’ perspectives on engagement with mobile apps for anxiety management have not been examined, and there is little research concerning the ex-
oration of personalized mental health technologies. There is a need for a richer understanding of the different possibilities available for the design of such systems, and of individual users’ needs affecting user engagement and personalization.
3

Ecological Momentary Interventions for Mental Health | A scoping review

3.1 Introduction

The previous chapter showed that technological advances have increased the proliferation of mental health apps and the need for research on the different possibilities for the design of such apps to support user engagement and personalization. Perhaps the most sophisticated vision of the future of mobile health interventions is the concept of Ecological Momentary Intervention. Ecological momentary interventions (EMIs) hold the potential to deliver psychological interventions in real-time and in real-life situations. However, the different possibilities available for the design of ecological momentary interventions for mental health technologies are unknown. This chapter examines the literature on EMIs over the last decade to see how they are defined, and what they comprise in practice, as compared to the original vision. This scoping
review complements and extends the review of Heron & Smyth (114) of 2010, which presented 27 studies, 9 of which were in the area of mental health, and none of which involved a smartphone app. We do this by considering work on mobile technology-based EMIs for mental health published since 2009, and exploring the design features of the interventions delivered. We present a scoping review categorizing the design options available for the deployment of these interventions in the domain of mobile mental health technologies. This scoping review was undertaken in order to generate an up-to-date understanding of mobile technology-based EMIs for mental health published in the last ten years based on an exploration of the design features of the interventions delivered to reveal the options available and to identify opportunities for further work. The review revealed all the different components and design characteristics of the interventions. Furthermore, it explored all strategies for tailoring interventions, a mechanism that was discussed in the previous chapter and has been shown to improve engagement. A better understanding of the components of the interventions contributed to the development of a model containing all the different possibilities available for the design of such interventions. Informed by this analysis, we explored the variety of capabilities exhibited by EMIs and we introduced a more explicit terminology for capturing both automatic and human tailoring of these interventions. This chapter contributes to answering the first\(^1\) and second research questions of this thesis\(^2\).

\(^1\)RQ1. How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?

\(^2\)RQ2. What is the functionality of mobile mental health interventions for anxiety both in the academic literature and in practice?
3.2 Method

We performed a scoping review to map EMI literature in the field of mental health. A scoping review methodology using the framework presented by Arksey and O’Malley (172) and advanced by Levac et al. (173) was applied. A scoping review requires analytical reinterpretation of the literature and is commonly undertaken to clarify a complex concept and refine subsequent research inquiries (174).

3.2.1 Eligibility criteria

Studies were included if they 1) were concerned with the prevention or treatment of a mental health disorder 2) concerned technology as part of the intervention or treatment delivery; 3) concerned momentary intervention or components of a momentary intervention; 4) were published in the English language.

Review articles regarding EMI were included if the studies they covered met the inclusion criteria, as they necessarily operationalize a definition of EMI, and provide an overview of perceptions of EMI within particular areas of mental health. Theoretical/analytic articles were included if they discussed EMI within the inclusion criteria. Studies were excluded if they 1) provided assessments without intervention; 2) examined interventions in a laboratory setting and not in a real-world setting.

3.2.2 Information sources

In order to cover both clinical, psychological, and computing research, this review was based on the PubMed, PsycINFO and ACM Guide to the Computing Literature databases. The selection of keywords for the search string related to mental health was informed by previous studies (114, 175, 176). The search terms combined two main concepts: “momentary intervention” and “mental health” (a list of specific
search terms are available in Appendix A1.1.1). The initial search was carried out in June 2019, yielding 43 articles, and repeated using the same criteria in October 2020 in order to identify articles published since June 2019, resulting in an additional 21 publications, for a total of 64 articles. As the review is intended to complement and extend the review of Heron & Smyth and focus on EMI during the smartphone era, the search was limited to studies published between 2009 and 2020. The Heron and Smyth corpus included no smartphone apps; the first smartphone app in our corpus appears in 2011, and thus the review period covers the transition to smartphone app implementation.

3.2.3 Selection of sources of evidence

The results from the search were imported into a Zotero citation manager where duplicate citations were removed and then exported into a spreadsheet for the screening process. I independently screened all retrieved titles and abstracts for eligibility. A member of the research team (G.D.) then reviewed a random sample of forty results to assess agreement and resolve any uncertainty about the inclusion or exclusion criteria. The study selection process is illustrated in Fig 3.1.

3.2.4 Charting, summarizing, and reporting the results of the review

I and another member of the research team (G.D.) agreed on the data extraction protocol. A standardized data extraction tool was developed and piloted by me, and refined based on feedback from a second member of the research team (G.D.). I then conducted the extraction. The data extracted comprised basic study information (author, year, location), sample characteristics (number of participants, age, gender), intervention aim, target of intervention, definition of intervention (if it is pro-
vided), platforms used for the delivery of the intervention, intervention strategies (CBT, ACT, etc.), components of intervention (psychoeducation, goal setting etc.), design/delivery of intervention components (discrete messages, multimedia pages, audio etc.), tailoring of intervention, timing of delivery, intervention period, human involvement. Human involvement was included as it is a powerful means of improving engagement (177), a mechanism by which treatment can be tailored to the individual, and supports deployment of EMI within higher intensity treatment. The model of Mohr et al. (67) was used to categorize sensors for automated monitoring,
the features that are derived through data collected from sensors, and the prediction of behavioral markers and clinical targets.

The data were further coded under emergent themes using an iterative process. The coding scheme was created under the following categories: definitions of momentary interventions, components of ecological momentary interventions including devices used, information delivery, prompting times, sensors (if any used), feedback, training, tailoring, and support.

### 3.3 Results

#### 3.3.1 Characteristics of source documents

In total 583 articles were identified in the database search, and following screening a final total of 64 articles were included in the review (see Fig 3.1 for details).

Of these papers, 42 studies described delivery of an intervention, 12 used sensors for the detection of mental health problems (with a specific stated aim to enable EMI), and 10 were reviews related to EMIs for mental health problems. Appendix A1.1.2 lists the characteristics of the studies included in this review.

Table 3.1 lists the mental health conditions targeted by those studies that involved delivery of an intervention, the intervention techniques employed. The studies’ general characteristics, type of technology, intervention delivery and intervention strategies related to each intervention are presented in Appendix A1.1.3.

<table>
<thead>
<tr>
<th>Study</th>
<th>Target</th>
<th>Sample</th>
<th>Intervention strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pramana et al.</td>
<td>Anxiety</td>
<td>Clinical</td>
<td>CBT</td>
</tr>
<tr>
<td>(2014)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Diagnosis</td>
<td>Setting</td>
<td>Therapeutic Interventions</td>
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<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Kivity and Huppert (2016)</td>
<td>Anxiety</td>
<td>Clinical</td>
<td>Reappraisal</td>
</tr>
<tr>
<td>Pramana et al. (2018)</td>
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<td>Clinical</td>
<td>CBT</td>
</tr>
<tr>
<td>Silk et al. (2020)</td>
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<td>Clinical</td>
<td>CBT</td>
</tr>
<tr>
<td>Newman et al. (2014)</td>
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<td>Clinical</td>
<td>Cognitive therapy, relaxation</td>
</tr>
<tr>
<td>LaFreniere and Newman (2016)</td>
<td>Anxiety (GAD)</td>
<td>Clinical</td>
<td>CBT (worry outcome monitoring)</td>
</tr>
<tr>
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<td>CBT (worry outcome monitoring)</td>
</tr>
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<td>Clinical</td>
<td>CBT</td>
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<tr>
<td>Depp et al. (2015)</td>
<td>Bipolar Disorder</td>
<td>Clinical</td>
<td>Self-management strategies</td>
</tr>
<tr>
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<td>Clinical</td>
<td>Cognitive behavioral principles</td>
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<td>Depression</td>
<td>Clinical</td>
<td>BA</td>
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<td>Depression</td>
<td>Clinical</td>
<td>CBT</td>
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<td>Depression and anxiety</td>
<td>Non-clinical</td>
<td>ACT</td>
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<td>Non-clinical</td>
<td>ACT</td>
</tr>
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<td>van Aubel et al. (2020)</td>
<td>Depressive psychotic complaints</td>
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<td>ACT</td>
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<tr>
<td>Juarascio et al. (2020)</td>
<td>Eating disorders</td>
<td>Clinical</td>
<td>CAT</td>
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<tr>
<td>Merkouris et al. (2020)</td>
<td>Gambling disorder</td>
<td>Clinical</td>
<td>CBT, motivational interviewing</td>
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<tr>
<td>Meinlschmidt et al. (2016)</td>
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<td>Non-clinical</td>
<td>Mindfulness-based strategies</td>
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<td>Study</td>
<td>Domain</td>
<td>Setting</td>
<td>Intervention</td>
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<td>ACT</td>
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<td>Clinical</td>
<td>Coping strategies</td>
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<td>Coping strategies (coping strategy enhancement) framework</td>
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<td>CBT</td>
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<td>Moitra et al. (2020)</td>
<td>Schizophrenia</td>
<td>Clinical</td>
<td>CBT</td>
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<td>Pulantara et al. (2018)</td>
<td>Sleep disturbances</td>
<td>Clinical</td>
<td>Military-version brief BT for Insomnia (CBTI)</td>
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<tr>
<td>Versluis et al. (2018)</td>
<td>Stress</td>
<td>Clinical</td>
<td>Worry reduction training, mindfulness</td>
</tr>
<tr>
<td>Beute and Kort (2018)</td>
<td>Stress</td>
<td>Clinical</td>
<td>Exposure to natural scenes</td>
</tr>
<tr>
<td>Nguyen-Feng et al. (2019)</td>
<td>Stress</td>
<td>Clinical</td>
<td>Theory-based stress management intervention (by being the first to translate it into an EMI)</td>
</tr>
<tr>
<td>Lucas-Thompson et al. (2019)</td>
<td>Stress and anxiety</td>
<td>Clinical</td>
<td>Mindfulness</td>
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<td>Dennis et al. (2015)</td>
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<td>Clinical</td>
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<td>Clinical</td>
<td>Psychoeducation about alcohol use and consequences</td>
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<td>Clinical</td>
<td>CBT, Motivational interviewing</td>
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<td>Setting</td>
<td>Intervention</td>
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<td>Substance use (Alcohol)</td>
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<td>Cognitive and behavioral alcohol use disorder interventions</td>
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<td>Substance use (Alcohol)</td>
<td>Clinical</td>
<td>Active implementation intentions</td>
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<td>Substance use (Alcohol)</td>
<td>Non-Clinical</td>
<td>Motivational Interviewing</td>
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<tr>
<td>Haug et al. (2020)</td>
<td>Substance use (Alcohol)</td>
<td>Clinical</td>
<td>Implementation intention and action planning</td>
</tr>
<tr>
<td>Blevins et al. (2020)</td>
<td>Substance use (Alcohol)</td>
<td>Clinical</td>
<td>Coping strategies</td>
</tr>
<tr>
<td>Businelle et al. (2020)</td>
<td>Substance use (Alcohol)</td>
<td>Clinical</td>
<td>Motivational interviewing, self efficacy (SCT)</td>
</tr>
<tr>
<td>Shrier et al. (2018)</td>
<td>Substance use (Marijuana)</td>
<td>Clinical</td>
<td>Motivational enhancement therapy</td>
</tr>
<tr>
<td>Morgiève et al. (2020)</td>
<td>Suicide prevention</td>
<td>Clinical</td>
<td>Suicide prevention</td>
</tr>
</tbody>
</table>

### 3.3.2 Definitions of Ecological Momentary Interventions

Twenty three of the studies cited the Heron & Smith definition of ecological momentary interventions (117, 175, 176, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 190, 191, 192, 193, 194, 195, 196). Others provide their own definitions which are nevertheless consistent with the Heron and Smyth definition, such as “any technology-based device or application that can enhance care of patients ... through the delivery of regular, momentary intervention in the context of daily life outside face-to-face therapy” (197).
A further sixteen studies used an implicit definition without clearly outlining and clarifying a definition for the interventions they deployed (198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213). Three of these studies described delivery of micro-interventions to participants without providing a definition (214, 215, 216). The micro-interventions delivered mindfulness-based strategies through video presentation and the delivery of an online daily diary for the practice of a cognitive reappraisal technique.

**EMA linked definitions:** Several authors make an explicit link to EMA; a review that explored the feasibility, acceptability and clinical outcomes of EMA and EMI in the treatment of psychotic disorders, stated that “EMI is a derivative of EMA that extends the methodology of repeated within-environment prompting into the domain of clinical intervention” (197).

Another review of the use of EMA and EMI in the context of alcohol use refers to EMI as interventions that are delivered via mobile devices when the user needs it (i.e. in a high-risk situation)(217), an instantiation of the general point also made by Heron & Smith. The authors consider key characteristics of EMI as being the intervention aim and the timing of them. The review discusses the conjunction of EMA and EMI together since EMA can help inform the timing and content tailoring of EMIs (217). The combination of ecological momentary intervention and assessment (EMAI) and its potential to intervene in high-risk situations, as stated by Beckjord et al., is mentioned in a study that examined the influence of smartphone-delivered in-the-moment coping strategies on drinking after experiencing a craving among participants utilizing an intervention (218).

Bell et al. also refer to EMI as an extension of EMA and refer to the notion of blended therapy (219). Blended therapy is the combination of face-to-face and internet ap-
proaches for the delivery of an intervention (220). While human involvement in the delivery of momentary interventions is possible, the notion of “ecological momentary intervention” is sometimes interpreted as minimizing or even substituting the role of human involvement.

**Just-in-time interventions:** Even though it has been stated that EMIs and assessments run in parallel (114), the move towards the use of technology sensing and sophisticated algorithms to drive the delivery of interventions will change the role of real-time assessments. Thus, several studies discuss the potential of JITAI’s (193, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234).

As stated by Nahum-Shani et al., a just-in-time adaptive intervention (JITAI) is “an intervention design aiming to provide the right type/amount of support, at the right time, by adapting to an individual’s changing internal and contextual state” (115). In a just-in-time adaptive intervention, the information gathered from a person or their environment are used to eliminate support that is not beneficial (115). The distinguishing feature of just-in-time interventions compared to ecological momentary interventions is the use of statistical methods to improve and tailor the interventions over time for a given individual (117).

Foreseeable technology advances inspired both the original vision of EMI, and subclasses such as JITAI; thus we see that definitions emerge and evolve together with new technologies and components, and so it is appropriate to revisit and reconsider terminology as the technological ecosystem develops. In the following sections, I systematically describe the different components and characteristics of the EMI systems and studies included on this review.
3.3.3 Devices used for the delivery of Ecological Momentary Interventions

Mobile technology offers the opportunity for the delivery of interventions in daily life and allows for the observation of participant behavior in daily life settings and contexts. As expected from the selected date range for the review, 39 out of 42 intervention studies used mobile phones as the main platform for the intervention deployment; the remaining 3 studies used a palmtop computer. Of these intervention studies, eight used mobile phones for the delivery of prompts to access the intervention content online through a web browser (184, 186, 187, 211, 212, 214, 215, 216), and four to deliver intervention content through SMS messages (185, 194, 205, 227). The shift towards smartphone implementation is clearly seen in the corpus; 38 of 54 studies deployed mobile apps. More specifically, mobile apps were used for the delivery of an intervention in 30 studies, and the remaining 8 studies used an app for the collection of sensor data. One intervention delivered intervention content with the use of two different applications, each of them for the delivery of different intervention techniques (213). Another study used an external application to measure cardiac activity (213). Twelve studies additionally used a wearable device to collect measurements of bio-physiological (175, 200, 203, 224, 225, 226, 230, 233, 234, 235) and physical data (222, 223).

Two of the studies used a website to supplement individual CBT (179) and group CBT (180, 181), one to provide psychoeducation and feedback (199), one to assign additional interventions and monitor participant’s progress (182), one to assign additional interventions and set EMA schedules (222), and one to provide just-in-time support by the clinicians that reviewed participants entries on the mobile phone (223). The widespread adoption of smartphones has made ecologically valid deployments
easier to implement; twenty four of the studies delivered intervention content to
smartphones that were owned by the participants (178, 181, 182, 189, 190, 192, 193,
194, 202, 203, 206, 207, 210, 211, 214, 215, 219, 221, 223, 224, 225, 227, 229, 230). Five of
the studies provided smartphones to participants if they did not own one (175, 198,
205, 208, 209). Participants in twelve of the studies received wearable devices for the
collection of sensor data (175, 200, 203, 222, 223, 224, 225, 226, 230, 233, 234).

3.3.4 Information delivery

The EMIs included in this review delivered a variety of intervention strategies to par-
ticipants. Many of the studies combined different psycho-social intervention strate-
gies to achieve their aim. The interventions used different types of technology for
the delivery of intervention content including the use of messages, applications and
additional treatment components such as websites.

External delivery: paper, SMS and web links

Paper-based exercises have long been used in mental health, and written exercises
may have a role to play in EMI to avoid laborious text entry, or where participants
are concerned about the privacy of electronic data. Two interventions in this corpus
prompted participants with SMS messages to complete written exercises as part of the
intervention delivery (211, 212). Four interventions delivered intervention content
online. Participants received text messages (187, 215) or invitation emails (214, 216)
to access mobile web-based programs for the delivery of the interventions.

Several studies used messages for the delivery of intervention content through SMS (185,
194, 205, 227). Two of these studies used both SMS and web links for delivery of in-
tervention content (194) (227). Novel uses of SMS included delivery of a quiz, and a
contest involving creation of motivational text messages (227).
Mobile phone applications

Intervention content was delivered via a native mobile phone app in 30 studies. Four of those studies provided a linear program, delivering the content to participants in a predefined manner (188, 213, 223, 226). The remaining applications allowed participants to access the different intervention components at any time (179, 180, 181, 182, 190, 191, 192, 193, 195, 199, 203, 204, 206, 207, 208, 209, 210, 219, 221, 222, 224, 224, 228, 229, 230, 236). One intervention contained only one component (188) while the rest offered a variety of components to users.

There is often little information available about the rationale for the design of components, and the mechanisms for delivery of content. Therefore the following sections present findings from those studies that offered some description of the different modalities for intervention content delivery.

Textual content

Text was used for the delivery of both psychoeducation (190, 195, 205, 224) and intervention strategies (191, 192, 207, 208, 219, 221). For example, one of the interventions provided textual educational material spanning multiple screens (e.g. ‘On the following three pages, you will get an introduction to awareness’) (224). Another intervention used a library component which provided participants with single pages of text on a range of skills, each conveying a strategy from acceptance and commitment therapy, and instructing them to practice it in the moment (221).

Question-based delivery

Nine studies delivered psychoeducation and intervention strategies through the use of questions (179, 180, 181, 184, 195, 203, 213, 224, 226). For example, psychoeducation was delivered with the use of a quiz element that asked questions about educational
material shown to the user previously (e.g. “How do you define awareness?”) (224). Another intervention, aiming to prevent relapse to heavy drinking, delivered psychoeducation with the use of frequently asked questions (203).

**Conversational interaction**

One intervention integrated aspects of motivational interviewing into a virtual coach component which guided participants through an exercise to explore the pros and cons of making a change in personal alcohol use. The app engages in a “conversation” with the participant to elicit information and present strategies (e.g. “Would you like to calculate your blood alcohol concentration from yesterday?”) (190).

**Multimedia content delivery**

Several studies offered multimedia content to participants. Mindfulness and relaxation were typically offered through the use of audio and video. Six studies delivered breathing exercises with the use of video (180, 181), audio (213, 224), and audio or text (221). Seven of the studies used audio recordings to deliver mindfulness based exercises (193, 213), relaxation (179, 180, 181), or other kinds of audio content (218, 221). For example, a study comparing in-the-moment skill coaching effects from tailored to non-tailored ACT, included audio-guided (or text-based) exercises to practice skills such as acceptance of a difficult emotion, cognitive defusion, breathing mindfulness and reflecting on a valued moment (221). Video was used to deliver psychoeducation (206) or to introduce and demonstrate the various features of an application (190, 222, 230). One study delivered intervention content with the use of audio-visual components and minimal text (193).

Others focused on the use of visual images; for example, exposure to natural images through the use of slideshows delivered on the phone (188). One of the studies
displayed photos taken by participants to remind them of the reasons for deciding to change their drinking behaviors (218). Video messages from therapists together with photographs and documents have been used to remind participants to practice skills learned during face-to-face sessions (i.e. “coping cards” completed during session) (179, 180, 181). In another exercise, participants could see themselves on the smartphone, using the front camera in order to receive an instruction (e.g. “You will see yourself on the phone. Look yourself in the eye and smile for at least 20 seconds”) (224).

3.3.5 On-demand support

A distinct category of support feature relates to functionality that is used by clients when they feel they are particularly in need, or at risk (e.g. at risk of relapse) (191, 203, 208, 210, 222, 228). One of the interventions integrated additional components to provide in-app and on-demand support with the provision of immediate help to avoid an imminent relapse, alerts to key people who may reach out to the participant, and recovery experiences (203). Other studies offered in-app support by providing the options to contact a social network of relatives or a mental health professional (210), or by automatically contacting a list of contacts identified by the participants in case they travel to a gambling venue (228). On-demand support was provided in two studies by integrating weekly exercises based on topics covered in previous therapy sessions (191), or by presenting intervention strategies previously selected by the participants (208).

Some interventions provide links to external resources outside of the intervention. Six of the studies in this corpus implemented a resources feature with links to external web resources (203, 205, 210) or through the app (190, 206, 222).
3.3.6 Prompting interaction with EMI interventions

The use of an EMI in daily life entails remembering to access the intervention. For that reason, when designing an EMI, participants are typically prompted to interact with the intervention during the day. I use the term ‘prompt’ to describe features that prompt users to interact with the EMI intervention.

Some form of prompting was described in 38 intervention studies. Prompting may occur at specific or random times determined before the delivery of the intervention, user-initiated times, and at opportune moments based on sensor data collected during the intervention period (Table 3.2).

3.3.7 Gamification

Gamification refers to the use of game design elements in non-game contexts (237). Four studies employed gamification techniques. One study deployed educational games with the use of multiple choice and true/false questions (190). Another intervention familiarized participants with intervention content through a conversation via SMS between the children participating in the study and a virtual friend (180, 181). All four studies offered points and rewards for completing assessment entries (179, 180, 181), or based on scores received when engaging in competitions with other participants (190). While gamification is used to encourage client engagement, game metaphors may also be more deeply integrated with the therapeutic material.

3.3.8 Sensors for automated data monitoring

Twenty two of the studies used sensors to automatically collect data, provide sensor-based responses or attempt to predict psychological states. I use the hierarchical
framework of Mohr et al. (67) to categorise the sensors used (Table 3.3), and the transformation of the sensor data into features for the prediction of behavioral markers (Table 3.4). Appendix A1.1.3 provides a list of the studies that used sensors.

**Sensor-based measurements**

Three of the studies used sensors as part of the intervention in order to collect outcome measurements. The studies collected cardiac activity data with the use of a chest band worn underneath participants clothing (213), measured heart rate when participants held their fingers in front of the phone camera by using an external application (MyHeartRate) (188), or collected sleep, heart rate, and steps data through an activity tracker (230).

**Sensing for detecting and predicting states relevant to mental health**

Twelve studies utilized sensors for the prediction or detection of psychological states. Sensors were used to detect stress episodes (225, 233, 238), negative emotions (178), substance use (i.e. high-risk drinking events) (202), predict subjective measures of social anxiety (232), stress and drug craving events (234), symptoms of schizophrenia (201), or depressive states (198, 199, 200, 231). Appendix A1.1.4 provides an overview of the devices used and the collected data from sensors for the prediction of each mental health condition.

**Sensor-based responses**

Seven studies attempted to tailor intervention content based on data collected by sensors.

**Activity-based responses** One study incorporated a variety of sensors for data collection that were analyzed and transformed into context information that in combi-
nation with user preference and decision logics were used to recommend evidence-based interventions presented via the application. For example, when a low activity level was detected by the system, participants were recommended to take a walk (224).

**Location based responses** Four of the studies used geofencing to complement time-based reminders and provide support to the participants (180, 203, 222, 228). Just-in-time prompting to access intervention content was initiated based on locations predefined during a face-to-face session with a therapist (180), registered by the participants through an app (203, 228), or determined based on assessment responses (222). One of the studies used GPS to collect geofencing data when an internet connection was enabled and implemented an algorithm using phone sensor data (gyroscope, accelerometer, and magnetometer) to detect location when an internet connection was not available (228).

**Physiologically based responses** Two of the studies used physiological data to provide interventions (223, 226). The studies used wearable devices to measure sleep-wake patterns (223) or electrodermal activity (EDA) (226) to decide when to prompt users to interact with personalized recommendation or intervention content.

### 3.3.9 Feedback

Feedback can be important for maintaining engagement by participants; 25 studies delivered feedback messages to participants as part of the intervention.

**Motivational messages**

Five of the interventions delivered motivational messages to participants after the completion of assessments (179, 189, 194, 206, 214). For example, in a RCT study
aiming to reduce marijuana use in youth, participants received motivational messages via the application after the completion of a momentary report of personal triggers for marijuana use, desire, use or effort to avoid use. Where their response rate was low, the messages reminded participants to respond and advised them to seek technical support (189). Another intervention sent one motivational message daily that was drawn from a pool of messages based on motivational interviewing techniques, mindfulness-based therapy approaches and encouraging language found in other motivational messaging EMIs (206).

**Self-monitoring and semi-individualized feedback**

Seventeen of the studies provided semi-individualized feedback with the use of branching rules that were programmed into the software, and based on EMA responses (182, 184, 186, 191, 192, 193, 194, 195, 199, 207, 209, 210, 221, 222, 226, 227, 230). Feedback included the delivery of intervention strategies or encouragement messages based on the answers provided during check-in assessments. For example, in one intervention participants, with the use of CBT-informed questions, provided their current emotions and level of intensity, and current context. When a positive emotion was identified they received an affirmational statement; a coping strategy was suggested when they selected a negative emotion. Additionally, when they selected a negative emotion, they were asked about their intentions to drink alcohol and their current context in order to receive specific coping strategies (226).

**Data visualization and Graphical feedback**

Nine of the interventions provided data visualization of past entries (179, 180, 181, 182, 187, 190, 199, 223, 230). Five of the interventions allowed therapists to monitor participant entries through the integration of a web-based portal which displayed a graphical representation of participants entries (179, 180, 181, 182, 223). Three inter-
ventions provided feedback to participants to identify changes over time (187, 190, 230). Another intervention provided graphs through a website for a variety of purposes such as progress over time, exploration of emotion changes based on location data, and identification of patterns based on graphs created by a therapist (199).

3.3.10 Tailoring Ecological Momentary Interventions

The tailoring of interventions can be categorized into three groups based on the level of human involvement needed for the delivery of personalized content:

**Manual tailoring**

We define manual tailoring as where a participant, a clinician or other professional configures the EMI behaviour for participants. Clinicians performed tailoring in eleven of the studies. This has been achieved through use of a clinician portal. For example, such a portal has been used to monitor patient adherence, manage rewards points, send audiovisual material to patients, customize instructional messages, and send customized motivational messages (179, 180, 181). Additionally, clinicians performed tailoring by selecting intervention strategies (182, 219, 222), and setting the time ranges for participants to be notified (179, 180, 181, 222).

Research assistants and therapists in two studies that used sensors as part of their strategy offered manual tailoring during the intervention period. This was done by setting a threshold to alert participants when EDA was high (226), or by predefining rules to prevent unreasonable intervention recommendations by an application that used a learning system to deliver appropriate interventions depending on participants context(224).

In three of the studies participants selected intervention content during face-to-face sessions, which was then integrated into the mobile application (187, 191, 219). The
intervention content selected during those sessions was presented based on mood scale ratings (187, 191) or based on a predefined plan for the intervention (219).

Two of the studies offered the option to modify the content and order of suggestions provided through the app (210) or to upload pictures/videos and sounds to customize future visual and auditory alerts (228).

**Semi-individualized tailoring**

Semi-individualized tailoring involves automated selection of interventions, common across participants, that are selected based on participant preferences. Eight of the interventions delivered EMIs based on participant preferences before the delivery of the intervention (190, 192, 205, 207, 208, 210, 227) or based on clinician decisions (223). One study populated a matrix with ACT-based interventions on the home screen of the app based on assessment responses (230).

Sensor data may be used to drive tailoring, as in the case of the intervention aiming to prevent drinking relapse mentioned previously, where participants voluntarily registered places they consumed alcohol and based on GPS data the system provided just-in-time support (203).

**Automated tailoring based on collected data**

We define automated tailoring as tailoring which does not involve any configuration input from clinicians or clients. One intervention aiming to deliver CBT for people with depression automatically presented interventions to users based on sensor and phone usage data. The application made recommendations based on a variety of features including time of the day, location, smartphone usage and physical activity data (224).
3.3.11 Training

Training often forms part of the delivery of ecological momentary interventions. In 27 of the studies included on this review, research staff and clinicians offered training to participants before the delivery of the interventions for a variety of purposes, including instructions for use of intervention content, and the use of the technology (180, 181, 186, 187, 188, 189, 192, 193, 194, 195, 198, 199, 201, 206, 207, 208, 209, 210, 211, 212, 214, 215, 219, 221). Three of the studies delivered video tutorials of the intervention after downloading the app (190, 222, 230).

3.3.12 Human support

The involvement of research staff and clinicians is not restricted to the tailoring of interventions. Support is provided during the intervention period for a variety of reasons.

Support between treatment sessions

Support was provided in six studies where EMI was delivered in parallel with face-to-face treatment sessions with therapists. In one of those studies, the therapist used the information gathered from the intervention to gauge client progress (195). Four interventions offered support between face-to-face sessions through the EMI platform to provide feedback to participants upon request, and to select intervention strategies to be delivered via the app (179, 180, 181, 191). Therapists in one study offered technical support during face to face sessions and integrated intervention content into the app in between sessions (182).
**Therapist initiated remote support**

In fourteen studies, support was provided during the intervention period from research staff and clinicians without the use of face-to-face meetings with participants. This often involved therapists calling participants to address any technical problems with the software and hardware (184, 186, 187, 193, 198, 208, 222, 226) or to support adherence by calling participants when necessary (199, 209, 215). In three studies, support was provided to participants who reported a deterioration of symptoms based on answers derived from EMA responses (201, 223), or when accessing a component of the app when in need of help (210).

**Social features and in-app human support**

Professional and peer support was provided to participants through the integration of a variety of features into the applications deployed. Five studies integrated support directly into the applications.

Therapist support was provided in four studies through the integration of features that allowed participants to compose messages on the phone that were sent to a portal administered by therapists (179, 180, 181), or by offering the ability to receive personal responses to questions from experts in addiction within 48 hours through SMS messages (203).

Peer support was offered in two studies (203, 218). One of the studies implemented discussion groups where participants could anonymously exchange emotional support and information with others (203). Another intervention offered in-app peer support through components that provided text or phone contact details of a person selected by the participants, or a link to their smartphones contact list to contact a friend or family member (218).
3.4 Discussion

This scoping review aimed to review the definitions used across the literature to describe EMIs for mental health disorders, and to categorize the design options available for the deployment of these interventions. To conclude this chapter, I reflect on the findings, and discuss the challenges of defining EMIs, the evolution of EMIs in the smartphone area, the use of sensors and machine learning to advance research in the field, and the different experimental study approaches. Finally, we propose recommendations for future research, encouraging researchers to present the rationale of choices made when designing an intervention.

3.4.1 Defining EMIs in the literature

The vision of Patrick et al. (113) to deliver tailored ecological momentary interventions based on ecological momentary assessment responses became feasible a decade ago, as demonstrated in the synthesis and critique of technology-based EMIs by Heron & Smyth (114). In their review, they provided a concise definition for the term as “treatments that are provided to people during their everyday lives (i.e. in real-time) and in natural settings (i.e. in real-world)”. Twenty three of the papers in our corpus used that definition and another sixteen provided an implicit definition by delivering an intervention that they described as an EMI. We thus must consider the components of these interventions, and in this regard we have seen that a modern EMI typically entails a range of information delivery, engagement and communication features.

Bell et al., in this corpus, provided a more precise definition of EMI as “any technology-based device or application that can enhance care of patients ... through the delivery of regular, momentary intervention in the context of daily life outside face-to-face
therapy” (197). Even though this definition describes the ecological aspect of an intervention in more detail, the notion of *momentary* interventions is not defined as clearly. A decade ago, the “momentary” aspect was restricted to delivering interventions at random and scheduled times (114). The concept of “just-in-time interventions”, which use statistical methods, and algorithms for the optimization of the time of delivery of individual interventions (117), has expanded the momentary aspect of EMI definitions, and fifteen studies in this review refer to the notion of “just-in-time” interventions.

As noted in the Definitions section, several authors discuss the conjunction of EMA and EMI in EMAI systems, and wrote about the importance of EMA to inform the timing and content tailoring of EMIs and thus intervene in high-risk situations (217, 218). As EMA alone may have a therapeutic effect, extending EMA through the introduction of sensing capabilities may further blur the distinction between EMA and EMI. There was no consistency in the definition used, if any, among application areas. Multiple definitions may also apply to a given intervention; the development of JITAI offers the potential for altering the role of ecological momentary assessments in the future, and hence while not all JITAI are EMAI systems, some are.

We have seen in this review that key characteristics in the design of these interventions include the set of intervention components, decision mechanisms regarding when and which interventions should be provided to users, tailoring variables, and decision rules that link tailoring variables to intervention options. As the development of these components continues, the variety of approaches to tailoring and use of sensor data motivates further, more specific terminology to provide clarity for an understanding of the different characteristics deployed in any intervention given among different application areas. This terminology should convey the characteristics of an intervention including (a) the use of momentary assessment technology, (b)
the use of sensors, (c) the involvement of professionals, and (d) the use of just-in-time algorithms that adapt the provision of support over time based on time-varying (dynamic) information collected from the user. Future studies should explicitly specify in their terminology these different aspects used for the deployment of their interventions and provide a rationale for the different components integrated into them.

3.4.2 Designing EMI in the smartphone era

Mobile apps are now the most common medium used for the delivery of EMIs. This change has created opportunities for the use of multimedia as a medium for presentation of different intervention strategies and the deployment of more interactive interventions. Furthermore, mobile phone capacities have allowed for the integration of techniques such as gamification in order to enhance the experience of users. The expansion of technology offers the possibility of providing support not just with the incorporation of additional intervention channels such as interactive websites (114), but also with the integration of communication features. This extends the channels through which support can be provided and expands the options available for social support and enabling communication between individuals and clinicians. Furthermore, the advance of technology has allowed researchers to utilize sensors embedded on phones or wearable devices for the collection of environmental or other contextual data. Figure 3.2 shows a graphical example of an EMI.

3.4.3 Using sensing and machine learning in the design of EMIs

Patrick et al. envisioned the collection of environmental data or other contextual factors for the delivery of ecological momentary interventions in daily life. Heron & Smyth referred to the possibility of tailoring momentary health behavioral messages with the use of assessments of physiological or environmental cues as technology
continues to become more sophisticated. The approach of delivering intervention content based on unobtrusive data collection has become feasible in recent years. Researchers are using sensors embedded on mobile phones and wearable devices to collect data for the provision of just-in-time support and prediction of mental health states, with 10 of the intervention studies incorporating sensor based components, and a further 12 studies focused on development of such components. Machine learning algorithms have been used to identify and predict a variety of states relevant to stress, depression, schizophrenia, and alcohol abuse. We have also seen that the use of sensors can enable opportunistic delivery timing by providing support when the participants are in need of support.

Two previous reviews emphasize the importance of tailoring interventions based on individual needs (239, 240). Truly individualized tailoring requires a more sophisticated technology implementation, and research has explored various levels of human involvement in tailoring. The use of machine learning models offers the possibility
for systems to make decisions with reduced human involvement, which carries with it a new set of concerns, and must be approached carefully (241). Perhaps surprisingly, all studies that targeted depression used machine learning to identify depressive states.

These attempts to integrate machine learning models highlight a promising area for future development; that as technology advances we will be able to enhance the “momentary” aspect of the interventions by delivering interventions at event-based times and presenting content relevant to the person’s context.

3.4.4 Maturity of the field and clinical validation

The EMIs delivered a variety of different intervention techniques and most of the interventions combined different psycho-social strategies to achieve their aims. The literature, while growing in size and significance, can thus be seen as still constituting a very preliminary investigation of the topic.

The majority of studies focused on delivering interventions for anxiety and substance use disorders, with major topics in mental health unaddressed; for example, only one study was found that targeted an eating disorder, consistent with previous review findings (183). This scoping review includes a variety of experimental design approaches, ranging from a (n=3) case study to randomized controlled trials (RCTs). Nine RCTs of EMIs are included in this review, for anxiety, stress, bipolar disorder, substance use (i.e. alcohol), mood and depression. Of these RCTs four used EMA (without EMI) as a comparison group, one used CBT, one compared EMI with a paper and pencil condition, and two compared two different versions of the application in addition to an EMA only condition. Randomized controlled trials are the gold standard for evaluating interventions since they might tell us what treatments are beneficial. However, traditional two-armed RCTs can not provide insights about
the timing, type and frequency of different interventions. An alternative promising methodology to address these issues when evaluating EMIs is the use of microrandomized trials (MRTs) to optimize treatment and to compare interventions to each other and to no intervention (117).

3.4.5 Recommendations for future research

The studies in the corpus provided little information about the design choices for the deployment of the interventions beyond describing (often briefly) the delivery platform. We therefore recommend that researchers present the rationale for choices made when designing an intervention in order to provide an understanding for the usefulness of different components deployed on them. This further raises the question of evidence for the effectiveness of different intervention components and different intervention designs. The studies targeted a variety of mental health disorders and deployed a variety of intervention techniques. This suggests the need to explore the effectiveness of different technological and interaction possibilities designed for specific mental health conditions and intervention techniques.

3.4.6 Strengths and limitations

To the best of our knowledge, this is the first review to present an overview of the different definitions used to describe ecological momentary interventions, and the first attempt to categorize the design options available for the deployment of these interventions. However, there are limitations in the interpretation of these findings. A quality appraisal was not included in the aims of this review. It is also worth noting that this was a scoping review of the literature rather than a quantitative synthesis of EMIs, such as a meta-analysis would provide. Given the advances of this field
in recent years, it is worthwhile to understand what is being done and how EMIs are being conceptualized. Clarity on these aspects might help in the development of standardized strategies for delivery, and facilitate future quantitative synthesis. This review focused on the delivery of interventions for people with mental health disorders; examining other work within mobile health interventions generally would also be valuable.

3.5 Conclusion

This chapter reviewed 64 studies and examined how ecological momentary interventions for mental health are defined and the different components that comprise such interventions. We have looked at the particular case of mental health technologies and reviewed the characteristics of 64 studies. Within these, we have identified that with the introduction and widespread adoption of smartphones, the literature has begun to realise the ambitious vision of EMIs. EMI implementation has shifted definitively towards smartphone app implementation, supporting a range of delivery modalities and engagement and communication features. The research literature has begun to explore the capabilities of both sensing and machine learning in the delivery of momentary interventions, as well as a variety of engagement features enabled through the use of smartphones. Exploitation of data from EMA has also been a key topic for researchers in the area. Clinical validation of these systems is still in the early stages, and a particular problem is the many design parameters involved in EMI delivery, concerning the timing and content of interventions. While the term JITAI has been introduced to describe the subset of EMIs with more sophisticated targeting of interventions, important design dimensions such as human involvement and the type of tailoring are not captured in existing terminology. This initial review revealed the need to foster a more comprehensive understanding of the many design
parameters involved in mental health applications given the often brief descriptions of interventions noted in this chapter. We should understand the content of apps that are currently publicly available for use and examine deeply the functionality of these systems in order to inform the design of mobile mental health applications. The widespread adoption of publicly available smartphone apps offers the opportunity to deliver ecological momentary interventions in real-world settings in users’ daily life settings. In order to design apps that are effective and engaging, an understanding of users’ perspectives on the enablers and barriers to engagement with publicly available apps is needed. This chapter allowed us to construct a model containing the different characteristics for the design of mobile-based mental health interventions. Figure 3.3 shows the model (represented as a mind map) derived from the results of this study.
Figure 3.3: Model of mobile mental health interventions
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Fixed times: Prompt delivered at specific times; Random times: Prompt delivered at random times; User-initiated: Prompt delivered upon user preferences; Event-based: Prompt delivered based on the collection of sensor data.
Table 3.3: Sensors for automated data monitoring

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Mic= microphone, Comms=in-phone communication, Phys= Physiological Sensors

Table 3.4: Features derived from data collected from sensors

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Movement = movement intensity, Paraling = paralinguistic information, Social = in-phone social activity
4.1 Introduction

The literature review in chapter 2 brought out the different approaches to designing and evaluating mental health technologies. The scoping review in chapter 3 revealed approaches to the definition and different components of EMI technologies. It also highlighted the need for a more in-depth understanding of the different design components and the content of such interventions. In this chapter, we will present a review of the functionalities employed by consumer mobile applications to identify the key features these apps integrate for people to use. By doing this, we can improve our understanding of the design space for these applications, since consumer apps
are publicly available to download and use. We investigated the engagement features that encourage regular use, make app content more appealing, and in general, help users to stay engaged with therapy or the app itself. Similar to the previous chapter, we explored the tailoring that these applications offer since tailoring is key to driving engagement. As mentioned in Chapter 2, within the context of anxiety apps, this relates primarily to the tailoring of content to specific user groups and needs. Additionally, we aimed to explore the extent to which these apps incorporate the advanced functionalities (e.g. such as sensors) highlighted in the academic literature. Within the academic literature, the use of functionality based on sensors is seen as a key strategy for delivering more effective content in future systems (116, 180, 224, 242, 243). Chapter 3 showed that many studies attempted to use sensors for a variety of different purposes; therefore, any use of such features is of interest.

We focused on applications targeting anxiety disorders, one of the most common forms of illness, and incorporating components of cognitive behavioural therapy (CBT), one of the most common evidence-based therapy for anxiety, into their design. Although as mentioned in chapter 2, various studies have explored the evidence base of and evidence-based content in anxiety apps (38, 82, 108), no review of apps has been conducted exploring content delivery in apps for anxiety disorders. The design of usable and effective mental health apps is a key challenge and depends on an understanding of what works, for whom, and under which circumstances. This chapter provides a greater understanding of what these apps actually provide and what strategies they employ to engage and deliver treatment to users. Thus, we examined both the provision of features that encourage regular use and the tailoring of content delivery to provide interaction that is both engaging and effective for particular users. To conclude this chapter, we reflect on the findings and propose recommendations for future research, encouraging researchers to examine the impact of different features
and evidence-based components on engagement. The work presented in this chapter contributes to answering the second Research Question 1.

4.2 Method

4.2.1 Overview

Apps were identified through a systematic search of the two most widely used platforms: Android’s Google Play Store and Apple’s iOS App Store (35). Initial searches were conducted in February 2020 to explore the inclusion criteria and analysis methodology. The corpus presented here is based on a final search conducted in June 2020. The search was based on the following keywords related to anxiety disorders: anxiety, stress, worry, phobia, and panic. In addition, we searched for the following keyword related to CBT: cognitive behavioural. Separate searches for each of these keywords were conducted on each app store and applied across all categories of apps.

Studies suggest that only a small number of users look beyond the first 10 ranked apps (244). In addition, the first five apps for a given search term are the most downloaded (244). Therefore, as a conservative approximation of those visible to potential users, only the first 50 results were included from each unique search. Search results for each of these keywords were automatically downloaded using scripts from the US version of Google Play and Apple’s App Store (245, 246). Recorded information included app name, description, price, developer name, average rating, and the number of user ratings.

1RQ2. What is the functionality of mobile mental health interventions for anxiety both in the academic literature and in practice?
4.2.2 Selection criteria

Apps were included that met the following criteria: (1) the app was in the health and fitness or medical category of the app store, (2) mentioned the use of CBT in the title or store description when we searched for anxiety-related keywords, (3) mentioned anxiety-related disorders when we searched for “cognitive behavioural,” (4) were currently available to download, and (5) were available in English. Apps were excluded if (6) they did not mention the treatment or management of anxiety-related symptoms in their description pages and (7) were last updated more than two years ago. Apps that were free or offered in-app purchases were downloaded to have the broadest appeal because studies suggest that free apps are more likely to be downloaded than paid apps (247). We coded both the free and premium features of these apps. I and another reviewer of the research team (G.D.) reviewed a pilot sample of apps to clarify the inclusion criteria before proceeding. I independently applied the inclusion criteria. The study selection process is illustrated in Figure 4.1.

4.2.3 Data extraction and coding

Apps meeting the inclusion criteria were downloaded onto either a Samsung Galaxy S9 Plus (Android version 9) or an iPhone 8 Plus (iOS version 14.0). The American Psychiatric Association model for assessing mobile mental health apps was used as a starting point (94). Descriptive characteristics related to the following features were extracted from the marketplaces: general background information (store, price, target audience, popularity, privacy and safety, accessibility, claimed scientific underpinning, and medical disclaimer). Accessibility was assessed manually by checking each app to identify options relevant to visual, auditory, or motor impairment or explicitly termed accessibility options within the apps.
Engagement features were extracted using a classification from a review by Stawarz et al. (98) on the functionality of CBT apps for depression. They examined the functionality of CBT apps for depression by recording both therapeutic and engagement features from their description pages. As mentioned already in the introduction of this chapter, we recorded features that encourage regular use, make app content more appealing, and in general, help users to stay engaged with therapy or the app itself. In addition, we recorded CBT therapeutic features; two researchers (myself and S.S.) independently indicated whether a given feature type represented a CBT component used in the treatment of anxiety, similar to other efforts used to characterize evidence-
based app content (101, 108, 248). In cases of disagreement, discussions between myself and other members of the research team (A.C., G.D., S.S.) were conducted until full agreement was established before proceeding. See Table 4.1 for definitions of how components were operationalized for study coders.

Table 4.1: Evidence-based treatment components within study apps

<table>
<thead>
<tr>
<th>Category</th>
<th>Defined as the presence of any of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychoeducation</td>
<td>Education about anxiety (definition, description of cycle of reinforcement, description of symptoms)</td>
</tr>
<tr>
<td></td>
<td>Education on the cognitive-behavioural model</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>Monitoring cognitions</td>
</tr>
<tr>
<td></td>
<td>Monitoring emotions/symptoms</td>
</tr>
<tr>
<td></td>
<td>Monitoring behaviors</td>
</tr>
<tr>
<td>Cognitive techniques</td>
<td>Identifying thoughts</td>
</tr>
<tr>
<td></td>
<td>Cognitive restructuring</td>
</tr>
<tr>
<td>Behavioural techniques</td>
<td>Behavioral activation</td>
</tr>
<tr>
<td></td>
<td>Behavioral experimentation</td>
</tr>
<tr>
<td>Relaxation skills</td>
<td>Mindfulness exercises</td>
</tr>
<tr>
<td></td>
<td>Progressive muscle relaxation</td>
</tr>
<tr>
<td></td>
<td>Breathing exercises</td>
</tr>
</tbody>
</table>

A sample of apps was reviewed to identify functionality features; 10 apps were then open-coded to create the initial codebook. The codebook was refined following discussion with all members of the research team, and all the apps were coded to the refined scheme. In cases of disagreement, discussions between the members were conducted until full agreement was established before proceeding.

We coded general characteristics for each app, including target audience, popularity, privacy and safety, accessibility, claimed scientific underpinnings, and medical disclaimers. We coded six main types of functionality and recorded the engagement features—screening, self-monitoring, visualization of data entries, gamification, social features and support (immediate support and crisis support), and features used to deliver CBT treatment elements. We also recorded CBT treatment components,
including psychoeducation, cognitive techniques, behavioral techniques, and relaxation skills.

In addition, we recorded tailoring features that aim to personalize treatment, for example, by delivering content targeted to individual user needs or allowing users to customize content based on their needs. As mentioned in chapter 2, we distinguished personalization and customization based on the nature of user involvement. Personalization is used to tailor the user’s experience based on their previous behaviors, whereas customization is initiated by users and allows the modification of app features based on their preferences. The codes covered five main types of tailoring functionality: interface customization, treatment-oriented customization, content tailoring offered immediately after installation (app-driven personalization), tailoring based on self-monitoring entries (mood-driven personalization), and customization of push notifications. We also recorded (1) the use of sensors and (2) the provision of support based on sensor data. Table 4.2 lists the features identified in the apps in a hierarchical manner. See Table 4.3 for the classification of functionality and engagement features.
### Table 4.2: Hierarchical organization of the results section

<table>
<thead>
<tr>
<th>Category</th>
<th>Content</th>
</tr>
</thead>
</table>
| General characteristics | Target audience  
|                  | Popularity  
|                  | Privacy and safety  
|                  | Accessibility  
|                  | Claimed scientific underpinning  
|                  | Medical disclaimer  |
| Functionality   | Screening  
|                  | Self-monitoring  
|                  | Visualization of data entries  
|                  | Gamification  
|                  | Social features and support (Immediate support & Crisis support)  
|                  | Features used for delivery of cognitive behavioral therapy treatment elements (Psychoeducation, Cognitive techniques, Behavioral techniques, Relaxation skills)  |
| Tailoring features | Interface customization  
|                  | Treatment-oriented customization  
|                  | App-driven tailoring  
|                  | Mood-driven personalization  
|                  | Customization of push notifications  |

### 4.3 Results

#### 4.3.1 General characteristics

**Target audience**

Both marketplaces provide formal age classification. The majority of Android apps in the sample were classified as being suitable for children 3 years (31/32, 97%), and only 1 app recommended parental guidance. Most apps (15/25, 60%) in the Apple Store were classified as being suitable for adolescents 12 years, 32% (8/25) for children 4 years, and 8% (2/25) for adolescents 17 years. In addition, 1 app recommended use for ages between 11 and 19 years and allowed use by younger children with the support of a carer, although it was classified as being suitable for children 3 years.
Table 4.3: Functionality types and engagement features

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Engagement features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening</td>
<td>graphs and charts, reports supporting graphs and charts</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>games and gamification</td>
</tr>
<tr>
<td>Data visualization</td>
<td>customization options, notifications, and reminders</td>
</tr>
<tr>
<td>Gamification</td>
<td>ability to share data with others, peer support, and ability to contact a therapist</td>
</tr>
<tr>
<td>Tailoring</td>
<td>chat with a bot, treatment program format, ability to add pictures and videos, audio content, video content, and question and answer interface</td>
</tr>
<tr>
<td>Social features and support</td>
<td>features used for delivery of cognitive behavioral therapy treatment elements</td>
</tr>
<tr>
<td>Features used for delivery of cognitive behavioral therapy treatment elements</td>
<td>(Android) and 4 years (Apple).</td>
</tr>
</tbody>
</table>

### Popularity

Most apps provided a rating score in the marketplace (33/36, 92%). The rating for most apps (out of 5 stars) was above 4.0 (26/33, 79%). Two apps in the Android marketplace received an editor’s choice award and another received a standout well-being app award.

### 4.3.2 Privacy and safety

Privacy policies were available, either in the app or as a link from the app store description for most apps (34/36, 94%). Two apps lacked a privacy policy, which means no protection for personal information or safeguards against misuse of mental health data. The privacy policy for 1 app was not in English. Of all the apps with a privacy policy, an account or password creation was mandatory for 9 (out of 35, 26%) and optional for 1 (out of 35, 3%). A total of 15 apps provided the option to set up a personal identification number (13/15, 87%) or biometric authentication (2/15, 13%). The setup for password protection was offered in the premium version for one app. The remaining apps did not provide any security features to restrict access to the
4.3.3 Accessibility

Most of the apps required an internet connection to function (24/36, 67%), and a small number (3/36, 8%) provided reduced functionality without an internet connection, which may disadvantage those without a reliable connection. Accessibility options for those with impaired vision or other disabilities were offered by only 2 apps (out of 36, 5%). One of these apps allowed the text size to be changed. The other app (Hap-pify) offered a variety of options, including compatibility with assistive technology (such as voice assistants), high-contrast mode for those with low vision or color blindness, accessibility warnings for activities that require visual or audio interactions, font resize support for low-vision users, and the option to disable animations.

4.3.4 Claimed scientific underpinning

All the apps claimed in their description page to be designed based on validated psychological treatments. A total of 20 apps were designed to provide techniques based on CBT (20/36, 56%). The remainder integrated CBT techniques combined with other psychological treatment approaches, including positive psychology (5/36, 14%), acceptance and commitment therapy (4/36, 11%), and dialectical behavior therapy (3/36, 8%).

4.3.5 Medical disclaimer

Most apps provided a medical disclaimer, indicating that the app was not a replacement for clinical treatment (21/36, 58%). A total of 15 apps did not provide any disclaimer on the marketplace or app’s website. In addition, 10 apps made the disclaimer easy to find and read by presenting it on the description page of the app on
the marketplace (8/10, 80%) or when downloading the app (2/10, 20%). The remainder presented the disclaimer in their terms of use (4/11, 36%), on the app menu (5/11, 45%), or in the frequently asked questions section (2/11, 18%).

4.3.6 Functionality Analysis

Functionality Types

The following section discusses the functionality of the identified apps, with a focus on engagement and tailoring features. For all apps, we recorded details of features to support user engagement with therapy or the app itself offered in the free (Table 4.4) and premium versions (Table 4.5).

Screening

In total, 12 (12/36, 33%) apps offered functionality to screen for a variety of psychological disorders using questionnaires. The screening was user-initiated for five apps. The remaining apps provided screening when downloading the app (5/12, 42%) or during app use (2/12, 17%). The purpose of the screening was to help users track and manage their progress and provide insights. In addition, 1 app offered screening to train the chatbot to learn which intervention strategies would be most relevant for each user.

Self-monitoring

Of the 36 apps, 22 (61%) offered functionality entailing tracking feelings (8/22, 36%), mood (11/22, 50%), emotions (1/22, 5%), or mood and anxiety levels (2/22, 9%). A diverse range of designs was used for self-monitoring. Common modalities included the use of emoticons or tags for different feelings, an avatar that changes based on interaction with it, and scales used to rate the intensity of different emotions. Colors
<table>
<thead>
<tr>
<th>App Name</th>
<th>Visualization</th>
<th>Gamification</th>
<th>Customization</th>
<th>Social</th>
<th>Chatbot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom: CBT Therapy &amp; Self-Care</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Companion</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Diary</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Journey</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Mental Health Application</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT thought diary</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Tools for Healthy Living</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear Fear</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Behavioral Therapy</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Behavioral Therapy (2)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-StressMe</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ezeCBT</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>FearTools</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MindShift CBT - Anxiety Canada</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moodfit</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moodnotes</td>
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<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<tr>
<td>Panic Pit Stop</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflectly</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanvello</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Stress &amp; Anxiety Companion</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoughts</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UpLift</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What’s up</td>
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<tr>
<td>Woebot</td>
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<td></td>
</tr>
<tr>
<td>Worry tree</td>
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<tr>
<td>Wysa</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youper</td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>7</strong></td>
<td><strong>25</strong></td>
<td><strong>16</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
Table 4.5: Engagement Features Available in the premium version of apps

<table>
<thead>
<tr>
<th>App Name</th>
<th>Therapist</th>
<th>Program</th>
<th>Visualization</th>
<th>Reports</th>
<th>Other</th>
<th>Data sharing</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td></td>
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<tr>
<td>CBT diary</td>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>CBT Companion</td>
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<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-stressMe</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
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<td>Happify</td>
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<tr>
<td>Innerhour</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>Mindshift</td>
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<tr>
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<td>✓</td>
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<tr>
<td>Pocketcoach</td>
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<td>✓</td>
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<td></td>
</tr>
<tr>
<td>Reflectly</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<td>Sanvello</td>
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</tr>
<tr>
<td>Stress&amp;Anxiety Companion</td>
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</tr>
<tr>
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<tr>
<td>WorryTree</td>
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</tr>
<tr>
<td>Wysa</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Youper</td>
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</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

were used to indicate the intensity of feelings and text to support the meaning of different emoticons. A total of 13 apps supported the entry of additional information related to the selected feeling, such as situations (4/13, 31%), factors (5/13, 38%), thoughts (3/13, 23%), or journal entries (1/13, 8%). The number of options for the selection of feelings differed among apps, with the majority presenting from 5 to 7 different feelings. Apps varied in how often users can track their mood and how mood tracking is presented. Tracking was unlimited and user-initiated in 20 apps. One app allowed 2 different types of tracking: daily tracking of worry level presented on the home page of the app, and mood tracking, which was triggered every time the user opened the chatbot feature of the app. All of the apps supported momentary tracking, with some allowing retrospective completion.
Visualization of Data Entries

A total of 30 apps provided ways to reflect on the data collected through the app. The apps offered a reflection on mood tracking data (20/30, 67%) or other kinds of data collected through the app (22/30, 73%), such as data from intervention tools. Color and emoticons were the most common elements used to display data on graphs. One app used cards showing a feeling and the factors related to that specific feeling. Other types of data included past entries in intervention tools (13/22, 59%), chatbot conversations (2/22, 9%), and frequency of app use (7/22, 32%). Customization options included the choice of the time range to display data (6/17, 35%), graph type (2/17, 12%), and selection of different variables (eg, mood vs sleep; 1/17, 6%). In addition, 3 apps provided weekly or monthly reports, including charts.

Gamification

Gamification techniques were integrated in 7 of the apps, including level upgrades (2/7, 29%), points (3/7, 43%), and badges (5/7, 71%) based on points earned from practicing different activities. One app mentioned that the reason for integrating points was to encourage regular use of the different activities. In addition, 1 app included a game to make negative thoughts concrete by knocking out negative feelings presented as cartoons.

Social Features and Support

All the apps were designed to function without professional guidance. Four of the apps offered the opportunity to involve health care experts by supporting access to counseling sessions either through the app (2/4, 50%) or over the internet with links to external websites in the premium version (2/4, 50%). In total, 15 apps allowed users to either share their data directly through the app with a therapist (2/15, 13%)
or export and download data (13/15, 87%). Interestingly, 2 of the apps allowed for data sharing with wearable devices regarding mindfulness. Peer support was provided in five apps by integrating discussion and chat groups for various topics related to mental health. One of these apps required users to download another app for community features.

**Immediate Support**

Eight of the apps integrated a feature to provide additional momentary support. Seven of these apps provided a feature to access different intervention strategies to manage their mood and anxiety. A feature in one of the apps connected the user directly with an available professional through WhatsApp upon paying a “nominal” fee.

**Crisis Support**

In total, 14 apps offered in-app support via a feature that provided links to external support services and hotlines. One of the apps offered additional support by integrating a crisis feature that, apart from providing information on hotlines, created a safety plan and integrated a grounding technique for panic management. This feature presented different types of exercises (breathing, mindfulness, and physical exercises) through a chatbot. In another app, a chatbot presented resources on the screen when the user indicated a crisis by typing a specific word (ie, SOS). However, this feature was presented only when the user first used the app, potentially making it difficult to remember.
4.3.7 Features Used for Delivery of CBT Treatment Elements

Delivery Format

Six apps used the format of one or more treatment programs, each comprising a number of modules. Four of these apps provided a single treatment program, whereas the rest provided access to multiple treatment programs at any time. Users had to complete each module in the program to access the next module. An alternative delivery format, used by 5 apps, was to use a chatbot to deliver intervention strategies; in 2 cases, the chatbot was used to deliver intervention strategies based on self-monitoring entries.

One app that integrated a chatbot provided intervention strategies only in the premium version of the app. Table 4.6 lists the CBT elements identified in the apps.

Psychoeducation

Most apps delivered psychoeducation material (21/36, 58%) using a distinct feature integrated into the apps (16/21, 76%). Modalities for the delivery of psychoeducation included the use of text (11/21, 52%) separated into chunks (6/21, 29%) accompanied by illustrations (3/21, 14%). One of these apps additionally offered video and audio delivery for psychoeducation. Two apps delivered psychoeducation using a question-and-answer interface. Another 2 offered psychoeducation through a chatbot using multiple-choice topic selection or through users’ interaction with the app (eg, after check-in assessments, to explain different intervention strategies).

Cognitive Techniques

Cognitive techniques were supported by 56% (20/36) of apps and were mainly delivered through structured exercises, providing suggestions and prompts based on
Table 4.6: CBT evidence-based elements available in the apps

<table>
<thead>
<tr>
<th>App Name</th>
<th>Psychoeducation</th>
<th>Self-monitoring</th>
<th>Cognitive</th>
<th>Behavioural</th>
<th>Relaxation skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Companion</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT diary</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Journey</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT MH</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT diary</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT Tools</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ClearFear</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBT(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>De-stressMe</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ezeCBT</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FearTools</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>FreeCBT</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happify</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innerhour</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindease</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindshift</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moodfit</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moodnotes</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moodpath</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MoodSpace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panic Pit Stop</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pocketcoach</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflectly</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanvello</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Stress &amp; Anxiety Companion</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoughts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UpLift</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What’s up</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woebot</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WorryKit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WorryTree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wysa</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youper</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>24</td>
<td>20</td>
<td>7</td>
<td>20</td>
</tr>
</tbody>
</table>

Checkmark Symbol (✓), element offered in the free version of the app;
Bullet Symbol (●), additional element/s offered in the premium version of the app
previously entered data. Many cognitive techniques, such as cognitive restructuring, were implemented through textual representations of thoughts, lists of thinking traps, and cognitive distortions. One app allowed audio entries as an alternative. Some apps supported a greater degree of interactivity; for example, 1 app supported identifying negative thoughts by dragging a finger over words, and a window would appear with a selection of thinking traps. Two of the apps used a chatbot to deliver a cognitive exercise aimed at reducing the burden on users by delivering content based on data collected during app use. More specifically, one of the apps remembers and presents a rethink list with unhelpful thoughts previously provided by the user. The user can remove or add thoughts from the list. The other app remembers and presents the most frequent distortions identified by the user in the past, allowing them to decide what to work on.

Behavioral Techniques

Behavioral techniques supported (7/36, 19%) included behavioral activation, exposure, and action planning. For example, 2 apps supported behavioral activation, focusing on positive rewarding activities. In one app (Woebot), users, after identifying negative thoughts, could schedule an activity and rate their feelings after activity completion. The other app used a chatbot, issued text instructions, and suggested activities to be completed based on the setting (home or outside).

Relaxation Skills

Most apps supported relaxation skills such as breathing (14/36, 39%), relaxation (10/36, 28%), and mindfulness exercises (17/36, 47%). Relaxation and mindfulness exercises were provided using audio tracks or text instructions and illustrations. In 22% (8/36) of apps, breathing exercises were delivered using a breathing indicator that visually represented a full breath. For example, a circle expands as users inhale...
and contracts as they exhale. Interestingly, one of the apps monitored heart-rate variability through the application of a finger to the phone camera to detect changes in detected stress during the breathing exercise.

4.3.8 Tailoring: Customization and Personalization

Customization and Personalization Types

Table 4.7 shows the personalization offered across three types. We characterized customization as interface customization, treatment-oriented customization, and customization of data visualization.

Interface Customization

In total, 24 apps allowed users to customize the app either at the beginning (14/24, 58%) or through a menu (24/24, 100%). Customization options covered user profiles (nicknames, avatars, and profile photo), user interface appearance (themes, display options, animations, and language), and technical features covering notifications and location tracking.

Treatment-Oriented Customization

Three apps allowed the customization of different treatment elements from the settings menu, such as adding, deactivating, or changing the position of emotion management (1/24, 4%), hiding navigation arrows on a diary entry (1/24, 4%), enabling voice dictation for a thought diary (1/24, 4%), adding a therapist’s number (1/24, 4%), and stopping sharing data with a professional (1/24, 4%).
Table 4.7: Tailoring of mobile apps

<table>
<thead>
<tr>
<th>App Name</th>
<th>App-driven</th>
<th>Mood-driven</th>
<th>Notifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom: CBT Therapy &amp; Self-Care</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>CBT Companion: (Cognitive Behavioral Therapy app)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>CBT thought diary</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CBT Journey</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CBT Mental Health Application</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CBT Diary</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CBT Tools for Healthy Living</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Clear Fear</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Cognitive Behavioral Therapy - CBT</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Cognitive Behavioral Therapy</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>De-StressMe:CBT Tools to Manage Stress</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>ezeCBT - (CBT - Cognitive Behavioral Therapy)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>FearTools- Anxiety Aid</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>FreeCBT</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Happify</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Innerhour Self-Care Therapy - Anxiety &amp; Depression</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Life - Behavioral Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mind Ease: Anxiety Relief</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>MindShift CBT - Anxiety Canada</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Moodfit</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Moodnotes - CBT &amp; Mood Tracker</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Moodpath - Depression &amp; Anxiety</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>MoodSpace - Stress, anxiety, &amp; low mood self-help</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Panic Pit Stop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pocketcoach - Anxiety helper</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reflectly - Journal / Diary</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Sanvello for Anxiety, Depression &amp; Stress</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Stress &amp; Anxiety Companion</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Thoughts - CBT trainer and thought diary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UpLift - Depression &amp; Anxiety</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>What’s up - A Mental Health App</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woebot: your self-care expert in CBT &amp; mindfulness</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Worry Kit</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Worry tree</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Wysa: stress, sleep &amp; mindfulness therapy chatbot</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Youper - Feel your best</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>9</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

App-Driven Personalization

A total of 16 apps provided onboarding screens to educate users about the functions and benefits of each app. As part of this onboarding, nine apps allowed users to select the challenges or goals they wanted to work on (8/9, 89%) or request information
about things that calm the user and phone numbers to be presented for emergency support (1/9, 11%). App-driven tailoring of app content was compulsory in 4 apps with no option to skip that step. Two apps did not provide information on the purpose of therapeutic tailoring.

Mood-Driven Personalization

Eleven apps suggested intervention strategies based on users’ self-monitoring data. The suggested intervention strategies were either randomized (3/11, 27%) or the same set of strategies (8/11, 73%) were presented to the users each time they tracked their mood, although in 1 chatbot-based intervention, the last activity practiced would also be suggested. Four of these apps presented intervention strategies only when low mood levels were indicated. One app allowed access to intervention strategies only in the premium version.

Customization of Notifications

Notifications are used to prompt users to interact with apps. Nineteen apps integrated notifications and prompted access to the intervention content. Three apps offered notifications for tracking only in the premium version. Notifications were provided at fixed times by the user (8/19, 42%), fixed times by the app (4/19, 21%), randomly (3/19, 16%), or in combination (4/19, 21%). Users could customize notification timing for different purposes, such as tracking (16/19, 84%), accessing intervention strategies (7/19, 37%), or accessing other app features (7/19, 37%). Two apps allowed the customization of the reminder message.
4.4 Discussion

This chapter aimed to review the functionality of mobile apps integrating CBT techniques for anxiety disorders with a focus on engagement and tailoring features. To conclude this chapter, we reflect on the findings, discuss the challenges associated with the existing designs, and opportunities to support engagement and encourage regular use of the apps. Finally, we propose recommendations for future research to improve delivery within CBT apps and we encourage researchers to use the results of our study as a starting point to determine the most effective functionality for delivering evidence-based treatment content.

4.4.1 General findings of consumer apps

Despite increased scholarly interest in the review of apps for a variety of mental health conditions (86, 87, 88, 91, 98, 99, 100, 101, 102, 103, 104), this is the first to examine the delivery of content in CBT apps for anxiety, with a focus on engagement and tailoring features.

The reviewed apps targeted a variety of anxiety conditions and were not designed to tackle a specific anxiety disorder (eg, general anxiety disorder), which may limit the degree to which treatment could be tailored to individual users. There is also confusion around the appropriate age for these apps. Most apps were in the health and fitness category. However, some apps were advertised in the medical category without providing a medical disclaimer. These findings align with the results of a recent review that explored the functionality of top-rated apps for depression (99).

Three of the apps received awards from the marketplace (Google Play Store) based on the quality of their design and overall functionality. However, there are no clear guidelines on how an app’s content quality is assessed.
4.4.2 Considering accessibility and access

The results showed that accessibility was rarely considered when designing apps. The lack of consideration of accessibility during the design process potentially excludes a variety of users. To address accessibility issues, researchers have begun developing guidelines to gauge mobile app accessibility (119). In addition, many apps cannot function or offer reduced functionality when an internet connection is not available. Several engagement features or full access to features are offered only in the premium version. Hence, valuable functionality is offered as a premium feature, and issues of access and cost should be addressed at the public health level.

4.4.3 Engagement with apps and therapeutic content

Overall, our results indicate that self-monitoring and visualization were relatively well explored by the apps in the sample in comparison with other feature types. Screening was provided using multiple-choice questions without involving any engagement feature for that purpose, which suggests an assumption by designers that screening itself could potentially be engaging. Several types of self-monitoring functionality are used to make the process more appealing and easier to use by minimizing the completion time. A minority of apps made use of basic gamification techniques such as points, badges, and level upgrades, in line with those found in a recent review of gamification in mental health (249). Future work should explore the correlation between user app ratings for each engagement feature described in this study.
4.4.4 Integrating human support

Human support is a powerful mechanism for increasing engagement and enabling the tailoring of treatment. The most common engagement feature related to human support was the ability to share data through the app. A minority of apps provided some form of peer support feature, and for understandable reasons, the ability to contact a therapist was not offered in the free version of the apps. The therapeutic alliance is an important part of CBT treatment, and developing a relationship between a healthcare professional and a user could enhance the regular use of apps (250, 251, 252). There is limited evidence from randomized controlled trials that supports claims that technology-delivered cognitive-behavioral therapy for anxiety disorders is not inferior to in-person delivery (253). As mentioned in chapter 2, psychological interventions delivered via smartphone devices can reduce symptoms of anxiety (38, 83, 89). However, previous research has shown that technology-delivered CBT supported by a therapist or other helping professionals or paired with face-to-face or internet-based therapies had better outcomes and lower dropout rates (38, 82, 83, 90). Further research is required to reveal the amount and type of clinician support needed to optimize the effectiveness of CBT for specific groups (41).

4.4.5 Delivery of CBT elements

CBT elements use various features, such as audio and video, illustrations, and interactive screens, to increase engagement. By using multimedia elements and interactive exercises, we can enrich the therapy experience and support learning (224). In particular, behavioral techniques can be enhanced through sensing.

The CBT apps identified in this review were designed to support low-intensity CBT exercises. Although a structured treatment program was offered by a minority of
apps, studies have shown that mobile apps do not provide a full course of CBT but are limited to specific techniques (82). Limited support for clinician integration reduces the opportunity to use such apps in higher-intensity CBT.

4.4.6 Customization and personalization

The majority of apps allowed the customization of the interface. However, customization options for CBT elements were lacking, with only 3 apps supporting this. The results showed that app-driven therapeutic personalization is restricted to push notifications and goal selection, although CBT involves the individualization of treatment.

Many apps offered tailoring based on self-monitoring data by delivering intervention strategies to users. The results indicated that either the same set of strategies is presented after reporting a particular score in self-monitoring or intervention strategies are presented at random. Thus, there are opportunities for more interactive and integrated approaches that incorporate both user preferences and mood-based recommendations.

4.4.7 Sensors and Just-in-time intervention

Only one app used physiological sensing. Two of the apps provided helplines and resource information based on location data. This contrasts with the academic literature and the results from chapter 3, in which much recent research concerns the vision of just-in-time adaptive interventions that allow the provision of intervention content when users are in need of support (116) and the interest in exploiting machine learning to optimize treatment delivery within mental health (254).
4.4.8 Improving delivery within CBT apps for Anxiety

Engagement with apps may be increased if we target mobile apps to specific types of anxiety disorders and user needs to enhance the degree of tailored content to individual user needs. Greater interactivity, for example, through increased user agency or better use of gamification, could enhance engagement (112). Human support offered through the apps should be enhanced to increase engagement with low-intensity CBT apps and explore mechanisms for use in higher-intensity treatment. Designers should consider accessibility issues and offline functionality to increase the potential reach of these systems to wider populations.

4.4.9 Evidence-Based Content and Effectiveness of Mobile Apps

The results showed that all apps claim on their description page to be designed based on validated psychological treatments. Previous research has shown that most apps are inconsistent with evidence-based treatments (86, 102, 103). In addition, an app’s consistency with evidence-based treatment elements does not guarantee the efficacy and effectiveness of treatment elements delivered in an app-based format. As mentioned in chapter 2, randomized controlled trials are considered to provide the most reliable evidence for the effectiveness of an intervention. However, these studies test the effectiveness of an intervention as a whole and do not examine the mechanisms that lead to improvement in one’s mental health state. Further research is thus required to determine the most effective functionality for delivering evidence-based treatment content. We hope that the breakdown of app functionality in this study will be useful as a starting point for such efforts. In addition to effectiveness, future work could also examine proximal outcomes, such as the impact of different features and evidence-based components on engagement.
4.5 Limitations

The search was based on US app stores and might not be representative of all anxiety apps available in the global market. This study focuses on apps integrating CBT elements and thus may have excluded potentially useful apps for people with anxiety. This review focused on investigating engagement features and tailoring of content; therefore, we did not evaluate the quality of content in the apps. Even though the codebook in this study was refined following discussion with all members of the research team, the included apps were assessed by one reviewer. This limited the ability to measure consistency among multiple reviewers. We believe that by exploring the functionality of the apps for tailored and engaging delivery, our work complements existing research and can help inform future design efforts. The results reflect consumer mobile apps available in the marketplace rather than the current state-of-the-art in research.

4.6 Conclusions

This chapter reviewed the functionality of 36 commercial apps for anxiety disorders that integrate CBT techniques with a focus on examining the engagement and tailoring features. Within these, we have identified that even though apps integrate a range of functionalities and engagement features, the provision of these features is highly uneven. Self-monitoring and visualization are relatively well explored, with social features and human support rarely integrated. Our results show that, within currently available apps, accessibility is neglected, and tailoring options are limited. Furthermore, consumer apps do not currently take advantage of the technological capabilities of smartphones to deliver just-in-time interventions at opportune moments (115). The results, highlight the need for future work to explore design from
a closer perspective by offering an understanding of what kinds of engagement features work, for whom, and under which circumstances. Additionally, future research should explore strategies for tailoring therapeutic content and involving clinicians to facilitate user engagement. This chapter allowed us to expand our model of the different characteristics for the design of mobile-based mental health interventions created in the previous chapter. Figure 4.2 shows how the model (represented as a mind map) evolved based on the results of this study. Understanding what works for individual users requires a user-centered approach to a qualitative understanding of users’ needs.
Figure 4.2: Evolution of model of mobile mental health interventions
5

Understanding users’ perspectives on mobile apps for anxiety management | A mixed-methods study

5.1 Introduction

The results from both the scoping review presented earlier and the review of consumer smartphone applications provide us with knowledge of the different components that comprise mental health applications at the present time. The results reveal that existing interventions integrate a variety of different components, several engagement features, and different ways to tailor content. To design for engagement, it is crucial to understand users’ reasons for and the barriers they perceive to using these apps. This will provide us with a greater understanding of users’ self-management practices with such apps, and of the different design aspects that affect user adoption and sustained use. As mentioned in chapter 2, although some research has examined users’ opinions of mental health apps for specific conditions and target groups, an un-
derstanding of users’ needs and expectations of mobile apps for anxiety disorders has not been documented. As mentioned in chapter 1, the clinical symptoms of anxiety disorders raise some unique considerations and might impact one’s motivation and interest in using a mental health app to self-manage these symptoms. As such, the characteristics of anxiety disorders and the treatments that are effective at addressing them might guide the feature of apps intended to promote anxiety self-management. The aim of this chapter is to understand the user burden of, and motivations for, engagement with mobile apps for anxiety management. More specifically, we seek to understand user needs and expectations for the self-management of their health through the use of those mobile apps, which factors facilitate or hinder engagement, and how apps can be improved to better support their mental health. Through this understanding, we seek to improve the design of mobile applications targeted for that purpose.

We aimed to build a holistic understanding by gathering rich data from two methods to counterbalance inherent biases in each method. The data sources we utilized comprise reviews from app stores (Study 1); and interviews with the users of apps designed to support anxiety management (Study 2). Study 1 helped to identify the barriers to engagement, unmet requirements, and reasons for sustained use. Study 2 explored these issues further by investigating positive and negative experiences with apps in-the-wild, understanding user expectations for apps targeting anxiety management, and exploring how apps can be improved to facilitate engagement. These studies aimed to analyze user perspectives on the enablers and barriers to their use of such apps rather than to evaluate the quality of individual apps. User reviews allowed the collection of perspectives from a broad range of users, but contain only information that the users consider important and see as appropriate to put forward in app reviews. It is also unclear if users of Study 1 are using the apps for anxiety man-
agement purposes only and for how long users are engaged with an app. Therefore, we conducted an interview study to complement observations naturally offered by users in Study 1 by allowing researchers to ask more direct questions about the real-world usage of apps used for anxiety management only. Both studies contributed to a set of design implications and recommendations produced through the synthesis of these complementary perspectives. To conclude this chapter, we reflect on the findings and recommendations for future research. The work presented in this chapter contributes to answering the third Research Question.

5.2 Method of Study 1: Analysing user reviews of mental health apps

Our first study seeks to identify the features considered useful and most important for the users of mobile apps for anxiety, and the barriers preventing sustained use. The set of candidate apps for inclusion was taken from the list of anxiety apps identified in chapter 4. Starting from this list of the apps, we further searched for a subset of apps that present some evidence for effectiveness for anxiety management (255, 256, 257, 258, 259, 260, 261, 262), with empirical research suggesting app use is associated with reductions in anxiety. We used one of the app rating platforms mentioned in chapter 2 that reviews digital tools (including both apps and web-based programs) for mental health and wellness (https://onemindpsyberguide.org/) and allows consumers and clinicians to identify high-quality apps, including those with demonstrated research evidence. We consulted the apps’ credibility metric which includes a synthesis of the research evidence for that app (263). Additionally, we conducted literature searches to identify any additional published studies demonstrating effectiveness for reduction.

1 RQ3. What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?
of anxiety symptoms. This resulted in a total number of five apps for inclusion in our study. The app selection process is illustrated in Fig 5.1. Details about app features and characteristics are available in Appendix A1.2.1.

As mentioned in chapter 2, the analysis of publicly available app reviews has been successfully used in the past and allows us to gain insights into consumer perspectives on mobile apps, and identify specific aspects of functionality that users value (98, 125, 147, 149). These reviews can be sorted based on rating scores (ranging from 0-5), and based on positive and critical reviews. Android and iOS app reviews were

Figure 5.1: Flow diagram for app eligibility

As mentioned in chapter 2, the analysis of publicly available app reviews has been successfully used in the past and allows us to gain insights into consumer perspectives on mobile apps, and identify specific aspects of functionality that users value (98, 125, 147, 149). These reviews can be sorted based on rating scores (ranging from 0-5), and based on positive and critical reviews. Android and iOS app reviews were
exported in a CSV file by using an online software tool (Appbot.co). We downloaded all the available reviews for each app included in our study. The initial search yielded approximately 140,917 reviews in total, from which we selected a subset of reviews for qualitative coding. There was a diversity in the age and number of reviews among apps and app stores. The goal of the analysis of these reviews was not to evaluate individual apps, but rather to identify barriers and enablers to use from a user perspective. Therefore, we selected a random subset of 20 reviews for each possible rating (ranging from 1 to 5) and included reviews that were longer than 20 characters. This resulted in a total of 100 reviews for analysis for each app. Positive reviews were often general in nature and did not provide specific details on which features of the app were valued. For example, R348 “I really think this app helped me with my anxiety and also it helped with my every day mind set five stars I love it”. Therefore we selected a subset of 20 additional reviews per app with a rating of 5 in an attempt to identify specific details about the enablers. Previous studies have used supervised machine learning algorithms to conduct sentiment analysis of user reviews (125). However, using advanced techniques in qualitative studies such as review mining and automated analysis such as topic modeling does not provide a reliable quality metric that closely matches human judgment in understanding topics. In addition, advanced techniques are unable to indicate specific subtopics that a specific qualitative study may be most interested in mining (264). The lead author manually assessed all reviews, and conducted a thematic analysis of these reviews, following the framework of Braun and Clarke (265). The framework consists of six steps including becoming familiar with the data, generating initial codes, searching for themes, defining themes, reviewing themes, and writing up the results. We used a single coder approach, where the first author iteratively identified codes from the data, and refined themes throughout the analysis. Open coding was conducted and
a line-by-line analysis of the identified reviews to allow distinguish enablers and barriers to engagement on reviews that included a contrasting statement and generate categories (266, 267). Coding was done by the author of this thesis and regularly discussed with other members of the research team to allow for better familiarization with the codes assigned to specific data and reduce the potential for bias. The team of researchers involved in this study then agreed upon a final coding framework to be applied to the remaining data. Coding procedures took approximately three months until a coding framework was applied to the remaining data. This time frame was needed to allow for better familiarization of the dataset. This iterative process led to codes gradually being merged into broader categories and researchers identifying overarching themes. One researcher reread the entire data set before defining the themes to review the validity of individual themes in relation to the data set.

5.3 Analysing user reviews of mental health apps: Findings

The 120 reviews from each app resulted in 600 reviews for analysis. We present the results from user reviews according to positive and negative aspects that affect user experience. A few both positive and negative reviews included a contrasting statement, most commonly a request for additional features. We recorded and reported separately the content of reviews that used a contrasting statement. We identified and categorized reviews into barriers to engagement and reasons for engagement. This categorization helped us explore the different factors that affect user adoption and sustained use in different parts of the user journey. Figure 5.2 shows the factors affecting positively and negatively the user experience with the apps. Additionally, we merged or categorized themes that were closely related and categorized themes
based on their relevance. We present the results by referring to reviewers’ comments using a unique number for each identified review. User reviews are included in exactly the same words as were used originally, including any possible spelling and grammar mistakes.

Figure 5.2: Factors affecting user experience with mental health apps

5.3.1 Barriers to engagement with apps

The analysis of the reviews revealed several factors negatively affecting the experience of users with the apps. We distinguish the barriers to engagement into two categories: barriers to start using the app and barriers preventing sustained use. We define sustained use as the ability to continue actively using an app for an extended period.
Barriers to adoption

Three factors affect negatively the experience of users as they start using an app: privacy issues \(N=31\), onboarding usability \(N=13\), and accessibility issues \(N=6\).

Privacy issues Users are concerned about their data privacy and security when privacy policies fail to provide clear or concise information on data collection, handling, sharing, storing, and use. “This is a great idea, and I’d love to try it, but. It requires an account, and sharing data with a company. This is the kind of data you should never trust a company with - many will simply sell it on - this is how they make money. Others are more trust worthy but get bought or hacked. Deleting it until there’s an option to share no data”[R53]

Onboarding usability Another barrier to adoption is the presence of bugs preventing users from creating an account or resetting their password, for example “The app doesn’t let me log in, even resetting the password doesn’t work. This made a bad day worse. Have to find another app” [R311].

Accessibility issues Barriers to accessibility make apps difficult or impossible for some people with disabilities to use, for example “Not accessible with voiceover. I am almost blind and I can’t work with this app. Also, with what little vision I do have, there is no dark mode available and it look like I am looking at a blank screen with circles of color. Please make this accessible for blind and visually impaired users.”[R351]. Additionally, the specified target audience of the apps was misleading preventing the use for specific groups of people. For example, “It says in the App Store 4+ yet when you open the app the youngest age is 18. What about younger people? What do we do?” [R477].
Barriers preventing sustained use

Several factors impact a user’s ability or motivation to persist with an app over time. These factors might not impact an initial decision to use an app but would have an impact on sustained use. The factors negatively affecting the user experience while using an app are lack of usability (N=87), irrelevant content (N=85), cost-related issues (N=67), lack of customization options (N=66), features not meeting user needs (N=51), generic content (N=26), ineffective in-app human support (N=18), poor customer support (N=15), unavailability and lack of interoperability (N=10), ineffective peer support (N=5), unsolicited messages (N=2).

Lack of Usability  Some factors affect the degree to which an app allows users to perform the tasks safely, effectively, and efficiently while enjoying the experience (268). Usability factors that negatively affect the experience of interacting with an app are related to issues with the design of the interface. User experience is disrupted when navigation is not taken into consideration when designing apps preventing access to app features or redirecting to the wrong location. For example, “It’s incredibly clunky to navigate through this app and tell what’s what and where it is” [R201], and “Going back to home removes the previous conversation it’s annoying as hell...”[R110]

Other users were frustrated by the presence of many elements on one page or the lack of guidance during use. For example, “The app is quite chaotic. There are no guidance to read before I get started or explanation as to why I’m doing all this” [R263].

Sustained use is affected by functionality issues such as bugs causing app crashes, update issues, and broken functionality of app features. Lastly, users discussed an app’s incapability to respond quickly to their needs due to slow response times, for
example: “Nice app to distract brain on rainy day. Please check its performance, its been painfully slow lately. Checked on multiple phones I have” [R434].

**Irrelevant content**  Apps and mainly chatbot apps provided users with responses that were not relevant to their unique inputs. For instance, “I do like this app but at times it’s responses doesn’t take into account what you’ve actually said. When it does it is pretty good” [R76]. Finally, a few users reported low-production value content. For instance, “the new meditations are the same thing except read in a scratchier voice and sped up 1.25x. It’s hard to meditate when you get a new prompt every 15 seconds.....” [R304]. Users were dissatisfied with different elements used to deliver intervention content such as excessive use of emojis, and the language used for that purpose. For example, “I would rate this app before four of five although it has appropriate emotional language that younger youth may understand I think older adolescents may not identified with those presented and may want to elaborate their feelings...” [R371], and “The 5 minute ‘float through the cloud’ audio uses words like ‘untroubled’ and ‘not worried’ (rather than ‘serene’ or ‘peaceful’) so the sleepy listener is reminded of worry and trouble. A CBT practitioner would know this... " [R112].

**Cost-related issues**  Some reviewers discussed barriers associated with costs that negatively affect their experience with the apps. Users feel that apps offer costly in-app purchases and subscriptions, and complained about hidden costs when purchasing a subscription. Additionally, existing app users are affected by new payment plans that block content after an update. Users mentioned that apps provide limited content in the free version, complained about unexpected payment patterns during app use, and felt that premium sale is forced. For example, “… However I am pissed that the ‘free’ tracks are peppered with premium content that is locked. I can’t even
have a decent test run of the content” [R416].

In addition, consistent bugs have an adverse effect on user’s willingness to purchase a subscription plan, for example “I’m not sure I’m gonna pay for the full version of even the free stuff doesn’t work right” [R221]. Lastly, an unexpected invoicing process disengaged some users from interacting with an app. For example, “Don’t bother. They obsessively bill your bank account way before it’s due and have poor communication with billing on the app.” [R221].

**Lack of customisation options** Several users were unable to customize the interface of app features and requested more options to respond when interacting with an app and options to recall a decision during an interaction. For example, “Needs a “maybe” button between the “yes” and “no” and a way to say, “You’re on the wrong track,” before it decides it knows all your usual problems and keeps assuming them over and over with no way to remediate” [R64]. Additionally, users valued the possibility to use the app in different contexts and prevent screen lock while practicing specific strategies such as breathing exercises.

Users want the ability to track their mood more often and be offered more self-monitoring options. Similarly, users prefer enriched reflection on the collected data they provide through the apps. For example, “I’ve been using this app everyday for about two months. In theory, the bot should be learning about me or identifying trends, but that never happens. The ‘mood over time’ screen will only show your mood over the last 5 days or so, and there’s nonway to look back further in time. There is no feedback for CBT” [R14].

Users also requested localization of app content and adaptation of app features in their area of residence. For example, “What about adding Italian? Meditating in a foreign language is not relaxing” [R273], and “It seems that because coaching is not
available in my area a large part of the application is not relevant” [R282].

Users requested options to customize reminder timing but there were mixed views about the number of notifications they would like to receive. For example, “I also wish it had a bit of a stronger presence (checking in on you when you haven’t used it for a while, for example)” [R26], but R54 stated “But what really bothered me about the app was the first reminder I got when I didn’t use the app a second day in a row because it sucked was definitely guilt inducing”.

**Features not meeting user needs** Several users mentioned that the content did not address their needs or had opposite effects on their mental health. Users sometimes felt that the interaction with the app did not provide any benefits to them, and the content was not helpful. Additionally, lack of content variation and updates on content delivery can have an adverse effect on user experience. For instance, “Also the app didn’t give me a lot options to work out MY stress. I wouldn’t recommend this app” [R463].

Apps are not designed to assist with specific conditions such as addressing trauma and/or abuse. Additionally, app content did not adapt to unexpected situations such as the pandemic. As R473 stated, “I used it for 6 months but it doesn’t account for people wanting to take a break on the weekends. It as heck was not helpful during the COVID. A lot of the stuff was unrealistic during a pandemic if you were stuck at home and could not leave” [R473].

**Generic content** Several users discussed the issue of receiving repetitive content when interacting with a chatbot app. For example, “Repetitive keyword-based therabot. I liked the idea of having someone to chat with when I needed it, but really all this bot does is ask ‘How does this make you feel?’ and give canned responses to keywords. If you need a therapy app that walks you through, this might help you.
But if you’re looking for conversation to help you feel less alone, this won’t help” [R113].

**Ineffective in-app human support**  Apps can support users through their journey by providing access to counseling sessions through the app. User reviews showed that in-app support can have a negative impact on their experience for a variety of reasons. Users expressed dissatisfaction with the therapist support provided through the apps, feeling that they accrued no value through the sessions, or that therapists were judgemental. Additionally, users discussed the lack of therapeutic alliance and in-person contact with a therapist due to the nature of a text-based interaction. For example, “I don’t think text based therapy is working out for me. I just don’t think it is personal or effective enough for me... I had a therapist I was talking to called ⟨name⟩ and now suddenly I get a new one for my next session. I would have loved to continue and build the relationship with one therapist” [R152]. Moreover, the text-based nature of counseling sessions results in slow response times from the therapist. For example, “BUT I don’t recommend THERAPISTS. In 30 minutes, around 10 are spent waiting for them to read and answer, feels like they have someone else talking to...” [R132]. Lastly, users also disengage from receiving therapist support through the apps when different time zones affect a therapist’s availability.

**Poor customer support**  Users disengage with an app when assistance from an agent or support team is ineffective or not provided to them. For example, “I tried to change therapists but there is no way to contact this company” [R157], and “I try to contact them but very poor customers service.... Be aware...” [R358].

**Unavailability and lack of interoperability**  Users referred to the inability to use an app in different contexts or during a crisis when an internet connection is not available, “It was good the first couple of days. But there is no offline mode so if your
in crisis you can’t use the app…”[R15]. Additionally, apps are not designed to work across multiple devices and do not support data transfer across devices preventing sustained app use. For example, R277 stated, “…Plus, it’s one more device. So, I thought I’d simplify things: recycle the iPod and use the app on my iPad. Except that the app doesn’t rotate to landscape, which is how practically everyone uses iPads. It only displays in portrait. If an app doesn’t display on an iPad the way iPads are used, then it’s not an iPad app, just an iPhone/iPod app”.

**Ineffective peer support** Some apps incorporated peer support by integrating discussion and chat groups for a variety of topics related to mental health. Such support may be ineffective for specific target groups, for example, “The app have several negatives. I’m in my late 40’s. To me, it seems everyone on the app are in their 20’s. The communities are gear towards college students with jobs” [R263]. Additionally, one user mentioned the lack of a feature that allows them to block people on the discussion groups and another one requested a function that allows them to show empathy to other user posts. For instance, “Community is okay but be forewarned there’s no way to block or mute someone. I had someone commenting triggering stuff on all my posts for a while and had no way to avoid them” [R212], and “The only real issue I have with it is that people don’t get to say what the think in terms of I agree or disagree on posts like if someone says they are struggling and you like it to say you agree then it could be taken as you liked that they were struggling” [R284].

**Unsolicited messages** A few users received unwanted messages when stopping use of the app, for example “This is really annoying. After I deleted the app, it kept sending me messages like, “You will feel a million times better after...” I hate it...” [R463].
5.3.2 Reasons for engaging with the mobile apps

Positive reviews revealed reasons provoking sustained use with the apps. The factors positively affecting the user experience while using an app include adequate intervention content (N=353), cost-related factors (N=47), good interface design (N=42), non-judgemental support (N=24), context of use (N=20), in-app support (N=14). The review analysis showed that adequate intervention content was significantly the most common reason for engaging with the apps.

Adequate intervention content: Users mentioned improvement in their mental health state and indicated that the app content was helpful. For example, R576 stated, “I suffer from general and social anxiety and this app has been so much help!!! If you suffer from anxiety a lot or every so often I definitely recommend this app. It calmed me down so quickly!!”. This response also suggests that the app is being used in-the-moment during episodes of high anxiety.

Users appreciated high-quality content and content variation in the apps. For example, “Good app. Lots of features to teach you about anxiety and different types, as well as features to help you. I find myself most frequently using the thought journal, but I’ve used most of the features” [R337]. Additionally, users value apps that are accessible at any time, and provide evidence-based content.

Apps offered users the opportunity to learn new tools, and provided insights about themselves. For example, R82 stated, “I find this App helpful to learn tools and definitions associated with my anxiety, and the daily check-in is reassuring”. Finally, users value content customised to their needs. As R293 stated, “The information has been important and relevant to what I am going through since it is customized to me".
**Costs**  Users value apps that are free or at an affordable price, provide adequate content in the free version, and do not restrict access to content behind a paywall. In addition, users take advantage of alternative payment options such as fees covered by their insurance. For example, “This app was made available through work benefits to support us through this pandemic. This was honestly something I needed but did not know how to get” [R553].

**Good interface design**  Users often valued aspects of the interface design such as an app’s user-friendliness, simplicity, and aesthetically pleasing interface. For example, “I really really like this app. It’s simple, clean, visually good, complete and very helpful” [R332]

**Non-judgemental support**  Users feel that apps are non-judgemental and substitute of other forms of interaction. For example, “Things have been tough lately at home and I didn’t want to open to family. With this app I thankfully have someone to talk to and help me out” [R534], and “I have always been someone who struggles to open up and tell people about my problems, but this app makes that so much easier and is a good place to vent without fear of being judged...” [R194].

**Context of use**  The reviews revealed different contexts under which apps are used in daily life. Apps are used as an alternative to therapy. For example, R597 stated, “I don’t have access to mental health treatment/therapy but this is a good alternative for now. It helps me practice positive thinking and being aware of how my thoughts affect my wellbeing” [R597]. Other users interact with the app while on the waitlist to receive therapy; “This app has really helped me while waiting for my first therapy session” [R506].

Apps are used in-between therapy sessions either by users integrating apps into their
therapy sessions or by therapists who recommend apps to their clients. For example, “As a therapist I have referred many of my clients to this app. It really is very helpful” [R372].

**In-app support** Users can be satisfied with the therapist support provided through the app. For example, R554 stated, “The coaches are also really well-trained and thoughtful with their responses”.

Users value the variety of groups offered through social support features, and the opportunity to share their experiences with other people. For example, R246 stated, “...and I really enjoy being able to chat in the community section and choose specific topics has needed. 10/10 would recommend”, and “The community chats are also really nice and make me feel like I’m no o the only one struggling. It really is a great app” [R235].

### 5.3.3 Limitations of analysing user reviews

As mentioned in chapter 2, prior research has examined the reasons for disengagement from mental health apps (125, 126). The results from this study distinguish the reasons that negatively affect engagement into barriers affecting user adoption and barriers preventing sustained use. The app reviews analysed in this study allowed identification of several issues that affect user adoption and prevent sustained use. However, such reviews have the limitation of including only those details the users saw as relevant and were willing to disclose in the form of a public review. User reviews may not be representative of the entire customer base as only a small percentage of customers may leave a review. Many of these reviews are likely to be written by genuine app users, but many fake reviews exist that can be difficult to distinguish from genuine ones (269). While natural and unprompted, user reviews were brief
and did not provide in-depth information. In addition, we were unable to determine the factors that influence how and why people choose to use apps to support anxiety management. This form of study does not support us in probing specific issues such as how apps are used in real-world settings, for how long, nor if users are using/have used such apps for anxiety management purposes only.

Therefore, we conducted a second study to explore the in-the-wild experiences of users with anxiety management apps to understand in more depth the motives for use, the challenges they encounter with such apps, and suggestions for improvement. The results from the interview study captured information related to app selection, users’ motives, and expectations for such apps; information related to the real-world selection and use of such apps which could not be captured from the analysis of user reviews. Thus, the interview results allowed us to further understand the user experiences with the apps and to elicit suggestions for improvement. Combining insights from these two studies would support the analysis of complementary user perspectives on the enablers and barriers to engagement with apps for anxiety management.

### 5.3.4 Method of Study 2: Interviews with users of mobile apps for anxiety management

In order to address the limitations of study 1, our second study further investigates users’ perspectives on mobile apps for anxiety. Specifically, we investigated how and why people use apps to support their mental health in relation to anxiety management, challenges users encounter, and suggestions for improvement. To explore these issues we collected qualitative data using semi-structured interviews. Topics discussed during the interviews comprised positive and negative experiences with the apps, features users liked/disliked, desired features, and suggestions for improve-
We conducted interviews that lasted about 30 minutes and were recorded and transcribed by one author. The study was approved by the relevant institutional research ethics committee.

Researchers estimate that 10 to 50 participants is sufficient for most types of research (270, 271), the most common sample size in qualitative research is between 15 and 50 participants (272), and some have argued that the smallest acceptable qualitative sample size is 15 interviews (273). Given the detailed design of the study, which includes mixed-method qualitative studies to counterbalance inherent biases in each method, 15 participants were selected. This enabled the collection of rich data for analysis to answer the research questions of this study. We recruited 15 participants from June to August 2021 via social media, and the researchers’ personal and professional networks. Participants were required to be at least 18 years old, be proficient in English, and have used or are currently using a mobile app to support their mental health in relation to anxiety management. Social media posts and emails listed these eligibility criteria, the length of study participation, and the study compensation. All participants received a 20€ voucher upon completion of the semi-structured interview. Several procedures were in place in case participants experienced discomfort during the interview ². The interviewer transcribed all recordings. Transcripts were then coded and analyzed using a general inductive approach (274). The primary purpose of the inductive approach is to allow research findings to be generated from the frequent, dominant, or significant themes inherent in raw data. This is a more descriptive approach that seeks to understand the people’s perspectives. It’s flexibility allows the development of categories and topic summaries, as well as themes. It suits the anal-

²If participants experience discomfort during the interviews, they were advised to let the facilitator know, and take a break. If a participant experiences significant distress, the facilitator would advise them to withdraw from the study and seek help. They will refer them to the local emergency number provided at the beginning of the interview session. In addition, the facilitator also would provide the respondents with online resources on mental wellbeing for the cases when they might have any concerns or discomfort regarding the topics covered in this study.
ysis of interview data as it acknowledges the more targeted nature of the interviews, and the specific questions posed. One author engaged in close reading of responses and developed initial categories through inductive coding. The author then grouped categories with similar meanings into broader categories to develop the themes. The categorization of codes and themes were then discussed with the last author.

Table 5.1 presents participant demographics. The majority of participants were women, consistent with data suggesting that women are more likely to use mental health apps (275). Our sample had a range of ages and was highly educated with all participants indicating familiarity with the use of technology in daily life. We present the results by referring to participants’ comments using a unique number for each of them.

Table 5.1: Demographic characteristics of interview participants

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Range</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
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<td>11</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Non-binary/ third gender</td>
<td>0</td>
</tr>
<tr>
<td>Age</td>
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<td>2</td>
</tr>
<tr>
<td></td>
<td>25-34</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
<td>2</td>
</tr>
<tr>
<td>Education level</td>
<td>High school degree or equivalent (e.g. GED)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Some college, no degree</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s degree (e.g. BA, BS)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Master’s degree (e.g. MA, MS, MEd)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Doctorate or professional degree (e.g. MD, DDS, PhD)</td>
<td>4</td>
</tr>
<tr>
<td>Experience with technology</td>
<td>Fundamental awareness (basic experience)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Novice (some limited experience)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Intermediate (experience of using tech in practice)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Advanced (experience using tech in complex projects)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Expert (others come to you to ask about your experience)</td>
<td>3</td>
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</table>
5.4 Interviews with users of mobile apps for anxiety management: Findings

Several broad themes emerged from the interviews regarding reasons for using mental health apps for anxiety, positive experiences, barriers to engagement, and suggestions for improvement.

5.4.1 App use

Participants reported using a diverse set of apps to support their mental health in relation to anxiety management, and 45% of them are using more than one app for that purpose (See Table 5.2). Participants use multiple apps to access different features on each of them, or use apps with the same functionality but with specific preferences for content delivery among them. Participants support their anxiety by using either one specific app function (e.g. to meditate) or with the use of a variety of features offered through the apps. Almost half of them have used or are currently using the same apps to meditate (i.e Calm and Headspace). Interestingly, two participants use other health apps to support their mental health. One of them uses a health app to check her sleep quality and a mental health app to meditate. The other participant has stopped using mental health apps and uses only health apps to monitor his sleep patterns and to meditate. Most of the participants are currently using the apps even though a few of them reported noncontinuous periods of use based on life events or improvements in their mental state. Table 5.2 presents participant experiences with mental health apps.

The majority of participants are currently using mobile apps to support their anxiety. Six participants use the app because they noticed an improvement in their mental
state. Another three still use the apps because their use has been integrated into their daily life. For example, P13 stated, “I still use the app because it has become a habit to me because even maybe when I am unwell I still need to track what I’m doing.” Other reasons for using the apps include awareness of one’s self, low cost, dedication to subscriptions, and the willingness for continued practice to support future anxiety events. One participant uses the app in addition to having paid the yearly subscription because of shared experiences with friends. As P11 stated, “So yeah, I think I will continue using it. And also a couple of my friends use it and they’ll sort of say their message me. And they say, have you seen today’s daily calm? It will really speak through some of the things you’re going through. And so you can kind of and I’ll say have you heard this bedtime story? So because quite a few people are using it, you can have kind of shared experiences.”

Participants stopped using mental health apps because of high costs or based on improvement in their mental health. For example, P3 stated, “I felt like I have gone to the stage that I feel I did not need to use the app. I am on a stage where I am quite busy and my mental health has been ok. I did not feel I need to use the app.” P14 stopped using an app when patterns on the data and treatment elements became non-useful to her, “And then over time, I used it less and less and less. I think basically I wasn’t really seeing any pattern that I wasn’t necessarily picking up anything that was useful. And then I say I got all the tips and things I was just doing the ones that were useful anyway, didn’t need the app to keep doing that.”

5.4.2 Motivations and expectations for mental health mobile apps for anxiety management

Participants discovered apps through recommendations from their social network, through social media, or through relevant institutions. Eight participants received
Table 5.2: Characteristics of mental health resources

<table>
<thead>
<tr>
<th>Participant</th>
<th>Main sources/ App/s Name/s</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Calm harm, Garmin</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>Fitbit, Headspace</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Wysa</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>Insight timer</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>Calm, Headspace</td>
<td></td>
</tr>
<tr>
<td>P6</td>
<td>Calm, Balance</td>
<td></td>
</tr>
<tr>
<td>P7</td>
<td>Calm, Sanvello, Headspace</td>
<td></td>
</tr>
<tr>
<td>P8</td>
<td>Medito</td>
<td></td>
</tr>
<tr>
<td>P9</td>
<td>Woebot, Insight timer</td>
<td></td>
</tr>
<tr>
<td>P10</td>
<td>Powerflower</td>
<td>homework between therapy sessions</td>
</tr>
<tr>
<td>P11</td>
<td>Calm, Insight timer</td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td>Calm</td>
<td>Relaxed melodies app</td>
</tr>
<tr>
<td>P13</td>
<td>What’s up?</td>
<td></td>
</tr>
<tr>
<td>P14</td>
<td>Welltrack</td>
<td>meditation podcast</td>
</tr>
<tr>
<td>P15</td>
<td>Calm</td>
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<table>
<thead>
<tr>
<th>Length of app use</th>
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<tbody>
<tr>
<td>&gt;1 month</td>
<td>1</td>
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<tr>
<td>&gt;2 months</td>
<td>2</td>
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<tr>
<td>&gt;4 months</td>
<td>1</td>
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<td>&gt;6 months</td>
<td>2</td>
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<tr>
<td>&gt;1 year</td>
<td>7</td>
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<tr>
<td>&gt;2 years</td>
<td>1</td>
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<table>
<thead>
<tr>
<th>Timing of app use</th>
<th></th>
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<tbody>
<tr>
<td>Current users</td>
<td>11</td>
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<tr>
<td>Past users</td>
<td>4</td>
</tr>
</tbody>
</table>

recommendations from other people, 3 participants chose apps based on advertisements in their social media, 3 based on recommendations from participants’ relevant institutions, and 1 based on a search in the NHS digital library. These recommendations included personal and professional sources such as friends, family members, and therapists. For example, P11 stated, “...and then my mum has been using ‘Calm’ and recommended it and I got a free trial and then I accidentally forgot to cancel so I signed for a year so I thought I will keep using it and then ‘Insight Timer’ a colleague recommended it to me and said it is free, this is how you use it."

Similarly, one of the participants started using an app based on a recommendation
from a therapist, P10 “This one I have been using it since February because we had a trauma-focused yoga instructor doing sessions with us and something that he suggested with some of the facilitators for the rest of the therapy sessions, and I have been trying to use it since then.”

Three participants started using an app based on recommendations from relevant institutions. As P7 stated, “Headspace I could get for free through my university and Calm I could get for free through my health insurance, and that kind of encouraged me to really use it in a daily basis.”

Participants’ motives for starting to use a mobile app to support their mental health in relation to anxiety management include stressful life events or recommendations from other people. Six participants started to use an app to improve their mental state in relation to anxiety management. For example, P2 stated, “The main purpose is to calm down and to stop the flow of thoughts and be able to focus because it is impossible to focus when you are super anxious. For me the main goal was to reduce anxiety, that was the purpose.” Five participants reported that they started using an app without having any expectations in particular. For example, P15 stated, “So initially, when I got it, I got it because a friend was using it and she had, like, a free code so you can sign up and use it. And she said it was really, really good. So I got it and I wasn’t really expecting anything from it. And then I started using it and in particular, using it if I was feeling really stressed or anxious, you know? And actually, it has probably the most, it helped the most out of everything I’ve done tried, like, anxiety and stress. So it’s been much more useful to me than I ever thought it could be.” P9 started using an app to check if there any similarities with CBT therapy practices, “I knew it was a chat-based bot and I knew it was CBT and I had CBT, I have done mindfulness based cognitive therapy course in the past so I assume that it was going be some similarities”.

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Another participant started using an app in order to integrate a regular routine by practicing meditation daily. Similarly, another participant used two apps, one to manage anxiety symptoms, and another for long-term support of meditation practice.

5.4.3 Positive and negative experiences with mental health mobile apps for anxiety

We detail participants’ responses according to positive and negative aspects of the apps for self-management of anxiety and stress symptoms. Figure 5.3 summarizes participants’ positive and negative experiences with the apps.

![Figure 5.3: Positive and negative experiences with mental health apps](image)

**Figure 5.3:** Positive and negative experiences with mental health apps
Positive experiences

Interview results revealed reasons affecting their experience positively with the mental health apps similar to the results from the review analysis. Eight participants reported that some in-app features provided benefits to them in terms of addressing anxiety-related symptoms: “So the positive aspect would be that it’s just really helped me, you know, it’s really helped manage my emotions” (P15). Many participants reported satisfaction with the content of the apps and five valued content variety. For example, P4 stated, “I have a feeling with this app, it was been useful in the kind of variety of content so in comparison to other apps which are just like this is what you are getting and that’s it. There is a wide variety of approaches, of topics, of formats on this app. I quite like that because it means I can pick and choose what I feel I need at a particular point I come to”. Other positive aspects include the ability to customize app content and use an app in a time-efficient manner. For example, P11 stated, “And daily calm, because it’s only ten minutes. Yeah, that’s feasible because, you know, I’m so busy, I don’t have time for yoga and meditation. And then you think you’ve got ten minutes. You need to have a screen break from kind of sitting at the computer, so just do it. And so I find that really useful”.

Two participants valued opportunities for low-effort interaction with the apps, for example receiving audio instructions for guided meditation without the need to hold the phone or view the screen, and the ability to use it in different contexts: “And it also supports different conditions, different modalities for instance I am walking in the forest, I am sitting at home doing some mediation or laying in my bed before going to sleep and there is support for that as well so the good thing about it for me is that it supports different conditions during the day” (P2).

Other aspects appreciated by a lot of participants are the aesthetics and the ease of
use of the apps. For example, P3 stated, “The Wysa app. I think it is ok, I have good experience with it, it is quite easy to use and seems like the app gives good advice, good personalised tips to you. And it has a nice layout.”

Five participants valued the opportunity for personalised experiences by receiving suggestions based on previous searches or based on self-monitoring data. In addition, one of the participants valued the ability to personalise the experience by selecting activities to be integrated into the algorithm. As P10 stated, “And I also like that you can select your favorite activities, if you found them particularly helpful, it lets you go through the settings and let you know which ones are repeatable, not all of them are but you can have a scroll and tick the ones that you like and works for you and then it will integrate that back to the algorithm which I found I could not do on some of the meditation apps”.

Other positive aspects based on participants’ experiences with the apps include the ability to use an app offline, at any time, and receive encouraging feedback. Three participants appreciated the potential of optional and free app use when interacting with prompts or app content. P4 stated, “It allows you to do what you want without keep asking you to try new stuff or to subscribe to the premium package. ” and P10 “I also find that in some of the apps the notifications are a bit of a passive-aggressive, it’s like oh you haven’t done this today and then I think that this is quite passive-aggressive. This one would be like do you want to work on x,y,z today? It feels quite kind. Sometimes I am too sad to do it but today I will look at this.”

P3 reflected on how the experience of self-monitoring through the app provides a space for self-expression “I use the chatbot function, I liked saying how I am feeling kind of having a diary and you do get a response back so it is just like expressing myself because there are not really many places where I can do that. That is the main function I really like”.  

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Negative experiences

The interviews revealed that the same factors affecting participants’ experiences positively can have an opposite impact if not addressed. These factors include cost-related issues such as perceived high costs, limited free content, and pushed premium content. Other factors include in-app features not providing any benefits in terms of addressing anxiety-related symptoms or the inability to use the app in certain contexts. For example, P2 stated, “For example, if they say sit in the room alone, but maybe I do not have a room where I can stay alone, our previous apartment was really small and it was not feasible you know. So they are restricting you to use the app in certain conditions that you may not be able to create. That is a negative feature. Or maybe it says close your eyes and breathe but you may cannot close your eyes because you are maybe outdoors or you are walking and that is the only time you are alone and it’s not feasible and immediately you are like excluded from this intervention.”

Other factors negatively affecting a user’s experience with the apps are unexpected interactions such as pop-up messages or unexpected sounds during app use, app freezes, and the long duration of some treatment elements. For example, P7 reported, “I never really fully tried them but there are some recordings that are 45 minutes. As soon as I see that I just do not want to do it. I think it would be easier for me to do it if they were broken it up into like 10 minute sessions, so for example they also have courses that I guess are a couple of hours long but they break them down in like videos or like 10 minutes and that’s much easier for me”.

Two participants who used apps with a chatbot as their main functionality reported that factors affecting negatively their experience included misinterpretation of inputs and limited AI responses. Additionally, the language used makes chatbots feel less human-like. As P9 stated, “the AI chatbot is limited, it does try to be funny but it’s
not like that funny. I know it is not a real person so I feel that I am talking to an app basically so there is definitely benefit to it but it does not have that humanistic touch which is important I think as well”.

Comments from several participants suggested that they may disengage from apps that provide non-personalized content and limited customization options. For example, two participants reported that the apps target specific demographic audiences which do not suit participants’ interests. For example, P4 stated, “I do not like the landing page when you open the app there is a lot of new content but it is very focused on an American audience I think so you get notifications about things that are happening in the middle of the night but they are for an American audience, although you can access in different languages and there are practitioners from all over the world, I think is still very much focused in North America so all your notifications and stuff are weird and may not accessible in Europe. That is annoying, they just clutter up your landing page with content that is not relevant and there is no option to switch that off”.

P7 reported mixed feelings about the need to interact with the app using the mobile phone, “The thing I love about it being an app is also what I hate so when I want to fall asleep the last thing I want to grab is my phone” Finally, P1 discussed the lack of engagement with all the mental health apps he used to support his anxiety, “The lack of feeling really connected and enthralled by the app such that I want to keep using it, whether it’s daily, weekly, monthly over a long period of time, and the fact that I haven’t got one or two apps that I really call my friends, as it were. That’s the negative experience because the fact that I have an interest in wanting to maybe find an app like that is is a good sign from a technology point of view. But the fact that the app doesn’t match that would be the negative”.

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5.4.4 Unmet needs and suggestions for improvement

All participants provided suggestions to improve the experience with the apps to support better their mental state in relation to anxiety management.

Personalization of intervention content

Eight participants requested a more personalized experience while interacting with an app. Such experience would provide them some sort of variation in the suggestive features received based on an app’s history data, or based on specific parameters such as self-monitoring data or other kinds of data. For example, P12 stated, “And don’t keep suggesting me stuff I don’t like and also try and understand me. I’ve never answered any questions about how I feel and what would help me. So it’s really just feeling like there was some kind of more personalized experience and that it learnt from my interaction with it, and I don’t think it’s doing that at the moment. I think it’s just pumping out the same odd stuff that it pumps out to everyone”. Two of the participants discussed receiving content based on specific needs, “Maybe. I guess for me, it’s kind of more focused around particular issues. So if there’s because I’ve got obsessive-compulsive disorder, if I could find content kind of specifically related to that” (P11).

Improved social and therapeutic support

Many participants requested the ability to integrate social features in the apps such as to provide the opportunity to contact a therapist, connect with other people, or download and share progress with a therapist. As P9 stated, “I can’t think of anything to completely improve it other than having an actual coach, like an actual text-based coach instead of the chatbot which might be more effective”, and P13 stated, “So what will make it more engaging is maybe if there will be a chat there where people, maybe
it will track you then put you to a relevant group there with other people then maybe you can chat together like an online community to assist each other”.

**Customization of input and output modalities**

Several participants appreciated opportunities to customize different app features and alter the delivery format of treatment elements. For example, P13 requested, “Okay, I will suggest like the application does have something like you’re able to talk to. Like it should have maybe something like a microphone, you click it. Then maybe talk or your feeling how your day is being”, and P6 “I think maybe having a few variants of voices because you only get like two people a male and a female voice which is fine but some days I do not know I feel I just listened to them so often so you feel you need some variety so having that would be good”.

**More detailed in-app guidance**

Four participants reported that apps need to provide more guidance on how to use them and explain the benefits of different treatment elements. For example, P10 stated, “I wonder after you completed the activity or whatever the task it would be, it would suggest, it would explain like why is this helpful, why is this beneficial when you may want to use this in the wild. Like this helps you identify the emotion you are feeling and that will help you stay more connected or this helps get your heart rate up which is good for your well-being and fitness in general, this relates to this particular CBT skill”.

**Making use of sensor data**

Interestingly, three participants wanted to integrate other sources of data such as physiological data into the apps. For example, P7 stated, “I do not know if this could work well in practice but maybe linking it more with physiological data so people
can measure heart rates or approximate stress level. If you could measure in a way when people maybe are more stressed or anxious and advice appropriate exercises”, and P2 “Add physiological data, for example, heart rate or some sort of physiological response maybe being able to link it with your smartwatch or some sort of fitness bracelet without really creating their own fitness bracelet but maybe using the technology that you already have is an additional option that could be interesting”.

5.5 Discussion

This chapter presented two studies that investigated factors affecting user burden and engagement with mental health apps for anxiety management: in study 1 we analyzed user reviews from app stores to examine factors affecting positively and negatively the user experience with the apps; in study 2, we conducted interviews with users of such apps to further investigate user expectations and motivations, barriers to engagement within the context of use, and unmet needs. These studies provide complementary perspectives, allowing us to build our understanding of reasons for app selection, user motives and experiences with anxiety management mobile apps, and barriers and enablers for engagement with such apps. To conclude this chapter, we reflect on the findings and discuss the challenges users face with the current apps. Finally, we propose recommendations for future research to improve the design of current available and promote sustain use.

5.5.1 Principal Results

Our results show that apps are used in a wide range of contexts to cover diverse user needs and expectations. People find anxiety apps through recommendations or search in social media in line with the results from a previous study (92). A good proportion of the participants use more than one app for anxiety management. Al-
most half of the participants use the same specific apps to meditate (i.e. Calm and Headspace), in line with the results from previous work showing that these apps are among the most used apps for anxiety management (30). People with common mental health problems use mental health apps to relax, track their moods, practice mindfulness, self-care, or build healthy habits. They value the ability to self-reflect on the collected data, learn and practice new skills, and progress with their health (276) in line with the results of our study focusing on users of anxiety apps. Users may use multiple apps and other kinds of resources to support their mental well-being in relation to anxiety management; they may also have periods of noncontinuous use based on life events and changes or improvement in their mental health. The results indicate that temporary improvement in anxiety symptoms impacts a person’s willingness to engage with an app.

Anxiety causes physical responses to stressful situations, and the nature of anxiety symptoms is linked to deficits in multiple domains of functioning such as sleep problems (277). Therefore, a few participants use health apps to capture patterns in their sleep quality or other kinds of physiological data.

Synthesizing across these two studies identified consistent findings despite data collected in different formats. The user reviews analysis identified the barriers to engagement into two categories: barriers to starting using the app, such as accessibility issues, usability, and privacy issues, and barriers preventing sustained use including lack of usability, costs, unsolicited messages, ineffective in-app support, poor customer support, irrelevant or repetitive content, features not meeting user needs, and lack of customization options. The user review analysis showed that the most prominent barrier to engagement is the presence of usability issues. Other prominent barriers that affect long term app use include cost-related issues, low-production value content irrelevant to users’ unique inputs and needs, and a lack of customization options. These barriers
to engagement are in line with the results from the interview study focused explicitly on users of anxiety management apps and revealed factors affecting user engagement from a diverse set of apps.

Conversely, some of these features (usability, costs, in-app support, customization options, adequate intervention content, features meeting user needs) are also the most common reasons for engaging with apps highlighting the need for the development of effective mental health applications. Users in both studies mentioned engaging with apps that improve their mental state, offer a variety of content, several customization options, and the ability to use them in different contexts and at any time. Thus, users value apps that are free or at an affordable price, offer an aesthetically pleasing interface, are easy to use, and can be used in a time-efficient manner. Our results are in line with previous studies that explored functionality and aspects that affect user experience with mental health apps (125, 126, 127, 153).

Study findings revealed that some users complained about app design elements related to price transparency and the language used for content delivery. Users felt that many apps hide the true costs of products from consumers behind gated features and use "guilt-inducing" notifications to access app content. In the future, designers should consider users’ perceptions of such barriers to engagement that may be associated with dark patterns. Dark patterns are design elements in a user interface that deliberately obscure, mislead and coerce app users into making unintended choices (278, 279).

Participants in both studies provided suggestions for improvement to increase engagement and sustained use. Users during the interviews often requested personalization of the experience by receiving content related to their needs based on their interaction with different app features, and the ability to customize app content. Similarly, the results of the user reviews analysis showed that users are dissatisfied with
apps that provide content not relevant to their unique inputs and that lack customization options. Previous research has shown that personalizing the user experience and customizing app content are critical factors affecting user engagement with mental health apps (125, 126).

Self-management apps often lack guidance on how to use an app and do not provide an explanation of the benefits of different app features. Interestingly, a few users in the interview study requested the integration of physiological data to capture physical signs and symptoms that occur before or during anxiety events. A growing body of research has started exploring users’ preferences in sharing their data for receiving tailored content (169, 280), and potential opportunities for such technologies (254). In the next section, we highlight the main barriers to engagement with mental health apps for anxiety management identified in both studies, leading to implications for design.

5.5.2 Main barriers to engagement

App Classification

Users’ needs and expectations differ and apps are used in diverse contexts. Therefore, users should be informed about an app’s benefits and features both before downloading an app and during use. The description page in the app stores should specify the target audience of an app to increase user adoption. Developers should consider the demographics of potential users and specify the types of anxiety disorders that can be addressed through a specific app. Apps need to be classified in ways that are useful and meaningful to potential users by addressing problems that they have, skills that they need, or features that they’re interested in (281). The information available on the description page should inform potential users of these apps about the expected values and benefits of using the app. Additionally, privacy policies should
provide clear information on which data is collected, how data is stored, if data is shared and with whom, and ensure data security to gain users’ trust. Several guidelines have been created for clinicians to assess such apps and evaluate those aspects (94, 96, 97, 106, 282). Future designs should ensure the provision of such information in the description pages to increase user adoption.

Quality issues

Functionality issues such as bugs and crashes, and interface design issues such as poor UI, lack of app guidance, and difficulties in navigation impede app use and prevent adoption and sustained engagement. Additionally, the apps restrict access to people with disabilities and are not necessarily compatible across different devices. These issues, identified within both studies, suggest a need for greater use of user-centered design methods during the development of apps, and following deployment. A key role for HCI professionals (including researchers) in the future is thus to ensure that issues of safety, usability, utility and user experience are addressed (283). Such technologies should be well engineered (hardware and software perform as intended), be safe and clinically effective, and should address user-centred requirements at different levels (being usable, useful, engaging, and fitting the context of use) (283). Future work could evaluate the coherence between the different app features by analyzing quantitative data regarding the number of positive and negative comments or based on the mean scores in the app store. In addition, future work on the prevalence of different barriers could draw on our analysis in the preparation of a codebook. Future research should consider end-users during different stages of an app’s implementation process and in different contexts of use.
Costs

Costly in-app purchases and subscriptions can also be a barrier to sustained engagement with the apps. Studies show that free apps are more likely to be downloaded than paid apps (247). In addition, users complained about inadequate content in the free version of apps limiting users from realizing an apps’ potential to improve their mental health, and to make informed judgements regarding the value of paid versions.

Personalization and Customization

Current apps are not designed by taking into consideration diverse target audiences, user needs, and contexts of use. The delivery of different functionality features is not considering specific group characteristics that may impact an app’s adoption. Participation in an intervention may be influenced by variability in age, education level, symptom burden, cognitive capacity, sociocultural influences, and other differences.

Previous studies have explored the design of tailored mobile interfaces based on collected data from participants or based on participants’ preferences (45, 46, 168). Other studies have explored the design of mobile interfaces based on different user characteristics such as the level of literacy (284), and language barriers (285) or even the design of specific functionality types such as chatbots (286). A language-free app was developed without any text to guide refugee users through specific therapeutic techniques and can be accessed by multiple cultural groups irrespective of the language of origin (285). Future research could further explore universal concepts that can be applied in the design of mental health apps. Users value options for content variety that can be customized based on their needs. Users should be allowed to customize different app features to meet their preferences and functionalities that be used in
different contexts. Future studies should explore which customization options are valued for specific groups of people and for different app functionalities.

Similarly, apps should personalize an experience with data collected through the app. Research shows that personalizing app content is critical for improving engagement with mental health apps (125, 126, 128, 129, 287). We should consider ways to personalize an experience in different stages of a user journey. When the user journey involves mental health recovery, this personalization should take into consideration the nature of anxiety. For example, previous HCI work has examined how the pathology of bipolar disorder impacts on the design of mental health interventions (288). Anxiety symptoms might increase or diminish when people may be more or less exposed to certain objects or situations, which impacts on the functionality which is most helpful at a given point in time. Future studies should explore effective ways to personalize the user experience with data collected during initial download and during app use. Such data can be collected based on collected answers from questionnaires, users’ app history and interaction with app features, users’ preferences for content delivery, and even through ubiquitous collection of data with the use of sensors, as in the case of ecological momentary interventions as seen in chapter 3. Future studies should explore whether the personalization of content should be automated or configured by the users. Additionally, existing users will benefit from adaptive content delivered based on their time interacting with an app. Future research is needed to understand the stages through the user journey where content becomes repetitive and adapt it to sustain engagement.

**In-app support**

Supporting users of such apps throughout their journey is important for sustaining engagement. Users requested guidance during their interaction, effective customer
support to address their queries, and value in-app social features. Previous research has shown that the most effective apps in efficacy and effectiveness tend to be those with human support, likely through their ability to boost engagement (289). Users value the option to contact a therapist through an app, even though the technological limitations of such an implementation, such as the text-based nature of therapist-user interaction, can impact use negatively. Assessing and optimizing the digital therapeutic alliance holds the potential to make such tools more effective and improve adherence to their use (250). Additionally, research suggests that mental health apps for anxiety often lack the involvement of experts during their development (84, 86, 87). Therefore, future HCI research should explore ways to increase therapist involvement in the design process and explore ways to optimize therapeutic alliance through an app.

Users with mental health issues value sharing and communicating with others through an app in line with the results of a previous study (128). There is hence an opportunity for HCI research to explore how to effectively integrate such functionality while minimizing the risks of miscommunication or misinformation by other users.

5.5.3 Recommendations

The studies showed that there is a diversity in users’ needs and the context that apps are used. HCI designers should consider the user experience in different stages of the user journey. Apps should be developed by using user-centered design methods to ensure good functionality and accessibility for diverse target audiences and needs. Customer support should be available for all users. In addition, HCI researchers should design apps considering different group characteristics and preferences. App developers should classify apps’ benefits and value on the description page of the app stores to enhance the adoption of such apps. During their interaction with the
apps, use guidance, customization of different app features, and personalization of the experience are essential factors to provoke user sustained engagement. Intervention content should be adapted based on users’ needs and interactions over time. This can be achieved by delivering new content at different time points of app use. Lastly, in-app therapists and social support can enhance regular use and improve app adoption. Usage of these features can be improved by supporting video therapy sessions and by monitoring discussion groups. Apps should offer valuable intervention content in the free version and offer alternative payment plans to satisfy the diverse user needs. Applying human-centered design in different stages of an app’s design cycle is essential to address the identified barriers in our study and improve users’ interactions with app features to support long-term use.

### 5.6 Limitations

Both studies made use of feedback from users of mobile apps targeting anxiety disorders. Potential limitations regarding the generalizability of the findings are taken into account when interpreting users’ feedback. The design recommendations are based on users’ needs and expectations from mobile apps for anxiety management. However, this work does not incorporate the perspectives of clinicians which may be complementary in terms of understanding opportunities for self-management. Participants’ experiences may not be representative of wider audiences since demographics and app use characteristics vary in our study. The apps used in the first study are not representative of the apps available in the app stores due to the selection criteria of the study (CBT apps that present some evidence for effectiveness for anxiety management) and the fact that most apps in the app store do not have evidence supporting their effectiveness (87). Thus, understanding the perspectives of a different set of stakeholders or a different set of apps might reveal different barriers,
facilitators, or design considerations. Additionally, no clinical measures were taken to determine if participants in both studies met the criteria for anxiety disorders or to understand the intensity of their feelings. Overall, this approach provided data on experience across a number of different apps used in different settings in daily life. User reviews analysis of individual apps provided a large volume of evaluation data, whereas the interview study provided more detailed insight into in-the-wild usage of such apps. However, none of the studies provided us with knowledge regarding the use of apps in specific contexts. In addition, we were unable to understand how apps are used over time and the factors affecting how apps are used over time.

5.7 Conclusions

Understanding users’ perspectives on the burden and engagement with mobile apps for anxiety are important to design apps for sustained use. In this chapter, we conducted two qualitative studies based on user reviews from app marketplaces and interviews with users of such apps. This chapter extends the existing literature by highlighting and distinguishing barriers preventing adoption and sustained use, and by exploring users’ experiences with apps targeted for anxiety management. The chapter provides a focused perspective on users’ attitudes and expectations towards mental health apps for anxiety, contributing to an important topic at the intersection of HCI and mental health. We have revealed negative and positive aspects affecting the experience with available anxiety management apps, as well as a range of unmet needs, and suggested improvements. Finally, we provided design implications to designers and developers of anxiety mental health apps to improve user adoption and sustained use. Addressing these factors can help realize the potential of mental health apps to support self-management of anxiety management. To further understand how these positive and negative aspects affect users’ experiences, research is needed
to examine daily perspectives on the usage of such apps in specific contexts.
Examining daily perspectives on usage of anxiety apps | A two-week user study

6.1 Introduction

The results from the previous chapter highlighted the diversity of user needs and expectations for the self-management of their health through the use of mobile apps for anxiety management. In addition, it shed light on the factors that facilitate and hinder engagement and provided suggestions on how apps can be improved to better support users’ mental health. The results showed that there are different barriers preventing user adoption and sustained use of these apps. However, the previous study did not provide us with an understanding of how apps are used daily over a period of time to understand in more depth what is affecting user engagement with such apps and reduce users’ recall bias. In addition, the previous study did not provide us with an understanding of how apps are used in a deployment setting, including a
more consistent user sample, especially among populations where such tools might add value to current models of care. Research on the use of these interventions in real-world settings has been scarce. It is important to understand how the target audiences of these products actually use such apps in their daily lives. This chapter explores users’ perspectives on the daily usage of commercially-available mobile apps for anxiety that integrate CBT, with a focus on understanding reasons for and barriers to engagement during app use at particular time points. We explored one specific client group, those on waitlists for mental health treatments, as this has been a proposed use case for these tools to expand access to care (290, 291). We recruited young adults while on the waitlist to receive therapy in a Student Counseling Service (SCS). Participants were asked to select up to two from a list of three selected apps (Wysa, Woebot, and Sanvello) and instructed to use the app for two weeks. We collected both qualitative and quantitative data from the participants. The study described in this chapter sheds light on specific engagement problems occurring during app use at particular time points from a user’s perspective and offers a resource for researchers and designers who want to develop or deploy mental health apps in the future. The section below details the method used for the selection and analysis of the collected data. To conclude this chapter, we reflect on the findings and propose recommendations for future research, encouraging researchers to consider different user needs for the design of mental health apps. The work presented in this chapter contributes to answering the third Research Question¹.

¹RQ3. What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?
6.2 Method

HCI longitudinal studies can last anywhere from a few days to several years, with equally diverse metrics (292). Evidence suggests that using a mental health app for more than a few days is not very likely (37). As such, we conducted a two-week study similar to previous studies that investigated users’ perspectives on the use of smartphone applications to support health symptom management (293). As mentioned above, in this user study, people on a counseling center waitlist were asked to use mental health apps from a suggested list for two weeks. We used the set of five candidate apps identified in Study 1 of chapter 5 that present some evidence for effectiveness for anxiety management. Similar to the previous study, the apps were used to elicit further feedback and design requirements for apps targeting anxiety disorders and would not be assessed for efficacy. Starting from this list of five apps, we searched and selected apps that are actively used by users. We considered apps as engaging based on available analytics data in relation to engagement metrics such as the number of yearly downloads, the number of daily active users (DAU), the number of monthly active users (MAU), and the number of active sessions worldwide and in the US market. We used a software tool (Apptopia.com) to gather analytic data showing the popularity of apps among stores based on these engagement metrics. This resulted in a total of three apps for inclusion in our study. The selected apps offer diverse functionality and features. Because app descriptions from research studies may not be exactly the same as those of the currently available product, we checked the apps available on the market for any inconsistencies.

Sanvello: Sanvello (former Pacifica) is an app targeting the management of stress, anxiety, and depression (257). Upon downloading the app, users select three goals they want to work on from a list of 8 options. Users receive recommended activities
based on self-monitoring data. The app offers psychoeducation, meditation, relaxation exercises, cognitive reframing, and goal setting (257). Social features provide professionals with access to a user’s profile, accompanied by a community feature comprising discussions and chat groups. Additionally, the app offers visualization of a variety of user inputs that allows the identification of factors contributing to specific events, and comparison of entries (257). Gamification is implemented with the use of level upgrades based on interaction with different app features. A randomized controlled trial published in 2019 showed greater decreases in depression, anxiety, and stress, and increases in self-efficacy for the participants in the active condition (257).

**Wysa:** Wysa is an automated conversational agent aimed at building mental resilience and promoting mental well-being using a text-based conversational interface (256). Users can select the areas they want to work on on the home screen. Additionally, the chatbot informed by self-monitoring data provides via written conversation evidence-based strategies such as cognitive re-framing, breathing exercises, and mindfulness (256). An ‘SOS’ feature creates a safety plan and provides access to crisis helplines. By paying an additional fee, users can also connect with a licensed therapist through the app. The app provides visualization of past journal entries. A study using a mixed-methods approach to evaluate impact and engagement levels among high engagement and low engagement users showed higher improvement on depression metrics for high users compared to low users. The majority of users found the app experience helpful and encouraging (256).

**Woebot:** Woebot is an automated conversational agent designed to deliver CBT and psychoeducation in the form of brief, daily conversations and mood tracking (255). After gathering responses to self-monitoring data, participants are prompted to learn
more about concepts related to CBT by means of video or text. Weekly graphs are used to provide users with weekly mood descriptions for pattern recognition. The chatbot uses empathetic responses, prompts users to interact with the app, and tailors content based on their mood state (255). An initial study showed that after two weeks people who spoke to Woebot felt better than those in the comparison group (255).

6.2.1 Data collection

This research employed remote methods for data collection as a way of accommodating the needs and challenges faced by people using self-management technologies to support anxiety management. The remote methods used were the use of daily online questionnaires hosted on the Qualtrics platform and optional online semi-structured interviews conducted on Zoom at the end of the study. The main reason for choosing methods that do not require in-person attendance was to cause minimum disruption to the daily lives of participants and lower participant burden. In addition, recruited participants awaited support for treatment and were not yet attending in-person counseling services. Data collection and communication took place individually for each participant. The study took place in Ireland and was approved by the SCSS Research Ethics Committee (REC) at Trinity College of Dublin.

6.2.2 Eligibility Criteria

A participant was considered eligible for recruitment if they were between 18-30 years old, proficient in English, and willing to use a mobile app to support their mental health in relation to anxiety management. Additionally, participants were eligible to participate if they owned a smartphone (Android running version of 4.1 or later, iOS version of 10 or later), and had internet access. We recruited participants cur-
rently on the waiting list to receive treatment at a university counselling service. Participants who contact the SCS for support are offered an initial 45-minute assessment appointment with a member of the counselling team to determine the most appropriate support needs. Students who are deemed high risk (at risk of harm to self, at risk of psychosis, or other mental health crisis) are assigned top priority and are seen as soon as possible. The purpose of the study is to inform the design of mobile apps targeted for that purpose, and did not involve an assessment of the mental health of participants. Therefore, we recruited all participants that met the inclusion criteria. However, it can be assumed, given the assessment procedure, that those participants who were invited to participate in the study had mild to moderate mental health difficulties. In addition, participants who voluntarily withdrew from our study remained on the waitlist to receive support from the service.

6.2.3 Procedure

The Student Counselling Service (SCS) of the university emailed an invitation (with a web link to the study’s Participant Information Leaflet, and Informed Consent Form) to all clients on the SCS waiting List. Additional emails were sent to new clients over time until recruitment was complete. The invitation provided the names of the three apps recommended, and the option to access the informed consent procedure where participants gave the researcher’s permission to email them the surveys. Upon giving consent, we emailed participants selected for inclusion in our study information about the start date of the study and the procedures that would follow. An app information sheet was available to the participants the day before the study started for them to decide which app/s they would be willing to use. We asked participants to read carefully the description page of each app on the marketplace before deciding which app/s to use for the study. The app information sheet is available in Appendix
A1.3.1. An email was sent to all participants at the start date of the study reminding them to download and start using the selected app/s.

All participants were then asked to use up to two of the suggested apps at least once per day for a period of two weeks. We provided users with this option to understand the reasons for app selection and allow for the fact that participants might in reality try a number of apps. As mentioned in chapter 2, previous research has shown that highly-rated apps tend to be downloaded more frequently than those with lower ratings (84, 91). All apps were free to download and two of them offered in-app purchases. Participants were requested to use the free version of the apps but had the possibility to use the premium version at their own expense. At the end of each day, participants were sent emails reminding them to complete an online questionnaire concerning feedback about the usage of different app features. Questionnaire responses were checked on a daily basis. Participants who did not respond in more than two days in a row, received an email reminding them about the study process. All participants were invited to an optional online semi-structured interview after the end of the two-week period. The aim of the semi-structured interview was to uncover in-depth the participants’ experience of using the mobile applications. We conducted interviews that lasted about 30 minutes and were recorded and transcribed by one author. Topics during the interviews comprised features users liked/disliked, suggestions for improving the existing apps, and overall positive and negative aspects of users’ experiences with the app/s over the period of two weeks. The survey items and interview questions are available in Appendix A1.3.2. Figure 6.1 shows the study process.

Procedures were in place to ensure the safety of the participants. If a participant were to experience discomfort during the study, as students of the university participants were eligible to avail of free support from the Student Counselling Service (SCS). Ad-
Additionally, standard out-of-hours supports normally advertised to SCS clients were discussed at debriefing. This list of support services was provided at the end of each survey daily and included contact information and direct links to the Student Counselling Service (SCS) and different crisis mental health services across Ireland. The same procedures were followed for participants who participated in an individual online interview at the end of the study period. The user study was conducted in English and data collection took place between June and August 2021. The initial recruitment started in June; an additional email was sent a month later to all clients on the waitlist to receive treatment in order to complete recruitment. All participants received a 40€ voucher after the end of the study.

6.2.4 Measures

The daily questionnaire took about 5-10 minutes to complete and participants provided responses to a set of questions related to the different functionality types, and time spent using the application daily. In addition, the first-day questionnaire included general questions regarding the interface design of the app, and the last day
questionnaire included questions related to the usage of app features during the two week period, and the User Version of the Mobile Application Rating Scale (uMARS) (106). uMARS provides a 20-item multidimensional measure of an app’s quality by assessing the dimensions of engagement, functionality, aesthetics, information, and subjective quality on 5-point scales. The subjective quality dimension is based on four questions: willingness to recommend the app, anticipated app usage frequency, willingness to pay for the app, and overall rating. One further subscale, consisting of 6 items is used to measure users’ perceived impact of the evaluated app on the users’ knowledge, attitudes, and intentions related to the target health behaviour (managing anxiety). A total uMARS score is calculated by averaging all subdomains, whereas subjective quality is calculated by averaging its related subitems or reporting individual items.

6.2.5 Data analysis

We used descriptive statistics to analyze the results from the uMARS questionnaires. We performed qualitative analyses on the participants’ feedback on what they liked and disliked on each day, and on the follow-up interviews following a general inductive approach (274). One author engaged in close reading of responses and developed initial categories through inductive coding. An inductive approach was used which allowed the codes to emerge from the data as they were analyzed. The goal was to generate new insights and this approach is often used in exploratory research (266, 267). Coding was discussed with other authors to allow for better familiarization with the data and reduce potential for bias. The authors then agreed upon a final coding framework to be applied to the data.
6.3 Results

Below, we present findings from our qualitative analysis. Semi-structured interviews were conducted to capture richer information and more details about users’ perspectives on the selected apps used during the study and were analyzed separately from the questionnaire data. However, there was a high level of overlap in the analysis among those. Therefore, we present the combined results relating to the same topics and representing the views and experiences of users. More specifically, we merged results for topics concerning participants’ reasons for using different app features, reasons for and barriers to engagement with the apps, as well as suggestions for improvement. We present the results by referring to participants’ comments using a unique number for each identified statement and distinguishing comments derived from interviews (I) and questionnaires (Q).

6.3.1 Participants

Seventeen participants completed the study and eleven participants participated in the optional semi-structured follow-up interviews after the end of the study. Participants completed a mean of 10.5 questionnaires (SD=2.37) during the two-week study period. Participants were young adults ranging in age from 18 to 30 with a mean of 24.17 years old and were mostly female. App selection varied among participants and most of them decided to use only one app during the study period (Table 6.1).

6.3.2 Reasons for selecting apps

Participants installed apps that seemed to be more suited to their needs (7/17) or based on satisfaction with app branding elements such as logos, app name, and app screenshots (6/17). Four participants installed apps based on consumer reports data.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Range</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Non-binary/ third gender</td>
<td>1</td>
</tr>
<tr>
<td>Age</td>
<td>18-25</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>26-30</td>
<td>7</td>
</tr>
<tr>
<td>Education level</td>
<td>Leaving Certificate</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s degree (e.g. BA, BS)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Master’s degree (e.g. MA, MS, MEd)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Doctorate or professional degree (e.g. MD, DDS, PhD)</td>
<td>1</td>
</tr>
<tr>
<td>App selection</td>
<td>Sanvello</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Wysa</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Woebot</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Sanvello &amp; Wysa</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Sanvello &amp; Woebot</td>
<td>2</td>
</tr>
</tbody>
</table>

such as positive reviews (3/17), and high rating scores (1/17). Other participants mentioned installing apps because they offered a variety of content (3/17), the option to connect with a therapist in the premium version (1/17), or based on the ordering of the options (1/17). One participant decided to try two different type of apps (an app that integrated an automated conversational agent and one that did not) (1/17).

Participants were informed before and during the study that they should download and use up to two apps. One of the participants (P11) decided to download a second app on the third day of the study to find specific functions not included in the initial app choice (i.e. screening, self-monitoring, and information on a specific issue). Another participant (P14) downloaded and used all three apps for the first two days before making a final decision. The participant discontinued use of one of the apps because he was not satisfied with chatbot conversations. Similarly, P3 downloaded two apps on the first day of the study but immediately stopped using one of them when it mentioned a paid membership.
6.3.3 App use

Average time spent

The average time spent using the apps daily differed among participants. The majority of them reported spending an average of 0-15 minutes daily with the app/s. Only three participants reported consistent regular average time spent. Two of them spent a daily time range of 0-15 minutes, and another spent approximately 30 minutes.

Daily reminders for app use

Participants used different strategies that reminded them to interact with the app/s daily (Table 6.2). Most of them used a combination of approaches to interact with the apps such as receiving reminders from the app (8/11), receiving email reminders from the research team (5/11), doing it in response to events or sensations (e.g. to stop a panic attack or reduce anxiety) (8/11), receiving notifications when they did not use the app for a while (3/11), doing it automatically (3/11), or by setting their own reminders. Six participants interacted with the apps because they received reminders from the app (4/6), or they received an email from the research team (3/6). Five of them mentioned that close to the end of the first week, they continued interacting with the app/s because it became part of their daily routine.

Interaction and use of app features

The results showed that there is variability in the functions that participants have used among the same apps during the study period. Self-monitoring and treatment elements seem to be the most used functions among all participants (See Figure 6.2).
Table 6.2: Participants reminders for app use

<table>
<thead>
<tr>
<th>Participant</th>
<th>Receive reminders from the app</th>
<th>Have my own reminders (e.g. in a separate reminder app)</th>
<th>Receive notifications when I don’t use the app for a while</th>
<th>It’s part of my daily routine</th>
<th>I do it automatically</th>
<th>I do it in response to events or sensations (e.g. to stop a panic attack or to reduce anxiety)</th>
<th>I receive an email reminder from the research team</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>✓</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P6</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>P7</td>
<td></td>
<td></td>
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<tr>
<td>P8</td>
<td></td>
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</tr>
<tr>
<td>P9</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P11</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P12</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P13</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>P14</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P15</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P16</td>
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<td></td>
</tr>
<tr>
<td>P17</td>
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<tr>
<td>Total</td>
<td>12</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

The main reasons for participants to use different app features included an interest to improve their mental state concerning anxiety or low mood symptoms (16/17), self-monitor their mood (12/16), use the features based on app recommendations (7/17), or to learn and try new tools to manage their mental health (7/17). Other reasons reported included an interest in reflecting on the collected data (4/17), to make progress (3/17), or due to an occurring crisis/panic attack (2/17). Six participants reported using an app based on reminder emails (2/17), for no particular reason (2/17), and in order to complete the study (2/17). One participant mentioned using the app one of the days because he felt lonely and had no one to talk to and share his thoughts. Table 6.3 summarizes user motives to interact with different app features.
### Engagement over time and barriers preventing sustained use

The results identified several reasons and barriers to engagement, as well as suggestions for improvements for the existing apps to different time points in real-world settings (See Figure 6.3). Participants’ impressions during the first days of use strongly influenced opinions about the apps, which remained consistent during the second week of the study. The following section describes participants’ experiences with the apps at different time points.

#### Figure 6.2: Features used most and least frequently

<table>
<thead>
<tr>
<th>APP NAME</th>
<th>PARTICIPANT</th>
<th>SELF-MONITORING</th>
<th>DATA VISUALIZATION</th>
<th>TREATMENT ELEMENTS</th>
<th>SCREENING</th>
<th>IMMEDIATE SUPPORT</th>
<th>SOCIAL FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANVELLO</td>
<td>P9</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>P10</td>
<td>3</td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>P12</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P16</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>WOEBOT</td>
<td>P3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>4</td>
<td>3</td>
<td>4</td>
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<tr>
<td></td>
<td>P7</td>
<td>3</td>
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<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>P13</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>WYSA</td>
<td>P2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>4</td>
<td></td>
<td>2</td>
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<td>1</td>
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<td>3</td>
<td>1</td>
<td>1</td>
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<tr>
<td>SANVELLO</td>
<td>P1</td>
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<td>1</td>
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### Figure 6.3: Experience Map

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<th>Onboarding &amp; first use</th>
<th>Days 2-4</th>
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**User Suggestions:**
- Offer more customization options for different functions
- Add more content in the free version
- Offer variety of content
- Improve understanding of inputs and response relevance
- Improve visuals
- Cheaper subscription rates
- Allow completion of a whole module for free
- Allow reflection on collected data
- Add more activities for specific issues
- Encourage use of the groups

New findings are highlighted in bold type.
### Table 6.3: Reasons for using app features

<table>
<thead>
<tr>
<th>App Features</th>
<th>Participants (N=17)</th>
<th>Reasons for use</th>
<th>Reasons for non-use</th>
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<td>Data sharing</td>
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<td></td>
<td>explain app benefits</td>
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<td>Customization</td>
<td>8</td>
<td>interface (select a different background, set a nickname)</td>
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<td>data visualization</td>
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<td></td>
<td>treatment elements (e.g. alter background sound for meditation exercises)</td>
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<td>Discussion groups</td>
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<td>check activity for specific groups of interest</td>
<td>no activity on the groups</td>
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<td></td>
<td></td>
<td>read other people’s stories and compare to themselves</td>
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<td>share something with the group</td>
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<tr>
<td></td>
<td></td>
<td>share something with the group rather with the family</td>
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<tr>
<td>Premium version</td>
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<td>motivation to use the app</td>
<td>high-subscription costs</td>
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<tr>
<td></td>
<td></td>
<td>inability to cover app costs through health insurance</td>
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<td></td>
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<td>limited free content</td>
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<td>repetitive content</td>
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<td></td>
<td>restricted access to other app features</td>
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<td>satisfaction with content offered in the free version</td>
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<tr>
<td></td>
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<td>no need of additional support</td>
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<tr>
<td>Gamification</td>
<td>9</td>
<td>track progress</td>
<td>inability to progress in the free version</td>
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<td></td>
<td></td>
<td>sense of accomplishment</td>
<td>little effort required for that purpose</td>
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<td></td>
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<td>felt rewarding</td>
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**Onboarding and first use**

Participants described both their positive and negative experiences during the first day of use. Participants valued apps that are easy to use, provide clear information,
offer an aesthetically pleasing interface, and variety of content that is educational. As P17(Q) stated, “I liked the interface and the various options on the app”. Additionally, one participant noticed an immediate effect on his mental state. P4(Q) “I’ve been feeling super anxious with <a personal event> coming up, so I wanted to check in to see what my needs were and then do some guided mediation to de-stress ” and “It calmed me down”. Participants mentioned satisfaction with apps that can be used in a time efficient manner and provide several customization options. For example, P17(Q) liked ”The interface and the various options on the app.”, and P3(Q) mentioned that the app "was very easy to use and very time-efficient".

Conversely, two participants experienced a confusing experience during their first-time use. For example, P11(Q) stated, “when I first downloaded it I felt slightly overwhelmed by all the content”. Participants reported that a variety of content or useful content is not available in the free version of the apps. As P12(Q) stated, “I wish more courses or mediation sounds were available without a subscription”, and P2(Q) “Most of the useful content is only accessible if you pay”. Additionally, participants were provided with limited response options during their interaction with a chatbot. As P6(Q) stated, “A lot of the replies you give have to be chosen from a preselected list”. Another participant mentioned receiving irrelevant content based on their inputs while interacting with the app. As P13(Q) stated, “the insight didn’t really pertain to the mental health problem I brought up”.

**Week 1**

Over the following days, participants reported additional positive and negative experiences with the apps. The apps helped participants to learn new tools, provide a sense of achievement, and can have a positive effect on participants’ mental health state. For example, P10(Q) stated, “I was able to check off some goals. Felt a sense of
achievement", and P11(Q) "I enjoyed learning how to reframe my thoughts as well as the examples of the 10 thinking traps." Participants value the reminder notifications, and different treatment elements offered in the apps. For example, P11(Q) stated, “I like using the reframing CBT component as I like to be able to view my thoughts in a different way”, and P7(Q) “It is a fast piece of work and reminds me to check in on myself even though I am feeling ok today.” In addition, participants value the encouragement language used to deliver different treatment elements. As P6(Q) stated, “The AI offered very kind words. It’s hard at first to take seriously words of encouragement from a scripted AI but I think the benefit is more about telling yourself those words”. Additionally, participants described liking the delivery format of different elements. For example, P3(Q) described “Very relaxing visuals”, and P5 stated “There were both videos and reading exercises to complete which made it less tedious”. Towards the end of the first week, participants appreciated the new content provided and the ability to reflect on the data collected through the apps. As P12(Q) reported, “I liked seeing the progress I have made mood wise”, and P9(Q) “was able to track my mood and see how it compared to other days”.

During the first days of use, participants disliked receiving repetitive content and generic statements based on their inputs. For example, P16(Q) stated, “I feel as if the app may become a tad too predictable. I would prefer if it felt less repetitive but with an app interface as opposed to a human this might be hard to avoid”. Other participants were dissatisfied with the content delivery and found the content delivered to them to be irrelevant. As P10(Q) stated, “The example given about having a fear of spoons was a bit ridiculous. Perhaps they were trying to be whimsical but it would have been more meaningful if they gave a more realistic example.”, and P11(Q) "the bot may be referring to the past tense when the stressful event was happening at present". In addition, participants reported mixed feelings about the time required
to use the app. For example, P2(Q) stated “Tends to want me to engage longer and I don’t have the time”, and P12 “The lesson for today’s guided journey was very short. It was reading a few slides that took me probably 30 seconds in total”. Some participants disliked the simplified delivery of content, “I found the module elements eg videos and reading to be oversimplified” P14(Q). Participants mentioned the lack of customization options for different app features such as interface, reminders, and different treatment elements. For example, P3(Q) stated, ”I wish I could pause session and continue later”, and P10(Q) ”I was unable to add multiple reminders”. Other participants’ experience was interrupted unexpectedly during app use caused by functionality issues such as broken functionality of app features. For example, P12(Q) stated, “I tried the 10-minute meditation and found that after a couple of minutes the sound would randomly turn off and I would have to go in, pause the music, then play it again for it to come back. It interrupted my meditation”, and P2(Q) ”I was really stressed, I told the app that, it told me to breathe and then the app stopped responding. There was no way of resuming the conversation and I could have done with it’s help”. Additionally, certain treatment elements require participants to use an app in their home environment, preventing them from using it in different settings. As P3(Q) stated, ”Asked me to work on my sense of smell but I was in public and wearing a mask but I couldn’t go back in the app so I had to click through the smelling exercise”.

Towards the end of the first week, participants also experienced problems with app navigation. For example, P11(Q) stated, “I found it difficult to remember where to find the specific progressive muscle relaxation exercise I had completed previously. This exercise was part of the guided journey so I had to back through each completed lesson to find it”. In addition, participants’ experience was interrupted during use when premium access was required to complete modules. As P10(Q) stated, “I was
stopped from completing the module I was working through this week. Premium access is needed for the last two tools in the module.

Week 2

There are a small number of new positive and negative experiences that participants reported during the second week of the study. P14(Q) reported that the app becomes more responsive and conversations feel less repetitive after a few days of use, “I actually feel like the longer I’ve used wysa the more responsive it seems so I was happy with that”. P16(Q) reflected on app’s positive effect on the mental state, “Today I really recognised the value of the app. It has had a positive effect on my mental health over the past two weeks”. Other participants valued the reflection on the collected data over the the two week study period. As P6(Q) stated, “Reviewing my mood graph over the past 2 weeks. My prevailing mood seems to be content or happy with some anxious periods that can last 2 or 3 days. The app in this case helped me realise that even though sometimes it feels like I’m never happy, the truth is I usually am but maybe I’m just going through a rough couple days.”

Collection of user data and reflection on data visualization can have an adverse affect for other users. As P9(Q) stated, “I disliked seeing how shit my mental health has been over the past few days”. In addition, the collected data visualized should provide value for the users. As P2(Q) stated, “I wanted to check my progress for the past week but it just listed everything that I had inputted. Wasn’t very helpful”. Participants described little activity in the group feature of the apps and lack of moderation of activity. As P12(Q) stated “I was upset because the groups I was interested in didn’t have any activity for the past couple of months, so I decided to leave them.”
Suggestions for improvement

Participants provided several suggestions for improvement during the first week of use. Many participants referred to cost related issues that affect app use in daily life. Participants requested the availability of more content, and the ability to complete interacting with app features in the free version, rather than being blocked halfway through. For example, P10(Q) stated, “Allow for completion of a complete module and reserve other complete modules for premium.”, and P17(Q) “Add more features to the basic subscription even if it’s for a trial period first”. In addition, participants requested cheaper subscription rates for specific types of users (i.e. students) and the possibility to access subscription plans through their healthcare insurance. For example, P11(Q) stated, “Have more content available without subscribing to premium, have a student premium subscription rate.”. Other participants requested more transparency on the content that is accessible in the free version. For example, P11(Q) stated, “The exercises I was recommended all required premium when I clicked into them. I would like a breakdown of what content can be accessed without premium and what content is accessed only with premium”, and P2(Q) "Less restricted features in the free version. Better transparency of what is/is not accessible through the free version. Tracking of time spent on the app/progress."

The majority of participants requested more customization options for different functions of the app. Participants wanted to be offered more options to alter the interface, the reminders, and the treatment elements on the apps. Participants wanted to customize the visual aspects of the interface such as to change the background colors or background music. For example, P16(Q) requested changing “the intense colours of the interface”. In addition, they requested better navigation during app use. As P13(I) stated, “I want the ability to take a break from topics easier”. Other participants requested the ability to set multiple reminders, and the option to view notification sug-
gestions later. As P2(Q) stated, “More freely accessible materials, if you receive a notification from the app offering a suggestion, allow me to view the suggestion later in my app. I cannot find most of the exercises it suggests later on when I have time to do them”, and P10(Q) requested the “Ability to add multiple reminders”. Participants requested more customization options for the treatment elements of the apps. Such customization options for example should allow to alter the delivery format of content. For example P7(Q) stated, “Audio options for the breathing exercises, a feature to track your mood/symptoms each day when you log on” and add the option to voice record the responses, and P4(Q) requested “less text oriented, more options for meditations”. Other users requested more options to enhance the experience with the treatment elements such as to change the speed of a meditation or to add a pause and continue button for this purpose. For example P11(Q) stated, “The audio clips could have the ability to fast forward and rewind”. Participants wanted to be able to use the apps in different contexts (add video subtitles, continued sound looping). As P7(Q) stated, “Option to give feedback on a scale rather than just negative or positive, subtitles for videos so they can be watched quietly”. Other participants requested the ability to customize the length of their interaction with different app features by offering shorter or longer app sessions to suit users’ unique needs. For example, P2(Q) requested, “Shorter conversations, less content restricted to Premium, track progress”. Participants wanted an enhanced experience with the chatbot conversations. Conversational interfaces should better understand users’ inputs and provide more relevant content to them. As P2(Q) stated, “Better understanding of what’s imputed or more multiple choice responses”. Participants requested more activities for specific type of issues or target user groups. For example, P6(Q) stated, “Maybe expand to include some LGBT supports, and also eating disorders”, and P11(Q) “More articles on general anxiety related issues or mental health issues ie. Relationship difficulties, grief,
addiction etc.”.

During the second week, participants discussed the need to receive new content that is non-repetitive. As P16(Q) stated, “To have a greater pool of content and responses from the bot so the experience feels fresher”. P11(Q) requested customization of the interface to have easier access to features of their preference, “Have the suggested exercises/ options at the top of the home page. Have less of the home page taken up by unnessessary/ not directly relevant information”. P12 wanted apps to encourage the use of the groups and P14 the ability to monitor chat groups. As P12(Q) stated, “somehow find a way to encourage more use of the groups”, and P14(Q), “I really strongly disliked the chats, they should be monitored so not to enhance individuals issues as people are likely opening them during moments of vulnerability”.

6.3.5 Overall engagement

Participants during the interviews described their overall motivation to use the apps during the two weeks. Five participants mentioned that their motivation to use the apps declined over time. Reasons for that included repetitive content, inability to complete a journey, lack of visual appeal in certain features, and an unimproved mental state.

Four participants reported pretty consistent motivation to use the apps. For example, P15(I) stated, “I probably used it between 10 and 15 minutes a day regularly but there were 2 or 3 days where I either used it a little bit longer or I went back to it and used it again a second time that day so my engagement was pretty steady with it most days”. Another participant was less inclined to use the app towards the end of the first week because of the lack of options but stated that at the start of the second week it became part of his daily routine. As P12(I) stated, “I think the first few days I was definitely the most intrigued to just kind figuring out like what the app was all about, what I
can access, how beneficial would be... my interest kind of renewed a bit then at the start of the second week kind of like OK cause now it is part of my routine and after work I would be checking with the app and then it just kind of felt instinctual so then it was not necessarily, it was just kind of time to do it now”. Only one participant mentioned an increased motivation to use the app based on data reflection. As P9(I) stated, “I would say the more I have used it if that makes sense so I was using it more because there were more data for me to look at and you know become more comfortable with the app.”

Participants also referred to their motivation to use the app in their daily life. Eight participants mentioned that they would have used the apps less frequently outside of a research setting. A few of them reported using the apps on specific occasions during stressful days. For example, P12(I) stated, “I would probably not use it as a daily type of thing but I think if I am having an issue with anxiety that day I probably will check in and check if there is a tool that I could use like meditation or mindfulness that day but I do not think it will be a daily routine”. Only one of the participants mentioned daily app use during and following the end of the study. As P4(I) stated, “I’ve actually continued using it just because I think it was a good way for me to keep track of how I’ve been doing and feeling. And so I really enjoyed that. And I kind of got in the habit of doing it over the time that I was doing it.”

### 6.3.6 Continued use

Despite the identified barriers to engagement, nine participants were interested in using the apps after the end of the study period. Only two participants reported unwillingness to use the apps after the end of the study, because the free version limits access to app features and restricts completion of modules. As P2(I) stated, “I would think of using it for the more general things, but the general things that are in
the free version are very, very limited.", and P10(I) stated, "And like I said, the thing that they know people with anxiety and OCD and who are stressed out like one of the things that they know affects them, like, you know, feeling like you’re always in the middle of things and not get in a sense of completion or accomplishment or progress or whatever."

Two of the participants that used the same set of two apps indicated different preferences among them for future use. As P14(I) stated, "I think Wysa is more engaging, I suppose when you attempt to direct the conversation you know sometimes it may not go with you but Sanvello is more like finding what you are looking for and then I was really disappointed with the chat/group discussions I found so I would definitely not use Sanvello then based on that."

In contrast, P11(I) considers the chatbot app time-consuming and indicated a preference to use only a specific feature on this app compared to the other app. "I was just drawn to Sanvello app more. I find it more user-friendly, I think again the Wysa is very focused on kind of self-talking and CBT which those require a lot of time, and to be able to have a conversation it requires 10 minutes or more."

6.3.7 App quality rating

Overall, the results of the uMARS questionnaire suggested that the 3 apps were of moderately good quality (106). We removed a single uMARS questionnaire from one participant who used multiple apps without clarifying which one was used. Functionality was the domain with the highest rating, followed by information, aesthetics and engagement (See Table 6.4). Subjective quality scores were generally high. Most users would use the apps in the future, consider recommending the apps to people, and provided an average or high overall rating for the apps (See Table 6.5). Even though the apps were considered highly functional and received good subjec-
tive quality scores, users were not willing to pay for the apps, in line with the results of the daily questionnaires and interviews. Perceived impact scores showed that for most of the participants, apps were felt to have increased intentions/motivation to manage anxiety, encouraged them to seek further help, and decreased anxiety symptoms.

Table 6.4: User version of the Mobile App Rating Scale scores

<table>
<thead>
<tr>
<th>Scores</th>
<th>Sanvello</th>
<th>Wysa</th>
<th>Woebot</th>
<th>Total Average Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement Mean Score</td>
<td>3.82</td>
<td>3.5</td>
<td>3.47</td>
<td>3.59</td>
</tr>
<tr>
<td>Functionality Mean Score</td>
<td>4.46</td>
<td>4.04</td>
<td>4.33</td>
<td>4.27</td>
</tr>
<tr>
<td>Aesthetics Mean Score</td>
<td>4.47</td>
<td>3.99</td>
<td>4.1</td>
<td>4.18</td>
</tr>
<tr>
<td>Information Quality Mean Score</td>
<td>4.39</td>
<td>4.16</td>
<td>4.15</td>
<td>4.23</td>
</tr>
<tr>
<td>App Quality Total Mean Score</td>
<td>4.28</td>
<td>3.92</td>
<td>4.01</td>
<td>4.07</td>
</tr>
</tbody>
</table>
### Table 6.5: Subjective quality scorers of the uMARS questionnaire

<table>
<thead>
<tr>
<th>Subjective Quality</th>
<th>Sanvello</th>
<th>Wysa</th>
<th>Woebot</th>
<th>Total Average Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would you recommend this app to people who might benefit from it?</td>
<td>4.14</td>
<td>3.33</td>
<td>3.66</td>
<td>3.71</td>
</tr>
<tr>
<td>How many times do you think you would use this app in the next 12 months if it was relevant to you?</td>
<td>3.71</td>
<td>2.83</td>
<td>3.5</td>
<td>3.34</td>
</tr>
<tr>
<td>Would you pay for this app?</td>
<td>2.57</td>
<td>2</td>
<td>1.5</td>
<td>2.02</td>
</tr>
<tr>
<td>What is your overall (star) rating of the app?</td>
<td>3.71</td>
<td>3.66</td>
<td>3.5</td>
<td>3.62</td>
</tr>
<tr>
<td>App Subjective Quality Total Mean Score</td>
<td>3.53</td>
<td>3.12</td>
<td>3.04</td>
<td>3.23</td>
</tr>
</tbody>
</table>

### 6.4 Discussion

This chapter offers the opportunity to understand how apps are used in a particular real-world setting and the reasons affecting user interactions at different time points over time. This work contributes to a deeper understanding of user engagement with mobile apps for anxiety on a day-to-day basis. The study also elaborates on the results of chapter 5 and of prior work (125, 126, 127, 153), which has identified reasons and barriers to engagement with such apps. Our study has further related the identified barriers and suggestions for improvement to different time points by investigating users’ perspectives in daily life over the period of two weeks. To conclude this chapter, we reflect on the findings and discuss opportunities for future work.
6.4.1 Principal Findings

The results showed that users form opinions about the apps during the first days of app use. During their first interactions with the apps, they identify barriers preventing long-term engagement and app adoption. User opinions remain consistent even after subsequent app interactions. In line with the results of a previous study (276), we found that users value the ability to self-reflect on the collected data, learn and practice new skills, and make improvements to their health with the use of such apps.

Users value apps that are easy to use, offer a variety of content, and customization options for different app functionalities. Conversely, participants’ motivation to interact with the apps is affected negatively by high subscription costs, limited free content, and a lack of customization options. Participants familiarize themselves with an app’s content quite quickly; content that remains unchanged after several interactions and affects the long-term use of such apps. Echoing (291), there is a need for mental health app developers and evaluators to better understand what leads to sustained engagement, and how to create products that achieve it.

6.4.2 Integrate apps into a system of health care

Mental health apps offer the possibility to provide instantaneous access to help in moments of need and have the potential to enhance care. Smartphone applications could enhance care for people on the long waitlists to in-person appointments with clinicians by offering low-intensity intervention content when in need of support. An interesting aspect of the study is the way that some participants used multiple apps, either by moving to a new app (abandoning the first), or used multiple apps simultaneously. Understanding use of apps in the wild may thus involve understanding user
interactions with a set of apps. Similarly, in a study that explored app-use patterns across a mental health app platform with 14 apps, participants seemed to settle on their preferred set of apps from a larger subset (294). Future studies should explore whether app usage is affected by the choices provided to the users on the waitlist to receive treatment and if single app use affects engagement. In addition, future work could include additional techniques to understand user engagement with the apps. Survival analysis and user retention rates are important tools for understanding user behavior and improving the success of digital products and services (295). A user retention curve shows the percentage of users who remain engaged with the product or service at various points in time after their initial interaction with an app. In the context of user retention rates, survival analysis can be used to estimate the length of time that users remain engaged with a product or service, and to identify factors that influence the likelihood of user retention or attrition (295, 296). These techniques could be used to help understand further users’ behaviors in order to improve the user experience. User impressions form fairly quickly, and additional support in the early stages of app adoption could help them identify apps relevant to their needs and enhance app use.

Another possible solution to enhance care could be the use of smartphone mental health apps in conjunction with therapy and to blend smartphone apps and offline tools. For example, a new ecosystem integrating apps and online resources into existing care pathways, provided via clinician referral and self-care pathways, expanded a health system’s ability to care for patients during the Covid-19 pandemic (297). Integrating digital tools in this way increased the uptake and engagement with these tools (297). The exploration of such services should involve collaboration with clinicians and service users to provide content relevant to clients and rethink app design by addressing user needs, and consider the setting of delivery, for example users that
are on the waitlist to receive counseling.

### 6.4.3 Understanding individuality and addressing diverse user needs

App content is not targeted to suit participants’ unique interests and needs. Similar to the results of previous research (84, 91), a few users in our study relied on the app description and reviews to assess their usefulness; descriptions that may not be representative of an app’s actual functionality. Users and providers need reliable resources to determine which apps may be most helpful for specific group of users. Therefore, several evaluation guidelines exist to guide users through a number of questions to decide whether or not to proceed with using an app (95, 97). In addition, independent app rating platforms offer an important service and help consumers and clinicians distinguish high-quality apps (298).

The results indicate that individual differences can influence an app’s uptake. We observed a variety of styles of use and preferences among app features with self-monitoring and treatment element features being the most used. In addition, we observed that users’ time spent interacting with the app differs. Future studies should explore such differences by investigating the design of mental health apps with a specific type of user. The variation in preferences for intervention content and features used among users indicates that mental health app designers should explore broader requirements when designing apps such as demographics, cultural background, and the diversity of mental health needs among users of such apps.

The commercial apps used in this study offer a subset of content and features in the free version. Users disengage from commercial apps due to perceived high subscription costs and limited content in the free version of such apps. The business models on which these apps are based require subscriptions or gated features, leading to a degree of conflict between user needs and the need to generate revenue to stay in
business. In addition, apps provide fixed content and do not take into consideration long-term user interactions. App designers should consider the different contexts that apps are used and the different time intervals and interactions of users with such apps. Users’ interaction with a limited amount of free content, and familiarity with unchanging app content, influence app uptake, and adherence. Future apps should be designed by adapting to the long-term needs of users.

Even though participants’ motivation to interact with the apps daily differ, most of them were willing to use the apps after the end of the study. Apps hold the potential to enhance care in daily life but sustained interactions are not well supported. Mental health app designers could design services that are more personalized and engaging by taking into consideration different user characteristics and interactions over time. This might involve refreshing content after a user has used an app for some period of time, and considering at the design stage the potential longer term use of the app. Future studies should explore further users’ interactions with different app features in real-world settings over time to inform the design of engaging apps.

6.4.4 Engagement and Technology Acceptance Models

User acceptance can provide useful information about the relative likelihood of technology success. One of the most influential acceptance models is the Technology Acceptance Model (TAM) (299). The TAM focuses on factors influencing individuals’ acceptance of technologies for the workplace. The original model presents three factors impacting individuals’ motivation to use a system perceived usefulness, perceived ease of use, and attitude toward using a system (299). In the Technology Acceptance Model (TAM), engagement is not explicitly defined as a separate construct. However, TAM does consider the concept of engagement as part of its core constructs and is closely related to an individual’s perceptions of usefulness and ease of use. The
model indicates that users are more likely to adopt and continue to use a technology when they are engaged with it and perceive it as useful and easy to use.

In the following years, the Unified Theory of Acceptance and Use of Technology (UTAUT) was formulated as an attempt to unify the growing number of theoretical frameworks of user acceptance that were developed. This model aims to explain employee technology acceptance and comprises the following constructs: performance expectancy, effort expectancy, social influence, facilitating conditions, and the individual’s level of experience and skill with the technology (300). Engagement is a multidimensional construct and an important construct in the UTAUT model and refers to an individual’s level of involvement and interaction with technology. Individuals’ engagement with technology is shaped by these factors, which in turn affect their intention to use and actual use of technology. This model can be used to understand user acceptance of mental health technologies and predict sustained use of the apps. In addition to user acceptance, long-term engagement should be examined with the use of user-centered methods to understand factors affecting the use and interactions with a mobile app over an extended period of time.

6.5 Limitations

This study has several limitations. Even though participants were on the waitlist to receive counseling and interested in using mobile applications to support their mental wellbeing in relation to anxiety management, no further measures were taken to determine if participants met the criteria for anxiety disorders. The apps used in this study are not representative of the full range of apps available in the app stores due to the selection criteria of the study (CBT apps that are widely used and present some evidence for effectiveness for anxiety management and engagement metrics).
and the fact that most apps in the app store do not have any evidence supporting their effectiveness (87). Thus, using a different set of apps might reveal different barriers, facilitators, or design considerations. In addition, participants did not have access to the full content within the applications which affects the understanding of user engagement with premium app features and content. As the aim of the study was to understand user perspectives, we did not focus on comparing individual apps. Overall, this approach provided data on real-world user experiences across a set of apps that are available, widely used, and have some evidence to support them.

6.6 Conclusions

In this chapter, a user study was conducted to understand how mental health apps are used on a daily basis by young people awaiting treatment, in order to identify barriers to engagement at particular time points and ways to improve the design of these apps. This chapter extends the results of chapter 5 and of the literature by highlighting barriers and factors affecting engagement at different time points. Understanding daily perspectives on the usage of mental health apps used for anxiety management is critical for the design of apps that are more likely to be adopted and used for a long period of time. Without clear, understandable requirements for the design of anxiety management apps in different contexts and conditions, engagement will remain an ongoing challenge for this type of mental health-related technology. Overall, our results show that initial usage forms and shapes users’ perspectives on these apps, which then remain largely unchanged. Although, as identified in chapter 4, apps integrate a range of functionalities, this study showed that many app features are not used often and the same apps are used differently by different people. Furthermore, we identified that long-term use is affected by cost-related issues, familiarization with an app’s content, and a lack of personalization options. The results showed that users
requested a more personalized experience and the ability to access app content for free. Therefore, it is important to explore the possibilities of integrating such apps with mental health care services and use such apps in high-intensity treatment. Additionally, in order to design for engagement, we need to understand the different possibilities for personalizing intervention content to meet different user needs.
Understanding therapists’ perspectives on the design of personalized interventions for anxiety management | A mixed-methods study

7.1 Introduction

The previous two chapters identified several enablers and barriers to engagement that users have with mobile apps for anxiety management. The results of the studies in both chapters showed that the lack of personalization and customization options is one of the main barriers to engagement with mental health apps for anxiety management. The user study in chapter 6 showed that the same apps are used differently by different people and that long-term use is affected by familiarization with an app’s content, and lack of customization options. In addition, the results of the stud-
ies in both chapters showed that cost-related issues including high subscription costs, and gated features are important factors affecting long-term engagement with mental health apps. Several users in both chapters requested access to app content through their university or health insurance. Therefore, it is important to explore the possibility of integrating such technologies with mental health services. Thus, understanding the opportunities for personalized intervention content is an important step in the development of more effective tailored, and engaging interventions. As mentioned in chapter 2, previous work has explored users’ suggestions on the personalization of mental health mobile technologies. However, the precise factors supporting effective personalization remain unclear due in part to a lack of insight into therapists’ perspectives in regard to technological tailoring; limiting what we know about the effective design of these mechanisms in support of care. The results from chapter 3 showed that several studies have attempted to personalize interventions by collecting data through the apps themselves. Such data can be collected automatically with the use of sensors, based on responses to ecological momentary assessment (EMA) questionnaires, or manually by research staff and therapists. Therapists can tailor intervention content through the use of a portal or by selecting intervention content between face-to-face therapy sessions. Chapter 4 showed that existing mobile apps tailor intervention content by allowing users to select the challenges or goals they want to work on during first use or suggest intervention strategies based on users’ self-monitoring data. We currently know little as to how therapists’ input might be best integrated into the personalization of mobile technologies, how therapists view this possibility, and which features and content are perceived as worth shaping.

The purpose of this chapter is to investigate further the design space of mobile mental health apps by exploring the possibility of using these technologies at higher levels of treatment intensity and integrating them in the context of mental health care
services. This chapter aims to understand CBT therapists’ perspectives on the delivery of tailored intervention content to users of mental health mobile technologies for anxiety management. More specifically, we sought to understand current therapy practices and strategies employed by therapists for the engagement of clients (if any) by conducting semi-structured interviews with 10 therapists. We then conducted ideation activities with 10 therapists to explore how tailoring can be offered in different stages of treatment, and what tailoring needs should be taken into consideration. Through this understanding, we sought to uncover a greater range of possibilities for the design of personalized mobile applications for therapist-supported CBT. We present the results of our work and discuss the implications of our findings and provide takeaways for designers of personalized mental health mobile applications. The work presented in this chapter contributes to answering the fourth Research Question.

### 7.2 Method

This paper presents findings from interviews and ideation activities conducted with CBT therapists. These methods were chosen to actively encourage therapists to make suggestions with regard to the potential design and tailoring possibilities of mental health apps for anxiety. Our study has a two-fold purpose: (1) to understand therapists’ current therapy practices in regard to facilitating client engagement with therapy (semi-structured interviews) and (2) to identify new possibilities for tailoring intervention content in between face-to-face CBT therapy sessions with therapists’ input, through ideation activities provided through design workshops.

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1RQ4. What perspectives do therapists have on how to deliver tailored intervention content to users for anxiety management?
7.2.1 Participants

Twenty therapists were recruited via social media, noticeboards, and the researchers’ personal and professional networks. A therapist was considered for recruitment if they were proficient in English, and were experienced with providing CBT treatment to people with anxiety disorders (i.e. treatment that is delivered to people with anxiety disorders, face-to-face or online). Each participant was compensated for their time and effort with a €20 voucher.

As mentioned in chapter 5, researchers estimate that 10 to 50 participants is sufficient for most types of research (270), and the most common sample size in qualitative research is between 15 and 50 participants (272). In the study, an expert group of users was recruited, therapists with experience in providing CBT, to understand their perspectives on the design of personalized mental health technologies. Given the expert nature of the participants, the iterative nature of the study, and the in-depth nature of the participation, 20 therapists were selected for inclusion. This number is fairly typical for this type of research (301, 302, 303).

7.2.2 Procedures

Semi-structured Interviews

Ten online semi-structured interviews were conducted. The interviews lasted approximately 40 minutes and were conducted by the author of this thesis. Therapists were asked to complete a short questionnaire covering sociodemographic characteristics, and professional experience. Each interview started with questions about therapists’ current therapy practices, clients’ engagement with therapy, and their use of technology. Thereafter, the researcher explored therapists’ perspectives on technology-supported therapy and different possibilities for delivering intervention content with

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the use of mobile apps. The interviews were audio recorded and transcribed by an external transcription service. A sample of the interview questions is available in Appendix A1.4.1.

**Ideation activities**

Afterwards, 7 ideation sessions were conducted with 10 therapists. Ideation sessions are held to generate creative ideas and solutions to a specific problem or challenge and generate a large volume of ideas in a short period of time. Ideation sessions can take many forms, from structured brainstorming exercises to more open-ended discussions. During an ideation session, participants are encouraged to freely express their thoughts and explore ideas to identify new opportunities (304, 305, 306). The sessions were facilitated by the researcher. Each session lasted 1.5 hours and was attended by 1 to 3 people, plus a facilitator. The focus of the ideation activities was on gaining insight into therapists’ perspectives on the delivery of tailored intervention content to users of mobile mental health technologies for anxiety management and understanding which aspects of a digitally delivered intervention might most effectively be tailored and how. All ideation sessions started with a brief description of the goal of the session. The facilitator presented previous examples of CBT apps showing different app functionalities and current strategies employed for the tailoring of intervention content. The set of candidate apps for inclusion was taken from the list of anxiety apps identified in chapter 4. The therapists had the opportunity to ask any questions. After the presentation, the facilitator presented a workflow exercise and two scenarios to enable therapists to generate ideas for tailoring intervention content. The workflow exercise represented a therapy timeline that was used to facilitate discussion for each scenario (Figure 7.1). Therapists were asked to use sticky notes in collaboration with the facilitator to generate ideas and talk about current therapy structure and homework practices, how a mobile app could support their work in
different stages of treatment, what content can be tailored, and what tailoring needs should be taken into consideration. All ideation activities were audio recorded and transcribed by an external transcription service.

7.2.3 Materials

Two scenarios were used to serve as prompts during the ideation design sessions. User scenarios are part of the user-centered design process. Our scenarios represented people with anxiety disorders (one with generalized anxiety disorder and another with panic disorder) to illustrate various reasons for treatment, as well as additional info about the different contexts of use. Scenarios were derived from case studies published on the American Psychological Association, Division 12: Society for Clinical Psychology website, which contain specific symptoms, and relate to a number of anxiety disorder diagnoses. Scenarios were used as a starting point to facilitate discussion and identify tailoring possibilities in different stages of treatment. The scenarios and questions asked to facilitate discussion are available in Appendix A1.4.2.

7.2.4 Data analysis

The interviews and the design sessions were analyzed inductively following a thematic analysis approach (265). This process entailed successive readings of the transcripts and familiarisation with the data, complete coding of the data, pattern identification and analysis, definition of themes, and reporting of findings. For the interviews, one researcher read the same transcripts and conducted open coding. The researcher coded the entire data set without any predefined codes. After all the transcripts had been coded, a second researcher (K.D.) familiarised himself with the dataset and the two researchers discussed and started collating them into themes.
Figure 7.1: Workflow exercise used to facilitate discussion
This led to the establishment of an initial set of themes. For the ideation sessions, the interactive sticky notes generated from the ideation sessions were copied onto a virtual board (307), where the researcher grouped them into clusters of similar themes and rearranged them as the analysis progressed to identify key themes.

### 7.3 Results | Interviews

Inductive thematic analysis of these 10 interviews provided insight into CBT therapists’ current therapy practices, client engagement with therapy, and understanding of current and future uses of technology for delivering intervention content between therapy sessions with the use of mobile apps. Table 7.1 shows the demographics of participants.

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<td>15-20</td>
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<td>more than 20 years</td>
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<td>Experience with technology</td>
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<td></td>
<td>(basic experience)</td>
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<td></td>
<td>Novice (some limited experience)</td>
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<td></td>
<td>Intermediate (experience of using tech in practice)</td>
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<td></td>
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<tr>
<td></td>
<td>Expert (others come to you to ask about your experience)</td>
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</table>
7.3.1 Therapists’ therapy practices

One of our primary aims of the interviews was to understand therapy practices and client engagement with therapy. Findings from the interviews highlighted the differences in therapists’ practices and clients’ needs (Figure 7.2). The results offered an understanding of (i) the individuality in therapy practices, (ii) clients’ central role in shaping the content of therapy sessions, (iii) supporting client engagement with therapy, (iv) understanding of individuality in homework practices, (v) and understanding different considerations for assigning homework.

Understanding the individuality in therapy practices

In order to understand how the personalization of digital CBT might best be designed in practice, I needed to first ensure a good understanding of the practice of therapy over time from clinicians’ perspectives. Therapy sessions are held to work out problematic behaviors, beliefs, feelings, relationship issues, and/or somatic responses.
The success of therapy, whether conducted online or in-person, rests to a significant extent on the first session, as these interviews revealed. Many therapists shared individual practices to enable a good beginning to this process. The aim of the first session for the therapist is to understand the client’s presenting issues, past experience with therapy, and expectations of therapy sessions. This allows therapists to decide on the therapeutic approach to be applied since different types of clients require different treatments. Therapists spoke of the first session as a way to co-create the goals with the clients and provide psychoeducation around anxiety or CBT depending on the approach that is applied, “So that would be looking at triggers for anxiety, for example, and how is it impacting on their life? And if our time together was to be successful, what would have changed at the end of six sessions? So my process there is trying to support and help the clients to explore the concrete changes. That means their anxiety is having less of an impact on their life.” (P8)

One therapist referred to applying a probing approach during the first session with the clients, "And then after that, I suppose for the first session, I say maybe we cover two things. Tell me, of course, about what issues you have, but also maybe we’ll try to spend a little bit of time towards the end on the flip side, I always ask that question, if you had that issue in your life, what sort of things would you be doing that you’re not doing?” (P2). Another therapist uses a whiteboard or screen sharing during the therapy to show diagrams, "Sometimes then if like in my old office, I used to have a whiteboard and I would sometimes stand up and do diagrams instead of that, I have some diagrams and stuff on my laptop and I would share my screen and I would show as I’m talking through.” (P7)

The tasks of the therapists are to take notes during the session and review those notes before each session. Other tasks may include therapist research for a specific issue that a client may bring up during the session, "If there’s something I’m not really sure
about, I might research it. If there’s an issue, if something is going on in their life, which I don’t really fully understand, I’d read up about it." (P1).

Therapists usually end a session by summarizing takeaways or by using scales to assess clients’ feelings, "And then I suppose the closing piece as well would be around scaling questions. How do you feel now on a scale of one to ten, how’s your mood with one being very low and ten being excellent, where would you rate yourself on the scale?" (P8). Other therapists use questionnaires to assess client progress and review their progress after six weeks, "Generally, every six sessions, I’ll do a review, and I make this known to the client at the beginning that’s just to see are they getting something from us do they feel they’re progressing, and if they’d like to make any changes to their therapy as well." (P6).

Clients’ central role in shaping the content of therapy sessions

Clients have a central role in filling in the structure of therapy sessions. The linear plans of treatment manuals usually do not fit the reality of everyday treatment. Even though therapists at the beginning of each session have a topic on their mind or ask for client feedback on homework to guide the session, clients’ may encounter life events and challenges that disrupt the prescribed sequence of sessions, "I think as a therapist is hugely valuable to be able to respond in session to what a client brings, which may be quite different to the presenting issue. So what I would find is that people present with anxiety, but other issues come up and that could be a real curve ball.. And I think it’s hugely important that I’m able to respond in the moment about that client need. " (P8).

Therapists need to remain flexible with clients’ presenting needs during the session. One participating CBT therapist described how they work to prioritize the topics presented by clients during sessions; "I would try and not have them go into too much
Therapists need to engage in a range of clients’ interpersonal stances and create responsive psychotherapy for each distinctive client. Therapists spoke about new information disclosed by clients during treatment which may change the picture of what the core problems actually are, "You might apply sort of a CBT approach that initially, or at least I would because of the way I work, and you might see pretty good results quite quickly. But then other things come up and things which are maybe a root cause of the anxiety maybe, or other issues that weren’t discussed in a couple of sessions, and then the approach is likely to change. There might be things that aren’t really suited to a CBT approach and they might just want the opportunity to talk." (P1)

**Supporting client engagement with therapy**

Client engagement within and outside of sessions is undoubtedly a driver of clinical change. Participating therapists noted that building a therapeutic relationship from the first session is an important component to enhance engagement in the therapy process since it allows clients to open up about their issues, "And then you might find that after a while of being maybe more person sensitive, they get to a point where they maybe trust you a bit more, and it’s possible to be a bit more challenging and change the approach a bit and be a bit more directive, whereas that might not have worked from day one, but maybe in the tenth session or something like that, the trust is there, and maybe you’ve got a bit of a relationship and it’s possible to ask
questions” (P1).

Most therapists do not provide support in-between therapy sessions unless a client is considered high-risk since therapeutic boundaries are important to maintain the professional relationship. Only one of the therapists we interviewed allowed some sort of communication with the clients’ in-between therapy sessions to support engagement, while boundaries are still maintained, "I have one client that does reach out more and I say I only respond to emails once, maybe twice a week. Know that. And we started this all at the beginning. But they find great comfort in reaching out to me and sending a quick thing." (P10).

Therapists discussed enhancing therapy efficacy and homework completion by explaining to the clients the importance of working by themselves and doing the homework outside of the therapy sessions, "That’s where maybe the difference between CBT is, for CBT it’s more you make it very clear from the beginning this is part of the therapy. These exercises, you have to do the work basically, and you have to complete these exercises in order to get the full effectiveness." (P5). P4 mentioned using homework as a way to understand the barriers and improve therapy practice, "And we sort of figure out what the barriers are sometimes to putting into action some of the things we talk about. And that’s really useful, to be honest, because most people know what to do, but they don’t do it figuring out what are the barriers to you being more assertive? Okay, so you tried to be more assertive and I’ve given you an assertiveness exercise. What happens when you try to do it?"

**Understanding individuality in homework practices**

Homework is an important component of cognitive behavior therapy (CBT) and other evidence-based treatments that have been built off CBT. Therapists assign and practice homework with the clients during the therapy sessions. Each therapist has a li-
library with their own resources that they use depending on clients’ mental states and needs. These resources include material from worksheets, websites, books or book chapters, podcasts, or Youtube videos. Two of the therapists "also recommend apps for anxiety management because Mindfulness and CBT are the top two treatments" (P10) for clients to practice different exercises.

The responsibility of therapists to respond to client’s needs during the session affects the way that CBT is delivered and the exercises assigned to each client. The way that CBT is used in practice differs among therapists; some therapists described using part of CBT only during the therapy session whereas others described using a more structured approach and sending worksheets for clients to practice in-between therapy sessions. For example, P2 discussed using CBT during the therapy sessions and verbally assigning homework material, "I sometimes use CBT, particularly with anxious conditions, and then, for instance, a little bit about, again, the thoughts, the feelings, the actions. So certainly some obvious things in relation to some CBT stuff is that if they identify coarse triggers that start their anxiety or that get their phobia going. So that’s an obvious one. Sometimes with CBT, you identify certain triggers. So, therefore, the obvious one is to try and agree in some ways. Well, you’re going to stop that.” (P2). The same therapist sometimes suggests only mindfulness and journaling techniques to the clients depending on their presenting needs.

**Understanding different considerations for assigning homework**

Homework provision requires a dedicated balance between task setting and client autonomy. Decisions on homework practices are the result of interacting considerations on the part of the client. A few therapists described assigning homework based on client past experience, based on the results of anxiety scale scores, or based on receptiveness to specific homework material and adapting homework based on client
needs. For example, P5 mentioned, "Again, I figure out what the client likes. Do they like being on their phone? Do they like being on apps? Do they want to be journaling or things like that, or do they need more recommendations for maybe physical movement or things like that?". Another factor to consider when setting homework is the frequency of the therapy sessions. While other therapists hold a weekly practice with their clients, P7 prefers to space out meetings and allow clients to absorb and practice the material, "And then I tend to space out the meetings. So maybe the fourth meeting might be in a fortnight and the fifth meeting might be in another three weeks. So the six sessions, it’s not always just six weeks. It might be over two or three months because some of the material takes a little bit of time to absorb or to practice."

An understanding of clients’ challenges in completing the homework exercises developed collaboratively during therapy sessions could influence the decisions for the delivery of personalized content. Therapists referred to time as a common barrier for preventing homework completion, "I think the number one barrier would be I’m meeting people who are extremely busy. So I’m thinking of professionals who have a full time job... They would say to me, oh, yeah, I just couldn’t open that email. I know you send me stuff I didn’t have time to." (P8). Another reason for clients’ irregular homework completion practice is therapists assigning homework that is not relevant to client needs, "So I think most people are pretty committed to doing the homework and will explain if they haven’t, they’ll also be happy to tell you ‘I didn’t find that relevant’ or ‘I’m not sure why you were sending out to me’, but is useful when we sort of go through it." (P4).
7.3.2 Understanding the role of technology to support clinical practice

Therapists discussed the possibilities for using technology to support their current practices. They referred to the features that mobile technologies could have and that would benefit therapy practices.

Most therapists were positive about the use of technology in their clinical practice and they proposed different activities that could be integrated into the mobile apps. Such activities usually included psycho-education, journaling, self-monitoring, thought challenging, identifying cognitive distortions, and some guidance on how to use such techniques. The activities could make clients aware of how they are thinking and help them identify patterns. Other techniques included mindfulness, grounding techniques, and graphical feedback of clients’ data entries. Other therapists were interested in integrating worksheets, or specific techniques they use in their practice, derived from sources such as books and websites, for example, P9 mentioned, "some things like the Johari Window are very good, but it’s often hard to kind of get someone to fill in the worksheets and send them on an email and then they have to send them back with it written on and they’ve got to scan them and all the rest”.

Integrating homework practices with the use of technology requires an understanding of the diversity of clients with anxiety disorders. P1 referred to the importance of assigning distinct homework exercises to meet individual unique clients’ needs, "Well, the thing with, the problem is that the activities are often individually tailored to the clients. For anxiety disorders, yes. We just talk about what triggers their anxiety and maybe some of the things that make them particularly anxious. An example might be driving so set a challenge to drive to a particular place where they know that maybe they don’t like stopping at traffic lights or they don’t like going, I mean,
M50 [busy motorway] or something like that, to try and set a task of doing one of those things.” P1 mentioned that treatment decisions on homework should be the result of interacting considerations with the client, "It’s a collaborative thing. We’re working out something between clients and therapists about what would be useful and maybe a way of logging on an app that they’ve done it and when they’ve done it.” Collaboration between the therapist and the client is key yet there is more to be done to understand what shape this might take.

A few therapists mentioned that integrating such techniques into an app would help them identify themes or understand the situations that challenged the clients during the week; information that can be used to guide therapy sessions, "So it would be helpful if I could get some before the session, get some examples of what they struggled with, because then that would help me to be prepared and to be able to tailor the session maybe towards some of those specific things." (P7) The use of technology in-between sessions could help to refresh learning of material introduced during the sessions, "I suppose it’s nearly like a crutch, if you like. It like a little something they can lean on in between sessions. Again, it might refresh the content of their learning, particularly with CBT, because with CBT, there is actually a lot of you’re learning how you think and how your thought processes, how they go for you. So maybe it could refresh learning in between sessions as well.” (P5)

**Challenges when integrating technology in therapy practices**

Therapists acknowledge that clients who are not receptive to using their phones, and clients with lower technology literacy would not benefit from such a solution. In addition, they mentioned that price affordability, the privacy of data security, and internet connectivity could enhance app use. Even though most of the therapists were positive towards the use of an app to support their clinical practice, therapists were
concerned that apps may cause clients to overthink their issues or reinforce attention function suicidality. For example, P1 stated, "But if there’s the examples we gave like if an emotional kind of a diary, just logging what’s happening and being fairly factual about it and keeping track of activities that they’ve done, but maybe being fairly cautious to that, not to have them disappear down the rabbit hole. Why is this happening? Why am I thinking this? So just being careful that it’s not counseling or it’s just a way of logging things to be dealt with at a later stage. I feel like that would be important."

P8 wanted technology to ensure not to dehumanize people through technology, an act antithetical to therapy, "They know if they talk to a human therapist, they’re getting a tailored therapeutic approach to them. And it’s acknowledging maybe their uniqueness as human beings and also why we have much in common as human beings. And if we take anxiety, it’s a symptom. And that’s one of our struggles we will share commonalities with a lot of others that struggle with anxiety, but the contextual piece is always unique."

Summary of Interview Results

The interview results revealed diverse therapy practices, the active role of clients in shaping the content of therapy sessions, and the challenges with technology that can impact the delivery of personalized intervention content with the use of mobile apps. Understanding the importance of individualizing therapy to meet client needs raises questions about the characteristics that could enable effective tailoring of mobile app content.
7.4 Results | Ideation sessions

Ideation sessions with 10 therapists were conducted to explore the possibilities for tailoring intervention content in between face-to-face CBT therapy sessions with the use of technology and understand the different client characteristics that should be taken into consideration for that purpose. Each session was audio recorded, totaling over 8h of audio. These recordings were anonymized and fully transcribed. Findings from the ideation sessions highlighted the need for a modular approach to the tailoring of content and the central role that therapists should have in personalizing mental health apps. In addition, they provided an understanding of the different characteristics that need to be taken into consideration when designing personalized technology-based interventions. Table 7.2 shows the demographics of participants in the ideation sessions.

Table 7.2: Demographic characteristics of design sessions participants

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<td>more than 20 years</td>
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<tr>
<td>Experience with technology</td>
<td>Fundamental awareness (basic experience)</td>
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<td>Intermediate (experience of using tech in practice)</td>
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<td>Advanced (experience using tech in complex projects)</td>
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</tr>
<tr>
<td></td>
<td>Expert (others come to you to ask about your experience)</td>
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</table>
7.4.1 Using technology to support clinical practice

Echoing the results of the interviews on the use of technology to support clinical practice, therapists spoke more directly about the integration of technological features into the design of personalized technologies depending on clients’ unique presentations. As with the interview results, feedback should be an important aspect of a personalized system to benefit both therapists and clients. A personalized system should provide some sort of visual feedback to therapists to understand clients’ progress. In addition, client feedback on homework practices is important for therapists to guide their homework practices, "You know everyone is different but it might be possible and I think as well somewhere where the client is able then to maybe rate their progress or something that they’re kind of rating therapy and their progress but as part of the treatment. So you might get a weekly feedback.” (P8) Feedback should also be provided to the clients to show progress during therapy sessions and provide encouragement. The focus of the ideation sessions was to understand therapists’ perspectives on the tailoring of mobile anxiety applications and what form they aspire for this to take. Therefore, the next sections focus on discussing these aspects.

7.4.2 Using a modular approach for the personalization of mental health apps for anxiety management

The ideation sessions highlighted that therapists’ would like to have a central role in the personalization of mental health applications. Therapists requested the need for a modular approach in which they can use information gathered from clients to tailor the design of an app for delivering personalized intervention content. The individuality of clients and the collaborative nature of homework assignments require the use of a flexible and modifiable system for clinicians to use. As P4 stated, "Obviously CBT
Therapists requested the use of a dashboard that could be used to assign homework relevant to client needs at the end of each session. Figure 7.3 illustrates the main idea therapists envisaged for the delivery of personalized interventions.

It is critical for therapists to design a system post-session with several options to suit clients with different characteristics and needs. As P1 envisaged, "Well, as a clinician, it would be nice to have my end of the app where I could push things to Phil which are relevant to things that we spoke about in session." and "it would be great to be able to say, okay, so Phil is telling me that he has a problem with self criticism and that I have got perhaps in the app or perhaps I can pull it into the app, I can copy and paste it or something that I can signpost him to other resources that might be relevant."
P2 envisaged a post-session system that builds up over time with resources and recommendations created by the therapist. Similarly, P6 envisioned selecting and providing unique intervention content from a pool of different exercises that would be tailored to each client’s presentation and needs. As P6 stated, "Because if you just give them an app with loads of stuff on it, that doesn’t really mean that you’ve really thought and understood what this person needs. So for him, it might be psychoeducation on panic. It might be information on safety behaviors... But his toolbox is different to somebody else’s toolbox because of the interaction you’ve had with him and how you understand his difficulties and how he understands what’s going to help him manage this into the future because this will always be an issue around stressful situations... So he goes away with a toolbox that’s specific for him based on the therapeutic support that you’ve worked on."

P8 envisaged the use of profiles for each client and the selection of a suite of exercises based on the client’s presentation, "I suppose to make it relevant if you’re going to individualize it or tailor it for your client if there was a function where you could maybe do a profile of their challenges or something, so I’m just trying to think if I have three, four clients they all have anxiety but that anxiety is going to be present very differently so if I was able to maybe profile and that then might link to the exercises or something or a suite of exercises that then you choose for that kind of profile of clients or something. I know with CBT exercises they are very individualized and that’s why you don’t do the same thing."

In addition to the solution of using a system in between face-to-face CBT therapy sessions to tailor intervention content, P9 envisioned the use of a synchronous app that could be used during the therapeutic session to push specific customizable assignments to clients based on their indirect feedback provided through the app. As P9 mentioned, this "would be extremely valuable because most of the existing setups
are actually not very good at that in a flexible sense you can’t make your own.”

Thus, P9 envisaged the use of technological capabilities such as natural language process, AI, and accumulated data to predict decisions on the therapist’s behalf and to predict the therapy trajectory over time. P9 referred to the importance of even just individual algorithms "to know what your expected trajectory would be on the basis of detailed scientific measurement would be huge.”

7.4.3 Identifying the characteristics for the tailoring of mental health app content

The ideation activities revealed many different individual characteristics and therapists’ preferences to take into consideration for the tailoring of intervention content. The therapist’s main goal is to identify what is helpful for the client. Therapists acknowledge that the individuality of clients’ needs affects the content of homework that is assigned to them. Client feedback on intervention strategies practiced during the session is critical when deciding on the tailoring of intervention content. In order to provide homework relevant to client needs, therapists need to understand the client, select the appropriate strategies for each client, and modify/adapt such strategies based on the client’s needs. Table 7.3 summarizes the characteristics for the tailoring of mental health content.

Understanding clients’ readiness for change

People presenting for treatment are not always motivated to engage in the process and make changes in their lives. A leading cause of treatment dropout and low adherence is a lack of motivation (308). Therapists should understand clients’ motivation for change for the tailoring of intervention content. As P1 stated, "Well, again, overall kind of readiness for change because he may be so panicked and so anxious
Table 7.3: Tailoring Characteristics

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<thead>
<tr>
<th>Setting</th>
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<td></td>
<td>receptivity to different intervention strategies</td>
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<tr>
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<td>awareness of client presenting issues</td>
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<td>past experience with therapy routine</td>
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<tr>
<td><strong>selecting/matching an intervention</strong></td>
<td>based on type of anxiety disorder</td>
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<tr>
<td></td>
<td>based on severity of symptoms</td>
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<tr>
<td><strong>modifying/adapting an intervention</strong></td>
<td>media communication style</td>
</tr>
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<td></td>
<td>client preferences for modality delivery</td>
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<td>familiarity with technology</td>
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<td>accessibility issues</td>
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<td>client availability in-between sessions</td>
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<td>modify language of content</td>
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</table>

that he might struggle to get into sessions at first. He may be a sporadic attender if he’s very panicked and doesn’t want to leave the house."

P6 requested the ability for the client to rate his readiness for change as a characteristic that would affect the delivery of intervention content with the use of technology, "Well, is he going to, number one I suppose feel able and number two be motivated. So actually something like a measure of readiness for change might be good for someone like Dave, where he can rate his readiness to actually make a change and do something, take on the task or whatever."
Understanding client receptivity to different intervention strategies

In order to identify what intervention strategies will benefit each client, determining whether or not a client is receptive to specific intervention strategies is another characteristic that should be taken into consideration for the tailoring of intervention content. For example, P3 mentioned that "if you have a very anxious client proposing a grounding exercise where they will be by themselves with their thoughts can have the opposite outcome of what you were hoping so I would most probably try and exercise with him in the room to see how he’s reacting a little bit of a breathing maybe just a body scan to be able to leave his mind and go into his body." Therapists practice different intervention strategies during the session to decide on the homework assignment.

Understanding clients’ awareness of their presenting issues

P9 referred to clients’ level of awareness of their situation as a factor that would alter the sequence of homework delivery. As P9 stated, "And this is the point where like something like panic that you may actually alter the sequence somewhat. If somebody comes in and they already thoroughly understand how their thoughts are perpetuating their symptoms, you might jump straight to exposure, but if they don’t want or they’re not even on the page to understand what a thought is, you probably have very different work that you might want to do. Important to be able to change it up at that stage."

Similarly, clients’ past experiences with therapy can influence decisions about the delivery of intervention strategies. As P5 stated, "also want to know maybe his level of CBT so maybe he’s going back for the 8th time to have CBT again but maybe it’s his first time. I know all these techniques, I want a ‘refresher’, maybe he’s come back again or maybe he’s new".
Understanding clients’ routines for the delivery of notifications

Understanding clients’ routines and availability are important for the delivery of notifications at times when they are able to interact with an app. As P3 stated, "I couldn’t have a notification at, let’s say, nine in the morning when he’s at work to do a specific exercise that can take ten minutes. I wouldn’t recommend that.", and P2 "It’s a notification that only he will take according to his presenting issues and again his routine and his way of life living basically."

Selecting intervention strategies based on the type of anxiety disorder

At a high level, different intervention strategies could be presented to a system controlled by therapists based on the type of anxiety disorder. As P8 stated, "once you go into your main presenting issue, anxiety, and then that will bring up maybe a tier of options. And then within that, you can go and look at different activities or different kind of tasks, work tasks, cognitive tasks, behavioral tasks, physical tasks, whatever."

Selecting intervention strategies based on the severity of the symptoms

Another characteristic to take into consideration when deciding on the intervention strategies assigned is the severity of anxiety symptoms for each client. Assessing the severity of clients’ symptoms would allow for the selection of tailored intervention strategies for each client. As P4 mentioned, "So that you have your different packages there that you can call on, different resources there that you can depending on severity", and P5 "I suppose if the therapist had access to all of the different tools and could tick certain tools for the client, particular client rather than giving a client everything and overwhelming them"
Modifying the delivery method of intervention content.

Therapists would like to assess a few client characteristics in order to alter the modality for the delivery of content. P4 and P5 referred to an understanding of clients’ media communication styles that could affect how content is delivered through an app. As P4 stated "I suppose it’d be helpful to know, Obviously Phil likes to read books, so he’s obviously quite well-read. It sounds like other clients don’t like to read. Maybe they want to watch videos or listen to podcasts or whatever. You might need different types of content on the app."

Therapists discussed delivering intervention content based on clients’ preferences for different types of modalities. As P7 stated, "I think some people like it’s a gender issue. They like to listen to a woman or a man. So I’d always ask people, do you want to hear a male or a female voice? Sometimes they want to hear your voice because you’re doing the therapy with them. Some people like to hear their own." Changing the modality requires therapists to be given a variety of options. As P10 stated, "We can use the right content as well. We can have a look at different, like for example, videos of meditation guidance or things like that, they might suit him more than another client."

Understanding clients’ familiarity with technology could influence the delivery method of intervention content and require the provision of an app that is easy to use for the client. In addition, the design of a personalized app should take into consideration accessibility issues such as dyslexic clients and therefore consider different input and output modes for content delivery.

Understanding clients’ availability to complete homework practice could alter the frequency and content of a personalized app. As P7 stated, "And also encouraging him with regular practice of the progressive muscular relaxation three times a week"
for 10, 15, 20 minutes, where would he do it? How is it for him? The grounding tech-
niques, as [participant name] was saying as well, using cognitive distraction when he
gets caught up in worries, looking at his surroundings, noticing buildings, noticing
people, taking his mind off the worry, in essence. So building on that, I think over the
next few weeks."

Therapists referred to the possibility of providing several customization options to
suit client needs. As P10 stated, "And then if there was a variety of male and female
voices, that kind of and then you would have to then have graded literacy as well. If
you’re not going to put a voice on, I think the voice is the better, and they can just talk
into it as well. It’s easiest."

Adapting the wording of intervention content to clients’ unique presentations

Other therapists referred to the importance of modifying the language of content to
individualize it for each client. As P8 stated, "So the exercise, say in a thought record,
the columns are going across the page, and they’re asking them to fill that in. But
below that, they would have an example. They give an example to prompt, but that
example might not exactly fit the client. So you might have to write in an exam-
ple from their experience that they will prompt them when they’re at home, because
the example that’s written down isn’t necessarily something that they’d have experi-
enced is that kind of way.", "And they’d be different wording from the person with
generalized anxiety. So, yeah, it would be to, the worksheets or whatever are adapted
to each presentation."
7.5 Discussion

This chapter offers the opportunity to understand CBT therapists’ processes to inform the development of personalized technologies to address anxiety. This work contributes to an understanding of the different possibilities for the design of personalized technologies for individual clients to support current therapy practices. In the present chapter, we presented two studies that investigated CBT therapists’ perspectives on the personalization of mobile technologies and identified new possibilities for delivering intervention content. In study 1 we conducted semi-structured interviews to understand current therapist practices, client engagement with therapy, as well as therapists’ perspectives on technology-supported therapy. In study 2, we conducted ideation sessions with therapists to explore the possibilities for the delivery of tailored intervention content and characteristics to achieve a high degree of personalization. These studies provide complementary perspectives, allowing us to build an understanding of designing effective tailored mobile interventions to support clinical practice. To conclude this chapter, we reflect on the findings and discuss the challenges associated with the implementation and integration of personalized technologies in clinical practice. Finally, we propose recommendations for future research to advance our understanding of the different possibilities for the design of personalized technologies.

7.5.1 Principal Findings

The personalization of mental health mobile technologies is an important element to support the tailoring of care for individual clients. The results from the interviews showed that clients play a central role in shaping the content of the therapeutic sessions and consequently affecting the delivery of intervention content with the use of
apps. The design of personalized apps should support flexibility considering clients’ unique context of anxiety. We identified several barriers preventing homework compliance, similar to the barriers to homework compliance that have been identified in the literature (309, 310, 311, 312, 313). Such factors include a lack of motivation to change the situation when experiencing negative feelings, disregard for the importance or relevance of the homework, effort associated with pen-and-paper homework formats, the inconvenience of completing homework because of the amount of time consumed, not understanding the purpose of the homework, lack of instruction, and failure to anticipate potential difficulties in completing the homework. Similar to existing guidelines for enhancing homework compliance and providing appropriate ways for CBT homework (314), therapists discussed assigning homework that is relevant to the central goals of therapy, agreeable to both therapist and client, practiced in session, doable, has a clear rationale, and includes a backup plan with homework challenges. In addition, our results showed that therapy and homework practices are diverse, allowing space for further exploration of different possibilities for tailoring intervention content. Even though the results from the previous two chapters and of prior research show that one of the main reasons for disengagement from self-management mental health apps includes the lack of personalization and customization options (43, 125, 126, 127, 155, 170, 171, 287), our study results show that involving mental health professionals in design informs the development of a wide range of options for the personalization of mental health apps. Therapists requested a modular approach in which a dashboard is used to tailor the content of predefined modules based on different client characteristics. Similar to the results of previous studies (315, 316), it is important to not overwhelm the client with unnecessary materials. Recognizing this need, therapists requested an active role in the personalization of such systems. In contrast to existing technology-based systems for intervention
delivery, effective personalization requires the modification of predefined modules. Our study shows that personalizing strategies for the delivery of intervention content based only on the type of anxiety disorder (e.g. GAD) or severity of symptoms are inadequate for the design of highly personalized interventions and different user characteristics should be taken into consideration. The application of these personalization strategies cannot be carried out in a fully automated way and is not without difficulties.

7.5.2 Therapist-Led Personalization and the Value of Flexibility

The results from the ideation activities highlighted the need for flexibility in the choice of intervention strategies and materials that clients should access. A mobile app should deliver useful content and be congruent with the therapy being delivered and the therapeutic goals agreed upon between clients and therapists. Almost all therapists who participated in our study suggested digitizing existing homework practices and adjusting intervention content based on specific client characteristics. Only one therapist referred to the use of advanced technological capabilities such as the use of sensors or machine learning algorithms. In this case, predictions could be made for both the mental health state of clients and therapists’ decisions about session practices. Therapists spoke about the integration of different types of homework in CBT, including, psychoeducational homework, self-assessment, and intervention strategies homework.

Therapists referred to the provision of more effective tailoring which may be supported by more information gathering. In that case, different levels of tailoring can be offered over time based on assessing different client characteristics. Therapists spoke about different client characteristics that should be taken into consideration during therapy sessions that would influence the sequence of delivering intervention
strategies. The types of homework that will be assigned depend on different client characteristics assessed during sessions such as the type of anxiety disorder, severity of symptoms, clients’ receptivity to different homework, clients’ past experience with therapy, and different preferences for the modality of content delivery. Therapists emphasized the need for different delivery formats of intervention content based on different clients’ needs. Similar to the results of a previous study (317), clients often find the length of time spent doing homework and the lack of clear instructions discouraging. Therefore, therapists mentioned the importance of understanding clients’ preferences in task duration and providing detailed instructions for app use.

Therapists highlighted the need to adjust treatment based on the client’s presenting issues and preferences beyond the delivery of a CBT treatment manual. The application of different CBT techniques depends on client presentation during therapeutic sessions with psychoeducation being the most steady component of treatment. This indicates the difficulty in making predefined decisions for the personalization of intervention content. Self-monitoring and psychoeducation are major components in the early stage of CBT therapy for anxiety disorders. Other intervention strategies such as thought records, identifying cognitive distortions, and behavioral exercises depend on initiated conversations among therapists and clients. In addition, the wording of intervention content and behavioral exercises delivery require unique design considerations to match individual needs. Therefore, the treatment modules delivered via mobile phones should meet the specific needs of each client. Previous research in blended therapy and delivery of CCBT has shown that the ability to support flexibility influences the acceptability of a system for clients (318, 319). In addition, our results showed that there is more being shaped in the provision of homework than might at first meet the eye. Therapists use homework as a way to understand client barriers and client receptiveness in homework provision.
7.5.3 Automate encouragement and maintain therapeutic barriers

On the whole, therapists were positive toward the use of technology to support clinical practice and enhance therapeutic outcomes. They suggested using technology as a reminder of the material discussed during sessions and as a substitute for current homework practices. In addition, therapists spoke about the potential benefits of monitoring clients’ activity before sessions while maintaining therapeutic boundaries. This can be achieved by active data collection that allows the patient to decide what they are disclosing or by passive data collection which might reduce the burden on the client but reduces their autonomy. As identified in chapter 3, a lot of current work in academic settings focuses on the use of passive sensing to collect user data and provide content relevant to client needs. Therapists referred to the value of providing tailored encouragement which is automatically delivered for clients’ progress based on the commitment to homework practices and completion of different intervention activities. They also discussed the possibility of reviewing part of client data to guide therapy sessions that will benefit existing practices. Even though therapists value integrating technology into their practice, it is important for them to maintain therapeutic boundaries in-between sessions and avoid adding expectations on the clients’ side. The goals of the technology and its limitations need to be clear to clients.

7.5.4 Considering Therapists’ Workload and Current Practices

The use of an integrated system to support clinical practice and personalization entails the risk of increasing therapists’ workload. Modifying intervention wording or behavioral exercises based on client presentation could increase therapists’ workload. The design of a personalization system should offer quick interactions for therapists to use. This can be achieved with the use of predefined modules that are adjustable
based on specific client characteristics identified in our study. Such a system should provide modularity and allow for flexibility considering both different modalities and the wording for the delivery of intervention content. In addition, the use of a system requires changes in current therapy practices and raises considerations of how such a system should be integrated into traditional care settings among different providers.

7.6 Future work and Limitations

The results showed that personalized systems should support flexibility for therapists in making decisions at the end of each therapeutic session. Future work could explore the possibility of designing a personalization system to support therapy practices and integrating it into current therapy care settings. This study answered the question with regard to specific tailoring needs that should be taken into consideration; however, future design work should explore in more detail the design options for such systems. In addition, future work should explore further how tailoring can be offered at different stages of treatment and what content can be tailored for that purpose. Machine learning algorithms and data analytics could help to improve the design of such systems by learning over time from different therapists’ decisions and different clients’ characteristics that affect such decisions. Through AI-based technologies (e.g., machine learning, deep learning), it is possible to detect or predict the occurrence of psychological problems in an objective and reliable way (320). This could open possibilities for the creation of more effective personalized systems and could consequently help improve the design of self-management mental health apps.

There are a couple of limitations to our current study. First, we have very broad recruitment criteria in the study; recruiting therapists with experience in providing
computerized therapy may provide different results. Similarly, it is possible that therapists’ experiences may differ according to treatment modality (i.e., for therapists applying cognitive-behavioral vs. psychodynamic therapy), and given that other factors could be identified for particular therapies, future studies should aim to assess for differences according to these factors. An additional study exploring the design of a personalized system could reveal more insights regarding therapists’ perspectives.

7.7 Conclusions

This chapter explored therapists’ perspectives on the design of personalized mental health interventions for anxiety disorders in-between face-to-face CBT therapy sessions. To achieve this objective, we interviewed 10 therapists and conducted ideation activities with 10 therapists. The findings showed that each individual’s unique anxiety context requires clinicians to take an active role in personalizing such technologies. Therapists prefer a modular approach to tailoring intervention content and assign homework based on different client assessments and characteristics. We highlighted the different characteristics of clients that should be taken into consideration for the design of personalized technologies, but these design decisions can have an impact on therapists’ workloads. Designing personalized digital interventions for anxiety disorders requires supporting flexibility and taking different individual characteristics into account. This chapter showed that there are many possibilities to be explored for the design of effective personalized systems to support both client needs and therapists’ practices. Future research should explore the implementation of a personalized system to support clinical practice and client needs. This chapter explored the possibilities for tailored interventions, a prominent feature of EMIs technologies. It informed the design space by highlighting the importance of manual tailoring for
the design of highly personalized interventions. It showed that different levels of tailoring can be achieved by assessing different user characteristics that can impact the delivery of content to provide the most relevant intervention content in real-world settings and in real-time.
This final chapter summarizes the research aims, reviews the research questions, and reflects on the contributions of this thesis. It concludes by calling for future research aiming to support the design of technologies for engagement and increased personalization and adopt longitudinal approaches to the design of mobile mental health technologies within a human-centered design process. Finally, this chapter provides a brief overview of the different promising areas for future directions of mental health technologies as presented by researchers in the field.

8.1 In Summary

This thesis investigates the set of interactions and technological possibilities of mobile mental health applications. It also explores users’ perspectives affecting engagement with such apps and therapists’ perspectives on the possibilities for designing personalized systems in clinical settings. In the work described in this thesis, we complemented and extended the literature with an extensive review of current research defining ecological momentary interventions for the treatment of common mental
health problems and examined the different possibilities available for the design of such systems. This revealed existing ambiguities in defining ecological momentary interventions for mental health and a set of different design possibilities. Building on this knowledge, we investigated further the functionality of mobile apps for anxiety management based on cognitive behavioral therapy with a focus on examining engagement and tailoring features. This led to the creation of a model of the various components of such interventions. In order to understand how to design apps that can be used for a long period of time, we explored users’ perspectives on enablers and barriers to engagement and provided suggestions for improvements. Based on the results of this study, we explored users’ daily perspectives on the usage of anxiety apps to identify the reasons for and barriers to engagement at particular time points during use in daily life. In addition, we explored therapists’ perspectives on exploring the tailoring possibilities of such systems, with personalization being considered an effective strategy to increase engagement.

8.2 The Research Questions and Contributions

The four research questions stated in chapter 1 aimed to (i) understand how ecological momentary interventions are defined in the literature on the treatment of common mental health problems, (ii) explore the functionality of mobile mental health apps for anxiety both in the academic literature and in practice, (iii) understand the reasons for and main barriers to engagement with mobile apps for anxiety and provide suggestions for improvement, and (iv) understand therapists’ perspectives on the design of personalized mental health apps to users for anxiety management (See Table 8.1). This section details how the work of this thesis has addressed these research questions within the context of digital mental health and describes the contributions to the HCI field.
Table 8.1: Thesis Research Questions

<table>
<thead>
<tr>
<th>Thesis Research Questions</th>
<th>Chapter</th>
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<tr>
<td>How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>What is the functionality of mobile mental health applications for anxiety both in the academic literature and in practice?</td>
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</tr>
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<td>What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?</td>
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8.2.1 Understanding the definitions used to describe ecological momentary interventions

Research Question 1: How are ecological momentary interventions defined in the literature on the treatment of common mental health problems?

Mobile technologies offer the opportunity to deliver psychological interventions in real time, and technological advances have enabled the delivery of treatment that adapts over time to provide the most beneficial interventions based on data collected from sensors or users. Chapter 2 introduced the concept of ecological momentary interventions and the initial explorations of delivering technology-based EMIs presented over a decade ago. To advance our knowledge of ecological momentary interventions for mental health, chapter 3 explored how researchers understood the notion of ecological momentary interventions. In particular, this scoping review pointed out that many studies provided an implicit definition by delivering an intervention that they described as an EMI, provided their own definition (197), discussed the conjunction of EMA and EMI in EMAI systems (34, 218), or expanded the momentary aspect
of EMIs by introducing the notion of just-in-time interventions. In addition, there was no consistency in the definition used, if any, among application areas. However, advances in technology, the development of the components of these interventions, and the variety of approaches to the use of sensor data indicate the need for a more specific terminology for modern EMIs.

In light of this scoping review, we propose the need for more specific terminology to clarify the different characteristics deployed in interventions across various application areas. We suggest that terminology in future studies should explicitly specify the characteristics of intervention including (a) the use of momentary assessment technology, (b) the use of sensors, (c) the involvement of professionals, and (d) the use of just-in-time algorithms that adapt the provision of support over time based on information collected from the user.

8.2.2 Exploring the different possibilities for the design of mobile mental health apps

Research Question 2: What is the functionality of mobile mental health applications for anxiety both in the academic literature and in practice?

Investigating the different possibilities of designing mobile mental health technologies is key in order to informing design work for future technologies. Chapter 2 revealed that there is a lack of knowledge concerning the set of different technological and interaction possibilities of such systems. To address this gap we explored the functionality of such systems both in the academic literature (Chapter 3) and in practice (Chapter 4). As a starting point for the exploration of the design space, in chapter 3 we explored the design features delivered by technology-based EMIs. The results allowed the construction of a model of the different design characteristics of
In chapter 4, we examined further the functionality of consumer apps for anxiety management that integrate intervention techniques derived from cognitive behavioral therapy. We focused on exploring engagement features and also exploring the ways that apps tailor intervention content in practice. The results from this chapter allowed the expansion of the model created in chapter 3.

Results from both studies showed that mobile mental health applications integrate a variety of different functionalities and use different modalities to deliver intervention content. Mobile mental health interventions provide a variety of intervention strategies, enable communication with mental health professionals and peers, and allow for reflection on collected data. In addition, many studies in the academic literature focus on the use of sensors for the detection or prediction of mental states. The identified mobile interventions in academic literature provided scant information about the delivered interventions and no rationale for the choices made when designing an intervention. The functionality analysis in chapter 4 showed that even though the apps integrate a variety of features, many of the features are not well explored. Based on the findings of both studies, the two main strategies to provide user feedback are based on self-monitoring entries and reflection on collected data. Human support is an effective mechanism for change and results from both studies showed that current smartphone apps integrate limited functions to enable both professional and peer support. In academic settings, support is also offered to address technical issues and support adherence. Even though a few studies in the academic literature attempted to use advanced functionalities to tailor intervention content such as the use of sensors and machine learning, results from both studies showed that existing tailoring strategies are limited.
8.2.3 Designing digital mental health interventions to support engagement

Research Question 3: What are the reasons for and main barriers to engagement with mobile apps for anxiety and how could the apps be improved to support user engagement?

Having explored the set of interaction and design possibilities of mobile mental health apps both in the academic literature and in practice, the next step was to understand users’ perspectives on the enablers and barriers to engagement with such apps as well as their perspectives on how apps can be improved to support sustained use. In chapter 5 we investigated these objectives by conducting a mixed-method study analyzing user reviews from apps on the app stores and conducting interviews with app users. Synthesizing results across these two studies we identified that users of mobile mental health apps disengage from apps because of usability issues, cost-related issues, low-production value content irrelevant to users’ unique inputs and needs, lack of content variety, and lack of customization options. Users value apps that address the issues mentioned above, offer the ability to use an app in different contexts, in a time-efficient manner, and are easy to use. In addition, users of such apps often requested a more personalized experience while interacting with the apps and the ability to integrate social features to provide the opportunity to connect with a therapist or with others. At the end of this chapter, we reflected on the main barriers to engagement with mental health apps for anxiety management identified in both studies, leading to implications for design.

We then conducted a two-week user study to understand how such apps are used on a day-to-day basis. We explored daily perspectives on the usage of mobile apps for anxiety management that integrate CBT, with a focus on understanding reasons for and barriers to engagement during app use at particular time points. We ana-
lyzed both qualitative and quantitative data collected through daily questionnaires and optional interviews after the end of the study to capture participants’ experiences with the mobile apps. The results on reasons and barriers to engagement with mobile mental health apps from this chapter align with the results from chapter 5. Both studies showed that users appreciate apps that offer a variety of content, good interface design, and customizability options and often requested an enhanced, personalized experience. Our study further related the identified barriers and suggestions for improvement to different time points. The results showed that users form opinions about the apps during the first days of use; opinions which remain largely unchanged. In addition, we detected that the same apps are used differently by users and intervention content remains unchanged during app use affecting long-term interactions with the apps.

Finally, drawing on the findings, we discussed the challenges of using mobile apps in daily settings and reflected on alternatives to enhance the regular use of such apps. Both chapters highlighted the need for more research to address further the reasons affecting engagement and the opportunities to personalize intervention content for that purpose.

8.2.4 Understanding the possibilities for delivering personalized digital mental health interventions

Research Question 4: What perspectives do therapists have on how to deliver tailored intervention content to users for anxiety management?

As mentioned in chapter 2, throughout this thesis we distinguish personalization and customization based on the nature of user involvement. Personalization is used to refer to the tailoring of the user’s experience based on their previous behaviors; tai-
loring that can be offered automatically or with the use of therapist support, whereas customization is initiated by users and allows the modification of app features based on their preferences. As stated in chapter 2, previous studies have shown that the lack of personalization and customization options is one barrier to engagement with mental health apps. In chapters 5 and 6 we identified that the lack of personalization and customization options affects negatively users’ engagement with mental health apps for anxiety management. Moreover, we found that cost-related issues such as high subscription fees and gated features negatively affect long-term use. To explore further the design space of these apps, we conducted a study with clinicians. This was to understand how apps can be used at higher intensity treatment integrated into mental health care settings and to understand the opportunities for delivering personalized intervention content. Chapter 7 aimed to understand CBT therapists’ perspectives on the delivery of tailored intervention content to users of mental health mobile technologies for anxiety management. Chapter 2 showed that there is a lack of insight into therapists’ perspectives in regard to technological tailoring and previous work has explored mainly users’ suggestions for the personalization of such apps. The next two chapters (chapters 3 and 4) identified the existing mechanisms of tailoring intervention content in current mobile interventions both in academia and in practice. Thus, the next two chapters (chapters 5 and 6) that examined users’ perspectives on such apps highlighted the need for more effective tailoring to support diverse user needs and the need to provide alternative solutions to address cost-related issues.

We explored therapists’ current therapy practices, client engagement with therapy, and homework exercises with the use of interviews. We then conducted ideation sessions to identify the possibilities for delivering intervention content in between face-to-face therapy sessions. The interview results showed that clients’ unique contexts
of anxiety and therapists’ diverse practices can affect the delivery of personalized inter-
vention content with the use of technology to support clinical practice. The results
of the study in chapter 7 shed light on how therapists might play a more central role
in the personalization of mental health apps for anxiety. Therapists requested a mod-
ular approach to tailoring content and the opportunity to assign homework at the end
of therapy sessions based on assessing different client characteristics. We identified
the different characteristics that affect the personalization of app content. Finally, we
discussed the implications of our findings and provided takeaways for designers of
personalized mental health mobile applications.

8.3 Future Work

The exploratory nature of this work and the constant evolution of mobile mental
health technologies open up many opportunities for future work. This section pro-
poses directions for further evaluation of such systems. It also describes and outlines
recommendations for future research mentioned throughout the thesis to support the
design of engaging and personalized technologies for mental health.

8.3.1 Evaluating mobile mental health technologies

This thesis explores the design space of mobile-based technology mental health inter-
ventions for anxiety management to support user engagement and personalization.
As a starting point, chapter 3 examined the literature of a special case of mobile in-
terventions, the use of EMIs, over the last decade to see how they are defined, and
what they comprise in practice, as compared to the original vision. As mentioned
above, the results showed that the identified studies provided only limited informa-
tion about the design choices for the deployment of the interventions, and most com-
monly they did not provide a rationale for the different components integrated into
these interventions. To understand the usefulness of different components deployed in such interventions, we recommend researchers present the rationale for the choices made when designing an intervention.

Similarly, the investigation of the various functionalities of publicly available apps that integrate cognitive-behavioral elements did not provide us with an understanding of the different intervention components and different intervention designs that affect user engagement with the apps. In addition, technological interventions in both studies (chapters 3 and 4) targeted a variety of types of mental health disorders and deployed a variety of intervention techniques. This further raises the question of the effectiveness of different technological and interaction possibilities designed for specific mental health conditions and intervention techniques. Previous research highlighted the need for a better understanding of the numerous factors that influence outcomes of smartphone interventions for anxiety (38).

As mentioned in chapter 2, different approaches are used for the evaluation of health technologies with randomized controlled trials (RCTs) being considered to provide the most reliable evidence for the effectiveness of an intervention. However, RCTs test the effectiveness of an intervention as a whole and do not provide an understanding of different intervention aspects that are effective in improving one’s mental health state. Additionally, RCTs often do not provide information about uptake and usage in naturalistic settings. It is important to explore the aspects of mental health apps that facilitate or hinder user engagement, and examine the impact this may have on intervention efficacy (38). Therefore, we recommend that future research should explore the most effective functionality for delivering evidence-based treatment content. The model created by investigating the functionality in chapters 3 and 4 could be used as a starting point for such efforts. We also suggest that proximal outcomes, such as the impact of different features and evidence-based components on engagement should
be examined in future attempts.

8.3.2 Designing mobile mental health technologies to support long-term engagement

The functionality analysis in chapters 3 and 4 allowed us to identify potential barriers that can affect engagement with mental health apps. The mixed-method study in chapter 5 showed the enablers and barriers to engagement with mental health apps for anxiety and chapter 6 further related the identified barriers to different time points. Throughout both chapters, participants provided suggestions for improving existing apps to support engagement. Drawing on the findings of these two chapters, we propose the following guidelines for designers of mental health apps aiming to improve engagement and enable long-term use of the apps. Table 8.2 shows the recommendations for the design of mobile apps for anxiety management.

Selecting apps

Chapter 4 shows that mobile apps target a variety of different disorders and integrate techniques from common psychological treatments. The results from the mixed-method study and the user study suggest that users’ needs and expectations for mental health apps for anxiety management differ and apps should provide content relevant to their needs. Users of apps for anxiety management may use multiple apps and other kinds of resources to support their mental well-being. In addition, chapter 6 showed that user impressions form fairly quickly and users’ app selection criteria differ among participants. Therefore, it is important to include information on the description page of publicly available apps about the expected values and benefits of using an app to enhance the adoption of such apps. In addition, designers should envision ways of providing additional support in the early stages of app adoption.
that could help users identify apps relevant to their needs and enhance app use. For example, as mentioned in chapter 2, several frameworks and app rating platforms provide clear information, and rate apps based on different criteria (84). Frameworks can be used by experts to evaluate the impact of different mental health apps. Thus, app rating platforms can be used to inform users to identify apps relevant to their needs.

Chapter 5 showed that users disengage from apps in which privacy policies do not provide clear information on which data is collected, how data is stored, and if data is shared and with whom. Many currently available mental health apps do not provide a privacy policy despite this being a standard recommendation of privacy regulations (321, 322), and many apps with privacy policies are deemed unsatisfactory for conveying security and privacy (322, 323). In addition, a recent study showed that the readability of privacy policies and terms of agreement of such apps is too difficult for the general population (324). Future designs should warrant providing clear information to the users since data security must be assured to gain users’ trust. As mentioned in chapter 5, several guidelines have been created for clinicians to assess such apps and evaluate those aspects (94, 95, 96, 97, 282). In addition, recommendations have been developed to enable all the key stakeholders, particularly the app developers to ensure the privacy of the data of mental health apps (323). Mobile app platforms such as Google Play store and Apple Store can enhance privacy by increasing the vetting process for mental health apps (325). App analysis should be conducted to check for EU’s General Data Protection Regulation (GDPR) compliance which includes dozens of rules that organizations must follow in order to protect the personal information they collect about their users (326).
Increasing access

Chapter 4 shows that the majority of commercially available apps in our study are not built to conform to the Web Content Accessibility Guidelines. In addition, many apps offer reduced functionality or cannot function when an internet connection is not available. Similarly, the results from the review’s analysis in chapter 5 showed that the lack of accessibility options for people with disabilities prevents adoption and sustained use and apps are not necessarily compatible across different devices. Other barriers preventing adoption identified in chapter 5 include functionality issues such as bugs and crashes and difficulties with navigation. These issues suggest a need for designers to consider users with diverse needs in order to increase the potential reach of these systems to wider populations. In addition, developers of such apps should ensure the good functionality of such apps.

Cost-related issues are another significant factor that affects engagement with apps. Most of the publicly available apps identified in chapter 4 were free to use offering in-app purchases. Chapter 5 showed that costly in-app purchases, restricted access to content behind paywalls, and limited content in the free version of the apps prevent sustained use. Similarly, the results from chapter 6 examining the daily perspectives of users, suggest that limited access to content and gated features were factors affecting long-term use and engagement. It is understandable that the business models on which these apps are based require subscriptions or gated features to generate revenue to stay in business. However, increasing access requires alternative strategies to satisfy user needs and generate revenue. As mentioned in the previous chapters, issues of costs should be addressed at a public health level. In addition, alternate payment plans should be made available, such as providing free access through their employers and through public health services. There are opportunities to provide such apps at scale through employee assistance schemes or through health insurance.
Designers should also consider the interaction of users with content in the free version of the apps to improve user experience and enable long-term interactions with them.

**Considering diverse user needs**

The results from the mixed-method study showed that users have a diversity of needs and use the apps for different purposes and in different contexts. In addition, users have periods of discontinuous use based on life events and changes or improvements in mental health. Complementary, the results from chapter 6 which examined daily perspectives indicate that individual differences can influence an app’s uptake. The same mobile apps are used differently by participants, users’ time spent interacting with the app differs, and self-monitoring and treatment elements features were the most used. These results suggest the need to investigate further such differences that affect app use and interactions with different app features. Previous studies have highlighted the need to consider different user cultural backgrounds such as age, gender, sexuality, race, ethnicity, and nationality to advance the ability of app-based interventions to serve people in different communities (327, 328, 329). Designers of mental health apps should explore broader requirements during the design process such as demographics, users’ cultural backgrounds, and other user needs to understand better how apps will be used in a deployment setting and by whom. As mentioned in chapter 5, future research could also explore universal concepts that can be applied in the design of mental health apps.

**Integrating human support**

One of the components of mental health apps is the integration of features involving some sort of human support. Support from mental health clinicians or peers is an active component of an app to increase user engagement (37). In chapter 2 it
is stated that the therapeutic alliance is a key part of CBT treatment that could enhance the regular use of apps. The results of chapters 3 and 4 showed that a few apps offer limited sort of support from mental health professionals. This is done by allowing access to online counseling sessions in the premium version or enabling data sharing of user data. Limited support for clinician integration allows the delivery of low-intensity CBT treatment components and reduces the opportunity to use such apps for higher-intensity CBT. The studies in the following chapters showed that users value the option to contact a therapist through the app even though the text-based nature of therapist-user interaction in a few of them can impact app use negatively. An understudied topic is the digital therapeutic alliance with fully automated mental health smartphone apps. Bonds and empathy are difficult to achieve in a digital format, limiting the potential of designing highly effective self-management apps and requiring alternative strategies to achieve some sort of therapeutic alliance (330). We suggest that integrating human support could increase engagement with low-intensity CBT apps and that mechanisms for use in higher-intensity treatment should be explored. As mentioned in chapter 3, several studies highlighted the need to integrate human support and build therapeutic alliance to increase an app’s uptake (250, 251, 252). It has been found that apps with some form of human involvement are more effective than those without (289). Future research is needed to reveal the amount and type of clinician support needed and to explore ways to optimize the therapeutic alliance through an app.

Peer support is another important component of mobile mental health apps. Chapters 3 and 4 showed that peer support is provided through the use of discussion and chat groups on topics related to mental health. The results from chapters 5 and 6 suggest that users value sharing or communicating with others through an app or reading stories from people with similar mental health difficulties. However, such groups re-
main unmonitored limiting the possibility to use them effectively. Recent evidence exists on digital platforms targeting psychotic disorders and suggests high rates of acceptability and engagement for peer-to-peer interactions (331). However, more research is needed to understand the potential of integrating peer support (332). There is hence an opportunity for HCI research to explore how to effectively integrate such functionality while minimizing the risks of miscommunication or misinformation by other users.

**Supporting personalization and customization**

As mentioned in chapter 2, personalization and customization are important strategies to increase engagement with mental health apps. The next two chapters identified the different strategies that apps use to tailor intervention content either by tailoring the user’s experience based on their previous behaviors or by allowing users to modify app features based on their preferences. The functionality analysis of publicly available mobile apps showed that apps offer limited customization options for different treatment elements and personalization is restricted to either goal selection in the beginning or by delivering intervention strategies based on self-monitoring entries. Thus, the intervention strategies delivered based on such entries are either randomized or the same set of strategies is delivered to users. Both the mixed-method and the user study showed that users request a more personalized experience and several customization options for different app functionalities to support their unique needs and preferences. Thus, there are opportunities for more interactive and integrated approaches that incorporate both user preferences and mood-based recommendations.

Additionally, the results of chapter 6 showed that apps provide fixed content and do not take into consideration long-term user interactions. Future research is needed
to address both the design of effective personalization and customization for mental health app users. Users familiarize themselves with unchanging app content that influences an app’s uptake. Designers should consider exploring the adaption of intervention content to suit the long-term needs of users. As already mentioned in chapter 6, this might involve refreshing content after a user has used an app for some period of time, and considering at the design stage the potential longer-term use of the app. Future research is needed to understand the stages through the user journey where content becomes repetitive and adapt it to sustain engagement. App designers should consider ways to personalize an experience in different stages of a user journey and explore other strategies for tailoring therapeutic content. Personalization of mental health technologies should also take into consideration the nature of each mental health disorder which can affect user interactions during app use.

As mentioned in chapter 3, several attempts have been made that used mobile sensing and machine learning to both predict mental states or deliver intervention content at opportune moments. The use of such methods allows the development of digital phenotype which is a novel approach still in its infancy. It relies on collecting both active and passive data to build a behavioral, emotional, cognitive, and physical picture of the user by analyzing different data to provide tailored responses (333). Such advancements motivated researchers to develop a framework to guide the design of mobile sensing systems for personalized mental health interventions (334). In addition, as mentioned in chapter 2, JITAIIs use real-time surveys or smartphone sensor data to infer a user’s mental state and/or context to then respond with a personalized intervention responsive to the current needs of the user (36, 116). Machine learning could be applied to allow for more effective tailoring of interventions to each user’s unique mental health and support needs (254).

Designers should also explore which customization options are valued for specific
groups of people and for different app functionalities. Future studies should also explore whether the personalization of content should be automated or configured by the users.

Chapter 7 showed that a high degree of personalization can be achieved by involving professional support during app use. Most of the tailoring characteristics identified in this study demand the involvement of mental health professionals. This requires the modification of predefined modules to offer different levels of tailoring based on assessing different client characteristics. The unique context of anxiety for individuals and preferences for different media communication styles can impact the delivery of personalized content. Mental health professionals suggested that personalized systems should support flexibility for therapists in making decisions. They also suggested that personalized systems should provide different customization options to support different needs. Future work could explore the possibility of designing a personalization system to support therapy practices and integrating it into current therapy care settings. In addition, future research should explore the possibilities of integrating apps into the mental health care pathway and opportunities to prescribe apps for different groups of users. Several researchers envisioned the deployment of mental health technologies not in isolation, but as an integrated continuum working to rapidly expand access to care that is more personalized, proactive, engaging, and effective (335, 336).

### 8.3.3 Beyond applying human-centered design

Chapters 5 and 6 identified several barriers to engagement with mobile apps and users provided several suggestions for improvement. The results suggest the need for applying human-centered design at different stages of an app’s design cycle. Human-centered design methods should be applied during development and following app
deployment. Apps need to ensure proper functionality and accessibility for diverse target audiences and needs. In addition, HCI designers should consider the user experience at different stages of the user journey. User guidance during app use, customizing app features, and personalizing the experience are essential factors to promote sustained engagement with the apps. Intervention content should be adapted based on users’ needs and interactions over time. As mentioned in chapter 5, a key role for HCI professionals (including researchers) in the future is to ensure that issues of safety, usability, utility, and user experience are addressed (283). App designers could collaborate with clinicians and targeted service users to provide content relevant to user needs and rethink app design. There is a need to extend HCI techniques to design for digital technologies that will be components of complex adaptive systems, involving multiple users with different roles and various other interoperating systems (283). In addition, for digital health technologies to have a significant, cost-effective impact, they need to be deployed at scale (283). Human-centered design focuses on the deployment of digital mental health interventions based on specific objectives and targets during the design phase. Moving beyond human-centered design processes, attention and time can be given to longer-term use considering changes in the user’s journey and actions associated with ending the end-user journey (337). It is important to design technologies considering long-term interactions and objectives to increase user acceptance and prevent undesirable situations for end users during app use. Future designs should consider when the end of a user journey for the targeted intervention can occur and consider aspects affecting user interactions during app use.

Overall, this thesis identified the barriers and enablers to engagement with mental health apps for anxiety management. This thesis provided suggestions for improvement to realize the true potential of apps to enhance care. By considering diverse
needs and functionalities that affect user engagement, apps could play an important role in supporting users with their mental health difficulties.

8.4 The future of mental health technologies

As mentioned in chapter 1, mental health apps can be used in conjunction with therapy, as standalone treatments, or for use in the prevention of mental illness (16). Recent years have seen increased development of technologies to enhance the detection of mental health states and the provision of support in opportune moments. Just-in-time adaptive interventions and machine learning techniques are being employed to realize the potential of technologies to support mental health. Although personal sensing is still in its infancy, it holds great promise as a method for conducting mental health research and providing the foundation for the next generation of mobile mental health intervention (67). Artificial intelligence-based technologies such as machine learning, deep learning, and "big data" offer the opportunity to detect or prevent the occurrence of psychological problems (338, 339). In addition, current research in digital phenotyping allows more accurate predictions in the prevention, treatment, and facilitation of support resources to promote motivation for self-management of health behavior (338, 340).

Recent reviews synthesizing the literature on machine learning for mental health identified that the application of machine learning to mental health has demonstrated a range of benefits across the areas of diagnosis, treatment and support, research, and clinical administration (254, 341). There is significant room for the application of machine learning to other areas of mental health such as anxiety management since recent research demonstrates that the most common mental health conditions addressed include depression (341). However, the field of machine learning in mental
health carries a new set of ethical considerations that must be approached carefully (254). These technologies have the potential to threaten user autonomy, compromise users’ privacy and security, rise the costs of healthcare, and increase inequality by amplifying biases and assumptions that are invisible to users (283, 337). In the future, machine learning could be used to design mental health interventions to address not only the needs of users but to support the practices of mental health care experts (254).

Apart from the use of advanced technologies to create the next generation of mobile mental health interventions, as already mentioned in chapter 6, apps offer the opportunity to be integrated into existing care pathways. A paper that explored the promise and pitfalls of apps, among other technologies, posed to transform mental health education, practice and research highlighted the need to conceptualize apps as one component of a holistic integrated care plan that complements and does not replace therapy (336). Mental health professionals should actively engage to successfully navigate this complex landscape of digital mental health and lead public conversations about the potential impact and different needs (36, 336, 342). Indeed, using technology to offer hybrid care that blends complementary face-to-face and app-delivered services offers a means to incorporate the best features of both people and technology, including therapeutic alliance (343). Authors have argued that mobile apps are likely much more impactful if used in conjunction with ongoing care, rather than replacing it (36). Mobile apps can be used to complement existing face-to-face therapy practices and increase therapy effectiveness. Clinical leaders who aim for improvements in the processes and quality of care can positively contribute to successful information technologies adoption in healthcare organizations (344).

Another concept of ‘virtual psychiatry clinics’ has been introduced to realize the scalability of apps, increase access to care, and offer effective clinical services that im-
prove mental health outcomes (343). Such clinics would see clients in person for new intakes but then prescribe apps that are monitored by clinicians followed up by primarily digital visits with in-person assessments when necessary (343). An alternative potential new model of care is the introduction of humans to help support app use (345). In order to implement hybrid models of care in clinical practice, the analysis of client characteristics is essential in determining the type of psychological care to be delivered, considering the potential of mobile mental health interventions, face-to-face therapy, or both formats (320). As already mentioned in chapter 6, a new ecosystem integrating apps and online resources into existing care pathways, provided via clinician referral and self-care pathways, expanded a health system’s ability to care for patients during the Covid-19 pandemic (297).

Moving beyond the use of smartphones, in November 2022, a natural language processing tool driven by AI technology and developed by OpenAI called ChatGPT was launched. The widespread global adoption of ChatGPT has demonstrated the tremendous range of use cases for the technology including software development and testing, poetry, essays, business letters, and contracts (346). ChatGPT significantly extends the capabilities of chatbots via the integration of deep learning and language models that allows human-like conversations and the ability to answer questions and assist with tasks like composing emails, essays, and code (346, 347, 348). A recent article used the chatbot with the aim to discuss the use of AI chatbots in the field of psychology and concluded that no study discussed the impact of ChatGPT on psychology (347). ChatGPT can be used to provide information on health-related issues, answer questions about health promotion, disease prevention strategies, and about community health programs and services (346, 348). However, several limitations should be taken into consideration when using the chatbot. It provides limited accuracy, bias, and limitations of data, and does not involve direct interaction with
health professionals (346, 348). These aspects could have serious consequences on users with mental health difficulties who seek support. Without clear regulations of the information it provides and regulations to ensure users’ privacy and safety, its feasibility up to date to provide mental health support is questionable.

Limited attempts have also been made to use other sophisticated technological tools such as VR and AR for the assessment and treatment of mental disorders (336, 338, 349). Considering that a new class of smaller computers is developed about every decade, other authors have envisioned that in the future apps will be controlled by voice (342). Voice-activated devices such as voice interfaces, smart wearables, earpads, smart devices, and home control systems are predicted to replace many of the functions of today’s smartphone (342). The widespread use of such devices enables the delivery of mental health support with the use of conversation-based interfaces (350). In that instance, patterns of usage of current smartphone devices will change in the future creating opportunities for the design of mental health technologies that considers many types of consumer technologies during design and requires alternative design approaches (342).

Overall, mental health apps have yet to reach their full potential. They hold the potential to enhance care and transform the delivery of mental health care to benefit both users of such services and clinical practices. Digital mental health has a promising future due to technological advances and attempts to integrate such tools into clinical practice.
<table>
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<th><strong>Table 8.2: Recommendations for the design of mobile apps for anxiety management</strong></th>
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<td><strong>Recommendations</strong></td>
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<td><strong>Design phase</strong></td>
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<tr>
<td>Involve therapists in the design process</td>
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<tr>
<td>Consider different user characteristics and preferences</td>
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<tr>
<td>Consider user interactions in different stages of a user journey (e.g. interactions in the free version, interactions over time)</td>
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<td><strong>Personalization</strong></td>
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<tr>
<td>Consider diverse user needs, target audiences, and contexts of use</td>
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<td>Consider the nature of mental disorder</td>
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<td>Consider adaptation of intervention content based on user interactions during app use</td>
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<td><strong>Customization</strong></td>
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<td>Provide interface customization options</td>
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<td><strong>In-app support</strong></td>
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<td>Consider ways to enhance therapeutic alliance through an app</td>
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<td>Integrate therapist support and support video therapy sessions</td>
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<td>Integrate peer support and monitor discussion groups</td>
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<td><strong>Design with accessibility in mind</strong></td>
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<td>Design according to Web Content Accessibility Guidelines (WCAG) and the Mobile Web Best Practices</td>
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<td>Consider offline app interactions</td>
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<td>Consider compatibility among devices</td>
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<td><strong>Software performance</strong></td>
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<td>Ensure good app functionality</td>
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<td>Provide clear navigation</td>
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<td><strong>Customer support</strong></td>
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<td>Provide customer support</td>
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<td><strong>Costs</strong></td>
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<tr>
<td>Provide adequate intervention content in the free version</td>
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<td>Clarify app costs in the beginning (avoid hidden paywalls)</td>
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<td>Consider alternative payment plans</td>
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<td><strong>App store description</strong></td>
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<tr>
<td>Determine who your target audience is</td>
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<td>Indicate the exact symptoms that the app can address</td>
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<td>Inform user's about the app's features and benefits</td>
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<td><strong>Privacy policies</strong></td>
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<td>Provide clear info on which data is collected, how data is stored, and if data is shared and with whom</td>
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<tr>
<td>Provide readable information in the description page on the app store</td>
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<td>Follow well-established recommendations to ensure the privacy of the data of mental health apps</td>
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<td><strong>During app use</strong></td>
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<td>Ensure the interface is aesthetically pleasant</td>
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<td>Provide app guidance during app use</td>
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<td>Explain the benefits of different app features during use</td>
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<td>Adapt intervention content based on user interactions over time</td>
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Conclusions

Technological advances have opened up possibilities for improving mental health delivery and care. Smartphone technologies have enabled the delivery of psychological interventions in daily life and in real-world settings termed ecological momentary interventions. However, the set of technological and interaction possibilities for mental health interventions is under-explored. In addition, lack of engagement with such technologies affects long-term use resulting in discontinued use of digital mental health interventions. User engagement is therefore a core challenge for effective mental health technologies, and personalization is a core opportunity to enhance engagement with such technologies.

This thesis brings together multiple perspectives on the design of mobile mental health interventions and advances our knowledge of the set of technological and interaction possibilities of such systems, so far under-explored in the field. It identifies a set of implications for designing mental health interventions for anxiety management in mobile applications with a focus on supporting engagement and discusses the implications for designing personalized systems in clinical settings. Overall, this thesis
achieved these aims informed by analysis of the state of the art, user perspectives and experience, and therapist perspectives.

The first contribution of this thesis was to advance our knowledge of how ecological momentary interventions are defined across the literature for mental health disorders and to identify the different design options available for the deployment of these interventions. It extended existing knowledge and contributed to the design of mental health interventions by (i) defining ecological momentary interventions for mental health, and (ii) identifying the set of technological and interaction possibilities of such systems.

This thesis then explored further the functionality of consumer applications for anxiety management that integrate CBT, with a focus on engagement and tailoring features to advance our understanding of the different possibilities available for the design of such systems. It reviewed the delivery of cognitive behavioral elements, their functionalities to support engagement, and the different strategies used to personalize intervention content to suit different user needs.

This thesis investigated users’ perspectives on the enablers and barriers to engagement with mental health apps targeting anxiety management by reviewing app store reviews of apps that present some evidence of effectiveness for anxiety management and interviewing users of consumer mental health apps. It extended the existing literature by highlighting and distinguishing barriers preventing adoption and sustained use, and by exploring users’ experiences with apps targeting anxiety management. Following this, a two-week user study was conducted exploring the daily perspectives on the usage of such apps by collecting data from online questionnaires from young adults on the waitlist to receive treatment. This offered the opportunity to understand how apps are used in daily life and the reasons affecting user interactions at different time points. Both studies emphasized the need to understand the
precise factors supporting effective personalization and design more personalized experiences to suit different user needs. This could be achieved by exploring therapists’ perceptions.

This thesis finally explored therapists’ perspectives on the investigation of different possibilities for personalizing intervention content. This study was conducted with the aims of understanding therapists’ practices and client engagement with therapy as well as identifying new possibilities for tailoring intervention content in-between face-to-face CBT therapy sessions. To explore these objectives we conducted semi-structured interviews and ideation sessions with therapists experienced in providing CBT treatment to people with anxiety disorders. This thesis provided an understanding of the different possibilities for the delivery of personalized content to support individual needs.

This thesis thus brings together multiple perspectives on the design of these apps and enriches the HCI field with a better understanding of the different possibilities of mobile mental health technologies to support user engagement and personalization across the different stages of the user journey.

9.1 Personal Reflections

The work presented in this thesis addresses a complex research problem that demands expertise in different research fields, mainly in the fields of mental health technologies and HCI. This work lays the groundwork for future work concerning mental health technologies design with a focus on designing for engagement and personalization. Researchers and designers could build on the core contributions of this thesis and gain an overview of the opportunities and complex factors leading to sustained use.
My existing knowledge of design techniques, methods, and limitations informed this thesis research. I gained this knowledge through previous work and training in HCI and advanced it throughout the research process. The limitations of the individual studies have been discussed in previous sections (Sections 3.4.6, 4.5, 5.6, 6.5, 7.6). Here I will reflect to a few limitations of the research presented in this thesis. While the qualitative methodology allowed the exploration of complex social phenomena, and gaining in-depth insights into human behavior and experiences (57), the small sample sizes limit the ability to generalize findings to larger populations (57). Although participants satisfied eligibility criteria, I note that the results may not necessarily be applicable to other user groups or different contexts. A limitation of the studies was the inability to recruit participants with mental health difficulties. As mentioned in chapter 2, HCI researchers face several challenges in the design of mental health technologies. These challenges include the involvement of users with severe mental health difficulties in the research process due to ethical considerations. In retrospect, chapters 5, and 6 would have been strengthened by collecting clinical measures to understand participants’ intensity of feelings to inform knowledge concerning user engagement. This would have ensured a more nuanced and respectful understanding, discussion, and presentation of the views of a more representative sample on apps targeting anxiety management. However, ethical approval for studies and data collection would be complicated and time-consuming. In addition, clinician recruitment in chapter 7 was challenging and time-consuming. To minimize this limitation, future efforts could be made to create a pool of participants at a national level. This pool should include both therapists who have an interest in conducting research in this area, and users who meet the criteria for mental health disorders. This may result in faster recruitment processes and higher feedback levels from both users and therapists. Further work is required to focus on the design of mobile mental health
technologies for users with specific mental health issues.

The functionality of mental health technologies was identified using review methodologies. In addition, the qualitative methods in this thesis were based on semi-structured interviews, questionnaires (with a focus on collecting data from open-ended questions), and ideation sessions. Most of the analysis of the collected data in this thesis was conducted by the thesis author. This led to a lack of interoperability measures and a lack of objectivity in the qualitative studies due to the interpretation of the data based on influences of my own biases and perspectives (265). This subjectivity influences the construction of knowledge in this thesis. As a researcher, I had to be reflexive and examine my own judgments, practices, and belief systems during data collection. This was to identify any personal beliefs that may have incidentally affected this research. I tried to be constantly aware of any biases that could influence the study outcome by actively examining the decisions during data analysis. In addition, exchanges with colleagues and thesis supervisors supported reflexivity.

As there is little research on the design possibilities of mobile mental health technologies, this thesis focused on the high-level issues of engagement in the area. Even though the studies were rich in understanding barriers to and reasons for engagement with mental health technologies, individual differences affecting app use were not captured. The results from chapter 5 showed different motives for app use, and chapter 6 showed that the same apps are used differently by different users. It is important to understand deeper what individual characteristics affect engagement with such technologies to increase app uptake and engagement. Future work should explore the differences in app usage among the same apps to inform mental health technology design.

This thesis examines user engagement with mobile applications for anxiety management. As mentioned in chapter 2, since the concept of engagement is broad, en-
gagement was defined in each individual study by considering specifications (and definitions) for the different subdomains examined in this thesis. The complex and interconnected factors of user behavior (usage), cognition, and affect were used as an angle to help triangulate my understanding of user engagement with mental health apps. As mentioned in chapter 2, HCI conceptualizes engagement not just as the quantity of use, but also as the quality of use (112). An app can improve users’ mental states even after a few interactions which may lead to non-continuous app usage afterwards. The results of the studies showed among others that the nature of anxiety affects app use in such systems. Users may have periods of noncontinuous use based on life events and changes or improvements in their mental health. This indicates that objective/behavioral metrics of use or interactions are not enough to capture the unique human experiences and reasons that influence user engagement. Therefore, qualitative metrics are critical to understanding the reasons for both continued and discontinued interactions with mental health apps to understand in-depth reasons affecting user engagement.

Overall, my Ph.D. journey required dedication, tenacity, and hard work. During my Ph.D., I developed strong problem-solving and critical thinking skills, and the ability to conduct independent research and communicate findings effectively. This thesis allowed me to collect a rich data set of different, diverse perspectives by involving different stakeholders including both users’ and therapists’ perspectives. I applied a range of qualitative techniques to data collection and analysis. I explored related work, presented the applied methods, and analyzed outcomes in a coherent manner. By exploring the resonance of this research through different forms of feedback and discussion as part of the publication process, presentations within the HCI research community, and interdisciplinary collaboration with colleagues in the HCI and mental health domains, I gained additional insights and reflection. I also assessed the
applicability or transferability of my findings to other contexts. Overall, my Ph.D. experience was both challenging and rewarding. This thesis required a significant amount of time and effort. It gave me the chance to contribute to knowledge advancement in digital mental health, with a focus on designing for engagement and personalization.

This work contributes a new perspective in the field of digital mental health by presenting all the available technological and interaction possibilities of such systems. It also provides an understanding of users’ perspectives on the design of engaging technologies and therapists’ perspectives on the design of personalized technologies. Overall, I hope this work will inspire future work toward developing mobile-based mental health technologies that are engaging and personalized to unique user needs. I hope to see more research and design work conducted in this direction in the future.


[27] Annemieke van Straten, Jacqueline Hill, David A Richards, and Pim Cuijpers.


[34] Stefan Becker, Talya Miron-Shatz, Nikolaus Schumacher, Johann Krocza,


[62] Nessa Coyle and Roma Tickoo. Qualitative research: what this research paradigm has to offer to the understanding of pain, 2007.


[76] David H Barlow and Laura B Allen. Scientific basis of psychological treatments for anxiety disorders: Past, present, and future. In *Annual Meeting of the Amer-


[83] Jake Linardon, Pim Cuijpers, Per Carlbring, Mariel Messer, and Matthew Fuller-Tyszkiewicz. The efficacy of app-supported smartphone interventions
for mental health problems: A meta-analysis of randomized controlled trials. 


[85] Judith Gellatly, Peter Bower, Sue Hennessy, David Richards, Simon Gilbody, 
and Karina Lovell. What makes self-help interventions effective in the man-
agement of depressive symptoms? meta-analysis and meta-regression. *Psycho-

[86] Sarah J Kertz, J MacLaren Kelly, Kimberly T Stevens, Matthew Schrock, and 
Sara B Danitz. A review of free iphone applications designed to target anxiety 

[87] Madalina Sucala, Pim Cuijpers, Frederick Muench, Roxana Cardoș, Radu 
Soflau, Anca Dobrean, Patriciu Achimas-Cadariu, and Daniel David. Anxiety: 
There is an app for that. a systematic review of anxiety apps. *Depression and 

[88] Mohsen Alyami, Bachan Giri, Hussain Alyami, and Frederick Sundram. Social 
anxiety apps: a systematic review and assessment of app descriptors across 

[89] Brendan Loo Gee, Kathleen M Griffiths, and Amelia Gulliver. Effectiveness of 
mobile technologies delivering ecological momentary interventions for stress 
and anxiety: a systematic review. *Journal of the American Medical Informatics 

[90] Kien Hoa Ly, Naira Topoooco, Hanna Cederlund, Anna Wallin, Jan Bergström, 
Olof Molander, Per Carlbring, and Gerhard Andersson. Smartphone-supported


[104] Carolina Rodriguez-Paras, Kathryn Tippey, Elaine Brown, Farzan Sasangohar, Suzannah Creech, Hye-Chung Kum, Mark Lawley, and Justin K Benzer. Post-


[140] Andrew D Carlo, Reza Hosseini Ghomi, Brenna N Renn, Michael A Strong, and Patricia A Areán. Assessment of real-world use of behavioral health mobile


[154] Fernando Estrada Martinez de Alva, Greg Wadley, and Reeva Lederman. It


[183] Kathryn E Smith and Adrienne Juarascio. From ecological momentary assessment (ema) to ecological momentary intervention (emi): Past and future direc-


[189] Lydia A Shrier, Pamela J Burke, Meredith Kells, Emily A Scherer, Vishnudas Sarda, Cassandra Jonestrask, Ziming Xuan, and Sion Kim Harris. Pilot ran-
domized trial of moment, a motivational counseling-plus-ecological momentary intervention to reduce marijuana use in youth. *mHealth, 4*, 2018.


[194] Rachel Lucas-Thompson, Natasha Seiter, Patricia C Broderick, James Douglas Coatsworth, Kimberly L Henry, Charlotte J McKernan, and Joshua M Smyth. Moving 2 mindful (m2m) study protocol: testing a mindfulness group plus ecological momentary intervention to decrease stress and anxiety in adoles-


[200] Rui Wang, Weichen Wang, Alex daSilva, Jeremy F Huckins, William M Kelley, Todd F Heatherton, and Andrew T Campbell. Tracking depression dynamics


[206] Viann N Nguyen-Feng, Federico N Romano, and Patricia Frazier. Emotional


[212] Lucas S LaFreniere and Michelle G Newman. The impact of uncontrollability
beliefs and thought-related distress on ecological momentary interventions for
generalized anxiety disorder: A moderated mediation model. *Journal of Anxiety


[218] Patrick L Dulin and Vivian M Gonzalez. Smartphone-based, momentary inter-


[241] Anja Thieme, Danielle Belgrave, and Gavin Doherty. Machine learning in mental health: A systematic review of the hci literature to support effective ml sys-


[260] John F Hunter, Meryl S Olah, Allison L Williams, Acacia C Parks, and Sarah D


[334] Mehdi Boukhechba, Anna N Baglione, and Laura E Barnes. Leveraging mobile


[342] Michael Bauer, Tasha Glenn, John Geddes, Michael Gitlin, Paul Grof, Lars V Kessing, Scott Monteith, Maria Faurholt-Jepsen, Emanuel Severus, and Peter C


Appendix

A1.1 Chapter 3

A1.1.1 Search string

"(""momentary intervention"" OR ""momentary interventions"" OR ""adaptive intervention"" OR ""adaptive interventions"" OR ""just-in-time intervention"" OR ""just-in-time interventions"" OR ""micro-intervention"" OR ""micro-interventions"") AND (""mental health"" OR ""mood disorder"" OR ""affective disorder*"" OR ""mental disorder*"" OR ""neuropsychiatric disorder*"" OR ""mental illness*"" OR ""therap*y"" OR ""psychotherapy"" OR ""psychiatry"" OR ""anxiety"" OR ""stress"" OR ""GAD"" OR ""OCD"" OR ""obsessive compulsive"" OR ""phobi*"" OR ""psychotic disorder"" OR ""depression"" OR ""bipolar disorder"" OR ""schizophrenia"" OR ""substance abuse"" ) "

A1.1.2 List of included papers

319
S2 Table - List of included papers

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Target</th>
<th>Category</th>
<th>Study Aim</th>
<th>Study Design</th>
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</thead>
<tbody>
<tr>
<td>McTavis et al.</td>
<td>2012</td>
<td>Substance use</td>
<td>Intervention</td>
<td>improve competence, social relatedness, and motivation (tenets of Self-Determination Theory)</td>
<td>Clinical Trial Randomized</td>
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<tr>
<td>Leonard et al.</td>
<td>2017</td>
<td>Substance use</td>
<td>Intervention</td>
<td>reduce risks associated with drinking</td>
<td>Feasibility and Acceptability</td>
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<tr>
<td>Dulin and González</td>
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<td>Substance use</td>
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<td>reduce or eliminate drinking</td>
<td>Effectiveness</td>
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<td>Moody et al.</td>
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<td>Substance use</td>
<td>Intervention</td>
<td>reduce alcohol consumption</td>
<td>RCT</td>
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<td>Kazemi et al</td>
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<td>reduce risky alcohol use</td>
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<td>Riordan et al.</td>
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<td>Kazemi et al</td>
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<td>reduce alcohol use and drinking to cope</td>
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<td>enhance treatment for anxious youth</td>
<td>Pilot feasibility</td>
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<td>Intervention</td>
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<td>Praman et al.</td>
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<td>Intervention</td>
<td>enhance treatment for anxious youth with gamification</td>
<td>Acceptability and Effectiveness</td>
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<td>Silk et al.</td>
<td>2020</td>
<td>Anxiety</td>
<td>Intervention</td>
<td>explore improvement in skills targeted by the mHealth platform.</td>
<td>Usability, Feasibility, Acceptability, Preliminary efficacy</td>
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<td>Wenze et al.</td>
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<td>Bipolar Disorder</td>
<td>Intervention</td>
<td>improve treatment adherence</td>
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<td>Depp et al.</td>
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<td>Burns et al.</td>
<td>2011</td>
<td>Depression</td>
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<td>identify depression states and improve depressive symptoms</td>
<td>Single-arm field trial</td>
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<td>Year</td>
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<td>Wahle et al.</td>
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<td>Depression</td>
<td>Intervention</td>
<td>identify depression levels and provide in-situ support</td>
<td>Pilot trial</td>
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<td>Levin et al.</td>
<td>2019</td>
<td>Depression &amp; Anxiety</td>
<td>Intervention</td>
<td>improve psychological functioning</td>
<td>RCT</td>
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<td>Levin et al.</td>
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<td>Depression &amp; Anxiety</td>
<td>Intervention</td>
<td>improve psychological functioning</td>
<td>RCT</td>
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<td>van Aubel et al.</td>
<td>2020</td>
<td>Depressive &amp; Psychotic complaints</td>
<td>Intervention</td>
<td>improve subthreshold symptoms of depression, psychosis</td>
<td>Feasibility and Efficacy</td>
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<td>Juarascio et al.</td>
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<td>Intervention</td>
<td>facilitate treatment skills use between sessions</td>
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<td>Newman et al.</td>
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<td>Intervention</td>
<td>improve active coping</td>
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<td>secondary analysis of Lafreniere and Newman (2016) study</td>
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<td>Intervention</td>
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<td>Usability testing</td>
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<td>Shrier et al.</td>
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<td>Substance use (Marijuana)</td>
<td>Intervention</td>
<td>reduce marijuana use in youth</td>
<td>Pilot Randomized Trial</td>
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<td>Meinlschmidt et al.</td>
<td>2016</td>
<td>Mood</td>
<td>Intervention</td>
<td>estimate and improve mood changes</td>
<td>Exploratory study (experimental or control condition)</td>
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<td>Meinlschmidt et al.</td>
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<td>Intervention</td>
<td>improve mood</td>
<td>Empirical Study Quantitative Study</td>
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<td>Kroska et al.</td>
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<td>Mood</td>
<td>Intervention</td>
<td>optimize an ACT-based intervention in transdiagnostic populations</td>
<td>Protocol</td>
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<td>Stevens on et al.</td>
<td>2020</td>
<td>Mood, Alcohol</td>
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<td>explore relationship between mood, coping strategy use, alcohol use</td>
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<td>Bell et al.</td>
<td>2018</td>
<td>Schizophrenia</td>
<td>Intervention</td>
<td>improve coping with distressing voice hearing experiences</td>
<td>Case study</td>
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<td>Hanssen et al.</td>
<td>2020</td>
<td>Schizophrenia</td>
<td>Intervention</td>
<td>improve daily-social functioning and ameliorate symptoms in schizophrenia</td>
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<td>Intervention</td>
<td>reduce risk of relapse</td>
<td>Feasibility, Acceptability, Clinical effects</td>
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<td>Pulantara et al.</td>
<td>2018</td>
<td>Sleep disturbances</td>
<td>Intervention</td>
<td>improve insomnia severity, overall sleep quality, and disruptive nocturnal disturbances</td>
<td>Feasibility, Comparative Effectiveness Study</td>
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<td>Versluis et al.</td>
<td>2018</td>
<td>Stress</td>
<td>Intervention</td>
<td>improve a physiological marker of stress and unconscious stress</td>
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<td>Beute and Kort</td>
<td>2018</td>
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<td>Intervention</td>
<td>lower stress and improve mood</td>
<td>Pilot study</td>
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<td>Nguyen-Feng et al.</td>
<td>2019</td>
<td>Stress</td>
<td>Intervention</td>
<td>reduce psychological distress among students with and without an emotional abuse history</td>
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<td>Lucas-Thompson et al.</td>
<td>2019</td>
<td>Stress and Anxiety</td>
<td>Intervention</td>
<td>reduce stress and anxiety</td>
<td>Protocol</td>
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<td>Dennis et al.</td>
<td>2015</td>
<td>Substance use</td>
<td>Intervention</td>
<td>predict substance use and provide Recovery Support for Adolescents</td>
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<td>Morgièvre et al.</td>
<td>2020</td>
<td>Suicide prevention</td>
<td>Intervention</td>
<td>describe how participants at high risk of suicide use the emma app in real-word conditioning</td>
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<td>Bae et al.</td>
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<td>Substance use (Alcohol)</td>
<td>Sensor-based</td>
<td>detect alcohol use events</td>
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<td>Jacobsson et al.</td>
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<td>Depression</td>
<td>Sensor-based</td>
<td>predict depressed mood within a day</td>
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<td>Saeb et al.</td>
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<td>Sensor-based</td>
<td>identify depression symptoms severity</td>
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<td>Wang et al.</td>
<td>2018</td>
<td>Depression</td>
<td>Sensor-based</td>
<td>predict depression using passive sensing data from students' smartphones and wearables</td>
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<td>Coral et al.</td>
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<td>Gambling disorder</td>
<td>Sensor-based</td>
<td>reduce gambling behavior and improve psychological functioning</td>
<td>Simulation study</td>
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<td>Mood</td>
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<td>identify negative emotions</td>
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<td>Wang et al.</td>
<td>2017</td>
<td>Schizophrenia</td>
<td>Sensor-based</td>
<td>predict symptom trajectories</td>
<td>RCT</td>
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<td>Rashid et al.</td>
<td>2020</td>
<td>Social Anxiety</td>
<td>Sensor-based</td>
<td>predict subjective measures of social anxiety</td>
<td>Pilot study</td>
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<td>Methodology</td>
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<td>Sarker et al.</td>
<td>2016</td>
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<td>Sensor-based</td>
<td>detect stress episodes</td>
<td>Pilot study</td>
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<td>Mishra et al.</td>
<td>2020</td>
<td>Stress</td>
<td>Sensor-based</td>
<td>detect and predict stress events</td>
<td>Pilot study</td>
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<tr>
<td>Kaczor et al.</td>
<td>2020</td>
<td>Stress</td>
<td>Sensor-based</td>
<td>predict physicians stress</td>
<td>Pilot study</td>
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<td>Epstein et al.</td>
<td>2020</td>
<td>Stress and drug craving</td>
<td>Sensor-based</td>
<td>predict stress and drug craving</td>
<td>Pilot study</td>
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<td>Beckjord and Shiffman</td>
<td>2014</td>
<td>Alcohol</td>
<td>Review paper</td>
<td>discuss several examples of EMA and EMI in the context of alcohol use and provide guidance on how EMA and EMI can (and should) be used together as the foundation for a future of innovative, high-impact interventions to improve public health.</td>
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<td>Versluis et al.</td>
<td>2016</td>
<td>Anxiety, Depression and Stress</td>
<td>Review paper</td>
<td>to systematically assess and meta-analyze the effect of EMI on 3 highly prevalent mental health outcomes (anxiety, depression, and perceived stress) and positive psychological outcomes (eg, acceptance)</td>
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<td>Colombo et al.</td>
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<td>Depression</td>
<td>Review paper</td>
<td>to explore the state of the art of technology-based EMA and EMI for major depressive disorder (MDD)</td>
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<td>Schuelle r et al.</td>
<td>2017</td>
<td>Depression and Anxiety</td>
<td>Review paper</td>
<td>highlight the differences between EMI and other forms of treatment and discuss how technologies and analytics might usher in a new era of EMI</td>
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<td>Eating disorders</td>
<td>Review paper</td>
<td>synthesize recent literature pertaining to ambulatory assessment/EMA and EMI in EDs, and identify relevant limitations and future directions in these domains.</td>
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<td>McDevitt-Murphy et al.</td>
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<td>Psychological and behavioral issues</td>
<td>Review paper</td>
<td>Review the use of ecological momentary assessment (EMA) and ecological momentary intervention (EMI) in clinical research applications</td>
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<td>Heron and Smyth</td>
<td>2010</td>
<td>Psychological, behavioral, and physical issues</td>
<td>Review paper</td>
<td>Synthesize and critique mobile technology-based EMI aimed at improving health behaviours and psychological and physical symptoms</td>
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<tr>
<td>Bell et al.</td>
<td>2017</td>
<td>Psychotic disorders</td>
<td>Review paper</td>
<td>Synthesize current research exploring the feasibility, acceptability, and clinical outcomes of EMA and EMI in the treatment of psychotic disorders</td>
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<td>Myin-Germeys et al.</td>
<td>2016</td>
<td>Schizophrenia, bipolar disorder and major depression disorder</td>
<td>Review paper</td>
<td>Discuss EMIs in the field of schizophrenia, bipolar disorder and major depression disorder, as well as one generic, transdiagnostic EMI</td>
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<td>Loo Gee et al.</td>
<td>2016</td>
<td>Stress and Anxiety</td>
<td>Review paper</td>
<td>Synthesize evidence on the effectiveness of EMI for treating anxiety conditions.</td>
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### A1.1.3 Characteristics of Ecological Momentary Interventions

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<th>Target</th>
<th>Sample</th>
<th>No of participants</th>
<th>Gender</th>
<th>EMI Duration</th>
<th>Type of technology</th>
<th>Intervention Delivery</th>
<th>Additional Components</th>
<th>Intervention strategy</th>
<th>Sensors</th>
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<tr>
<td>Pramana et al.</td>
<td>2014</td>
<td>Anxiety</td>
<td>Clinical</td>
<td>9 Children</td>
<td>N/A</td>
<td>8 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Portal</td>
<td>F2F, CBT</td>
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<td>Kity and Huppert</td>
<td>2016</td>
<td>Anxiety</td>
<td>Clinical</td>
<td>83 students</td>
<td>55 female, 28 male</td>
<td>1 week</td>
<td>Mobile phone</td>
<td>SMS, Online</td>
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<td>Reappraisal (emotion regulation strategy)</td>
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<td>Clinical</td>
<td>35 children</td>
<td>N/A</td>
<td>8 weeks</td>
<td>Mobile phone</td>
<td>Application, SMS</td>
<td>Portal</td>
<td>F2F, CBT</td>
<td>X</td>
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<td>Silk et al.</td>
<td>2020</td>
<td>Anxiety</td>
<td>Clinical</td>
<td>34 (age 9-14), 17 female</td>
<td>N/A</td>
<td>8 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Portal</td>
<td>F2F, CBT</td>
<td>-</td>
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<tr>
<td>Newman et al.</td>
<td>2014</td>
<td>Anxiety (GAD)</td>
<td>Clinical</td>
<td>34 (age 18-65)</td>
<td>20 female, 14 male</td>
<td>12 weeks</td>
<td>PDA</td>
<td>Application</td>
<td>-</td>
<td>Group-CBT, cognitive therapy, relaxation</td>
<td>-</td>
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<tr>
<td>LaFrenier and Newman 2016 Anxiety (GAD) Clinical</td>
<td>51 over 18</td>
<td>43 female, 8 male</td>
<td>30 days</td>
<td>Mobile phone</td>
<td>SMS, Paper Diary, Website</td>
<td>CBT (worry outcome monitoring)</td>
<td>-</td>
<td></td>
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<tr>
<td>LaFrenier and Newman 2019 Anxiety (GAD) Clinical</td>
<td>51 over 18</td>
<td>43 female, 8 male</td>
<td>30 days</td>
<td>Mobile phone</td>
<td>SMS, Paper Diary, Website</td>
<td>CBT (worry outcome monitoring)</td>
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<tr>
<td>Wenzel et al.</td>
<td>2014</td>
<td>Bipolar Disorder</td>
<td>Clinical</td>
<td>14 (age 18-65)</td>
<td>10 female, 10 male</td>
<td>2 weeks</td>
<td>PDA</td>
<td>Open software program</td>
<td>-</td>
<td>CBT</td>
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<tr>
<td>Depp et al.</td>
<td>2015</td>
<td>Bipolar Disorder</td>
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<td>82</td>
<td>47 female, 35 male</td>
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<td>F2F, psychoeducation, EMI self-management strategies</td>
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<td>Study Type</td>
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<td>Gender</td>
<td>Duration</td>
<td>Intervention Type</td>
<td>Platform(s)</td>
<td>Control</td>
<td>Methodology</td>
<td></td>
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<td>--------------------</td>
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<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Wu et al.</td>
<td>2016</td>
<td>Bipolar Disorder</td>
<td>Clinical</td>
<td>8 (age 18-65)</td>
<td>5 female, 3 male</td>
<td>12 weeks</td>
<td>Mobile phone</td>
<td>Open software program</td>
<td></td>
<td>F2F psychoeducation, cognitive behavioral principles</td>
<td></td>
</tr>
<tr>
<td>Burns et al.</td>
<td>2011</td>
<td>Depression</td>
<td>Clinical</td>
<td>N/A</td>
<td>7 female, 1 male</td>
<td>8 weeks</td>
<td>Mobile phone, ML</td>
<td>Application, Portal</td>
<td>BA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Wahle et al.</td>
<td>2016</td>
<td>Depression</td>
<td>Clinical</td>
<td>126</td>
<td>N/A</td>
<td>&gt;2 weeks</td>
<td>Mobile phone, ML</td>
<td>Application</td>
<td></td>
<td>CBT</td>
<td></td>
</tr>
<tr>
<td>Levin et al.</td>
<td>2019</td>
<td>Depression and Anxiety</td>
<td>Non-clinical</td>
<td>39</td>
<td>26 female, 13 male</td>
<td>13 days</td>
<td>Mobile phone, SMS</td>
<td>Application, ACT</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Levin et al.</td>
<td>2019</td>
<td>Depression and Anxiety</td>
<td>Non-clinical</td>
<td>69 adults</td>
<td>23 female, 46 male</td>
<td>4 weeks</td>
<td>Mobile phone</td>
<td>Application, ACT</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>van Aubel et al.</td>
<td>2020</td>
<td>Depressive and Psychotic complaints</td>
<td>Clinical</td>
<td>55 (age 16-25)</td>
<td>21 female, 34 male</td>
<td>5 weeks</td>
<td>Mobile phone</td>
<td>Application, ACT</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Juarascio et al.</td>
<td>2020</td>
<td>Eating disorders</td>
<td>Clinical</td>
<td>16 adult women (age 18-85)</td>
<td>16 female</td>
<td>19 weeks</td>
<td>Mobile phone</td>
<td>Application, Portal</td>
<td>F2F, CAT</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Meinlschmidt et al.</td>
<td>2016</td>
<td>Mood</td>
<td>Non-clinical</td>
<td>27 (age 18-65)</td>
<td>N/A</td>
<td>19 days</td>
<td>Mobile phone</td>
<td>Email, Online</td>
<td>CBT, motivational interviewing</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Meinlschmidt et al.</td>
<td>2020</td>
<td>Mood</td>
<td>Non-clinical</td>
<td>14</td>
<td>12 female, 2 male</td>
<td>19 days</td>
<td>Mobile phone</td>
<td>Email, Online</td>
<td>CBT, motivational interviewing</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Korsza et al.</td>
<td>2020</td>
<td>Mood</td>
<td>Clinical</td>
<td>80</td>
<td>N/A</td>
<td>6 weeks</td>
<td>Mobile phone</td>
<td>Application, Portal</td>
<td>ACT</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Stevensson et al.</td>
<td>2020</td>
<td>Mood, Alcohol use</td>
<td>Clinical</td>
<td>20 young adult (age 18-26)</td>
<td>11 female, 9 male</td>
<td>6 weeks</td>
<td>Mobile phone</td>
<td>Application, Coping strategies</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Condition</td>
<td>Clinical/Anxiety</td>
<td>Population</td>
<td>Duration</td>
<td>Intervention Description</td>
<td>Platform</td>
<td>Application Methodology</td>
<td></td>
<td></td>
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<tr>
<td>Bell et al.</td>
<td>2018</td>
<td>Schizophrenia</td>
<td>Clinical</td>
<td>38 females, 23 males</td>
<td>8 months (analysis of 4 months results)</td>
<td>Mobile phone Application (and online platform)</td>
<td>F2F psychoeducation, EMI coping strategies (coping strategy enhancement) framework</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hansen et al.</td>
<td>2020</td>
<td>Schizophrenia</td>
<td>Clinical</td>
<td>50 (age 18-60) females, 32 males</td>
<td>3 weeks</td>
<td>Mobile phone Application (and online platform)</td>
<td>CBT</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molla et al.</td>
<td>2020</td>
<td>Schizophrenia</td>
<td>Clinical</td>
<td>10 (over 18) females, 4 males</td>
<td>4 weeks</td>
<td>Mobile phone Application</td>
<td>CBT</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulantara et al.</td>
<td>2018</td>
<td>Sleep disturbances</td>
<td>Clinical</td>
<td>27 females, 24 males</td>
<td>12 months</td>
<td>Mobile phone Application Portal Military-version brief BT for Insomnia (CBTI)</td>
<td>-</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Versluis et al.</td>
<td>2018</td>
<td>Stress</td>
<td>Clinical</td>
<td>118 N/A</td>
<td>4 weeks</td>
<td>Mobile phone Application 2 Applications</td>
<td>Exposure to natural scenes</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beute and Kort</td>
<td>2018</td>
<td>Stress</td>
<td>Clinical</td>
<td>15 females, 3 males</td>
<td>2 periods of 6 days</td>
<td>PDA Application</td>
<td>Theory-based stress management intervention (by being the first to translate it into an EMI)</td>
<td>-</td>
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</tr>
<tr>
<td>Nguyen-Feng et al.</td>
<td>2019</td>
<td>Stress</td>
<td>Clinical</td>
<td>382 students females, 88 males</td>
<td>14 days</td>
<td>Mobile phone Application</td>
<td>Mindfulness</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucas-Thompson et al.</td>
<td>2019</td>
<td>Stress and Anxiety</td>
<td>Clinical</td>
<td>N/A (age 14-18 to be recruited)</td>
<td>N/A</td>
<td>Mobile phone SMS, online for on-demand support</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
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<tr>
<td>Dennis et al.</td>
<td>2015</td>
<td>Substance use</td>
<td>Clinical</td>
<td>29 females, 21 males</td>
<td>6 weeks</td>
<td>Mobile phone Application</td>
<td>Self-determination theory</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Substance</td>
<td>Clinical</td>
<td>Sample Size</td>
<td>Gender</td>
<td>Duration</td>
<td>Intervention</td>
<td>Method</td>
<td>Theory/Concepts</td>
<td></td>
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<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McTavish et al.</td>
<td>2012</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>349</td>
<td>N/A</td>
<td>3-4 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Self-determination theory, cognitive-behavioral relapse prevention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riordan et al.</td>
<td>2015</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>130</td>
<td>72 female, 58 male</td>
<td>4 months</td>
<td>Mobile phone</td>
<td>SMS</td>
<td>Psychoeducation about alcohol use and consequences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leonard et al.</td>
<td>2017</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>10</td>
<td>female</td>
<td>6 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>F2F, EM, CBT, MI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dulin and Gonzalez</td>
<td>2017</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>28</td>
<td>N/A</td>
<td>28 days</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Based on cognitive and behavioral alcohol use disorder interventions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leonard et al.</td>
<td>2017</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Behavioral theory, MI, TTM of change</td>
<td></td>
</tr>
<tr>
<td>Moody et al.</td>
<td>2018</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>35</td>
<td>16 female, 19 male</td>
<td>4 weeks</td>
<td>Mobile phone</td>
<td>SMS, Portal</td>
<td>Active implementation intentions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kazemi et al.</td>
<td>2019</td>
<td>Alcohol</td>
<td>Non-Clinical</td>
<td>10</td>
<td>N/A</td>
<td>2 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Motivational interviewing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haug et al.</td>
<td>2020</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>136 adolescents</td>
<td>66 female, 70 male</td>
<td>3 months</td>
<td>Mobile phone</td>
<td>SMS, online feedback</td>
<td>Implementation intention and action planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blevins et al.</td>
<td>2020</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>20 (age 18-25)</td>
<td>N/A</td>
<td>6 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>F2F, coping strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Businelle et al.</td>
<td>2020</td>
<td>Alcohol</td>
<td>Clinical</td>
<td>80 phase I + 40 phase III</td>
<td>N/A</td>
<td>N/A</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Motivational interviewing, self efficacy (SCT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrier et al.</td>
<td>2018</td>
<td>Marijuana</td>
<td>Clinical</td>
<td>70</td>
<td>42 female, 28 male</td>
<td>1 or 2 weeks</td>
<td>Mobile phone</td>
<td>Application</td>
<td>F2F, EM, Motivational enhancement therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morgèva et al.</td>
<td>2020</td>
<td>Suicide prevention</td>
<td>Clinical</td>
<td>14</td>
<td>12 female, 2 male</td>
<td>6 months</td>
<td>Mobile phone</td>
<td>Application</td>
<td>Suicide prevention</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table notes: GAD: Generalized Anxiety Disorder, ML: Machine learning, CBT: Cognitive behavioral therapy, ACT: Acceptance and commitment therapy, MI: Motivational interviewing, CAT: Cognitive affective therapy, BT: Behavioral therapy, F2F: Face-to-face sessions
### List of studies using sensors

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Target</th>
<th>Category</th>
<th>Device</th>
<th>Purpose of using sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pramana et al.</td>
<td>2018</td>
<td>Anxiety</td>
<td>Intervention</td>
<td>Mobile phone, App</td>
<td>provide location-aware reminders using geofencing</td>
</tr>
<tr>
<td>Burns et al.</td>
<td>2011</td>
<td>Depression</td>
<td>Intervention</td>
<td>Mobile phone, App</td>
<td>predict depressive states and improve depressive symptoms</td>
</tr>
<tr>
<td>Wahle et al.</td>
<td>2016</td>
<td>Depression</td>
<td>Intervention</td>
<td>Wearable, Mobile phone, App</td>
<td>used sensor data collected to provide evidence-based interventions</td>
</tr>
<tr>
<td>Kroksa et al.</td>
<td>2020</td>
<td>Mood</td>
<td>Intervention</td>
<td>Wearable</td>
<td>explore a possible relationship between mobile ACT effectiveness and sleep, activity, and heart rate, which are considered to both indicate and moderate symptoms of mania and depression</td>
</tr>
<tr>
<td>Pullantara et al.</td>
<td>2018</td>
<td>Sleep disturbances</td>
<td>Intervention</td>
<td>Wearable</td>
<td>allow objective measurement of the patient's sleep-wake pattern</td>
</tr>
<tr>
<td>Versluis et al.</td>
<td>2018</td>
<td>Stress</td>
<td>Intervention</td>
<td>Wearable, App</td>
<td>measure cardiac activity</td>
</tr>
<tr>
<td>Beute and Kort</td>
<td>2018</td>
<td>Stress</td>
<td>Intervention</td>
<td>Mobile phone, App</td>
<td>measure heart rate</td>
</tr>
<tr>
<td>McTavish et al.</td>
<td>2012</td>
<td>Substance use (Alcohol)</td>
<td>Intervention</td>
<td>Wearable, Mobile phone, App</td>
<td>provide support based on location data</td>
</tr>
<tr>
<td>Leonard et al.</td>
<td>2017</td>
<td>Substance use (Alcohol)</td>
<td>Intervention</td>
<td>Wearable, Mobile phone, App</td>
<td>set a threshold by the research assistants based on EDA measurements from the sensorband to provide support</td>
</tr>
<tr>
<td>Businelle et al.</td>
<td>2020</td>
<td>Substance use (Alcohol)</td>
<td>Intervention</td>
<td>Wearable</td>
<td>a wearable was used to estimate blood alcohol concentration, an algorithm will use geolocation and EMA responses to assess current risk for alcohol use and automatically push relevant tailored messages to participants</td>
</tr>
<tr>
<td>Jacobson et al. (2020)</td>
<td>2020</td>
<td>Depression</td>
<td>Sensor-based</td>
<td>Mobile phone, App</td>
<td>predict depressed mood</td>
</tr>
<tr>
<td>Saeb et al.</td>
<td>2015</td>
<td>Depression</td>
<td>Sensor-based</td>
<td>Mobile phone, App</td>
<td>predict depressive states</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>2018</td>
<td>Depression</td>
<td>Sensor-based</td>
<td>Mobile phone, App</td>
<td>predict depressive states</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Disorder</td>
<td>Platform</td>
<td>Feature</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Coral et al.</td>
<td>2020</td>
<td>Gambling disorder</td>
<td>Sensor-based Mobile phone, App</td>
<td>Mobile phone, App</td>
<td>construct a geofence around a gambler's favored gambling establishment, to discourage participation</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>2017</td>
<td>Schizophrenia</td>
<td>Sensor-based Mobile phone, App</td>
<td>Mobile phone, App</td>
<td>predict symptoms of schizophrenia</td>
</tr>
<tr>
<td>Rashid et al. (2020)</td>
<td>2020</td>
<td>Social Anxiety</td>
<td>Sensor-based Mobile phone, App</td>
<td>Mobile phone, App</td>
<td>predict subjective measures of social anxiety</td>
</tr>
<tr>
<td>Sarker et al.</td>
<td>2016</td>
<td>Stress</td>
<td>Sensor-based Physiological sensors, Mobile phone</td>
<td>Detect stress episodes</td>
<td></td>
</tr>
<tr>
<td>Mishra et al. (2020)</td>
<td>2020</td>
<td>Stress</td>
<td>Sensor-based Wearable, chest sensor</td>
<td>Detect stress</td>
<td></td>
</tr>
<tr>
<td>Kaczor et al. (2020)</td>
<td>2020</td>
<td>Stress</td>
<td>Sensor-based Wearable</td>
<td>Predict physicians stress</td>
<td></td>
</tr>
<tr>
<td>Epstein et al. (2020)</td>
<td>2020</td>
<td>Stress and drug craving</td>
<td>Sensor-based GPS logger</td>
<td>Predict stress and drug craving</td>
<td></td>
</tr>
<tr>
<td>Bae et al.</td>
<td>2018</td>
<td>Substance use (Alcohol)</td>
<td>Sensor-based Mobile phone, App</td>
<td>Mobile phone, App</td>
<td>Detect high-risk drinking events</td>
</tr>
</tbody>
</table>
### A1.1.4 Studies using sensors to predict/detect psychological states

<table>
<thead>
<tr>
<th>Author</th>
<th>Study Aim</th>
<th>Devices</th>
<th>Data collected with the use of sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarker et al.</td>
<td>detect stress episodes</td>
<td>Physiological sensors and Mobile phone</td>
<td>A suite of physiological sensors worn under participant’s clothes was used to measure expansion and contraction of the chest via inductive plethysmography. Mobile phones collected accelerometer data.</td>
</tr>
<tr>
<td>Hung et al.</td>
<td>detect negative emotions</td>
<td>Mobile application</td>
<td>The app collected the package name of the app and call states that included the idle state, the ringing state, and the off-hook state.</td>
</tr>
<tr>
<td>Bae et al.</td>
<td>detect high-risk drinking events</td>
<td>Mobile application</td>
<td>The app collected 56 sensor features related to time (e.g. day of the week, time of day), movement patterns (e.g. accelerometer, rotation), communication (e.g. phone calls, texts), and psychomotor impairment (e.g. keystroke speed, available for android phones only).</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>predict symptoms of schizophrenia</td>
<td>Mobile phone</td>
<td>Data collected included the detection of physical activity through android recognition API (foot, stationary, in-vehicle, on a bicycle, tilting, unknown activity) and conversational interaction (measured through the number and duration of independent conversations, and the ratio of human voice labels observed). Mobility and location were detected by measuring the distance traveled, the number of places visited and location entropy through GPS. Sleep was measured based on four sensors: ambient light, audio amplitude, activity, and screen on/off, and phone activity during the sleep period (e.g. lock/unlock data). Phone usage was measured by the number of lock/unlock events, duration of calls and SMS. The ambient environment was measured via ambient light and sound through audio amplitude and light amplitude.</td>
</tr>
<tr>
<td>Burns et al.</td>
<td>predict depressive states</td>
<td>Mobile phone and Application</td>
<td>The data collected directly from more than 38 phone sensors and an app. The data collected from the phone sensors included GPS, WiFi, accelerometer, ambient light, and Bluetooth detection of other wireless devices. The app collected the time/day and phone activities of the users (e.g. recent calls, active phone apps).</td>
</tr>
<tr>
<td>Saeid et al.</td>
<td>predict depressive states</td>
<td>Mobile phone and Wearables</td>
<td>A wearable was used to collect GPS data. Mobiles were used to collect phone usage data (the periods of time when the phone screen was on).</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>predict depressive states</td>
<td>Mobile application and Wearable</td>
<td>Features collected from the application included physical activities (e.g., stationary, in a vehicle, walking, running, cycling, sleep (duration, bedtime, and rise time)), and sociability (i.e., the number of independent conversations a participant is around and their duration). The app also collected audio amplitude, location coordinates, and phone lock/unlock events. The sleep inferences were based on four phone sensors: ambient light, audio amplitude, activity, and screen on/off. Physical activities through the Android activity recognition API and iOS core motion. Phone usage was measured by computing the number of phone lock/unlock events and the duration that the phone was unlocked during a day. A wearable device collected heart rate data to detect depressed mood and fatigue.</td>
</tr>
<tr>
<td>Mishra et al.</td>
<td>detect stress</td>
<td>Wearable and Chest sensor</td>
<td>A wearable was used to collect accelerometer data. Chest sensor collected heart rate variability (HRV).</td>
</tr>
<tr>
<td>Jacobson et al.</td>
<td>predict depressed mood</td>
<td>Mobile application</td>
<td>Features collected including direct location-based information, location type based on the Google Places location type (e.g., University, gym, bar, church), local weather information, heart rate information (by pressing their finger against the rear camera for 30 s), and outgoing phone calls.</td>
</tr>
<tr>
<td>Rashid et al.</td>
<td>predict subjective measures of social anxiety</td>
<td>Mobile application</td>
<td>The application collected data from GPS, pedometer, accelerometer, activity, call, and text data.</td>
</tr>
<tr>
<td>Epstein et al.</td>
<td>predict stress and drug craving</td>
<td>GPS logger</td>
<td>A GPS logger was used to collect GPS data</td>
</tr>
<tr>
<td>Kaczor et al.</td>
<td>predict stress</td>
<td>Wearable</td>
<td>A wearable was used to collect accelerometer, EDA, skin temperature, and heart rate variability data. A button on the wearable was used by participants to annotate stressful events.</td>
</tr>
</tbody>
</table>
## A1.2 Chapter 5

### A1.2.1 App functionality

<table>
<thead>
<tr>
<th>App Functionality</th>
<th>Happify</th>
<th>Mindshift CBT</th>
<th>Sanvello</th>
<th>Wysa</th>
<th>Woebot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>In-app purchases</td>
<td>Free</td>
<td>In-app purchases</td>
<td>In-app purchases</td>
<td>Free</td>
</tr>
<tr>
<td><strong>Premium version features</strong></td>
<td>Full access to all activities, data visualization, access to a 20-page character strengths report</td>
<td>N/A</td>
<td>Full access to all activities, unlimited self-monitoring, retrospective collection of self-monitoring entries, more background themes</td>
<td>Full access to all activities, unlock access to a therapist</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Screening</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Self-monitoring</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Momentary Support</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Data visualization</strong></td>
<td>In premium version</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Reports</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Gamification</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>In-app support</strong></td>
<td>Peer support</td>
<td>No</td>
<td>Peer support</td>
<td>In premium version</td>
<td>No</td>
</tr>
<tr>
<td><strong>Data sharing</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Push notifications</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Chatbot</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Treatment program format</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Psychoeducation</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Cognitive techniques</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Relaxation</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Behavioral activation</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## A1.3 Chapter 6

### A1.3.1 Participant app information sheet

**App Information Sheet**

The following table contains the list of apps available to download for the study. Please carefully read the description page of the apps available in the stores to decide the app/s you are willing to use during the study period.

**Please do not download and start using the app before the start day of your participation is confirmed!**

<table>
<thead>
<tr>
<th>App name:</th>
<th>Wysa</th>
<th>Sanvello</th>
<th>Woebot</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Wysa" /></td>
<td><img src="image" alt="Sanvello" /></td>
<td><img src="image" alt="Woebot" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>App design:</th>
<th>Automated conversational agent (chatbot)</th>
<th>Mobile App</th>
<th>Automated conversational agent (chatbot)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Targeted conditions:</th>
<th>Mood disorders, Stress &amp; Anxiety, Sleep</th>
<th>Mood disorders, Stress &amp; Anxiety</th>
<th>Mood disorders, Stress &amp; Anxiety, Addictions or Substance use, Chronic pain</th>
</tr>
</thead>
</table>

|---------------------------|---------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Availability:</th>
<th>Google Play, Apple app store</th>
<th>Google Play, Apple app store, Online</th>
<th>Google Play, Apple app store</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Available for:</th>
<th>iOS 10.0 or later, Android 4.1 and up</th>
<th>iOS 10.0 or later, Android 5 and up</th>
<th>iOS 11.0 or later, Android 6 and up</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>App store link:</th>
<th>Android</th>
<th>Android</th>
<th>Android</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>App store link:</th>
<th>iOS</th>
<th>iOS</th>
<th>iOS</th>
</tr>
</thead>
</table>
A1.3.2 Survey items and interview questions
Online Questionnaires

Online Questionnaire – Day 1

Q1 Which application/s did you install? Please select all that apply

☐ Sanvello
☐ Wysa
☐ Woebot

Q2 Why did you choose to install those applications?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q3 When you started using it, what were your first impressions?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

End of Block: General
Q4 Please answer the following questions (App Name)

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you like the overall interface of the application?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was the font size suitable for your needs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was the font colour suitable for your needs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you find the application easy to navigate?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you read all the user instructions the app provided?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you find them helpful?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was the application easy to use at first?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did it get easier to use the more you used it?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Could you remember how to navigate the application once you returned to it after a break?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q7 Did you use the application/s today?

- [ ] Yes
- [ ] No
Q8 Roughly how much time did you spend using the application today?

- 0-15 minutes
- 15-30 minutes
- 30-45 minutes
- 45-60 minutes
- More than an hour

Display This Question:
If Did you use the application/s today? = No

Q9 Why did you not use the application/s today?

Display This Question:
If Did you use the application/s today? = No

Q10 Please open the application/s now and use it for a while before filling the rest of the questionnaire
Q11 What app features did you use today? Select all that apply:

- Mental Health Screening (questionnaires used to exam your emotional health)
- Self-monitoring (track mood and/or other factors related to your mood)
- Therapeutic elements (information about mental health, exercises designed to help alleviate anxiety symptoms)
- Immediate support (on-demand support provided when indicated you are in immediate need of help)
- Data visualisation (graphs or charts of your mood, comparison of mood related data)

Q12 What are the reasons for using these functions today?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q13 Which options did you use to receive content through the app based on your inputs? Please select all that apply:

- I selected goal/s or challenge/s to work on when launching the app for first time
- I received recommendations of exercises to practice based on my mood entries
- I set up the notification timing
- None of the above
If Which options did you use to receive content through the app based on your inputs? Please select... = I selected goal/s or challenge/s to work on when launching the app for first time

Or Which options did you use to receive content through the app based on your inputs? Please select... = I received recommendations of exercises to practice based on my mood entries

Or Which options did you use to receive content through the app based on your inputs? Please select... = I set up the notification timing

Q14 Were you satisfied with the content provided to you based on your inputs?

☐ Yes

☐ No

Q15 Please explain why the content provided to you based on your inputs was effective/ineffective:

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________
Q16 Did you use any customisation options provided through the app? Please select all that apply

☐ Interface customisation (e.g. option to customize background theme, select nickname etc.)

☐ Treatment-oriented customisation (e.g. options to customise different exercises delivered through the app)

☐ Data visualisation customisation (e.g. option to compare data, view different visualisations of data entries etc.)

☐ I did not customise my app today

Q17 What customisation options did you value most and why? Please explain:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Q18 Which application/s did you install? Please select all that apply = Wysa
Or Which application/s did you install? Please select all that apply = Sanvello
Q18 Did you consider subscribing to the premium version of the app?

- Yes
- No

Q19 What are the reasons for considering to upgrade your subscription?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q20 If you have already purchased an upgrade, tell us about your experience with the premium version of the app.

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q21 If Which application/s did you install? Please select all that apply = Sanvello
Q21 Did you use the discussion or chat groups today?

- Yes
- No

Display This Question:
If Did you use the discussion or chat groups today? = Yes

Q22 What are the reasons for joining the discussions and/or chat groups today?
________________________________________________________________

Display This Question:
If Did you use the discussion or chat groups today? = Yes

Q23 How was your experience with the discussion and/or chat groups?
________________________________________________________________

Display This Question:
If Which application’s did you install? Please select all that apply = Sanvello

Q24 Did you complete any modules today?

- Yes
- No

Display This Question:
If Did you complete any modules today? = Yes

Q25 A user upgrades level by completing modules. How do you find the idea of upgrading levels after completing modules?
________________________________________________________________
Q26 Did you share with anyone any information you recorded in the app?

☐ Yes
☐ No

Q27 With whom do you/did you share the information you recorded through the app? (select all that apply)

☐ With my friends
☐ With family
☐ With my partner
☐ Other

Q28 Please specify your answer:
________________________________________________________________
Q29 How do you remember to use the app? (select all that apply)

- I receive reminders from the app
- I have my own reminders (e.g. in a separate reminder app)
- I receive notifications when I don’t use the app for a while
- It’s part of my daily routine
- I do it automatically
- I do it in response to events or sensations (e.g. to stop a panic attack or reduce anxiety)
- I receive an email reminder from the research team
- Other

Q30 What did you like most about your interactions with the app/s today?

____________________________________________________________________

Q31 What did you dislike about your interactions with the app/s today?

____________________________________________________________________

Online Questionnaire - Days 2-13
Q1 Which application/s did you download to use? Please select all that apply

☐ Sanvello
☐ Wysa
☐ Woebot

Q2 Did you use the application/s today?

☐ Yes
☐ No

Display This Question:
If Did you use the application/s today? = No

Q3 Why did you not use the application/s today?

________________________________________________________________

Display This Question:
If Did you use the application/s today? = No

Q4 Please open the application/s now and use it for a while before filling the rest of the questionnaire

Display This Question:
If Did you use the application/s today? = Yes
Q5 Roughly how much time did you spend using the application today?

- 0-15 minutes
- 15-30 minutes
- 30-45 minutes
- 45-60 minutes
- More than an hour

Q6 What app features did you use today? Select all that apply:

- Mental Health Screening (questionnaires used to exam your emotional health)
- Self-monitoring (track mood and/or other factors related to your mood)
- Therapeutic elements (information about mental health, exercises designed to help alleviate anxiety symptoms)
- Immediate support (on-demand support provided when indicated you are in immediate need of help)
- Data visualisation (graphs or charts of your mood, comparison of mood related data)

Q7 What are the reasons for using these functions today?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

________________________________________________________________________________
Q8 Which options did you use to receive content through the app based on your inputs? Please select all that apply:

- [ ] I selected goal/s or challenge/s to work on when launching the app for first time
- [ ] I received recommendations of exercises to practice based on my mood entries
- [ ] I set up the notification timing
- [ ] None of the above

Display This Question:
If Which options did you use to receive content through the app based on your inputs? Please select... = I selected goal/s or challenge/s to work on when launching the app for first time

Or Which options did you use to receive content through the app based on your inputs? Please select... = I received recommendations of exercises to practice based on my mood entries

Or Which options did you use to receive content through the app based on your inputs? Please select... = I set up the notification timing

Q9 Were you satisfied with the content provided to you based on your inputs?

- [ ] Yes
- [ ] No

Display This Question:
If Which options did you use to receive content through the app based on your inputs? Please select... = I selected goal/s or challenge/s to work on when launching the app for first time

Or Which options did you use to receive content through the app based on your inputs? Please select... = I received recommendations of exercises to practice based on my mood entries

Or Which options did you use to receive content through the app based on your inputs? Please select... = I set up the notification timing

Q10 Please explain why the content provided to you based on your inputs was effective/ineffective:

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________
Q11 Did you use any customisation options provided through the app? Please select all that apply

☐ Interface customisation (e.g. option to customize background theme, select nickname etc.)

☐ Treatment-oriented customisation (e.g. options to customise different exercises delivered through the app)

☐ Data visualisation customisation (e.g. option to compare data, view different visualisations of data entries etc.)

☐ I did not customise my app today

Q12 What customisation options did you value most and why? Please explain:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Display This Question:
If Did you use any customisation options provided through the app? Please select all that apply = Interface customisation (e.g. option to customize background theme, select nickname etc.)
Or Did you use any customisation options provided through the app? Please select all that apply = Treatment-oriented customisation (e.g. options to customise different exercises delivered through the app)
Or Did you use any customisation options provided through the app? Please select all that apply = Data visualisation customisation (e.g. option to compare data, view different visualisations of data entries etc.)

Display This Question:
If Which application's did you download to use? Please select all that apply = Wysa
Or Which application's did you download to use? Please select all that apply = Sanvello
Q13 Did you consider subscribing to the premium version of the app?

- Yes
- No

Display This Question:
If Did you consider subscribing to the premium version of the app? = Yes

Q14 What are the reasons for considering to upgrade your subscription?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Display This Question:
If Did you consider subscribing to the premium version of the app? = Yes

Q15 If you have already purchased an upgrade, tell us about your experience with the premium version of the app

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Display This Question:
If Which application/s did you download to use? Please select all that apply = Sanvello
Q16 Did you use the discussion or chat groups today?

- Yes
- No

**Display This Question:**
If Did you use the discussion or chat groups today? = Yes

Q17 What are the reasons for joining the discussions and/or chat groups today?

________________________________________________________________________

**Display This Question:**
If Did you use the discussion or chat groups today? = Yes

Q18 How was your experience with the discussion and/or chat groups?

________________________________________________________________________

**Display This Question:**
If Which application's did you download to use? Please select all that apply = Sanvello

Q19 Did you complete any modules today?

- Yes
- No

**Display This Question:**
If Did you complete any modules today? = Yes

Q20 A user upgrades level by completing modules. How do you find the idea of upgrading levels after completing modules?

________________________________________________________________________
Q21 Did you share with anyone any information you recorded in the app?

☐ Yes

☐ No

Q22 With whom do you/did you share the information you recorded through the app? (select all that apply)

☐ With my friends

☐ With family

☐ With my partner

☐ Other

Q23 Please specify your answer:

_________________________________________________________________________
Q24 How do you remember to use the app? (select all that apply)

- I receive reminders from the app
- I have my own reminders (e.g. in a separate reminder app)
- I receive notifications when I don't use the app for a while
- It's part of my daily routine
- I do it automatically
- I do it in response to events or sensations (e.g. to stop a panic attack or reduce anxiety)
- I receive an email reminder from the research team
- Other

Q25 What did you like most about your interactions with the app/s today?

__________________________________________________________________________

Q26 What did you dislike about your interactions with the app/s today?

__________________________________________________________________________

Q27 If you could suggest three features to add or improve the application what would these be?

__________________________________________________________________________

Online Questionnaire – Day 14
Q1 Which application/s did you download to use? Please select all that apply

- [ ] Sanvello
- [ ] Wysa
- [ ] Woebot

Q2 Did you use the application/s today?

- [ ] Yes
- [ ] No

Q3 Why did you not use the application/s today?

________________________________________________________________

Q4 Please open the application/s now and use it for a while before filling the rest of the questionnaire

Q5 Roughly how much time did you spend using the application today?

- [ ] 0-15 minutes
- [ ] 15-30 minutes
- [ ] 30-45 minutes
- [ ] 45-60 minutes
- [ ] More than an hour
Q6 What app features did you use today? Select all that apply:

- [ ] Mental Health Screening (questionnaires used to examine your emotional health)
- [ ] Self-monitoring (track mood and/or other factors related to your mood)
- [ ] Therapeutic elements (information about mental health, exercises designed to help alleviate anxiety symptoms)
- [ ] Immediate support (on-demand support provided when indicated you are in immediate need of help)
- [ ] Data visualisation (graphs or charts of your mood, comparison of mood related data)

Q7 What are the reasons for using these functions today?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q8 Which options did you use to receive content through the app based on your inputs? Please select all that apply:

- [ ] I selected goal/s or challenge/s to work on when launching the app for first time
- [ ] I received recommendations of exercises to practice based on my mood entries
- [ ] I set up the notification timing
- [ ] None of the above
Q9 Were you satisfied with the content provided to you based on your inputs?

- Yes
- No

Q10 Please explain why the content provided to you based on your inputs was effective/ineffective:

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q11 Did you use any customisation options provided through the app? Please select all that apply

- Interface customisation (e.g. option to customize background theme, select nickname etc.)
- Treatment-oriented customisation (e.g. options to customise different exercises delivered through the app)
- Data visualisation customisation (e.g. option to compare data, view different visualisations of data entries etc.)
- I did not customise my app today

Q12 What customisation options did you value most and why? Please explain:

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Q13 Did you consider subscribing to the premium version of the app?

○ Yes
○ No

Q14 What are the reasons for considering to upgrade your subscription?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q15 If you have already purchased an upgrade, tell us about your experience with the premium version of the app

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q16 Did you use the discussion or chat groups today?

○ Yes
○ No

Q17 What are the reasons for joining the discussions and/or chat groups today?

________________________________________________________________
Q18 How was your experience with the discussion and/or chat groups?
________________________________________________________________

Q19 Did you complete any modules today?
  ○ Yes
  ○ No

Q20 A user upgrades level by completing modules. How do you find the idea of upgrading levels after completing modules?
________________________________________________________________

Q21 Did you share with anyone any information you recorded in the app?
  ○ Yes
  ○ No

Q22 With whom do you/did you share the information you recorded through the app? (select all that apply)
  ○ With my friends
  ○ With family
  ○ With my partner
  ○ Other
Q23 Please specify your answer:

________________________________________________________________

Q24 How do you remember to use the app? (select all that apply)

  o I receive reminders from the app
  o I have my own reminders (e.g. in a separate reminder app)
  o I receive notifications when I don't use the app for a while
  o It's part of my daily routine
  o I do it automatically
  o I do it in response to events or sensations (e.g. to stop a panic attack or reduce anxiety)
  o I receive an email reminder from the research team
  o Other

Q25 What did you like most about your interactions with the app/s today?

________________________________________________________________

Q26 What did you dislike about your interactions with the app/s today?

________________________________________________________________
Using a scale of 1-4, with 1 being the least and 4 being the most, please indicate which of the following features you used most the last 2 weeks? Select N/A if the app component is irrelevant:

<table>
<thead>
<tr>
<th>Feature</th>
<th>1 - the least used</th>
<th>2</th>
<th>3</th>
<th>4 - the most used</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Health Screening (questionnaires used to exam your emotional health)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-monitoring (track mood and/or factors related to your mood)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therapeutic elements (features that help alleviate anxiety symptoms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate support (on-demand support provided when a need of immediate support is indicated)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social features (peer or professional support offered through the app or through links to online services)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data visualisation (visual presentation of past entries or other info entered through the app)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q28 If you could improve the application, please give a brief description of how you would do so:
________________________________________________________________

Start of Block: Section A - uMARS

Q29 Entertainment: Is the app fun/entertaining to use? Does it have components that make it more fun than other similar apps?

- Dull, not fun or entertaining at all
- Mostly boring
- OK, fun enough to entertain user for a brief time (< 5 minutes)
- Moderately fun and entertaining, would entertain user for some time (5-10 minutes total)
- Highly entertaining and fun, would stimulate repeat use

Q30 Interest: Is the app interesting to use? Does it present its information in an interesting way compared to other similar apps?

- Not interesting at all
- Mostly uninteresting
- OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
- Moderately interesting; would engage user for some time (5-10 minutes total)
- Very interesting, would engage user in repeat use
Q31 Customisation: Does it allow you to customise the settings and preferences that you would like to (e.g. sound, content and notifications)?

- Does not allow any customisation or requires setting to be input every time
- Allows little customisation and that limits app’s functions
- Basic customisation to function adequately
- Allows numerous options for customisation
- Allows complete tailoring the user’s characteristics/preferences, remembers all settings

Q32 Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)?

- No interactive features and/or no response to user input
- Some, but not enough interactive features which limits app’s functions
- Basic interactive features to function adequately
- Offers a variety of interactive features, feedback and user input options
- Very high level of responsiveness through interactive features, feedback and user input options

Q33 Target group: Is the app content (visuals, language, design) appropriate for the target audience?

- Completely inappropriate, unclear or confusing
- Mostly inappropriate, unclear or confusing
- Acceptable but not specifically designed for the target audience. May be inappropriate/unclear/confusing at times
- Designed for the target audience, with minor issues
- Designed specifically for the target audience, no issues found
Q34 Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?

- App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
- Some functions work, but lagging or contains major technical problems
- App works overall. Some technical problems need fixing, or is slow at times
- Mostly functional with minor/negligible problems
- Perfect/timely response; no technical bugs found, or contains a 'loading time left' indicator (if relevant)

Q35 Ease of use: How easy is it to learn how to use the app; how clear are the menu labels, icons and instructions?

- No/limited instructions; menu labels, icons are confusing; complicated
- Takes a lot of time or effort
- Takes some time or effort
- Easy to learn (or has clear instructions)
- Able to use app immediately; intuitive; simple (no instructions needed)

Q36 Navigation: Does moving between screens make sense; Does app have all necessary links between screens?

- No logical connection between screens at all /navigation is difficult
- Understandable after a lot of time/effort
- Understandable after some time/effort
- Easy to understand/navigate
- Perfectly logical, easy, clear and intuitive screen flow throughout, and/or has shortcuts
Q37 Gestural design: Do taps/swipes/pinches/scrolls make sense? Are they consistent across all components/screens?

- Completely inconsistent/confusing
- Often inconsistent/confusing
- OK with some inconsistencies/confusing elements
- Mostly consistent/intuitive with negligible problems
- Perfectly consistent and intuitive

Q38 Layout: Is arrangement and size of buttons, icons, menus and content on the screen appropriate?

- Very bad design, cluttered, some options impossible to select, locate, see or read
- Bad design, random, unclear, some options difficult to select/locate/see/read
- Satisfactory, few problems with selecting/locating/seeing/reading items
- Mostly clear, able to select/locate/see/read items
- Professional, simple, clear, orderly, logically organised

Q39 Graphics: How high is the quality/resolution of graphics used for buttons, icons, menus and content?

- 1 Graphics appear amateur, very poor visual design - disproportionate, stylistically inconsistent
- 2 Low quality/low resolution graphics; low quality visual design – disproportionate
- 3 Moderate quality graphics and visual design (generally consistent in style)
- 4 High quality/resolution graphics and visual design – mostly proportionate, consistent in style
- 5 Very high quality/resolution graphics and visual design - proportionate, consistent in style throughout
Q40 Visual appeal: How good does the app look?

- 1 Ugly, unpleasant to look at, poorly designed, clashing, mismatched colours
- 2 Bad – poorly designed, bad use of colour, visually boring
- 3 OK – average, neither pleasant, nor unpleasant
- 4 Pleasant – seamless graphics – consistent and professionally designed
- 5 Beautiful – very attractive, memorable, stands out; use of colour enhances app features/menus

Q41 Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?

- N/A There is no information within the app
- 1 Irrelevant/inappropriate/incoherent/incorrect
- 2 Poor. Barely relevant/appropriate/coherent/may be incorrect
- 3 Moderately relevant/appropriate/coherent/and appears correct
- 4 Relevant/appropriate/coherent/correct
- 5 Highly relevant, appropriate, coherent, and correct
Q42 Quantity of information: Is the information within the app comprehensive but concise?

- N/A There is no information within the app
- 1 Minimal or overwhelming
- 2 Insufficient or possibly overwhelming
- 3 OK but not comprehensive or concise
- 4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources
- 5 Comprehensive and concise; contains links to more information and resources

Q43 Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?

- N/A There is no visual information within the app (e.g. it only contains audio or text)
- 1 Completely unclear/confusing/wrong or necessary but missing
- 2 Mostly unclear/confusing/wrong
- 3 OK but often unclear/confusing/wrong
- 4 Mostly clear/logical/correct with negligible issues
- 5 Perfectly clear/logical/correct
Q44 Credibility of source: does the information within the app seem to come from a credible source?

- N/A There is no information within the app
- 1 Suspicious source
- 2 Lacks credibility
- 3 Not suspicious but legitimacy of source is unclear
- 4 Possibly comes from a legitimate source
- 5 Definitely comes from a legitimate/specialised source

Q45 Would you recommend this app to people who might benefit from it?

- 1 Not at all I would not recommend this app to anyone
- 2 There are very few people I would recommend this app to
- 3 Maybe There are several people I would recommend this app to
- 4 There are many people I would recommend this app to
- 5 Definitely I would recommend this app to everyone

Q46 How many times do you think you would use this app in the next 12 months if it was relevant to you?

- None
- 1-2
- 3-10
- 10-50
- >50
Q47 Would you pay for this app?

- 1 Definitely not
- 2
- 3
- 4
- 5 Definitely yes

Q48 What is your overall (star) rating of the app?

- 1 star - One of the worst apps I've used
- 2 stars
- 3 stars - Average
- 4 stars
- 5 stars - One of the best apps I've used
Q49 Using a scale of 1-5, with 1 being "Strongly disagree" and 5 being "Strongly agree", please indicate the impact of the app related to the targeted health behaviour (managing anxiety):

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree - 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Strongly agree - 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness – This app has increased my awareness of the importance of addressing the health behaviour</td>
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<tr>
<td>Knowledge – This app has increased my knowledge/understanding of the health behaviour</td>
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<td>Attitudes – The app has changed my attitudes toward improving this health behaviour</td>
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<tr>
<td>Intention to change – The app has increased my intentions/motivation to address this health behaviour</td>
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<tr>
<td>Help seeking – This app would encourage me to seek further help to address the health behaviour (if I needed it)</td>
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<tr>
<td>Behaviour change – Use of this app will increase/decrease the health behaviour</td>
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</table>

Q50 Further comments about the app?

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Semi-structured Interviews Guide (sample questions)

Opening questions

1. Can you tell me a little about yourself? What do you do? What kind of technologies do you use in your daily life?
2. Can you tell me about the technologies you have used to support your mental health and well-being? Which apps or other sources of data? For how long? Roughly how much time did you spend using the application daily?
3. What were your expectations of using an app of this kind? How did you use the app?

Experience with app/s

4. Can you describe your overall experience with the app/s?
   - What aspects of the app were useful to you and why?
   - What features you liked and why?
   - What features you disliked and why?
5. Which are the positive aspects of your experience?
6. Which are the negative aspects of your experience?

Continued use/Abandonment

7. Why do you still use/did you stop using the application? Please explain.

Design of app/s – Suggestions for improvement

8. If you could suggest three features to add to or improve the application what would these be?
9. What could have made the app easier or more engaging? Please explain.
10. Overall based on your experience with the app, what are your suggestions for improvement, if any? Please explain.
11. Do you have any final thoughts you would like to share?
A1.4 Chapter 7

A1.4.1 Interview questions

Opening questions
1. **Can you tell me a little about yourself?** What is your current role? How long have you been working as a therapist? Which client groups do you mainly work with?
2. **What kinds of technologies do you use for work or for work related tasks?** Do you use any apps? How do you communicate with your clients between sessions?

Therapist experience
3. **Can you describe a typical day at work?** What are your main tasks? Do you hold therapy sessions remotely? What work do you between and before preparing for sessions with clients? Do you always conduct one-to-one sessions or also group sessions?
4. **Could you describe a typical therapy session?** How are sessions structured? What you and the client do between sessions?
5. **What the ‘trajectory of therapy’ looks like over time?** What are the signs therapy is working or that they need to change strategy? Are there sequential phases you often see? How often do you meet?

Therapist experience with clients
6. **How do you help clients stay engaged in therapy?** (e.g. contact between sessions, providing materials to work on, suggesting online resources)
7. **Could you describe your clients’ perspectives on home exercises?** (e.g. what they find helpful, barriers preventing completion of homework)
8. **What is the purpose behind providing exercises to complete at home?** And do these exercises work well to fulfil those aims?
9. **Do your clients often express a need for additional support between therapy sessions?** Which are those? (e.g. need for additional support between therapy sessions) What works well?

Experience with digital mental health technologies (if any)

10. **Have your clients referred to using mental health app/s for anxiety management?** Which app/s? Have you had any input in this respect?
11. **Can you tell me about the technologies you have used/explored to support patients with their mental health, if any?** Which apps or other sources of data? What is your opinion of existing apps?
12. **Can you describe your overall experience with the app/s, if any?** How did you find it/them? What aspects of the app/s you considered useful and why?
Digitalizing intervention content

Imagine that you are able to use mobile technology as an adjunct to existing therapy in-between sessions and as a way to provide additional help to clients when in need of support.

13. What exercises/activities would you like the clients to practice between therapy sessions?
   a. What information perhaps through an app, might it help you to know before the start of a session?

14. What are the main problems clients would face in using these systems between face-to-face sessions?
   a. How do you think you could support clients’ needs between therapy sessions?
   b. How do you think a client would benefit when in need of additional support in between sessions?

15. Do you have any final thoughts you would like to share?
A1.4.2 Scenarios in Ideation sessions

Scenarios for ideation sessions

Scenarios describe the story and context behind why a specific user or user group comes to your site. Imagine you have the following client with GAD that visits you for first time.

Scenario 1 (20 min)

Case study (Generalized anxiety disorder)

Phil is a 67-year-old male who reports that his biggest problem is worrying. He worries all of the time and about “everything under the sun.” For example, he reports equal worry about his wife who is undergoing treatment for breast cancer and whether he returned his book to the library. He recognizes that his wife is more important than a book, and is bothered that both cause him similar levels of worry. Phil is unable to control his worrying. Accompanying this excessive and uncontrollable worry are difficulty failing asleep, impatience with others, difficulty focusing at work, and significant back and muscle tension. Phil has had a lifelong problem with worry, recalling that his mother called him a “worry wart.” His worrying does wax and wane, and worsened when his wife was recently diagnosed with breast cancer.

Symptoms
Anxiety, Concentration Difficulties, Irritability, Sleep Difficulties, Worry

Sample Questions
- Which treatment approach would you consider applying in the first session? How will the first session be structured?
- What homework would you suggest him practicing before the second session?
- How will the following sessions be structured?
- What homework will you suggest for the client to practice during the next sessions?
- How will the last session be structured?
- What challenges will you may encounter with this client during therapy sessions?

Now imagine you have a mobile app to support your practice of CBT with this client in-between sessions,

Sample Questions
- How could a mobile app support your work in different stages of treatment? Please provide a description on what you want an app to do
- How can you target the intervention content through an app to increase its relevance for this client?
- What are the client individual characteristics that you may take into consideration when deciding on the homework material?
Scenario 2 (20 min)

Case study (Panic Disorder)

Dave is a 41-year-old male who was referred by his primary care physician after presenting to the ER with difficulty breathing. Dave’s physician was unable to find a medical explanation for his symptoms, which left Dave feeling confused, stressed, and angry. Over the last 6 months, Dave has had several instances where he felt an intense fear that would reach a peak within a few minutes. During these instances, he would also experience sweating, heart palpitations, chest pain and discomfort, and shortness of breath. At times, Dave worried that he might die. As a result, Dave has persistent worry about having another attack. In addition, he has begun to avoid unfamiliar places and people where it may be difficult to get help in the event of another panic attack. The panic and associated avoidance are significantly impacting Dave’s life as he has been turning down social invitations, making excuses to stay at home whenever possible, and relying on his wife to drive their children to their various activities. Although she was understanding at first, Dave’s wife has grown frustrated with what she perceives as his irrational fear of panic attacks.

Symptoms
Agoraphobia, Anger, Anxiety, Panic, Suicidal thoughts, Worry

Sample Questions
- Which treatment approach would you consider applying in the first session? How will the first session be structured?
- What homework would you suggest him practicing before the second session?
- How will the following sessions be structured?
- What homework will you suggest for the client to practice during the next sessions?
- How will the last session be structured?
- What challenges will you may encounter with this client during therapy sessions?

Now imagine you have a mobile app to support your practice of CBT with this client in-between sessions
- How could a mobile app support your work in different stages of treatment? Please provide a description on what you want an app to do
- How can you target the intervention content through an app to increase its relevance for this client?
- What are the client individual characteristics that you may take into consideration when deciding on the homework material?