Exploring the Design Space of Mobile Applications for Addressing Depression-associated Autobiographical Memory Impairments

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A thesis submitted for the degree of
Doctor of Philosophy

November, 2022

Declaration

I declare that the work presented in this thesis is, to the best of my knowledge and belief, original and my own work. The material has not been submitted, either in whole or in part, for a degree at this, or any other university. This thesis does not exceed the maximum permitted word length of 80,000 words including appendices and footnotes, but excluding the bibliography. A rough estimate of the word count is: 30673

Chengcheng Qu

Abstract

Depression is an affective disorder with a range of cognitive biases and distortions, which drives depression onset, development and maintenance. This PhD research aims to support end users with non-clinical depression, by exploring the possibility of mitigating a range of depression-associated impairments in autobiographical memory processing (D-ABMs) through mobile applications.

Emerging psychological interventions targeting these disrupted D-ABMs issues hold enormous potential of mitigating depression symptoms and thus been widely explored in the field of psychology. However, they have received less support from HCI research in depression . Current HCI work on digital interventions mainly support the digitization of mainstream psychological interventions such as Cognitive Behavioural Therapy (CBT) as it is acknowledged as the most evidence-based interventions, and its pre-structured nature makes it easier to be transferred into digital app design. However, the pre-defined nature of CBT related interventions can also bring various limitations. Different to the pre-structured interventions such as CBT, D-ABMs interventions hold promises in bringing more person-centric training content that are more flexible to app users' needs.

This thesis aims to explore the design space of mobile apps for D-ABMs. For this purpose, first, I explored the key effective components in current depression interventions while addressing D-ABMs, and analysed how they can inform the design of apps for supporting these interventions. Then, I explored the combination of app features to be included in the design of D-ABM apps, which can support these therapeutic components. Finally, I investigated into an effective design method for helping future designers of D-ABM apps to utilise the empirical findings gained from this thesis work.

Overall, this thesis provides empirical exploration and design perspective that demonstrate ways of adapting memory assistive technologies to support the mitigation of depression associated cognitive dysfunctions and consequently alleviating depressive symptoms. The work aims to draw attention to depression-associated cognitive impairments as a less explored space in the filed of HCI, and to inspire HCI researchers to develop novel classes of mobile-based technologies for addressing a wide range of cognitive impairments that are associated depression. The contribution of this thesis opens up new design opportunities for both memory assistive and depression management technologies. The work aims to broaden the awareness of HCI researchers of mental conditions that involve autobiographical memory impairments besides episodic memory loss, such as depression, PTSD, or anxiety, which can be benefited from memory technologies that tailored for each specific conditions.

Publications

The list below details the publications which contribute to the research described in this thesis.

Chengcheng Qu, Corina Sas, and Gavin Doherty. "Exploring and Designing for Memory Impairments in Depression". In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. Glasgow, Scotland Uk: Association for Computing Machinery, 2019, pp. 1–15. ISBN: 9781450359702. DOI: 10.1145/3290605.3300740. URL: https://doi.org/10.1145/3290605.3300740

Chengcheng Qu, Corina Sas, and Gavin Doherty. "Reviewing and evaluating mobile apps for memory impairments in depression". English. In: 25th annual international CyberPsychology, CyberTherapy amp; Social Networking Conference, CYPSY25 ; Conference date: 05-06-2020. Mar. 2020

Chengcheng Qu et al. "Functionality of Top-Rated Mobile Apps for Depression: Systematic Search and Evaluation". In: *JMIR Ment Health* 7.1 (Jan. 2020), e15321. ISSN: 2368-7959. DOI: 10.2196/15321. URL: https://doi.org/10.2196/15321

Chengcheng Qu et al. "Functionality of Top-Rated Mobile Apps for Depression: Systematic Search and Evaluation". In: *JMIR Ment Health* 7.1 (Jan. 2020), e15321. ISSN: 2368-7959. DOI: 10.2196/15321. URL: https://doi.org/10.2196/15321

Additional publications

The list below details additional publications which do not contribute to the content of this thesis, but which I have written during my time as a PhD student.Pedro

Sanches et al. "HCI and Affective Health: Taking Stock of a Decade of Studies and Charting Future Research Directions". In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. Glasgow, Scotland Uk: Association for Computing Machinery, 2019, pp. 1–17. ISBN: 9781450359702. DOI: 10.1145/3290605.3300475. URL: https://doi.org/10.1145/3290605.3300475

Jessalyn Alvina et al. "MojiBoard: Generating Parametric Emojis with Gesture Keyboards". In: *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI EA '19. Glasgow, Scotland Uk: Association for Computing Machinery, 2019, pp. 1–6. ISBN: 9781450359719. DOI: 10.1145/3290607.3312771. URL: https://doi.org/10.1145/3290607.3312771

Acknowledgements

First I would like to thank the European Commission for funders who supported my PhD research ((AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 People Programme under Marie SkłodowskaCurie grant number 722022). I feel extremely lucky to work with all AffecTech cohorts, and I cannot thank them enough for the journey we have all shared.

I would also like to thank my supervisory team. Thank you, Professor Corina Sas for making this PhD possible and sharing valuable advice. Thank you, Dr Gavin Doherty for teaching me how to conduct good and rigours research studies. I would Particularly send my appreciation to Maria and Ian, who gave me the warmest encouragement, support, supervision, and mentorship that helped me through my darkest time. I cannot see how I would have made it so far without you.

A massive thanks to my parents who have always supported me and believed in me. Thank you, Kim, Daniel, and Shuting who gave me unconditional love and for holding my hand in various of phases in my weird, rollacoster-alike life journey. Love has made me thrown myself into this bizarre, deep, inherently existentialist PhD topic. I feel extremely lucky to have shared (and sharing) a part of my life with you.

Thank you, Ludwig and Gween, the brothers and sisters I never had, for provided me a sense of family during COVID. Thank you, Petter, king of wordplay, for your warmest and kindest friendship and always spotting the silver-lining in any situation of our lives. I will always remember our comedy club. Thank you, Xuesong, GingFung, Umair, Claudia, Camille, Peter, and more and more previous friends for your immeasurable support, laughs, dinner, coffee, encouragement, and inspiration throughout all the ups and downs.

Finally, a huge thank you to my original research family ex)Situ. Professor Wendy Mackay, thank you for opening the gate of academia for me. You are always my shiniest research superstar. Dr Jessalyn Alvina, thank you for your warmest mentorship during my first research study, and your kindest friendship for a life time. Thank you, Jiali, Carla, Germán, Philip, Alessandro and JP and more and more and more friends for seeing my potential and encouraged me to pursuit a PhD. We have all made it!

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Chapter 1

Introduction

1.1 Research Rationale

With significant socioeconomic costs, depression is a major affective disorder impacting over 300 million people worldwide [191]. Treatment of depression contributes £105.2 billion of the annual budget spend on healthcare in England alone [190]. The demand for clinical interventions and everyday self-care strategies has increased significantly for addressing the challenges raised by depression. However, the treatment of depression is a long-term process and requires in-person treatments with therapists, whilst individuals living with depression often experience a variety of barriers to receive support [142]. These barriers may include, for example, geographical location [24], time constraints [142], high treatment cost [142], and low mental health literacy [24]. Additionally, people living with depression can be reluctant to seek clinical treatment due to the stigma attached to mental illness [142, 24].

Digital apps can be a good support to expand the reach of treatments targeting depression [158]. Prior studies have already shown a high user acceptance and effectiveness of mobile-based interventions for depression [197, 168]. With over 90% penetration [206], mobile phones can provide easier access to digital apps. These mobile apps can provide cost-effective interventions to alleviate app users' depressive symptoms, and are particularly useful for accessing service users who cannot reach professional treatments offline [94]. Additionally, digital apps provide an alternative approach to access depression treatments in a private way with a minimal of human interaction, which can reduce the fear of stigma in public spaces [196]. The number of mobile apps offering treatments for depression has also been grown rapidly in recent decades [134].

Depression is a mental health condition that involves distinctive impairments in processing one's emotional autobiographical memories [39, 86]. Such Depression-

associated Autobiographical Memory Impairments (D-ABMs) have a negative impact on one's cognitive abilities (e.g., social functioning [86] and problem solving [100]) and can affect the onset, maintenance, and recurrence of depression [39, 16, 157]. Prior research has shown that addressing D-ABMs can reduce symptoms of depression and prevent relapse [39, 86]. There are several face-to-face treatments proven effective in treating D-ABMs [86]. However, these treatments are currently mainly used in lab-based settings and are not widely accessible to the general public. Mobile apps can offer a potential way to make these treatments more accessible to a wider range of populations living with depression.

Currently, little technology support has been developed to support D-ABMs management. Mainstream Human–computer interaction (HCI) research focuses on exploring prevention, detection, and treatment of mood disorders. Whilst most apps available for depression focus on providing intervention techniques from highly structured psychological treatments that target cognitive distortions. For instance, Cognitive behavioural therapy (CBT) is the most evidence-based and the most used psychological therapy for these apps for depression [36]. CBT mainly targets cognitive distortions (e.g., thinking patterns), instead of cognitive impairments (e.g., memory impairments). Only minor subsections of CBT involve the component that can potentially address users' impairments in processing self-memories (D-ABMs).

Albeit being one of the best-researched treatments, digital CBT has its own limitation, such as lack of interactivity, personalization, and user engagement [36]. Such issues are caused by a variety of reasons, such as the lack of interpersonal interaction while clients using an app without engaging with a human therapist, which is a common drawback of self-help apps. Moreover, the structural nature of CBT training protocol also involves a risk of high attrition rate in these online interventions. This is because these digital apps provide precisely pre-defined digital training content that are not flexible to app users' individual needs. App users might find it challenging to apply these rigid training content to their specific problems, and consequently lose interest in completing the interventions [36].

Apps that deliver intervention techniques that target D-ABMs [39, 86] might hold promises to introduce more personalized and interactive training content to improve users' engagement. This is because these interventions are more personal centric (e.g., particularly work with users' self-memories). However, this domain has received less attention from the HCI community.

Exploring the design space of mobile apps for D-ABMs is novel and promising. However, it remains unclear what the key components are in depression interventions for D-ABMs, and how they can inform the design of apps for supporting these interventions. Besides, to develop depression apps that target D-ABMs, we need to know what features are the best to include for addressing D-ABMs, and what other features are also important to include for depression management. Finally, we need

to investigate how to support the process of designing apps for addressing D-ABMs.

1.2 Research questions, Objective and Approach

The main research objective of this thesis is to explore how can we best design mobile apps for ABMs impairments. In order to answer this question, first, we need to understand the current best practices in addressing ABMs in depression. Therefore, this thesis involves five explorative studies (see figure 1.1):

First, I conducted study 1 and study 2, which aims to explore and analysis the current best practices about D-ABMs. Study 1 focuses on theoretical-based practices, while study 2 focuses on practice-based practices. Study 1 builds up the foundation of study 2, whose result will be used as key design requirements to guide the design of apps that can support treatments for addressing D-ABMs.

Study 1 and 2 sets the foundation of following studies, which aims to explore the best design of apps that can meet these requirements. This objective is then approached from two directions in parallel. This includes: (a) study 3 and study 4 (figure 1.1, left), which explores the best design of depression app features for supporting the needs of users living with D-ABMs, and (b) study 5 (figure 1.1, right), which explores the best design process of apps for addressing D-ABMs.

The thesis seeks to answer the following three research questions (marked as RQ1, RQ2(a), and RQ 2(b)):

RQ 1: **What can we learn from the best practices of ABM-based interventions in depression (both in theory and in practice?) How can current psychological approaches (from laboratory and therapeutic practice) inform the design of mobile-based technologies for D-ABMs?**

Study 1 and 2 aims to identify and analyse current effective treatments for treating D-ABMs. The analysis reveals the main types of D-ABMs addressed by each treatment, and how each intervention treats the target D-ABMs. For this, I first investigate current theory-based interventions in laboratory settings (study 1). Base on the result, I further explore the current practice-based approaches in clinical settings (study 2).

More specifically, in study 1, I first investigate state-of-the-art clinical psychology interventions (N=4) that are particularly designed for treating D-ABMs. I then conduct study 2 to carry out expert interviews to collect depression practitioners' approaches with a specific focus on emotional memories. The interviews were conducted with clinical-health professionals who have experience of working with people living with depression (N=10).

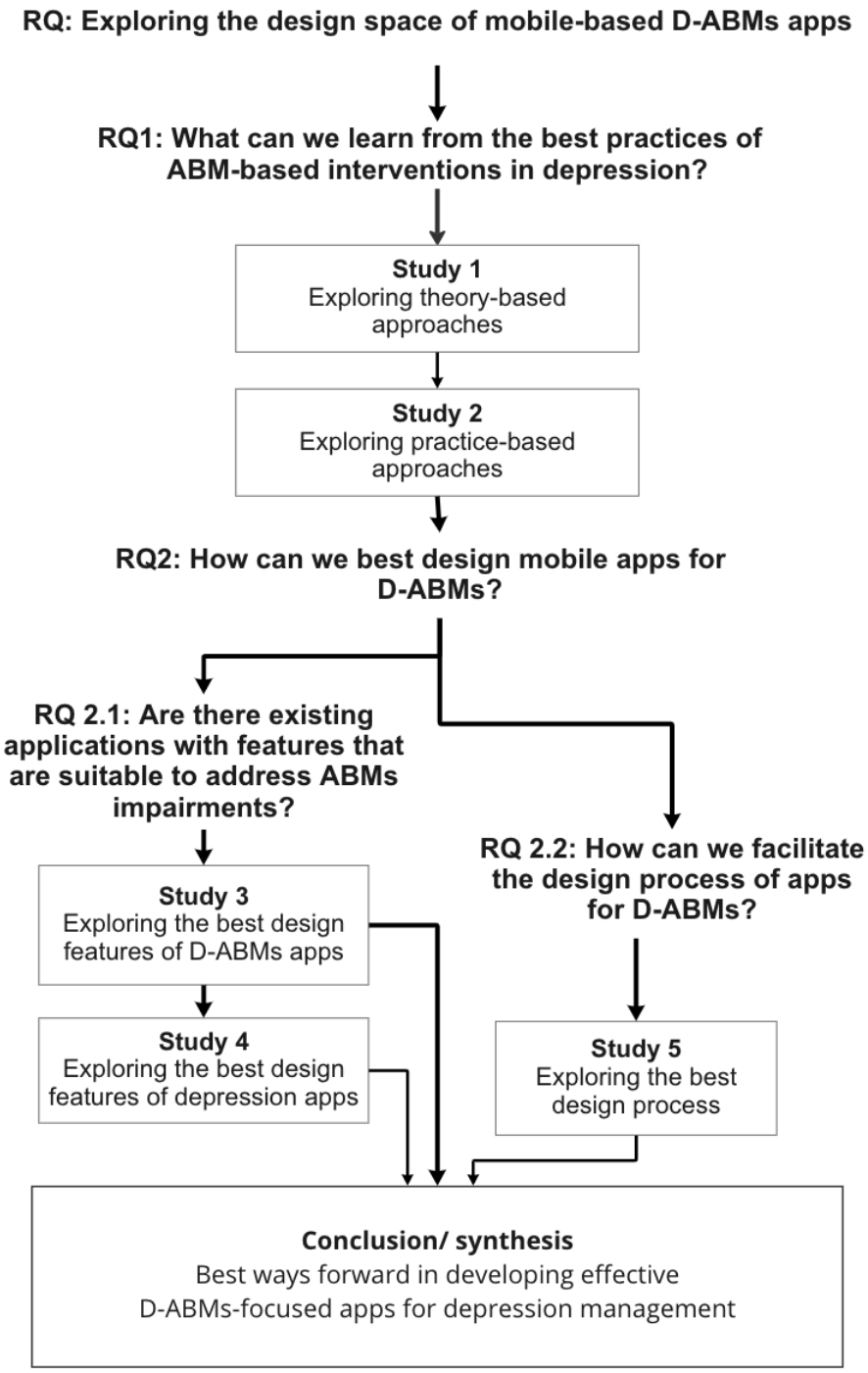

Figure 1.1: Overview of the thesis structure (How each research study answers each research question)

RQ 2 (a): **Are there existing applications with features that are suitable to address ABMs impairments? What are their gaps in sufficiently addressing D-ABMs, and how to leverage these features for building D-ABM apps?**

Studies for answering this research question aim to identify the best design of apps features for D-ABMs. This includes two app surveys being conducted to explore the existing apps features that have potential to address D-ABMs (study 3), and other important features that are suitable for global management of depressive symptoms (study 4). More specifically, study 3 focuses on apps features with the potential to address D-ABMs; and study 4 investigates general component of depression apps.

RQ 2 (b): **How can we facilitate the design process of apps for D-ABMs?**

Study 5 aims to identify the best design process for designers to design apps that can help manage D-ABMs in individuals with depression. Such design process could then be used to best inform and equip designers with the necessary knowledge and skills for designing for depression. For this, in study 5, I translate specialist clinical psychology knowledge about D-ABMs into a design supporting tool (i.e., design cards), and explore if and how such design supports can bridge the theory-practice gap while generating theory-informed apps.

1.3 Thesis Outline

This thesis is structured into six chapters, Figure 1.2 provides a visual overview of how each of the research chapters contributes to this PhD dissertation.

Chapter 2. Literature review

This chapter presents the relevant related literature, drawing from four relevant research areas. First, it reviews the design of depression technologies, which includes the research works targeting depression in the field of HCI and commercial apps designed for managing depression.

Secondly, the chapter introduces the domain knowledge about depression and its relationship with autobiographical deficits memory (D-ABMs). The D-ABMs is considered a substantial component of cognitive impairments in depression and is considered as a cardinal feature of affective disorders such as depression [39]. This is because depression is a mental health condition that results from cognition biases and perturbations [16, 157] (e.g., having negative internal mental constructions about the self, the world, and the future [16]), while D-ABMs serve to maintain and consolidate this distorted cognitive foundation. Then, I review how are D-ABMs related challenges can be addressed in various psychological domains. Through

reviewing literature in the domain of clinical psychology and cognitive sciences, I noticed that some treatments have been specifically designed to target D-ABMs and hold promises for mitigating the symptoms of depression [86, 39].

Thirdly, the thesis reviews HCI work in memory augmented technologies, including the memory impairments these technologies target, and functionalities provided by these technologies.

Finally, the chapter identifies the current challenge of between depression-related academic research and the actual HCI design practice.

Chapter 3. Methodology

The chapter describes an overview of the overall methodological framework, the specific research methods and approaches that were used in each of the studies, and how these methods were applied to each of the research studies that were conducted in this thesis (including participant recruitment, data collection, and data analysis).

Chapter 4. Exploring the Design of Apps for Autobiographical Memory Impairments in Depression

The chapter comprises two parts: 1) identifying requirements of app design, and 2) accessing existing app features. This includes four research studies conducted and published as part of this PhD thesis. In part 1, study 1 and study 2 explore design implications from uncovering the best practice in interventions that can treat D-ABMs. In part 2, study 3 and study 4 explore the most effective app features in existing apps with the potential to satisfy these implications.

Study 1 applies a content analysis method [59, 91] to analyse a range of selected peer-reviewed literature of four cutting edge memory-based treatments that are proven effective in alleviating depression with experimental evidence. The treatments were selected from a recent meta-analysis of memory-based interventions for depression [85]. Study 2 conducts in-depth interview sessions with ten experts of depression treatments, with aim of exploring practice-based approaches that are more widely used for treating depression in clinical settings.

Study 1 sets the foundation of study 2 by revealing the key memory challenges that are being addressed by current experimental psychology treatments. Study 2 further evolves our understanding D-ABMs a nd their treatments, and motivates the exploration of the main procedures within treatments for addressing these depression related memory challenges. The results drive the design requirement of key features for digital depression apps for D-ABMs. Such mobile apps can scale up the benefit of these treatments to a wider range of potential service users with depression.

The outcome motivates studies in the follow studies that approach the design space from two separate directions. This includes: accessing the best combination of app features to support the design solutions proposed in study 2 (study 3 and 4), and exploring ways of supporting designers to generate suitable design ideas of apps for D-ABMs, informed by theories and design knowledge revealed in study 2 (study 5,

see Chapter 5).

Both study 3 and 4 in part 2 apply systematic review method for analysing existing apps. Study 3 reveals currently existing features that can be leveraged to address D-ABMs. The features are extracted from memory apps that also target users living with depression. Since D-ABMs in depression is a novel domain, there are not many features to be explored. Consequently, study 4 reveals other existing features that are useful for managing depression in a more global way. The features are extracted from apps for depression.

The results lead to a discussion of ways of leveraging (e.g., what to include and how to include) currently existing features of apps for addressing D-ABMs.

Chapter 5. Exploring the best design process of apps for D-ABMs

This chapter presents a further study that explores the best practice in supporting the process of designing apps for D-ABMs. For this, I designed a toolkit to translate the knowledge about depression and its memory deficits into HCI design and evaluated the toolkit with 15 HCI design experts. The toolkit comprises a set of clinical psychology theory-informed materials, designed to support designers' understanding and using of D-ABMs related theories while designing theory-informed apps for depression. The design component of the toolkit comprises theory-informed persona, scenario, theory cards, and the description of a matching workshop procedure that guides designers to use the above design cards throughout their design practices. Using this toolkit, study 5 explores how designers understand, adapt, and leverage the domain knowledge presented in the materials during the design activities. The toolkit deploying workshop was performed through a design sprint format, and I analysed participants' feedback through conducting in-depth interview with each participants. The results drive a discussion about how to design such translational resources, to support the use of complex theory (e.g., D-ABMs) in industry.

The work is drafted in a full-paper format with the aim of submitting to CHI 2022. The full submission piece is attached in appendix E.

Chapter 6. Discussion and conclusion

This chapter summarizes the thesis work and synthesises the findings of the review and studies to answer the research questions. The chapter also discusses the limitations and future implications of this thesis work.

1.4 Contribution Statement

Through exploring three research questions outlined in the previous sections, this thesis contributes to digital mental health research in the field of HCI. The primary contribution of this work is the full exploration of the design space of mobile apps for alleviating app-users' depressive symptoms by addressing D-ABMs through app usage. More specifically, the overall contribution can be broken down into a 2 parts:

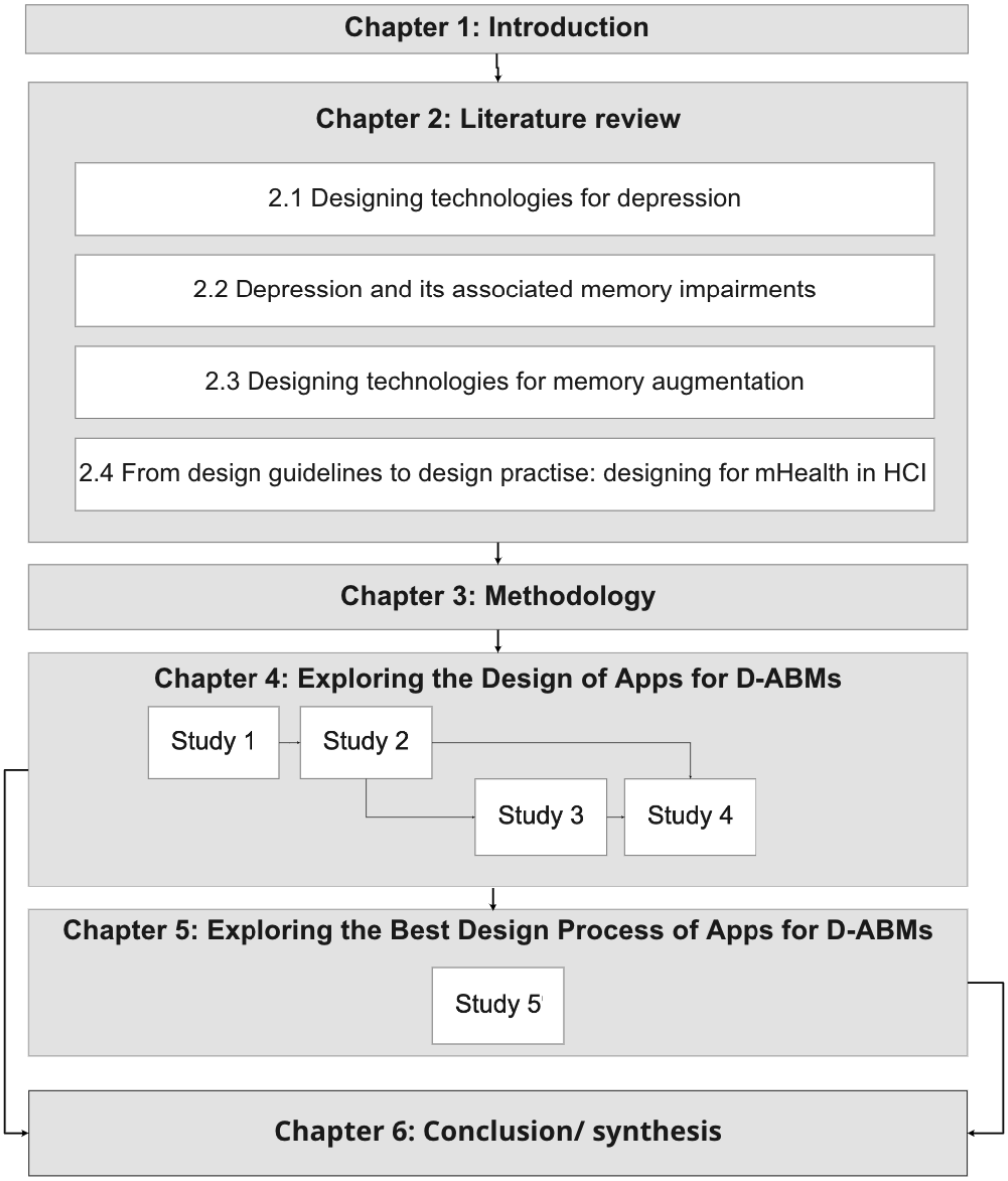

Figure 1.2: Overview of thesis structure (how each research study contributes to each research chapter

A framework for designing mobile apps to mitigate depression-associated memory impairments.

Through analysing theory-based and practice-based approaches for treating D-ABMs, the thesis explores key requirements to guide the design of apps that can support or deliver these therapeutic approaches digitally. In addition, the thesis also assesses features in existing apps to identify the best combination of features of D-ABMs apps to support individuals living with depression.

Informed by these findings, the thesis provides design recommendations regarding how to advance current mobile apps features to better satisfy the needs of users who live with depression and its associated memory impairments. The thesis also generates detailed guidelines to inform future designers how to provide safer and more effective digitally-delivered treatments while designing for this vulnerable user group.

The exploration opens up two opportunities: 1) the thesis stresses the benefit of designing memory technologies that are tailored to the distinctive challenge pose by depression 2) the thesis suggests the potential of improving the user experience (e.g., user engagement, interactivity, personalization) depression technologies with more person-centric intervention techniques.

A design toolkit to support designers' adoption of psychology theories into theory-informed app features.

The thesis contributes to the development and evaluation of a set of design toolkit to effectively support the design process of digital applications for end users with D-ABMs. The toolkit translates the design recommendations of this thesis, facilitates HCI designers' understanding of theories about D-ABMs, and supports designers in creating theory-grounded digital apps. The evaluation of the toolkit investigates the benefits and limitations of the toolkit in supporting designers' understanding and adaption of relevant psychology theories into actual design practice.

Chapter 2

Literature review

This chapter provides a review of the current literature relating to current HCI technologies for depression management, and psychological treatments in addressing depression and its associated autobiographical memory impairments. This provides an understanding of D-ABMs as a complex condition, and the potential for digitized D-ABM treatments in advancing current mobile apps for depression management.

The chapter then reviews HCI work in memory augmented technologies, and their current limitations in supporting autobiographical memory impairments. Following this, the chapter identifies current challenge in developing HCI design that informed by complex theories.

2.1 The Design of Technologies for Depression

2.1.1 Depression in HCI

Depression is a common mental disorder and affects more than 264 million people worldwide [152], and is projected to be the globally leading cause of burden of disease by 2030 [191]. Depression (at moderate or severe intensity) can lead to various consequences (e.g., reduced cognitive function, withdrawal) and diminish individuals' functioning at work, at school or at home [39, 152]. In the worst-case scenario, depression can be life-threatening. According to the World Health Organisation (WHO), depression causes eight hundred thousand deaths due to suicide every year globally[152]. Depression is also identified as the second leading causes of death in children, adolescents and youger adults(15-29 years old) [152].

Currently, accessing mental health support can be problematic due to several acknowledged barriers, such as high treatment costs [191, 152, 142], time constraints [142], low mental health awareness, stigma of receiving mental health support [142, 24, 29, 194], and geographical location [24]. Besides, there is a lack of clinical resources

(e.g., trained healthcare professionals) for meeting the high demands of mental health supports[152, 191]. The inequality of evidence-based services available for mental health is staggering [109]. According to a research global mental health care in 2017 [193], while one out of five persons with depression receive minimally adequate care in high income countries, only and one out of 27 can receive such care in lower-middle income countries [193]. WHO are calling for actions to be taken on this matter [152].

Digital applications have the potential to lower the barrier of entry for individuals living with depression to seek help. Besides, with over 90% worldwide penetration of mobile devices [206], digital apps are easily scaleable. Prior studies indicate that digital apps are particularly useful in reaching subgroup of users who are less likely to seek professional support offline but can well accommodate mobile technologies well, such as adolescents [73]. This is because digital apps can provide cheaper mental health supports that are more cost-effective than traditional face-to-face interventions for treating depression. Users can access mobile-based mental health support in private setting with minimum daily disruptions, which can be more comfortable for people living with stigma. Additionally, digital mental health supports can offer flexible and targeted support that are specifically tailored to each user's unique needs. Prior work has already indicated a high user acceptance and effectiveness of mobile-delivered interventions for depression [197, 168]. The global market of depression apps has been growing rapidly [158, 134].

In the last decade, there has been a massive growth of research on designing technologies for addressing various mental health needs [171]. In particular, research in the field of HCI (Human Computer Interaction) has considered a range of systems to support users living with depression. These are delivered through the design of technologies for supporting depression diagnosis [42, 43, 200, 131], emotion regulation [96, 41, 137, 146, 55], and treating depressive symptoms with structured long-term interventions [208, 36, 35, 54, 166].

For instance, work on **diagnosing depressive symptoms** has focused on analyzing online daily activities (e.g., Reddit [11, 43] , Twitter [42, 200], and Instagram [132]) to detect depression (e.g., postpartum changes [43], suicidal ideation [43], self-disclosure [11], severity of depression [200], and mental health issues in general [132]).

HCI work has also looked into **mood regulation supports**. For example, the design of interactive devices for guiding mindful practices [41] with the aim of reducing high-intensity negative emotions in the short-term [12]. Such interactive technologies can also support the tracking of depressive symptoms [138]. This body of work builds on positive psychology [92] to better support coping strategies (e.g., facilitating emotional expression [154] or increasing social communication[210]), with the help of lifelogging technologies [92].

In addition, the development of **computerized psychological treatments** for depression has been explored by HCI research [36, 166]. Such interventions tend to

include psychoeducation sessions, requiring users to complete a number of achievable goals [35]. Historically, these psychological interventions are often based on highly structured and goal-oriented psychological treatments such as Cognitive Behavioral Therapy (CBT) or Solution Focused Therapy (SFT) [36]. Currently, CBT is one of the most evidence-based and widely used approaches in both the clinical context and in internet-delivered therapy [36, 35, 166]. CBT is currently as one of the first-line treatment options for mild to moderate depression, especially in the UK [54]. Additionally, the the structured nature of the content of CBT and the goal-oriented user journey can make it more amenable to be delivered via computer-based digital systems [36].

However, this does not means CBT is the best intervention for all aspects that contributes to depression developments. It should be noted that the reason why CBT has the most extensive evidence base may be because of its structured and goal-oriented nature [36]. Compared to other, more free-form therapies (e.g., person-centered therapy), structured interventions like CBT may privilege with quantitative based research methodologies (e.g., double blind Random Controlled Trials (RCT)), and therefore it is easier for researchers to publish studies on their clinical validity.

In contrast to these clearly structured interventions, free-form therapies are embedded in less positivist epistemologies. Researchers of these therapies tend to use other research methodologies (e.g., qualitative research methods) for evaluating their therapeutic benefits. Although these results can be seen as 'less evidence based' by the positivist community, these therapies still hold promises to effectively managing depressive symptoms and complement the weaknesses of structured therapies. For example, one longstanding challenge for e-Health programs like online CBT is their high attrition rate [63], which typically defined as considerable number of users who have started course of depression treatment but drop out before completing it [54]. Prior researchers of online CBT interventions call for strategies to reduce attrition, as quitting treatment early may mean that some cognitive impairments remain and raise the risk of relapse [39].

One effective way of addressing such issue is to improve users' engagement in digital interventions. An interesting possibility is to investigate solutions that can provide more personal experience [54], which can be used inside or outside of treatment. Research into digital depression treatments[54] has suggested a number of strategies which might prove effective. For example, delivering more personalized and multimodal content can make interventions more engaging. This highlights the importance of digital interventions allowing users tailor their treatment path according to their unique needs and preferences. In addition, providing multi-model representation of treatment content has shown particular effectiveness in increasing young people's engagement with their treatment for depression. For example, intervention courses can be delivered through modalities such as video [35], games

[8, 35, 37], or conversation with embodied agents [67].

Prior researchers have suggested that clinical computer-aided treatment systems can benefit a broad range of therapists in different treatment settings by providing personalized treatments for addressing the individuals' needs from various types of clients [35]. There is thus an opportunity to support a range of person-focused therapies by addressing common factors in depression. For example, Coyle and colleagues [36] suggested including psychological therapies that focus on clients' sense of self and their life narrative. These interventions alleviate depression through identifying individuals' negative thinking patterns (or thought disruption) and helping them work on challenging them. This suggests that future exploration of free-form and person-centered interventions would be helpful, as these hold the promise to improving users' engagement with depression treatments [36]. We acknowledgement that CBT is still the most evidence-based intervention and has widely used as first-line treatment options for treating depression [54]. In the meantime, albeit the person-focused interventions this thesis mainly investigates have shown promises in treating depression, these interventions are still in experimental stage and requires further evaluation.

Therefore, in this thesis, I do not aim to explore the possibilities for CBT to completely replace the person-focus interventions, but rather explore ways to integrate these interventions as additional, person-centric components to improve the overall CBT treatments.

2.1.2 Commercial mobile applications for depression

The amount of commercial mobile applications (apps) targeting depression has been growing rapidly [163, 158, 181]. These apps provide access to a range of interventions in various contexts. Such mobile apps offer the potential to scale up the delivery of depression interventions, and especially to reach to under-served populations in need [158].

Mobile applications for depression management may provide a wide range of supports.Many applications focus on screening to provide self-diagnosis using standard depression test questionnaires such as the Patient Health Questionnaire [121, 112]. Applications that provide tracking functions may help users monitor their symptoms of depression as part of depression intervention [125], or allow the self-monitoring of moods, thoughts, or specific behavior patterns [75]. Depression apps also make use of a variety of interventions to support app users, utilising theories such as CBT [120] or positive psychology [187], or provides supports in emotional expression [6] and psycho-education [95]. Another relevant category comprises mindfulness applications which provide guided meditation [141], or breathing exercises [80]. These apps mainly help app users to take notice of thoughts, feelings, and bodily sensations, which has

showed major benefits for the health and well-being of people with depression [188]. These self-help exercises are mostly grounded in evidence-based interventions such as CBT [178].

One of the latest guideline regulating mental healthcare apps [209] suggests applications for mental healthcare should be developed with the close collaboration of healthcare professionals. Additionally, before these apps are made available for public use, the guidance suggests they should be assessed to make sure they follow specific standards [51]. However, many commercial online interventions delivered through mobile or web apps are not clearly evidence-based [181, 184] and lack clinical evaluation. This is concerning as it may pose a risk for service users from receiving less effective or even harmful approaches to regulate their depressive symptoms [171].

2.1.3 Session summary

Mental health is a rapidly growing research area within the Human-Computer Interaction (HCI) community. Depression, as one of the major mental health conditions with significant social costs, has especially raised significant challenges for both HCI researchers and designers. In this subsection, I reviewed current HCI academic works and commercial mobile apps for addressing the challenges depression pose. This subsection provides a contextual description of depression , and highlights the importance of studying into this domain.

2.2 Cognition and Depression

2.2.1 The cognitive model of depression

Depression can be characterised by a few cognitive difficulties such as mood fluctuation and biases in processing information [72]. Cognitive theories of depression began to emerge around half a century ago [72]. Several theoretical models have been proposed for understanding the psychological mechanisms of the development of depression, including onset, maintenance and recurrence [39, 52, 15]. This paper mainly draw on a cognitive model proposed by Beck et al., [16, 15, 39, 52], which is one of the most cited theories of the cognitive conceptualisations of depression. Beck's cognitive model proposes that depression results from two distinct cognitive characteristics: (1) **dysfunctional schema**, (2) a consequent **negative-biased style in information processing** [72, 16, 52, 39]. These two vulnerability factors for depression contribute to onset, are presumed to endure after a depressive episode, and eventually can lead to recurrence [72, 16, 15, 39, 52].

(1) **Depression-associated dysfunctional schemas**

One's self memories are closely associated with their core beliefs, or in other word, their **self-schema** [133]. According to cognitive theories [52], individuals constantly make cognitive sense of the world and their life experiences. Through processing, understanding, and remembering different events, individuals organize their cognitive constructs, which constantly iterates during the human development from childhood over years [52]. According to Beck [16, 72], people tend to direct their attention towards information that is congruent with their currently activated **schemas**, and filter out other stimuli from the environment. For people with depression, negative schemas tend to get activated in response of everyday adverse life events, which automatically produce attentional bias, and negatively biased interpretation. The connections with the negatively oriented schemas become strengthened over time [15, 72]. These negative constructions about the self, the world and the future form **dysfunctional schemas** [52, 39] that drive cognitive vulnerability [15] to depression [52, 39, 15].

Prior research has highlighted the interconnection between the formation of depressive schemas [72, 16, 15, 39, 33, 31] and one's Self-Memory System (SMS) [31]. The SMS is a framework that often refereed by researchers in the domain of memory theories for emphasizes the interconnectedness of self and memory [31]. Beck's cognitive model specifically posits that the depression-associated negative schemas are likely to be activated by congruent life events (e.g., unpleasant or even traumatic experiences) , thereby initiating a vicious cycle of negative automatic thoughts and information processing, which in turns further consolidates the negative schema, leading to depression. [39, 16, 15, 52, 72]. According to cognitive theories for depression [16, 15, 52, 39], negative schema comprise a consistent, negative core self-belief, which drives a negative form of memory reconstruction [39, 86]. In turn, this process then further consolidates the negative schema thus maintaining the symptoms of depression [39, 86].

According to Beck et al., [16, 15], a common theme found in depressed individuals' conscious cognition is having negative self-evaluations, negative expectations and exaggerated, over-dramatic memories [15].

(2) **Negative-biased information processing in depression**

According to Beck [16, 15], when individuals experience everyday life events, their negative-biased cognitive schemas lead to automatic information processing. Such automatic process rapidly dominates a person's cognitive resources, which leads to involuntary negative attentional and interpretational bias. The cognitive models of depression [16, 15, 72] emphasise that depressed individuals exhibit cognitive biases in all aspects of information processing which contributes to systematic negative bias in their processing of stimuli from the environment

[16, 15, 52, 39, 72]. This distinct cognitive pattern is associate with two types of cognitive dysfunction. These comprise[16, 15, 72] **reduced cognitive processing capacity in concentration and memory** and **preferential recall of negative compared to positive materials** [135].

(2, a) **Reduced cognitive processing capacity in concentration and memory recall.**

As shown by prior experimental research [72, 203], individuals living with depression do not show significant memory-bias in pure perceptual processing (i.e., while being asked to count letters in emotional words), as such processes are not associated and therefore not activating their schemes during the tasks. However, a broad range of difficulties involving concentration and memory processing are reported in prior literature [23]. For instance, evidence strongly suggests that depression involves distinct impairments in processing autobiographical memories [23, 135, 72], such as over-general memory recall. Such unique cognitive patterns lead to a few distinct depression-associated impairments in one's self-memory system [23, 135, 72].

Over-general memory recall, also called as over-generalization, is where in a form that depressed individuals tends to recall memories in an abstract (instead of vivid or detailed) manner. These over-general memories normally involve category style of memory recall. One popular explanation for why people adopt this overgeneralized recall style is that it facilitates emotional regulation which assists the person in coping with depression [136]. More specifically, by retrieving these memories in a less specific style individuals attempt to minimize negative affect attached to distressing memories by blocking access to details of such memories.

In addition to the reduced cognitive abilities in concentration and memory recall, people with a diagnosis of depression tend to concentrate on negative-biased information [72, 39]. Individuals with depression are also widely reported as easily focusing on negative self-focused thoughts, and such people exhibit enhanced recall of negative material, especially when expereincing negative mood [135, 72].

(2, b) **Preferential negative material processing.** Another distinct depression-associated pattern is preferential processing of negative information, material, or environmental stimuli [72, 16, 15]. In summary, people with depression tend to interpret current or future events in a negative-biased style, which is consistent with their negative self-schema (e.g., "I am terrible, the world is terrible, nothing good ever happened to me"). The processing this negative information or thoughts can easily spawn

rumination, and worsen individuals' mood, and make it harder to disengage from this negative information [39, 86, 72].

According to prior research, depressed individuals' attention is directed towards negative-biased information as such information is relevant to their negative core self-beliefs, especially when they are experiencing a negative mood. This mood-congruent attentional bias is in turn associated with a tendency to interpet neutral or ambiguous stimuli in a negative-biased way [72, 39, 86].

Additionally, individuals with depression shown significant difficulties in disengaging from negative stimuli and mood [39, 72]. Even when they are not automatically orienting their attention toward negative information in the environment, once such information has come to be the focus of their attention, such individuals would still show a greater difficulty disengaging from it [72].

In sum, although cognitive and memory impairments are associated with a wide range of mental disorders, the patterns found in depression are rather distinct [39, 72]. The following section provides an explanation of how these depression-associated cognitive impairments impact specifically on individuals' ability to process their self-memories.

2.2.2 Self-Memory System and its disruption due to depression

2.2.2.1 The structure of Self-memory system

The cognitive models of depression describe how such impairments impact one's ability to process their self memories [52]. This provides a rationale for exploring ways of addressing depression through working on individuals' personal memory [39, 86]. Approaches developed for this mainly target different components of peoples' Self-Memory System, using their autobiographical memories as training materials for adjusting the negative-biased cognitive distortions and their associated schema. This section will first explain the basic components of SMS, then discuss how the cognitive impairments in depression impacts ones' abilities to process self memories.

Conway describes the **Self-Memory System (SMS)** as a conceptual framework, consists of two main components: *core-self (working self)* and the *autobiographical knowledge system (also called Autobiographical Memory System, AMS)* [31, 34]. I will now describe these two concepts below:

SMS is a conceptual framework where memories, ideas, and concepts are dynamically connected. [89, 33, 31]. It can be considered as the 'database' of one's

self [33, 31], and has a reciprocal relationship with one's schemas. As suggested by Conway et al., [33, 31], the Self-Memory System is a long-term memory system, consist of two main components: *the working self* and *the autobiographical knowledge base*.

1. ***Working self***. *Working self*, also called self-beliefs, is an important component of both schema [16, 15, 39, 86] and the Self-Memory System [39, 86, 34, 31]. *Working self* is a complex set of active goals and self-images. It reflects and defines how one's autobiographical knowledge is being accumulated and accessed. Thus, individuals' ability to recollect and recall memories through the Self-Memory System depends on the interaction between the *working self* and the *autobiographical knowledge base*.

   People experience emotional events every day, with new memories either being quickly forgotten or integrated in their long-term memory system. While encoding or retrieving memories through the autobiographical knowledge base, memories that are considered as goal-related, or relevant to one's self-beliefs are more easily encoded or accessed, whilst individuals' capacity to encode or access memories that are considered threatening or incongruent to current self-beliefs is reduced [31].Repeatedly prompting recall of certain type of memories can enhance retrieving the path of these memories and shape one's self-belief, and consequently increase individuals' abilities to access and encode similar memories [33, 31].

2. ***Autobiographical knowledge system***. According to Conway [33, 31], people's *autobiographical knowledge system* is the knowledge of self across over lifespan [33, 31] (see figure 2.2, left-side). It is the knowledge of "experienced self, which contains remembered reality" [33]. By remembering, recollecting and analysing these memories, people are able to track their life history, shape their beliefs and self-identity [201], and activate schemas. The memories of prior experiences that are recalled through one's AMS (Autobiographical Memory System) are important materials for a range of cognitive abilities, such as problem solving, decision making, and predicting future outcomes of a person's current activities [32].

   People's autobiographical memory has a broad, hierarchical structure. According to Conway's theoretical model, people's autobiographical memory structure includes different levels of memory representations, from levels that are highly semantic and abstract (e.g., see the concept *Lifetime periods* in page 19), to levels that are rather episodic and detailed (e.g., see the concept of *general event* or *episodic memories* in page 19 [9, 31].

   According to Conway's theory, *working self* is a hypothetical concept involves information about one's self-identify (e.g., "who am I?") and active goal (e.g.,

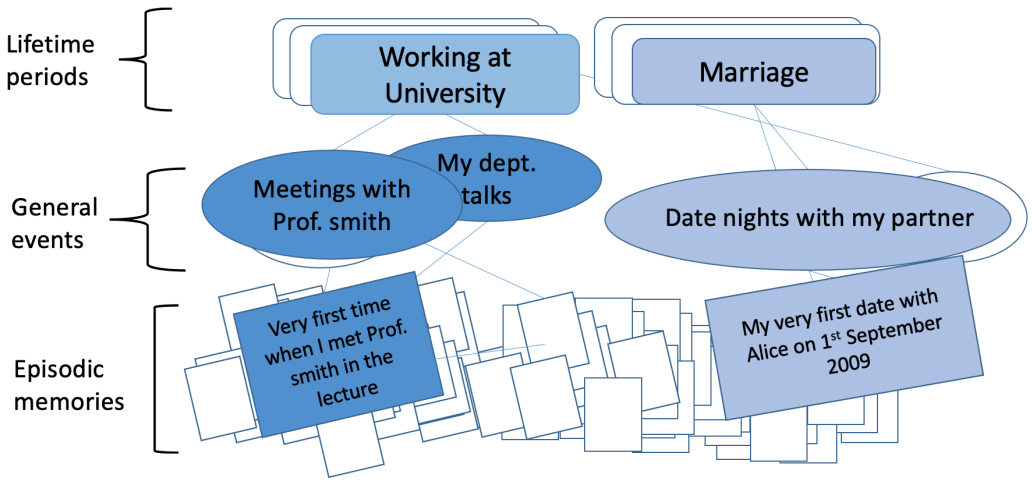

Figure 2.1: Example of AMS, adapted from Conway [31], (This figure visualises the structure of different AMS levels)

"what am I going to do?"). Individuals' *working self* (self-belief) [34] are critical for their ability in encoding and accessing certain memories through the AMS. Individuals' AMS organises (or framework) of different levels of memory representation, ranging from highly abstract levels such as lifetime periods, to highly detailed levels such as episodic memories. These abstract levels of autobiographical memories could comprise a few repeated events, such as the level of general events. A more detailed, visualised model of AMS can be seen in figure 2.2.

- **Lifetime periods.** The most semantic and abstract level. It represent personal conceptual knowledge during a few significant periods of time in life. According to Conway [34, 31], the common presentation of people's lifetime periods contain knowledge about goals, others, locations, activities, and evaluations, that were common in that period. Lifetime period knowledge can be used to access more specific autobiographical knowledge, such as general events.
- **General events.** General events combine both the abstract level of memories and a few vivid fragments of specific memories [33, 31]. It represents a few repeated or categoric events during the associated lifetime period. General events contains links to access associated episodic memories, where people can retrieve collective and sensorial information of their episodic memories regarding specific life events [33, 31].
- **Episodic memories.** [31, 33]. Episodic memories contain highly detailed

information about experiences normally from a specific, recent life event, with information which are considered to be highly sensory-perceptual while being recollected [33] but which can decay very quickly without integrating with the AMS [9].

EM could also remain accessible during the retrieval process throughout different levels of memory representations of the AMS. This is because EM is the level with most detailed, sensorial information in the *AMS*, whereas the Autobiographical memory is the "remembered self" across the lifespan, which provides a long-term framework for memories with different levels of abstraction [32, 33, 31]. Therefore, the process of processing EM through the AM system are closely impacted by one's sense of self.

2.2.2.2 Depression induced disruptions in AMS

People shape their self-image iteratively by encoding and retrieving specific episodic memories through the AMS. People's self-image determines the structure of their autobiographical memory, decides which memories with what specificity level can be accessed, and influences which episodic memories can be integrated with the AMS.

When people experience daily events through the process of encoding and (selectively) retrieving memories, they are repeatedly rehearsing connections and retrieval paths to different memories and ideas. These repeated practice can strengthen the connection to specific type of memories, and enhance certain concepts and beliefs over time [89]. Meanwhile, memories and beliefs that are not being accessed as frequently and have weaker connections could eventually be forgotten [89]. Since people's context, current knowledge, environmental stimuli are changing dynamically, the memories they can access are also changing over time, which in turn shapes their self-belief (*working self*) [34]. As one's self-image changes overtime, their AMS also changes dynamically.

The AMS supports two modes of retrieval: **generative retrieval** and **direct retrieval**. Figure 2.2 illustrates the two memory retrieval processes and the role that self-belief plays in both processes.

- **Generative retrieval** (dashed arrow on top left of figure 2.2) is a memory searching process that is highly influenced by one's self-identity. As shown in Figure 2.2, the generative memory-searching process starts with a cue activating the retrieval mode, accessing and evaluating memories at all three memory levels, and elaborating the search-cue iteratively until a matched specific memory is reached. Within the memories that are potentially matching with the search-cues, only the ones that are considered as congruent to the current *working self* can be activated, accessed and retrieved.

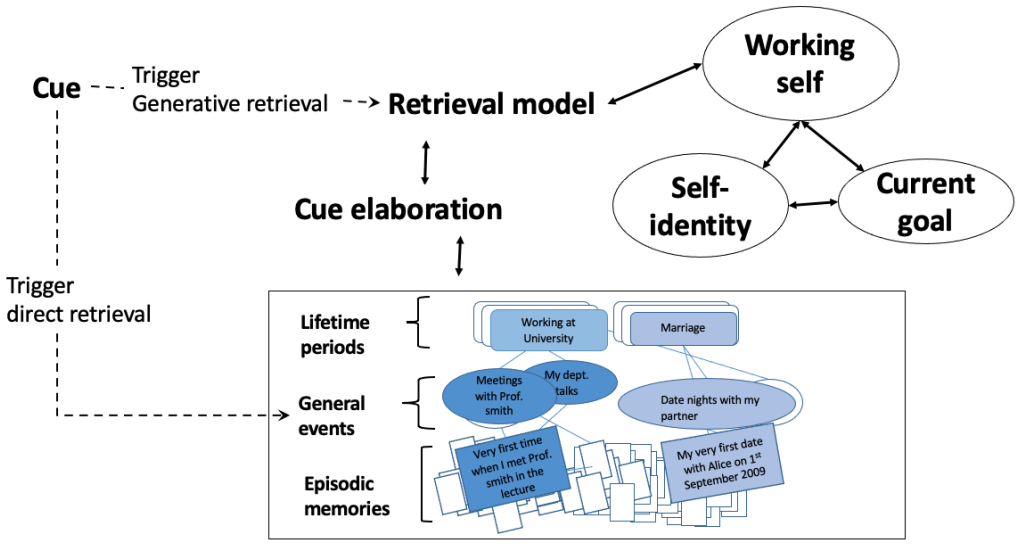

Figure 2.2: Simplified model of memory retrieval, adapted from Conway [31] (This figure visualise two types of memory retrieval processes triggered by memory cues).

- **Direct retrieval** (dashed arrow on the left side of figure 2.2) is triggered through cues with direct links to specific episodic memory, with less involvement of self-identity.

Depression-associated impairments in memory retrieval mainly lies in the generative retrieval process. Impairments in direct memory retrieval are mainly associated with mental health conditions such as Alzheimer's, which are not significantly associated with depression. Figure 2.3 illustrates how depression disrupt one's memory retrieving process, in comparison of the same process of individuals not living with depression.

2.2.3 Treating Depression Associated Cognitive and Autobiographical Memory Impairments

As one of the most effective depression treatment, CBT aims to reorganize individuals' underlying negative schemas into more adaptive and functional ones, through identifying and modifying their negative distorted cognitive information processing [39]. Under the umbrella of the broad CBT approach, another promising intervention is to address such cognitive distortions of depression by adjusting the **schemas** and **the negative-biased information processing**, through working with individuals' personal memory [39, 86].

Apart from CBT, a list of memory-based interventions have been developed

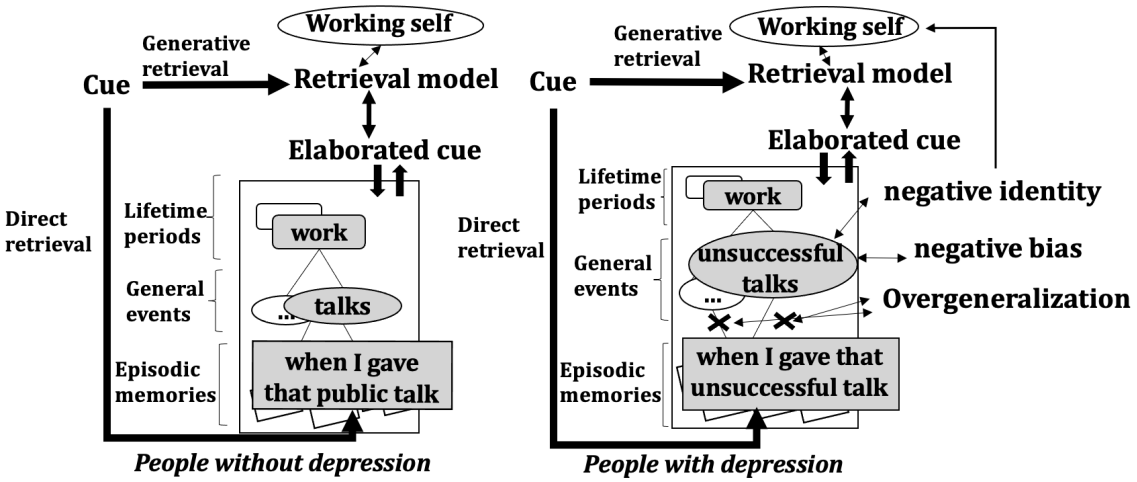

Figure 2.3: A visualisation of the memory retrieval process in people without depression (left), and with depression (right)

specifically for targeting this identified vicious cycle [39]. These interventions have a rich evidence base demonstrating their effectiveness. A meta-review and analysis of memory-based interventions by Hitchcock et al., [86] have provided a meta-review of such memory-based interventions for addressing depression-associated cognitive impairments, (e.g., over-general and negative-biased memory recall). However, these interventions are currently mostly conducted as lab-based experiments, and are not yet equipped with digital supports.

In short, for addressing depression, cognitive therapies (e.g., CBT) target the cognitive reconstruction to alleviate symptoms of depression, whilst memory-based interventions lay a foundation for this cognitive reconstruction by focusing on the processing of materials for cognitive re-appraisal. This thesis is mainly built on the theoretical approaches to addressing depression through memory-based interventions.

2.2.4 Session summary

This subsection reviewed theories for explaining the cognitive foundation that underpins depression, and it's interconnection with one's the Self-Memory System. The theories identified in this section provide the foundation which drive my field works reported in this thesis.

2.3 HCI Work in Memory Augmented Technologies

2.3.1 Overview of current memory technologies

Current memory technologies predominately support user needs in improving EM associated impairments by representing memory cues that explicitly target specific episodic memories [87]. For this, HCI work has explored lifelogging technologies such as SenseCam to help users capture and recall episodic memories in everyday life [172, 3, 78, 116, 117, 177]. Such supports could support individuals in reconstructing forgotten memories for later reminiscence [185], sharing emotional memories with others [110], regulating their emotions [96], and alleviating memory impairments associated with other memory loss conditions such as dementia [116].

Memory technologies are also being widely designed for supporting EM functions for people in the general population. One example of such a system is habit-tracking for individuals to recognise their behavioural patterns and identify changes over time. To support such needs, some researchers apply personal informatics technologies [13], which allow recollection and representation of end-users episodic data over time, revealing underlying behavioural patterns, and suggesting possible behaviour changes to end users. Besides, lifelogging technologies is also widely used for recollecting end users' memories and their daily events over time, with the aim of supporting their reminiscence [185, 47], mood regulation [97] and self-representation [38, 182].

The above illutrates the effort in the HCI community to support users better processing their episodic memories. HCI researchers have been widely aware of the needs from various user groups (with or without significant memory impairments [4, 79, 117, 177])in tracking self memories and maintaining self-identities [173]. However, since depression is a condition mainly associated with AM impairments, these memory technologies have not been adapted to the needs of users living with depression. This is surprising given that depression is a mental disorder with a few significant and distinguishable memory weaknesses, and addressing D-ABMs is a promising approach for alleviating depressive symptoms.

2.3.2 Systems supporting recollecting EM (Episodic Memories)

Episodic Memory (EM) contains highly detailed sensorial information regarding one's specific life events, which can become integrated within the AMS from where they can be vividly retrieved [33], or decay quickly and become forgotten. With the help of modern memory technologies (such as contextual sensors and massive digital storage techniques [179]), people can record more and more sensorial memory cues (e.g., visual

cues with camera [87, 115, 175], or verbal cues with microphones [47]) to support episodic memory processing in everyday life.

Such technologies can generate a huge amount of memory cues, which can be extremely challenging for users to review and make sense of without additional support (e.g. 1500 images a day [115]). However, not all memories have the same level of importance and have the same value for users to remember and reflect on. Thus, Sellen and colleagues [180] suggest selectively capturing episodic events for address particular memory impairments of end users. Other researchers also suggest filtering valuable memories at the moment of capturing the memory cues, either automatically (e.g., by filtering memories with high emotional arousal [175], or via users' manual selection (e.g., self-crafted memory cues [177]).

A framework is required to organize and represent the digital memory cues that are captured and accumulate over time. Recording captured memory cues and constructing them in a narrative representation is a method that aligns closely with users' preferences and natural habits [155]. Such work includes logging narrative diaries of everyday events, cues including video summaries [115], representation of bio-sensing data [183], or combined multimedia memory cues [143]. Viet Le et al. [115] created a narrative video summary of the captured images for story-telling of people's everyday life events, while Ståhl et al. [183] have created a visual representation of users' bio-sensing data through a narrative, visual representation. Additionally, Packer et al.,[153] created an online page collecting captured memory cues (location, images, and text desperation) in a narrative presentation form (e.g., personal narrative diaries).

2.3.3 Systems supporting the processing of AM (Autobiographical Memory) system

HCI memory research mainly focuses on the recording of self-memories for various reasons, such as supporting later reminiscence [185], or facilitating social communication via memory sharing between friends [102]). However, we should note that "capturing the memories" is not the same as "remembering the memories". As prior work [89] suggests, remembering is a process of re-construction within the self-memory system, and iterative retrieval of specific memories based on individuals' current beliefs. Retrieved memories will always be altered by people's current dominant self-beliefs, and their current interpretation of the memory. In other words, the captured memory cues are just data to help users remember, while remembering is a process of re-creating one's SMS, which is based on users' current beliefs, the relationships between memories and their current perspective on that event. People can neither recall all of their memories nor recall any of them without bias. The recollected memories will always be "twisted" by their currently dominant self-beliefs

and their current interpretation of their life stories. This is particularly concerning for individuals living with depression, as their negative-biased self-belief can disrupt their memory retrieval process [40, 86]. Therefore, prior researchers called for AM technologies with flexibility and can accommodate different impairments in memory retrieval [89]. More specifically, besides supporting the direct memory retrieval process by directly presenting EM memory cues, memory technologies can also be designed for accommodating the generative memory retrieval process for supporting users with AM impairments.

Besides supporting memory retrieval, end users living with depression can also benefit from systems designed for facilitating the re-construction of the current negative biased self-image. For example, one distinct characteristic of individuals living with depression is that they constantly recollect and ruminate on negative memories [39]. To address it, the design of memory technologies could consider helping such individuals to disengage from those negative memories, to retrieve such memories less frequently, and to strengthen their abilities in retrieving to more positive memories automatically. This process of selectively forgetting holds promise for making helping the users to develop a more positive perception of their life events which can eventually assist them with constructing a more positive self-image. This is because the intensity of their emotional reactions will fade over time, and negative emotions could fade faster than positive ones [202, 97].

However, HCI research has not widely addressed these important aspects of autobiographical memory impairments, especially how people's dynamically-changing sense of self can distort their ability to remember. These complex impairments arise in a variety of mental conditions, including autobiographical memory impairments in depression, and flashback trauma memories in PTSD. This thesis therefore aims to address the paucity of research into technologies designed to support memory impairments in depression.

2.3.4 Gap of designing memory technologies for depression

Little work has focused on building technologies to help people with difficulties in generative memory retrieval through autobiographical memory impairments. Experiment shows that depressed people have problems in generative memory retrieval, instead of direct memory retrieval [204] (figure 2.3). The AM impairments in depression (D-ABMs) are mainly caused by the negative self core beliefs [15], which is reciprocally interconnected with the dynamically formed AMS system [32, 33, 31]. Therefore, memory systems for depression need to be designed to facilitate the generative memory retrieval process, instead of the direct memory retrieval process. This also means the memory cues need to direct users to higher autobiographical memories levels (e.g., general events and lifetime periods), instead of the level of

EM. As text cues are the most widely used cues for triggering generative retrieval in psychological studies, such vague and abstract modality can serve this user group better than vivid and specific cueing modalities (e.g., picture cues).

Current memory technologies are predominately focusing on representing memories cues in the same format as they were captured. However, representing the same format is not always the best cueing method in all contexts. For example, Petrelli et al.,[155] identified the importance of abstracting low-level specific data into high-level representations so users could easily track their habits. A review of autobiographical memory technologies has revealed that, different modalities of memory cues can support different style of remembering [90], text cues can generate the largest number of memories compared to other types of cues (such as pictorial and verbal cues), while pictorial cues can encourage people to perceive the specific memories and relieving them specifically and deeply [90].

It is essential to stress the risk of presenting positive memories to users with depression, while designing memory technologies for this particular user group. Most HCI work in depression involving mood and memory tracking assume users could trivializing while looking at recorded positive memories. However, by cognitive nature of functional avoidance [39], depressed users could have resistance in retrieving specific details of their memories, but instead "spawn rumination process" with their over-general memories [39] and eventually being negatively impacted by the presented memory cues. Due to the nature of having low mood, people with a history of depression also show less mood improvement then never-depressed individuals from recollecting positive memories [102, 110]. For such individuals, directly looking back cues of past happy memories could actually lead them to compare happiness in the past with current sad mood, and contribute to a worsening mood [102], and even lead to rumination [39] and potentially lower their current mood. Additionally, even if depressed individuals try to recollect positive memories, such memories as normally "impoverished" [39], which means less vivid and not emotional intensive enough for such individuals relieve the happiness and improve mood.

Therefore, I would like to propose innovation in the representation of memory cues for serving the special needs of users living with depression. I propose that, instead of proving specific cues are directly pointing at a specific moment, the cues presented to users (with or at risk of depression) should be vague enough, so they have to challenge themselves and retrieve memories from their memory system. In the meantime, technologies should also provide guidance to assist users in retrieving memories until users retrieve them in detail, guide them through the resistance during the retrieving process, monitor users' thinking process, and stop users if they are distracted by rumination.

2.3.5 Section summary

This section reviewed the current state of HCI research into memory technologies, with the aim of highlighting the differences for users with memory processing difficulties that go beyond episodic memory loss. This was done to raise awareness amongst HCI researchers working on memory technologies of these differences [15, 16].

As depression is associated with distinctive memory impairments, I would like to argue that technologies designed for helping such a particular user group should particularly follow autobiographical memory theories [90], especially the ones in depression [40, 86].

2.4 Bridging clinical psychology research with HCI research and design

2.4.1 Complex user requirements of designing for depression-related cognitive impairments

Individuals living with depression often have a set of complex user requirements, which can be difficult to understand and to communicate to those who are not from a background of clinical psychology or mental health research. Therefore, for novice designers or researchers who are new to the field of depression-related projects, it can be exceptionally challenging to fully understand these requirements. The knowledge gap can limit designers' ability to create the best design to fit the needs of users with depression. For instance, one of the longstanding problem of digital depression intervention is having high user attrition rate. Such issues can be effectively mitigated by addressing a few distinct cognitive issues of intervention users with depression.

Having low motivation in engaging activities can also impact the effectiveness of depression treatment. As pointed out by prior researchers [186, 49, 128, 54], individuals with depression can easily drop-out from mental health interventions before finishing the full course. One reason for this is the difficulties users with depression experience with feeling like they can achieve successful outcomes from the treatments, which may lead to them eventually losing trust in the treatment [54]. This may be caused by a few distinctive goal setting and planning problems that are commonly found in individuals with depression [128, 49, 186].

For example, users with depression tend to set abstract goals that are difficult to measure, quantify, or track progress in achieving [186]. Therefore, individuals chasing such abstract goals often find it difficult to measure if their goal has been achieved or not. Consequently, abstract goals are more likely to induce frustration and a sense of failure in daily disruption of plans [186]. Moreover, depressed individuals tend to link

their sense of self-worth and happiness to the achievement of these abstract goals (i.e. "I will never feel happy unless I became *successful*" (here, "*successful*" is an example of one abstract goal that is hard to be measured or quantified))[49, 128]. Additionally, the highly abstracted personal goals and plans may facilitate heightened rumination, and individuals who pursue more abstract goals appear to become stuck while trying to fulfill these vague cues. This triggers cycles of rumination (i.e. "why don't my plans ever work?") [49] and further maintains depression.

Addressing the cognitive issues, namely GAP (goal setting and planning) difficulties [128, 49, 186], can be an effective way of improving users' engagement to the intervention sessions. For example, to avoid service users underestimating their progress and achievements, researchers have suggested intervention components such as reminding users of the efforts they have expended towards the goal/ treatment, and helping them to identity a more concrete method of measuring the gains they have made as result of engaging in the treatments [107, 186]. GAP difficulties in depression are also associated with the development of depression symptoms, and have a link with the depression associated memory impairments [86, 39]. The skill of goal setting and planning [128] is essential for mitigating depressive symptoms and D-ABMs (depression associated memory impairments) [129, 39, 86]. For example, the sustained engagement in potentially positive activities can help break up the ruminative cycle and reinforce positivity.

Prior studies [128, 49, 186, 86, 39] have shown the importance of addressing these issues for improving service users' well-being and moderating depression. However, such complex users requirements are often overlooked by HCI designers while developing systems for depression due to the challenges associated longstanding gap between academic research and design practice.

2.4.2 Communication gaps between clinical psychology research findings and HCI design practice

It is common for HCI researchers to base their design decisions on prior academic findings. For example, theories can support the selection of functionalities for a system and ways to implement them [83]. For instance, UbiFit [30] encourages end users to make specific and measurable weekly goals, informed by goal-setting theories [123]. Another common practice is to develop design guidelines from empirical work, in the form of design implications [57]. However, researchers have pointed out that design implications may not be sufficient to drive industrial application [22, 57, 149, 28], and may prove to be difficult for practitioners to understand and use [28, 22, 57, 149].

Research has found that one of the main reasons why practitioners do not incorporate theories into their design process, despite being interested in doing so, is that academic findings are often presented in a way that is hard for practitioners

to apply [22, 57, 149]. Prior HCI work has identified such challenges faced by UX and interaction designers who wish to apply psychology-based or ethnographic study-based resources in their design practiceas the *research-practice gap* [28, 26, 149, 50].

The reasons for this *research-practice gap* are twofold. 1) Traditionally, *experts in design* and *researchers* have different requirements, skill sets, and goals. *Designer practitioners* seek to create usable products to address clearly defined user requirements. In contrast, *researchers* mostly produce recommendations, guidelines, or design implications [57, 20, 149]. These may influence requirements, but such outputs are rarely formulated as requirements. 2) Empirical findings generated by *researchers* are rarely presented in actionable, ready-to-use format [22, 176]. Thus, they are more difficult to apply for *designers*, especially under time constraints [22].

In the domain of HCI, the boundary between research and design work is often blurred. HCI researchers have started to explore design methodologies to bridge the gap between psychology research and design practice by creating *theory cards* and employing them in workshops [26, 28]. However, prior works have mainly applied general psychological theories targeting healthy individuals, with less complex user requirements than people living with mental health difficulties [20]. Examples of such materials being developed for supporting design work includes design guide books [62] and strategy cards [26, 74, 70]. Colusso et al. [26] further examined the feasibility of utilizing such theory-informing materials in HCI design practice by applying them to the design process through design workshops. Existing research has used cards in the design process to introduce playfulness into the design [127], support the game design process [145, 46], and more recently to communicate metaphorical descriptions of depression experiences and the demonstrated postures of the individuals with depression [174].

However, prior research [28, 26, 62] has primarily aimed to apply general psychological theories (e.g., behavior change theories [26]) to non-clinical user groups. Whereas the theory-practice gap is even larger in the domain of HCI for mental health [28, 165, 83, 22, 93, 50], due to the specific complex needs of target users [148, 162, 181, 184], and the expert knowledge needed to support them. Therefore, there is an opportunity to extend these methods to present profiles of users with complex needs and challenges. This is particularly important when designing healthcare systems for depression. It is essential to effectively communicate the complex user needs and requirements [20] (e.g., D-ABMs, GAP) to generate the best designs [36, 166] .

For instance, users with depression may experience difficulties in processing and retrieving positive memories due to depression-associated autobiographical memory impairments [86, 39]. Overlooking these specific depression-related requirements may reduce the efficiency of mobile-based treatments for depression [161, 162] or even cause harm to service users making use of a product that was not specifically designed for them [161]. Therefore, it is essential to explore novel theory-informed methods

to better support designers' understand the relevant psychology theories and the complex challenges user requirements. Promoting interdisciplinary research involving HCI designers and health researchers or practitioners is one of the most sensible way forward to this issue, with HCI researchers already stressed the importance of engaging end-users and domain experts in the design process [36]. However engaging patients or clinicians is often a challenge in early stage of UCD design works in the mental healthcare domain, due to potential ethical risks and the complex procedures needed to safeguard service users [20], clinicians, and researchers [144, 58]. To help lower the barrier and better promote interdisciplinary research and design works for digital technologies for depression, this thesis aims to bridge the gap between these two distinct domains. New design methods will be explored and proposed to facilitate designers generating theory-informed design solutions before engaging with domain experts in later design stages.

2.4.3 Section summary

This section provides an overview of the complex user requirements and current HCI practices in bridging the research-practice communication gap. The review in this section aims to reveal the complexity of bridging clinical psychology research results and HCI research and design practice. The complexity lies in two features: 1) designing a system targeting end users with complex requirements driven by depression-associated cognitive and memory impairments; 2) bridging the *"research-practice gap"* by communicating the complex user requirements to designers who do not have background knowledge in clinical psychology.

The section further indicates the need to address the challenge of incorporating clinical theories into design practice, especially when designing for individuals with mental health conditions. This provides an theoretical background and motivation for the research work that is reported in this thesis.

2.5 Summary

Building upon the understanding of current practices in managing depression and its associated cognitive (memory) impairments, I identified the design opportunities in introducing digitized D-ABM supporting tools in advancing such technologies. For instance, to improve the user engagement by introducing training materials that are individually tailored according to their life narratives. I further confirmed the opportunities for D-ABM technologies to advance current HCI research in assisting memory processing. This motivates the research studies 1-4 (in chapter 4), which investigates the design of mobile apps for D-ABMs. Finally, I reviewed the current challenges of generating HCI design that are draw on complex empirical theories.

This motivates study 5, which explores ways to help future designers to bridge the theory-practice gap, and generate theory-informed D-ABM app design.

Chapter 3

Methodology

3.1 Introduction

This chapter provides a description of the research methodology, including a list of methodological approaches that each study within the thesis follows, a description of how I applied them in each of the research studies, and my approaches to data collection and analysis.

3.2 Research Approach

This thesis mainly follows the *interpretivism* paradigm [44, 82], which emphasises the exploration and understanding of the phenomena(s) and within the natural (ethnographic) settings where they occur [44]. I excluded *positivism* as the study cannot fit it's driven criteria (i.e., having pre-defined hypothesis that can be generated testing). This is because the domain of depression-associated cognitive impairments is a relatively new area and therefore lacks such pre-defined hypothesises. Additionally, findings in the *interpretivism* paradigm are usually produced from rich data with nuanced and intricate details, which can reveal the values and human experiences that relate to the phenomena being investigated [44]. Following this research paradigm, I mainly applied qualitative research methods while investigating my research questions [44] (table 3.1).

Harrison et al., [77] have proposed the three paradigms of HCI for describing the epistemological distinctions among the three paradigms:

1. **Human Factors**, which consider interaction as *"a form of man-machine coupling"*, with the aim of optimizing the the machine behaviors for its best fitting human (end users') requirements.

Research studies	**Participants**	**Data collected**	**Data analysis method**
Exploring theory-based intervention (Study 1)	-	Literature of selected D-ABM interventions	Content analysing the selected literature
Exploring practice-based treatments in clinical context(Study 2)	Clinical experts on depression	Audio recording of interview sessions	Thematic analysing the audio records of the semi-structured interviews
Identifying best app features (Study 3-4)	-	App information extracted on the website, the downloaded apps	Systematic evaluation of selected and downloaded apps
Bridging the theory-practice gap (study 5)	HCI experts and designers	Written note collected from design sprint sessions, audio record of follow-up interview sessions	Applying thematic analysis to the notes collected from the design sprint session and the audio record of semi-structured interview

Table 3.1: Overview of research studies, participants, and research methods

2. **Classical Cognitivism/ Information Processing**, which views the interaction between human and computer as *" enabling the communication between the machine and a person"*, with the ultimate aim for machines to facilities users to achieve a series of goals that can be measured or systematically measured.

3. **Phenomenologically Situated**, which views the human-computer interaction as *"phenomenologically situated"*, with the goal for *"supporting situated action* and *meaning making in specific contexts"*.

Given the epistemological position of this thesis being aligning with the paradigm of *interpretivism* and *phenomenologically-situated*, this thesis focuses on collecting knowledge that based on individuals' living experiences from different domains and perspectives, from conducting:

1. Interviews studies with the depression experts in study 2 (chapter 4),

2. Experimental evaluation [98] with HCI experts in study 3-4 (chapter 4),

3. Interviewing HCI experts in study 5 (chapter 5)

3.2.1 Study 1: Content Analysis of published literature

- **Procedure and Methods**: Study 1 aims to understand the key component of current state-of-the-art psychology interventions being particularly designed to treat D-ABMs. As the start of this thesis work, study 1 is an exploratory study of the four most evidence-based interventions with D-ABMs. It comprises two main steps: (1) identifying four interventions from reading a systematic review and meta-analysis of memory-based training for mood-related disorders [86], (2) analysing each intervention with using a content analysis method [59, 91].

- **Data collection**: To identify the interventions, I firstly collated a list of memory-based interventions from reviewing key literature related to memory impairments in depression, and listed the interventions standout from these review papers. The main source of reference rely on the research from Hitchcock et al., [86] and Dalgleish[40], as they provide thorough review of memory impairments in depression. I checked the reference lists of the articles obtained through in-depth reading of the identified meta-analysis [86, 39] to uncover the listed studies that associate with the identified memory-based interventions. In particular, I identified most interventions from the meta-review by Hitchcock et al., [86], which provides a systematic search and evaluation of D-ABM related psychology literature. In this paper, the evidence of each reviewed interventions were graded in four levels (high, moderate, low, and very low [86]). At the time

of accessing, this meta-analysis paper had one of the highest citation rate in the preceding 10 years.

After identifying the four interventions with the most-proven clinical effectiveness. I then searched keywords of each of the named memory based interventions (e.g., "MEST", "CNT" through major research article data bases) in online publication database to extract the literature where these interventions were published in.

- **Data analysis**: I extracted description of each intervention setting from the literature that are relevant to the selected memory interventions (e.g., MEST [164, 139], CNT [60], COMET [111], CBM-I [18, 21, 61, 207]). I then synthesised the data, following a content analysis method [59, 91] using a hybrid thematic analysis method [65]. An example of this analysis process can be seen in the table shown in figure 3.2.1).

  The initial coding involved each selected interventions' name, main procedure, their key value to their targeted memory deficits, as well as the formality of their input and output (see table 3.2). I also accessed the literature relating to other aspects of each intervention, such as intervention settings (i.e., if the intervention is group-based or individual-based; if therapists' supports are needed; duration of each intervention), and the expected outcome. To identify the design potential of memory technologies such as life-logging for supporting these interventions, I also identified key concepts as initial coding categories that were informed by existing theory or prior researches as through the lifelogging lenses.

  Following content analysis methodology [91, 59], each of the four interventions were analyzed respect to its aim, measures of success, and context of use and materials. To identify the design potential of memory technologies such as life-logging for supporting these interventions, I also identified key concepts as initial coding categories that informed by existing theory or prior researches as through the lifelogging lenses.

3.2.2 Study 2: Inductive, qualitative interview with domain experts

- **Procedure and Methods**:

  Study 2 explored the current practice of treating D- ABMs in clinical settings, with the aim of generating implications to guide the design of D-ABM apps. It applied qualitative, semi-structured interviews, which is a commonly used qualitative method for collecting data [48]. It allows in-depth exploration into a wide range of interviewee's experiences from a set of predetermined questions,

Inter-vention	Target	Aim	Main practice	Context	Duration	Input	Output
MEST	Overgeneralisation	Improving the ability to retrieve specific memories as much as possible. Recognising the warning sign of starting over-generalisation, and improve the ability to stop it and come up with a opposite positive one	Repeatedly practice to retrieve specific memory from cue words	Group training alone with other patients guided by therapists	5-6 weekly training(80 min each)	- Guided instructions (from therapist) -Cue words	Patients have to retrieve as much specific memories as possible for each cue words
CNT	Overgeneralisation Rumination	Reducing negative **overgeneralisation (categorical memory)** and subsequently rumination, by requires individuals to repeatedly make concrete interventions of their experiences.	Look back at difficult events in the past and analyses them in concrete style	Individual (guided self-help intervention at home)	1.5h face-to-face session+ 6 weekly training	(CD) guided-instructions	- Patients have to generate a conclusion of their past events, descrbe major cause of each difficult event, rate the extent to (internal, stable, global)
COMET	Negative attentional bias(low self-esteem) Rumination	Mitigating dysfunctional processes of rumination & avoidance around personal autobiographical material.	Build positive self-image as opposite of current negative self-image, repeatedly enrich the material and practice to get involve with such self-image	Small group based. Led by therapist	7-8 weeks. Weekly training	Self-generated from patient	-Identity the negative self-image -identify the positive self-image -writing self-relevant stories of instances with positive selfs -manipulate body posture and facial expression -active positive self with previously generated materials
Imagery CBM	Negative-oriented interpretation bias	Trigger automatically positive thoughts flashes in mind in everyday life scenarios	Repeatedly imagine oneself in a scenario, that starts from neutral, ends with positive	Individual (At home)	4 week. 12 session in total	Description of scenes(verbal +pictorial)	Use mental imagination to relive in described scene User mental imagination to combine the picture and the caption

Figure 3.1: Visualisation of how I analysed each literature-based D-ABM interventions using content analysis method.

Name of code	**Description of code**
Name	The name of each intervention
Main Procedure	Summary of the procedure of each memory interventions (e.g., contextual settings, duration)
Addressed memory deficits	The memory deficits that targeted by each memory-based interventions; The key value of each memory interventions to the improvement of targeted memory deficits
Input and output cues	The cue modality and content of the current input materials; The modality and content required to be generated from the end-user

Table 3.2: List of codes for the content analysis

and leaves space for free-form exploration of each participants' individual experiences [48]. This study have been approved by the Lancaster University FST ethics committee. Ethics documentation of this study can be seen in appendix F.

- **Participant recruitment**: For gaining the most in-depth understanding of the current practice of D-ABM therapeutic approaches, study 2 was conducted with 10 domain experts working with depression with in average 15 years of experience in working with depression. Participants were recruited through email advertisements circulated via an online database of clinical practitioners and researchers (e.g., the maillist of CBT associations).

  Among the ten recruited, eight participants (P1, P2, P3, P4, P7, P8, P10) had expertise in treating depression in clinical contexts: seven (P1, P2, P3, P4, P8, P10) mainly practised CBT, and one (P7) practised D-ABMs treatments (i.e., MEST). The other two participants (P5, P9) were less active in the clinical context at the time of the study, and were mainly performing experimental psychology interventions in lab settings. Additionally, five participants had Ph.D. degrees in Psychology, four had postgraduate degrees (MA, certificate, diploma) in psychotherapy, while another one had a BSc degree in psychology. Six participants were from the UK, while four were from mainland-Europe (Belgium and the Netherlands). Details of the recruited participants can be seen in table 3.4.

- **Data collection**: During the interviews, I followed a semi-structured interview

Participant' expertise	**Experience in detail**	**Context of practice**
CBT therapist: P1, P2, P3, P6*, P8, P10 Psychiatric nurse: P4 Neuropsychologist: P7*	Depression expert in clinical practice (8)	Private context (2). Hospital (5)
Memory training in depression (P5, P6*, P7*, P9)	Neuropsychologist (4)	Lab (all), hospital (2)

Table 3.3: Recruited participants of study 2 (* means the participant has both specific D-ABM domain knowledge and clinical practice experience)

guide to ask participants about their experience in addressing memory-related impairments while working with clients living with depression. The interview guide comprises three structured themes inspired by the three D-ABMs (i.e., overgeneralization, negative-bias, reduced positivity) that were produced from the results of study 1.

Within each theme, interview questions were designed for exploring participants' individual approaches for addressing each of the memory-impairments (theme), their experience and opinion of these approaches, and the challenges they encounter in practice. For instance, the questions in theme 2 (I.e., Over-generalization) includes "Have you worked with clients with overgeneralized memories?", "Have you tried to address this overgeneralization problem, if so, how?" Besides the structured themes, the interview guide also include space for unstructured questions that allows further exploration of the approaches each interviewee mentioned. For example: "For the [therapeutic approach you just mentioned], could tell me more about the latest time you use it in detail?"

The interview sessions were carried out individually through phone or Skype calls. Each intervention session lasted about an hour, were audio recorded and fully transcribed. In total the 10 semi-structure interviews sessions, lasted 9 hour 40 minutes of audio data was recorded, using the the pre-installed Voice Memo's App on my personal mobile phone (iOS, iPhone X) with written verbal consent from the participants. I transcribed each audio recording following a standard procedure [10] (also can be seen in the ethics documentation attached in appendix F).

- **Data analysis**: Study 2 used a hybrid form of thematic analysis method [65], which ensured that themes were partly grounded in the literature and partly derived from our findings, offering the advantage of balancing the knowledge of existing theory with the sensitivity to theoretical novelty. The hybrid method

combined both a "top-down" deductive and "bottom up" inductive coding method. I collected different experts' approaches for treating each identified D-ABMs through deductive coding, which is supported by a conceptual framework developed from study 1 and prior literaturex. For example, impairments such as overgeneralization, negative bias, reduced positivity, or memory processes such as encoding or retrieving. I then took a closer look at the approaches through inductive analysing methods, in which news codes started to emerge (e.g., approaches such as encoding positive memories or retrieving negative memories). After I completed the interviews and the initial coding, I shared, discussed, and iterated these codes with quotes with all authors in weekly meetings. The data analysis process took over three months, until agreement was reached regarding the final list of codes and their definitions.

3.2.3 Study 3 and 4: Systematic evaluation of mobile applications

- **Procedure and Methods**: Study 3 investigates the best combination of app functions that can be included in D-ABMs apps, while study 4 explores the app functions for global depression management. For this, study 3 explores the existing app features provided by the intersection of depression apps and memory apps, while study 4 particularly access the app functions provided by depression app.

  The app analysis reported in study 3 and 4 comprises four steps:

  (1) Systematic searching for target apps within the two major mobile app marketplaces (i.e., iOS and Android),

  (2) Identifying top-ranked, relevant apps from reviewing their information on the marketplace (e.g., app reviews, app rating score),

  (3) Filtering apps by employing a set of inclusion and exclusion criteria

  (4) Reviewing app descriptions (information extracted from both marketplace and the app's own website) and access apps using experimental evaluating [99] method.

- **Searching target apps**: Both study 3 and 4 yielded target apps from systematically searching the two major mobile app marketplaces in Spring 2019. I have identified two key groups of apps (i.e., memory apps and depression apps). Study 3 reviewed the apps fall in the intersection of group 1 and 2, while study 4 take a closer look at apps from group 2.

  - **Group 1, Memory apps**: Apps that self-identity as targeting users' general ability of processing emotional and daily memories. The keywords used for retrieving apps for memory processing, were: "diary", "mood tracker", "mood memory", "journal", and "daily event" to capture apps that support recording and retrieving of daily emotional events. Initially, 3119 memory apps were yielded.
  - **Group 2, Depression apps**: Apps that self-identity as targeting depression. The keywords used for retrieving the apps for depression is "depression". Initially, 482 depression apps were yielded.

  To extract and record information of all apps yielded, I entered the identified keywords to the identified app searching engines (App crawler and Google Play), and recorded all apps shown in research results with a script [69]. The script automatically downloaded information for each app from its marketplace, including name, category, marketplace description, price, review score, and number of reviewers. Since study 3 and study 4 focus on reviewing top-rated, publicly available apps targeting primarily depression, I decide to only include apps with high scores (i.e., 4 out of 5) that balances the review from at least 100 users.

- **Inclusion and exclusion of selected apps (study 3):** For extracting apps for assisting memory processing and depression management, I filtered the apps of group 1 and group 2 separately. The apps that meet the following criteria were excluded: 1) have less than 100 reviews, 2) are in irrelevant categories, 3) fail to mention keywords such as "depression", "diary" or "mood" in either title or description, 4) are not accessible at the time of selection, 5) had average user review scores lower than 4.0 (out of 5.0). The combined process resulted in 34 memory apps and 35 depression apps that meet the inclusion criteria. After removing duplication, 20 apps were finally selected for further evaluation (see table 3.5), which includes 7 apps yielded from searching memory-related keywords, 9 apps from depression keywords, and 4 apps yielded from searching both keywords.

- **Inclusion and exclusion of selected apps (study 4):** 444 apps from the initially yielded 482 depression apps were included in the later selection after removing duplication. Of these 444 apps, I further excluded those that (1) had less than 100 reviews; (2) were inaccessible at the time of selection; (3) belonged to irrelevant marketplace categories such as social, casual, business, news, or book; (4) had average user review scores lower than 4.0 (out of 5.0), and (5) did not focus primarily on depression (The criteria includes: (5.1) the words "depression" or "depressed" do not appear in the app's title or marketplace

description of the app, (5.2) the primary target is not people with depression (eg, yoga tracker), and (5.3) their marketplace description mentions that people with depression should not use the app. These criteria led to 31 apps, from which I have further excluded 2 more apps as their functionality was limited to the provision of therapy sessions to be purchased in-app. The remaining 29 apps were analyzed in this review (see table 3.6).

- **Reviewing app content**: The data includes app content as descriptive information, and as app-supported features. For reviewing the descriptive information, I visited each of the app's website and information page on the marketplaces (i.e., Apple store for iOS, and GooglePlay for Android), and manually extracted the descriptive information of each selected apps. The textual descriptive information extracted includes each app's name descriptions, customer rated scores and reviews on the marketplace, and data supporting analysis of ethical aspects such as the privacy policy.

  I accessed the selected apps through directly interacting with the app's functionality as HCI experts [101]: I also downloaded and all the selected apps that finally met the inclusion criteria, and manually recorded the features that I have identified in the excel sheet. In total, 29 apps were downloaded and examined in study 3, and another 20 apps were downloaded and examined in study 4. To fully experience the reviewed apps, the time I spent in using each apps were ranging from 30 minutes to 2 days, and record the functions I found provided by the app.

  I then used a hybrid method to analyse the app provided functions. Informed by prior work [1], The deductive codes consisted of 3 main types of functionality of depression apps: screening, tracking, and provision of interventions. Under each functionalities being identified above, I applied an inductive coding method to identify the specific sub-codes. For instance, the screening function was broken down into sub-codes such as symptom monitoring, self-diagnosis, and basis for personalization (details in appendix C).

3.2.4 Study 5: Qualitative evaluation of design materials

- **Procedure and Methods**: Study 5 explores ways of bridging the theory-practice gap of D-ABMs. This includes three steps: (1) creating a design supporting toolkit base on D-ABM theories, (2) distributed the design toolkit in design sprint workshop sessions to observe how HCI designers react and use these materials [2, 126, 27], (3) arranging follow-up interview with each of the designers individually to understand their experience.

- **Participant recruitment**: As the aim of study 5 is to involve participants with knowledge of HCI design process, participants are recruited with the following criteria: 1) they are currently taking, or have taken Human-Computer Interaction courses, 2) they have experience of interaction design, and 3) they have no prior knowledge or experience working in the mental health field. Including only such group of participants allow me to observe how participants gain knowledge from the theory-informed materials without being interfered by their prior domain knowledge.

  I initially recruited academics or designers in the field of HCI show interest in participating in the study through sending email invitations through research institutions. In the end, I have managed to recruit 15 participants (11 males, 4 females) through snowball sampling methods. All participants were over 18 years old. Of the 15 participants, 12 were enrolled as PhD candidates, 2 were academics with background knowledge in HCI, and 1 had completed HCI modules as part of a Bachelor degree and had prior experience in HCI research. Participants worked in the fields of engineering, sustainability, and virtual/augmented reality. In total, I conducted 5 workshop sessions each with 3 designers (altogether 15 HCI experts) while 10 out of these 15 participants participated in the follow-up interview study. This study have been approved by the Lancaster University FST ethics committee. The ethics document can be seen in appendix G.

- **Data collection and analysis**: The data that was captured in study 5 included the design ideas generated in the workshop (i.e., participants' written note during the workshop), and audio recordings of the follow-up participant interviews. The data generated in study 5 includes audio record and pictures (i.e., written notes) taken from the workshop sessions, and the audio record collected from the follow up interviews with 11 of the 15 workshop participants (i.e., audio recordings). These individual interviews - held online - explored participants' experience of the workshop. The semi-structured interviews aimed to elicit participants' experience of the design sprint process. Participants were interviewed via a video-conference tool (Microsoft Team or Skype).. For the follow-up interview study, a total of (11 hours 41 minutes) 701 minutes of audio was collected, with on average 1h per participant. One interview record was inaudible due to a technical issue.

  I then transcribed the other 10 audio recordings into textual format, following the Braun and Clarke approach to thematic analysis [25]. Hesitations, false starts, and cutoffs in speech were signaled by a dash (-); three full stops in a row (...) indicate editing of the transcript for brevity. The transcription process took around a week (32 hours).

The coding involved repeated readings of the transcripts by myself and my collaborator (Dr Camille Nadal, one of my collaborators in study 5 (manuscript can be seen in appendix E) using a inductive thematic analysis method E). The codes were mapped out, revised and reworked in consultation between myself and Camille. Both authors has iteratively produced codes and discussion in the final analysis. For supporting the data analysis process, I used the ATLAS.ti [192] software, which is a specific tool for qualitative data analysis and dataset management. For example, to arrange the inductive codes that generated, merged and adapted iteratively during several rounds of coding process.

3.3 Summary

This chapter provides an overview of the research method applied for each studies in this thesis, through exploring evidence-based approaches gathered from conducting in-depth interview with domain experts (study 2), from analysing top-ranked apps (study 3 and 4), and the exploration of design supporting toolkit to facilitate future designers to quick understand the background theories in specific domains, and generate theory-based design (study 5).This chapter also discusses the methods I used for analysing the data that generated from each of the research studies, as well as the methods for data sampling and participant recruitment.

ID	Gender	Years of experience	Method, Role, context	Country	Qualification
P1	Female	13 years (qualified for 10 years).	CBT, Private counsellor, private counselling	UK	Master of Arts (Integrative Psychotherapy and Counselling).
P2	Female	8 years	CBT, Therapist, (Physical) rehabilitate center	UK	PhD degree.
P3	Female	21 years	CBT therapist, NHS	UK	Bachelor of Arts (Psychology).
P4	Male	30 years	CBT, Psychiatric nurse, Secondary health care hospital	UK	Postgraduate Diploma (PGDip).
P5	Female	10 years	Researcher of neuropsychology (memory-based interventions for depression), working with laboratory data (analysing and synthesising).	UK	PhD degree.
P6	Male	17 years	Lead researcher of neuropsychology (MEST) & applying and supervising CBT therapies in clinical setting.	Belgium	PhD degree.
P7	Female	6 years	MEST, Clinical psychologist- Psychiatry hospital	Belgium	PhD degree.
P8	Female	10 years	CBT therapist, Private counsellor	Belgium	Postgraduate degree (clinical therapy).
P9	Female	10 years	Neuropsychologist, expertise in depression-associated memory research	Nether lands	PhD degree.
P10	Female	24 years	CBT& counsellor in private practice	UK	MSc (Advanced Cognitive Behavioural Therapy).

Table 3.4: Information of interview participants

App_ID	**App name**	**Tracking mood patterns (15)**	**Tracking thought patterns (13)**	**Encouraging positive activities (14)**
P1	Abide			Yes
P2	Daylio	Yes	Yes	Yes
P3	Fabulous: Motivate Me!			Yes
P4	Medication Reminder & Pill Tracker			Yes
P5	Mindfulness Daily	Yes	Yes	Yes
P6	Moodpath	Yes	Yes	Yes
P7	MoodSpace		Yes	Yes
P8	Pacifica	Yes	Yes	Yes
P9	Stop, Breathe & Think	Yes		Yes
P10	Youper	Yes	Yes	Yes
P11	Happify	Yes	Yes	Yes
P12	MoodKit	Yes	Yes	Yes
P13	What's Up?	Yes	Yes	Yes
P14	Wysa	Yes	Yes	Yes
P15	Chronicle		Yes	
P16	Gratitude Journal 365 Pro		Yes	
P17	iMoodJournal	Yes		
P18	MyMoodTracker	Yes		
P19	Pain Diary	Yes		
P20	UP!	Yes	Yes	

Table 3.5: Information of selected apps (study 3)

App_ID	**App name**
P1	Aware: Meditation & Mindfulness
P2	Breathe Easy
P3	CBT Thought Record Diary
P4	Cognitive Diary CBT Self-Help
P5	Depression CBT Self-Help Guide
P6	Depressive and sad wallpaper
P7	Disappointment Quotes
P8	eMoods Bipolar Mood Tracker
P9	Fight Depression Naturally
P10	Hypnosis for Anxiety, Stress Relief & Depression
P11	InnerHour - Self Help for Anxiety & Depression
P12	Lonely Wallpaper
P13	MindCare: mental well-being analytics made easy
P14	Mood Log
P15	MoodKit - Mood Improvement Tools
P16	Moodpath - Depression & Anxiety Test
P17	MoodSpace
P18	MoodTools - Depression Aid
P19	We are more - our support network (Original name: Reachout: My Support Network)
P20	Relieve Depression Hypnosis - Mood & Anxiety Help
P21	SuperBetter
P22	T2 Mood Tracker
P23	TalkLife
P24	The Szondi Test: Research of Depression
P25	ThinkUp: Positive Affirmations
P26	What's Up? - Mental Health App
P27	Wysa: stress, depression & anxiety therapy chatbot
P28	Youper - Anxiety & Depression
P29	Depression Test

Table 3.6: Information of the selected apps (study 4)

Chapter 4

Exploring the Design of Apps for Autobiographical Memory Impairments in Depression

4.1 Identifying Requirements of App Design

This study reports a fieldwork that I have conducted with supervision from Professor Corina Sas (as my main supervisor at the time), with the final phases of the project finished with joint supervision from Dr Gavin Doherty. Besides the supervision from Professor Sas and Dr Doherty, I solely undertook the research work, including participants screening, recruitment, study execution, data collection, transcription, analysis. The data and findings from this chapter have been published as a full paper in the 2019 Conference on Human Factors in Computing Systems [159]. The project idea, coding refinement and paper writing was iteratively refined through discussion with Professor Sas (mainly) and Dr Doherty (secondary) in weekly meetings.

Prior work has indicated that addressing autobiographical memory impairments (D-ABMs) can reduce symptoms of depression and prevent relapse [39, 86]. Several face-to-face interventions are specifically designed for treating the D-ABMs [86]. Mobile apps have the potential to support the delivery of these interventions. However, it is unclear if and how mobile apps could support these interventions. To investigate the design opportunities for mobile apps in this space, we need to understand current best practice relating to the treatment of D-ABMs. In order to explore this, I conducted two studies:

- **Study 1** explores state-of-the-art theory-based interventions that are specif-

ically designed to treat depression by manipulating how individuals process their autobiographical and episodic memories [86]. Currently, most of these interventions are experimental and applied only in laboratory settings.

- **Study 2** expands the exploration to a wider range of practice-based treatments. Different from the interventions reviewed in study 1, these treatments may not be specifically designed for D-ABMs but involve elements with the potential to be used for addressing the challenges associated with clients' processing of self memories. These treatments are mainly used in clinical settings.

4.1.1 Study 1: Exploring state-of-the-art interventions designed to target autobiographical memory impairments in depression (D-ABMs)

4.1.1.1 Background and objectives

To understand the existing theories relating to memory impairments in depression and its treatments, I decided to start by exploring experimental interventions. This is because the issue of D-ABMs is well explored in the psychology domain [72, 205, 122, 40], with several intervention strategies (e.g., MEST [164, 139], CBM-I [18, 21, 61]) being developed and already shown to have potential in managing depressive symptoms [86, 39, 72, 39]. Currently, these experimental interventions are the most promising treatments for addressing D-ABMs; they are fully grounded in psychology theories. Evidence of their effectiveness in mitigating depressive symptoms has been reported in peer-reviewed publications across different fields of psychology (e.g., cognitive psychology [39], experimental psychology [40, 204] and clinical psychology [86, 72]). However, these these treatments are mainly base on traditionally face-to-face setting, and little technologies (e.g., mobile apps) are designed to support them.

To explore this, I conducted study 1, which aims to (1) investigate the key mechanisms underpinning the theory-based interventions for D-ABMs, and (2) identify the design opportunities for mobile apps to support these treatments. I analysed four theory-based interventions that have been proven effective in addressing D-ABMs. The interventions (including MEST [164], CNT [60], COMET [111], and CBM-I [207]) were identified from a recent meta-analysis of memory-based interventions for depression [39]. In the analysis, I examined the interventions in terms of two key features:

(1) The key memory challenges targeted by each intervention, especially the issues in coping with emotional memories in depression,

(2) The key procedure of each intervention for addressing these challenges raised by D-ABMs (see table 4.1).

Interventions	**Main procedure**	**Main memory deficits targeted**
Memory Specific Training (MEST) [164]	Guided by trained therapists, this intervention presents a series of cue words, and asks people to retrieve as many specific memories as possible.	Overgeneralization
Concreteness Training (CNT) [60]	This intervention requires people to repeatedly imagine the sensory details, warning signs, and actions related to difficult events and to reflect on them in a concrete manner.	Overgeneralization, Rumination
Competitive memory training (COMET) [111]	This intervention asks people to identify a positive self-identity, enrich it iteratively and practice such imagination over several sessions.	Rumination, Negative bias (negative self-image)
Imagery Cognitive Bias Modification (CBM-I) [113]	This intervention asks people to imagine themselves involved in prescribed scenes. The scenes start ambiguously and are resolved positively.	Negative bias (future-oriented scenario)

Table 4.1: Overview of four interventions targeting memory impairments in depression

By revealing the underpinning mechanisms identified from these interventions, I reflected on the design opportunities for mobile applications to support the delivery of such interventions. The reflections are reported as design implications that discuss what mobile app features can be leveraged to support end users' memory functions. I particularly focus on memory technologies (e.g., life-logging tools), as these have been specifically developed to assist users' memory processing. Even though these memory technologies are not specifically designed for assisting end users with depression, some of their functionalities still have the potential to be used for addressing the memory processing disruption in depression.

4.1.1.2 Main findings

I discuss the key findings in this study from two standpoints. The first illustrates the main mechanism of the selected memory-based interventions, whilst the second discusses the design implications regarding how mobile-based memory technologies could support delivering interventions in a digital manner. I now present the main mechanism of current theory-based treatments (table 4.1).

1. **Commonly memory impairment targets of theory-based memory**

treatments for D-ABMs

- **Negative bias.** As highlighted by COMET [111, 40], individuals with depression tend to have a negative self-image, and keep revisiting negative life events. To them, negative events have more significant impact on their psychological state than positive events. This in turn could strengthen their negative self-image.

  While coping with their problems, individuals tend to form mental simulations based on their past experiences (i.e., self memories) [31, 100]. As pointed by CBM-I, individuals with depression struggle with forming vivid, positive imagery of future scenarios [19]. People who hold a negative view of their lives tend to interpret current or future events in a negative way, which can lead to problems such as reduced abilities in problem-solving, low motivation to engage with life events [100], and having a sense of hopelessness and frustration.

- **Over-generalisation.** As pointed by MEST and CNT, a reduced ability to recall details of past experiences prevents individuals with depression from reflecting on what had happened. Instead people with these diffiuclties repeatedly process abstract negative memories [164, 60]. Such deficits can be categorised as over-generalisation (OGM), which refers to individuals' cognitive deficits in retrieving self memories with rich details episodic details [40, 86].

  Overgeneralisation is a concomitant of depressive symptoms and can persist even after remission from depression and potentially contribute to the next depressive episode [40, 164]. MEST specifically pointed out that reducing OGM may be an important target of clinical interventions for depression [164].

- **Rumination.** As pointed by CNT and MEST, individuals with depression tends to dwell on repetitive negative thoughts or memories. Rumination goes hand in hand with the above two cognitive weaknesses (i.e., OGM and negative bias). As a result, they tend to dwell on the depressogenic categorical aspects of the personal past. Additionally, depression is also associated with difficulties in disengaging with negative repetitive thoughts, which spawn in rumination and contribute to a constant low mood and sense of hopelessness [40].

2 **Procedures used in each treatments for addressing D-ABMs:**

- **To address Negative Bias**, CBM-I and COMET help individuals with depression to build images of a positive future and a more positive self

image. For the former, CBM-I exposes participants to neutral scenes, and asks participants to imagine a vivid positive ending to the described neutral scenes. The scenes are normally presented acoustically and visually. During the COMET intervention, service users are asked to imagine a positive self-identity that is incompatible with their current negative one. COMET therapists will then help them strengthen this positive self-image by progressively adding verbalisation, body postures, background music, and facial expressions.

- **To address Over-generalization** of processing memories, MEST and CNT support their service users to improve their abilities in recollecting specific, emotional memories with enriched details. MEST is specifically designed to break service users' categorical negative thinking by training their abilities in retrieving specific episodic memories in detail. MEST training provides word-based cues associated with different emotional valence, and asks service users to recall specific memories in response of the cue-words. The therapists will then help service users to retrieve more and more episodic details. Whilst CNT trains participants' ability to review the specific details of negative memories, and re-evaluate them in concrete manner.
- **To address Rumination**, CNT and COMET help service users with depression to disengage from negative thoughts more easily while retrieving emotional memories. This is achieved by the re-evaluation process of CNT supports people to reveal the specific triggers of negative emotions that associate with their adverse life events. CNT also encourages participants to explore alternative solutions and to alter the viewpoints of their upsetting memories.

  COMET aims to improve service users' ability to retrieve positive memories to counter their negative thoughts. Additionally, the increased accessibility of positive memories can reduce the possibility for negative memories to hijack one's cognitive resources.

4.1.1.3 Design implication generated from findings

Base on the findings as stated above, I have identified a list of design opportunities for leveraging the features of memory apps to address the identified three D-ABMs (i.e., negative bias, over-generalisation, rumination) by delivering the four identified theory-based treatments.

- **Designing a digital memory bank with enriched memory cues:** Leveraging the features of memory apps, I can imagine a digital memory

bank that could capture and archive service users' positive memories across their lifespan. Such a memory bank with encoded personal memories could support ABMs treatments in various ways, which will be described in following paragraphs.

- **Designing apps that can support personalized training content for enhancing positive self-image:** Apps that help users to recollect specific episodic memories (especially positive ones) can support the main procedure of COMET, especially for building a positive self-image across time. Building on the intervention techniques of COMET, revisiting recorded positive memories could help users to enrich and practice their imagination of the positive self-image. Drawing on the intervention mechanism of MEST, such apps could use personal memory cues to help users practice their abilities in recalling specific episodic memories. Using one's personal memory cues as materials can make MEST and COMET training more engaging and personalized to service users.

- **Multimodal cues can improve the quality of positive memory recall:** With the help of biosensors, digital tools can capture multimodal memory cues (e.g., audio, visual, or haptic cues), alongside textual cues. Such multimodal cues could capture sensorial contents that can better reproduce the context of memory encoding. By providing a context that is similar to the moment of encoding, such digital tools can improve the quality of memory recall. This is especially helpful for helping individuals living with negative bias to improve their ability to remember positive memories

- **App features can support situational-tailored reflection on negative memories:** Informed by CNT, digital apps can help app-users to reflect on their negative memories in a structured manner. More specifically, with the help of mobile technologies, apps can provide personalized, interactive templates, or conversational agents to guide users through the reflection process. In addition, such systems could identify users' specific negative thinking patterns and help to address them in a timely fashion. This can help users to better disengage from their negative memories and manage depression in its early stage.

- **App features can support positive reinterpretation and imagination:** Inspired by CBM-I, digital tools can provide material to train users' abilities to imagine a positive ending of life events. This can help users build a more positive self-image that is more accurate.

4.1.1.4 Main contribution to the thesis

The main contribution of this study comprises three points:

1. A review of the state-of-the-art interventions for addressing D-ABMs,
2. Understanding the main memory impairment targets of such interventions, and the key procedures for addressing these targets,
3. The proposal of three design opportunities for memory technologies to address the depression-associated memory challenges

Exploring interventions that specifically target D-ABMs is a relative new area, as most of these interventions have only started to emerge in the last decade [86]. Additionally, ABMs-based interventions are mainly still under experimental exploration and are applied in lab settings [86]. Only a few service users with depression can receive these treatments. In order to fully understand the current best practices for addressing D-ABMs, I need to widen the scope of our research beyond theory-based interventions. This translates into the need of exploring other widely used approaches for treating memory impairments in depression.

4.1.2 Study 2: Exploring practice-based approaches that can be used for memory impairments in depression

4.1.2.1 Background and objectives

Current mainstream interventions in clinical practice (e.g., CBT) are not being specifically designed for D-ABMs, but are likely to include components that can address memory challenges associated with depression. For example, a major feature of depression is the constant negative interpretation of oneself and the world [16, 15], whose treatments will inevitably work on how individuals process their past experiences and memories. These components can potentially be leveraged for treating ABM deficits in depression.

Study 2 therefore aims to (1) identify intervention techniques within practice-based depression treatments that can be leveraged to treat D-ABMs, and (2) explore the design opportunities of mobile technologies to support these techniques. For this, in study 2, I conduct in-depth interviews with ten experts on depression treatments. On average, these participants have 15 years' experience in working with service users with depression. Participants' type of experience rang from cognitive psychologists who are expert in D-ABM interventions, psychiatrists to CBT therapies. During the interviews, I ask participants about their practice and how they address each memory impairments in depression. Examples of interview questions include: *"Have you worked with clients with overgeneralized memories?", and "Have you tried to address this overgeneralization problem? If so, how?"*

While analysing the data, I specifically investigate the key mechanisms underpinning clinicians' approaches in supporting each types of memory impairments

associated with depression. I apply a hybrid thematic analysis method to analyse the interview results [66]. The three memory impairments identified in study 1 inform the initial deductive codes, while inductive coding allow us to identify specific approaches for targeting each type of memory impairment. To analyse each approach, I specifically focus on *what type of memory (i.e., negative or positive)* these approaches apply to, and which *memory processing stages (i.e., encoding or retrieving)* are targeted by each approach. The list of codes and their definitions are revised throughout different rounds of deductive and inductive coding. Finally, I iterate the three key types of D-ABMs, as *negative bias, overgeneralization (OGM),* and *reduced positivity*, and reveal the approaches for addressing each of them (e.g., approaches such as encoding positive memories for *OGM* or retrieving negative memories for *negative bias*).

4.1.2.2 Main findings

I now present the key findings in this study, as the practice-based intervention strategies I identified from our participants. The key elements of current practice-based treatments for treating D-ABMs includes:

- **Strategies that can be used for addressing Negative Bias.** People with depression tend to pay more attention to negative materials and keep revisiting negative memories. This is because they tend to retrieve negative memories much faster and easier compared to positive ones [40, 86]. Additionally, such individuals tend to find it difficult to disengage from negative materials and memories, which increases the likelihood of rumination.

  To address this, our interview results indicate that both CBT therapists and D-ABM experts help clients to analyse their negative memories to support better disengagement. Another common practice in both CBT therapies and D-ABM treatments is to help clients to reframe their interpretation of the negative memories and encode the less negative reframed memory.

  While clients are retrieving memories, D-ABM experts encourage their clients focus on memory retrieval, and avoid rumination hijacking their attention. CBT therapists help their clients to actively plan and engage in positive events, and code the newly generated positive memories for creating a more balanced life overview.

- **Strategies that can be used for addressing OGM.** OGM in depression mainly impacts individuals' abilities in retrieving episodic memories through the generative retrieval process, instead of the direct retrieval process (detail see literature review). Negative bias and overgeneralization reinforce each other and contribute to a profound negative life summary and self-perception.

To treat this issue, I found that D-ABM experts intervene to improve clients' ability in episodic recall from emotional cues through a generative retrieval process. The key to their approach is to use generic cue words to ensure only generative retrieval is activated. The list of cue words involve certain emotional valence (e.g., negative, neutral, or positive). This is because people with depression experience different severe difficulty in retrieving memories with different emotional valence (e.g., individuals with depression tend to find it difficult to retrieve positive memories, whilst extremely easy to retrieve negative memories) [40, 86]. For example, users with depression tends to retrieve negative memories much faster and easier than positive ones, while experiencing difficulties in retrieving positive episodic memories in clear detail. Additionally, this approach requires therapists to provide a scaffolding process to make sure clients are focusing on the memory retrieval process, not rumination.

Meanwhile, CBT therapists address OGM by breaking their negative thinking patterns. Such therapists work on improving clients' ability to retrieve positive memories opposing their negative-biased overgeneralized thinking.

- **Strategies that can be used for addressing reduced positivity.** For depressed individuals, retrieving positive memories tends to has limited impact on their mood [40]. This is because even if a positive memory can be successfully retrieved, such memories are less vivid and emotionally-intensive, impeding depressed individuals from experiencing the positive emotions associated with it.

  I found all of our participants had strategies for addressing this issue. Their approaches mainly lay in improving clients' ability to retrieve positive memories and to re-experience the associated positive emotions. For instance, CBT therapists described their approaches in helping clients to relive and enhance the positive memories. They would also encourage their clients to encode these enhanced memories for later retrieval. These approaches are helpful for clients to build a better self-identity utilising positive memories.

4.1.2.3 Design implication generated from findings

The result of the study 2 revealed the key strategies of practice-based interventions for addressing D-ABMs, which enriched our understanding of D-ABMs and its target treatments. Combining with the design suggestions generated in study 1, I identified the design space of digital technologies, which can better deliver both clinical-practice based and theory-based techniques for treating D-ABMs.

- **It is beneficial to design a digital memory bank to enhance life positivity:** Findings indicate that improving service users' abilities to encode

positive memories is a widely used approach in clinical settings. Albeit not specifically designed for D-ABMs, this approach is useful for addressing the challenges these memory deficits pose.

Digital tools can support purposeful planning and encoding of positive life events and encode them for later retrieval. For example, such systems can prompt users to actively notice, identify, and better record everyday positive moments. By providing novel, rich, expressive, and multisensorial interfaces, such digital apps could further strengthen the *felt-life* [140] quality (providing a sense of lived, sensorial, emotional experience) when individuals retrieve their positive memories. Individuals who can recollect high-quality positive memories with vivid details could find it easier to form a more positive self-image.

- **To ensure safety of app usage, it is essential to support selective (mood-dependant) retrieval of positive memories:** Individuals with depression are vulnerable to the risk of having negative-biased, over-generalised (OGM) memory recall style (see finding 1.1 and 1.2), and digital tools need to be carefully designed to avoid harming them [45, 39]. For example, digital tools that work with app users' emotional memories may trigger a strong emotional response, and are likely to induce a negative mood [110, 143] or even trigger rumination [45]. The risk applies to both retrieving negative and positive memories. Designers need to understand the risk of working with users' emotional memories, and develop strategies to safeguard users while addressing the memory impairments associated with depression.

  For example, following our findings, digital tools could support selective retrieval of positive memories as resources to break specific negative thinking patterns. However, prior psychology literature shows that retrieving positive memories can be problematic for depressed clients [45, 39], especially when they are experiencing negative moods at the time [45]. This is because individuals with depression tend to compare past happiness with current low mood, which can worsen the present negative mood and trigger rumination [40]. Digital apps designed for end users with such issues should access users' current emotional state, and adapt the retrieval of emotional memories accordingly. For instance, to help service users experiencing ruminative mood, it is better to work on mitigating their negative mood than prompting the retrieval of happy memories. When users are in a positive or neutral mood, such systems can prompt them to identify and retrieve positive memories as counterexamples to guard against their repetitive ruminative thoughts.

- **It is essential to tailor memory tools to specifically fit the distinctive D-ABMs:** Current memory tools mainly aim to support people with Episodic

Memory (EM) impairments, but depression is not generally associated with such impairments. It should be noted that the autobiographical memory impairments in depression are fundamentally different from episodic memory impairments. Compares to memory loss related difficulties in direct retrieval of specific EMs, D-ABMs are associated with difficulties in the generative retrieval of specific EMs through higher levels of autobiographical memory systems (ABMs). Current memory tools are mainly designed for supporting users' direct memory retrieval of EM. When users with depression uses such tools, the apps can neither provide support for mitigating D-ABMs nor protect user if rumination hijack their attention while retrieving memories. This can be particularly risk of users in negative moods, as their moods may tint their past memories and leads to a stronger negative emotional response [110]. link back to findings

Drawing on the D-ABM experts' approaches to addressing OGM, apps that focus on addressing D-ABMs need to provide novel cues that assist the generative retrieval instead of direct retrieval of specific EMs. The content of such novel cues should be generic enough (i.e., relating to higher-level memory representations, such as lifetime periods and general events), rather than specific (e.g., about specific episodic memories). For instance, we can imagine such systems to hide the episodic details being recorded in the digital captured cues, and only present these details once users successfully achieve them by themselves. For example, such systems can remove or hide the episodic details of pictorial cues from specific life events, or only present meta-data (e.g., time, location, short textual note) of the captured emotional episodic events. These general cues can form a personalized training content for users to practice their abilities in retrieving episodic details through generative retrieval.

Additionally, it is safer to use such generic memory cues for users with depression, as it could encourage users to focus on the memory retrieval process, which reduce the risk of being distracted by rumination. For this, I suggest such technologies to also provide scaffolding questions (e.g, via AI conversational agent) to guide the users throughout the retrieval process.

- **Introducing tailored memory technologies can benefit digital apps for depression:** Besides tailoring memory apps for users with depression. Traditional depression interventions can also benefit from integrating D-ABM tailored memory systems as an additional feature. Such feature can provide personalized training materials that are relevant to users' life narrative. This can make the online treatment more person-centric. For instance, introducing a digital positive memory bank can help users to track positive memories from everyday life events and provide a visualized training progress and a sense of achievement. Adding these features to depression platforms can help increase

user engagement with the digital intervention, as these interventions can be more personalized, relevant, and interactive to app users.

4.1.2.4 Main contribution to the thesis

The main contributions of this work include:

1. Providing a rich understanding of how memory impairments in depression are being addressed by practice-based approaches,

2. Identifying the design opportunities for mobile apps to support mitigation of D-ABMs.

Study 2 extended the results of study 1 in two ways. First, study 2 explored how memory impairments in depression are addressed in a wider range of approaches in practice, which enriches our understanding of best practice in addressing D-ABMs (both in theory and in practice). This informs the iterated design requirements for mobile apps to support treatments for D-ABMs. The design requirements generated in this study guides the data analysis of study 3 for answering research question 2.1, which aims to explore current app features that are suitable to meet the requirements.

Study 2 also conducted an in-depth interview study with experts on depression, which enabled the researcher to gain a richer understanding of therapists' opinions, experiences, and incentives behind their approaches. Building on study 1, study 2 guides the generation of the design toolkit in study 5 (for answering research question 2.2), which aims to support designers' understanding of D-ABM related theories and the current best approaches for addressing the challenges these memory impairments pose.

4.2 Assessing Existing App Features

This section reports two systematic evaluation work of mobile applications that I have conducted with supervision from Professor Corina Sas (as my main supervisor at the time), with the final phases of the project finished with joint supervision from Dr Gavin Doherty. Besides the supervision from Professor Sas and Dr Doherty, I undertook the main research work, including review of literature, data extraction (including app searches and selection, as well as data extraction), data collection and data analysis (including app evaluation and data coding). Dr Claudia Dauden Roquet (at that time working as a PhD candidate) has also contributed in the second round of data coding and analysis for cross-checking data validity.

The design requirements proposed in study 1 leads to studies for answering research question 2 (see figure 1.1, RQ 2.1 and RQ 2.2). This section describes studies for answering RQ 2.1, which explores the best design of mobile apps that can meet the requirements proposed while answering research question 1. For this, we need to understand the best combination of app functionalities to be included for addressing the autobiographical memory impairments in depression. However, it is unclear what functionalities can be included and leveraged, as few mobile technologies have been developed for D-ABMs. This motivates the two app evaluation studies conducted in this stage:

1. **Study 3** specifically investigated app functions that can be included in D-ABM apps. This included functions not specifically designed for these apps but which have potential to address D-ABM related issues.

2. **Study 4** investigated the functions of currently available depression apps. This study focuses on functionalities that are useful in ensuring the design of D-ABM apps can manage users' depression globally. In addition, study 4 also identifies the common pitfalls in current depression app design, and suggestions for avoiding them.

   The reason why I applied app evaluation method for answering RQ 2.1 is because exploring commercial depression apps is the most straightforward way to understand what major end-users encounter when they search for depression support. Due to the rapidly changing market of depression apps, prior academic researches works on mobile app market for depression is not fast enough to cover the most up-to-date depression app analysis [158, 181].

   In this stage, I present a comprehensive view of app features for addressing D-ABMs, which combines the results from direct observation of current apps and the results of reviewing prior academic reviews of depression and memory apps.

4.2.1 Study 3: Exploring the most effective app functionalities for treating D-ABMs

4.2.1.1 Background and objectives

There are many apps functionalities available for addressing the various needs of users with different mental health challenges, many of these challenges have not yet being explored enough by HCI researchers and designers. The market of commercial apps is growing rapidly. By 2019, over 300,000 health apps had been developed, with a yearly growth in apps of 25%, making mental health apps one of the fastest-growing sectors. A variety of app functionalities are designed to meet different wellbeing needs to satisfy different types of user groups.

Some mental health apps may contain functionalities that can be leveraged to address D-ABMs, even though they are not particularly designed for it. For example, CBT apps contain cognitive diary functionalities for managing depression symptoms. These diary entries contain records of end users' life events and can be used as cues for service users to process their personal memories. Therefore, the diary recording function of CBT apps can be potentially leveraged for D-ABMs. Study 3 therefore aims to: (1) Discover currently existing functionalities that can be potentially leveraged to support D-ABMs; (2) Explore ways of leveraging these functionalities to fully address D-ABMs

In this study, I reviewed current apps that target memory and depression management (full study study protocol can be found in appendix C). Then, I extracted their functionalities suitable for D-ABMs. We choose to review top-ranked apps that fall in the intersection of memory apps and depression apps. This is because they are likely to provide functionality that can support memory processing and depression management at the same time.

The apps were retrieved from two major mobile app marketplaces (iOS and android), through searching relevant keywords (e.g., "memory" or "depression"). The initial search result yielded 482 depression apps and 3119 memory apps, and 20 apps were finally selected and evaluated for the study (details of app selection process can be seen in chapter 3 and peer-reviewed publication in appendix C).

To analyse the selected apps and access app functionalities, I used an experimental evaluation method [98], where the author directly used each of the selected apps to for a period in real world setting, to gain insight into the actual content of the downloaded app.

4.2.1.2 Findings

The findings comprise two parts. First, I explain existing app functionalities that are suitable to be leveraged for D-ABMs. The existing functionalities of selected apps are described from two perspectives: (1) functionalities for managing depressive symptoms that work with users' self-memories, (2) a closer look into how each these functionalities help users process these memories.

App functionalities that are suitable to support D-ABMs

I idenitifed the following three types of therapeutic functionality for managing depression: The results can be seen below:

- **Mood tracker (most popular function, employed by 75% (15/20) of apps):** Apps that provide mood tracking functions normally also encourage users to track and identify mood triggering factors (e.g., thoughts or their activities). Some apps only provide standalone mood tracking functionality. These apps are mainly designed to identify users' mood patterns and help users

understand factors affecting their mood. Some apps provide mood tracking functions alongside other therapeutic functionalities. For these apps, mood tracking is provided as an assistive tool integrated with the other app-based interventions. For example, CBT apps allow users to record their mood changes as part of CBT intervention. Such apps use tracking data to visualise user progress.

- **Thought diary (provided by 65% (13/20) of apps):** The function of thought diaries is mainly found in CBT apps, which allow users to record their thoughts as part of the intervention. App users can then review their recorded thoughts and apply CBT techniques to challenge them. For example, such apps can guide users to recognise thought distortions, then guide the users to read psychoeducational articles about their thought distortions to help them challenge these.

- **Encouraging positive activities, e.g., exercise, meditation (found in 60% (12/20) of apps):** Apps that provide this function mainly encourage users to either plan and engage in positive events or find everyday positive (appreciative) events. The apps then encourage users to encode these positive events for later retrieval. The process of engaging in positive activities is designed to have a therapeutic effect.

I then analysed how current app functionalities support users' memory processing. The results can be seen below:

- **Assisting memory encoding through structured templates.** Among the selected apps, I found 75% of apps provide templates to guide users through various stages of memory processing (i.e. recording, encoding, and reviewing). However, most templates are not designed in text-based, static, and generic manner, which may lack interactivity and can be thus less engaging to users. Some apps can provide templates in a more engaging form. For example, 2 apps allowed users to record their memories by conversing with AI chatbots).

- **Collecting cues to assist memory recall.** Most of the memory cues used by apps are generic and non-personalised. For example, all mood-tracking apps provide pre-defined tags (e.g., emoticons or texts) as cues for users to select and log their current moods. These general cues may have a limited effect in assisting memory retrieval. Some apps also allow users to record additional personal cues alongside the generic cues. For example, I found 12 apps that allow users to record short textual notes or attach photos to each mood logs. As for cue modality, I found textual cues are the most used cue modality, followed by pictures. Additionally, I also found 1 of the 20 selected apps allow voice input as memory cues.

4.2.1.3 Design implication generated from findings

I now present the design implications for leveraging current app functionalities for addressing D-ABMs, learning from the app evaluation result as stated above. Based on the findings, I identified several app features that should be included in apps for addressing D-ABMs.

- **Include functionalities that encourage active planning and purposefully encoding of positive memories.**

  Encouraging positive activities is a common app function for managing depression while working with self-memories. Our result of RQ 1 has already suggested the importance of D-ABM apps in supporting the recollection of positive activities, and in supporting such features

  However, current logs are mostly pre-defined and with little self-input content. App users may find it difficult to recall memories related to the recorded activities with such general cues. To better leverage such functionalities for addressing D-ABMs, I suggested providing more enriched content for app-assisted activity logging, by allowing users to enter more contextual information of the event to be recorded. For example, users could be encouraged to enter more details of the events or attach photos, video or audio records of the event.

  In addition, I have found that the reviewed 20 apps mainly recommend pre-defined sets of positive activities. To achieve the best effect, I suggest apps allow users to purposefully plan the positive activities that can fit their own life goals and address their own needs. I also suggest providing a visualised progress of achieved plans to further enhance engagement. Informed by prior research [128, 186, 108, 54], these features can be both beneficial for activity engagement and depression management.

- **Provide enriched cueing content to support sufficient memory recall (Tailoring memory cues for D-ABM apps).**

  The findings show that it is common for apps to provide tracking functions, such as of moods, thoughts, or everyday life activities. Due to D-ABMs, app users may experience a variety of challenges while processing emotional memories (e.g., negative biased over-general memory recall). Apps that provide such functions could use these track data as memory cues to improve users' abilities in processing the associated emotional memories. To satisfy the unique issues that D-ABMs pose, I need to tailor the current functionalities before adding them to D-ABM apps.

  There is an opportunities for D-ABM apps collect and present more enriched cues with more contextual information as a novel feature with potential of

supporting mitigating D-ABMs. General cues are less efficient to support memory processing, as the uniqueness of cue content is a key factor of cue efficiency.

One way of doing this is to allow users to record personal cues with activity logs, such as personal thoughts or mood changes during the event, or pictures with contextual information of the activities. Apps could also provide templates to assist users in recording events with more contextual information (e.g., who, where, what).

In addition, including multimodal cues (e.g., voice, pictures) can be also helpful for enriching the contextual information of memory cues. This is because cues in such modalities include more spatio-temporal content than textual memory cues. Such features can be easily implemented by leveraging the affordance of mobile devices (e.g., phone-integrated microphones and cameras). Engaging external sensors can also allow employing other cue modalities, such as odour, taste or haptic cues.

- **Protect users and prevent rumination while using the app.**

  Individuals with depression can be vulnerable to contents that can potentially induce negative emotions. It is important to safeguard users in these potential scenarios with risk of triggering negative or ruminative response. For example, prior studies have indicated that individuals with depression tend to find it challenging to engage in activities and tend to interrupt all future scenarios in a negative-biased manner. This can impede such individuals to engage in positive activities that can possibly create happy memories. This is due to depression-induced issues such as low motivation and reduced concentration. In addition, individuals with depression also tend to have negative self-identity, which leads to stronger negative responses in interpreting everyday life events. This means failing to engage with previously planned activities would induce a sense of failure, which may contribute to worsening of mood or even induce rumination. Therefore, such apps need further assistance to help users disengage from the plan due to low motivation. For instance, deciding to not to engage in pre-planned activities maybe due to or caused by ruminative thoughts (e.g., "this event is going to end in disaster" or "I am a failure, I cannot even keep up with my plans"). In such scenarios, we can imagine the D-ABM system can access users' current mood, and prompt users to engage in therapeutic strategies to help disengaging with such emotions.

  Moreover, prior literature has indicated a risk for users with depression to review their emotional memories. This is especially risky when users are in a sad mood, as reviewing emotional memories may trigger negative emotions

or even rumination, which can potentially induce rumination, worsen mood, or even play a negative impact on individuals' current depressive symptom [45]. Selective memory retrieval can be a good way to prevent this from happening. For example, such apps can access users' current mood, and avoid presenting them app-content that may induce a sad mood (e.g., memory cues related to users' current ruminative thoughts). I found that 2 apps identify users' moods while using the app. However, none of the current apps filtered their content according to users' current mood. Additionally, most apps do not allow users to view their emotional memories selectively. (I.e., only 4 apps allow users to search and view memories by entering keywords, no app allow users to only view positive memories). To improve this, I would like to highlight D-ABM apps' importance in accessing users' current moods and tailoring the app content to users' mood and contexts accordingly. For instance, to allow users to retrieve their emotional memories when they are in a happy or neutral mood.

4.2.1.4 Main contribution to the thesis

The main contribution of this work includes:

1. Accessing current digital app functionalities that can be added to the design of apps for D-ABMs.

2. Analysing limitations of current digital app functionalities.

3. Exploring the design opportunities of combining and leveraging these app functionalities into the design of apps for D-ABMs.

However, exploring ABM functionalities alone is not sufficient, as we need to ensure D-ABM apps are effective in depression management. In addition, since D-ABM apps are targeting app users with depression, we need to understand what are the universal requirement and regulations for depression apps are, and if ABMs-apps can meet these requirements. For instance, we are not sure if apps that solely provide functionalities for D-ABMs can be sufficient for the needs of app users with depression. This translates into the need of investigating current depression apps. Additionally, as study 1 and 2 suggested, digital ABMs-interventions can work the best while being integrated with other depression interventions. This leads us to explore how to best integrate D-ABM app functionalities to depression apps.

4.2.2 Study 4: Exploring best app functionalities for general depression management

4.2.2.1 Background and objectives

In addition to investigating the intersection of memory and depression apps to identify useful functions, I investigated apps more generally designed to manage depression. Therefore, we need to make sure such apps can support depression management globally. E.g., to know if and what other functionalities are effective in managing depression and therefore need to be included in the design of D-ABM apps). This motivates study 4, which aims to understand current depression apps from the following aspect:

(1) Key app functionalities for managing depression,

(2) Limitations and common pitfalls in app design,

(3) Ways to address or avoid these pitfalls.

In study 4 I therefore conducted a systematic evaluation of current depression apps on the major marketplace (iOS and android). I identified the apps through searching relevant keywords (i.e., "depressed" or "depression") in app searching engines. From the initial 484 apps, I have filtered finally selected 29 top-rated apps that meet the inclusion criteria for the review study. The inclusion criteria includes being accessible at the time of app selection, having had average user review scores high than 4.0 (out of 5.0), and the scores are generated by balancing over 100 reviews from app users (details in appendix D). The process of app selection includes steps such as removing apps that are duplicated, do not meet the inclusion criteria (e.g., , and are not relevant or top-rated

4.2.2.2 Findings

1. **Review of depression apps**

1.1. **Reviewing current functionalities of depression apps:**

Screening of depression severity (found in 9 of 29 apps). Screening functions are provided for either monitoring symptom changes during the engagement with app-delivered intervention, or as the standalone function for self-diagnosis purposes. Around half of the apps reviewed failed to provide validated screening tools (e.g., PhQ-9), but instead use less validated tools (e.g., Szondi test) or simply don't reference the tools they utilise.

Some apps use the screening results to inform the delivery of therapeutic strategies to help mitigate the symptoms. However, these apps mainly present

pre-defined psychoeducation articles to users, or suggest users discuss their results with health professionals. I found 2 apps that allowed personalised intervention content based on users' screening results, without providing evidence for validating their claims (i.e., I cannot find information regarding how this peronalisation is tailored to the screening result).

Tracking depression symptoms (popular function, found in 19 of 29 apps). At the time of review, I found that the selected apps allow users to track one or multiple aspects of their life, e.g., thoughts, behaviours, moods, or depression symptoms (e.g., depression screening result). The various purposes of these tracking function included:

- Assisting the provision of personalised intervention
- Visualising training progress, and
- Identifying mood-change patterns and triggers.

In terms of viewing the tracked records in apps, text can be the most employed modality for recording thoughts and moods, followed by emoticons and scales for recording moods. From the apps reviewed in this study, all the 14 apps do not provide searching function of the tracked data, but instead mainly present these data in chronological order. This means users cannot filter and only revisit some of their records. This is problematic as findings in study 2 has shown the importance of providing selective retrieval according to users' current mood state to avoid risking harm to users with depression (discussion see appendix B),.

This opens up opportunities to improve the presentation of tracked data, especially for allowing selective revisit of track data and supporting selective memory recall according to users' current state.

Provision of depression interventions (provided by 24 apps). Most of the therapeutic functionalities are informed by psychological interventions. I identified 7 types of therapeutic functionalities that can help managing depression. This comprises thought diaries, psychoeducation, mindfulness, scheduling, positive behaviours, emotion regulation strategies, and emotional expression. Most of these app functionalities reflect elements of recognised face to face psychological therapies. For instance, thought diaries are part of a traditional CBT intervention content. Besides, functionalities that encouraging positive behaviours are aligned with another traditional psychological intervention, i.e., behaviour activation.

Most of these functionalities were personalised to some degree in the apps reviewed in this study. For instance, around half of the apps that provided

psychoeducation articles tailored their content specifically to fit users' depression assessments. Additionally, app functionalities such as thought diaries were mostly tailored to users' real-time tracked thoughts or emotions. This app function guides users to identify and challenge their negative thought patterns and distorted thoughts.

1.2. **Reviewing ethics considerations of current depression apps**

In this subsection, I discuss ethical considerations raised while reviewing the depression apps. This is because embedding the ethical principles is essential while designing for such a vulnerable user group [147].

Apps are rated as safe for children or adolescent users, however, with a mismatch between apps' descriptions and the actual app content: For example, our results (see in appendix D) indicate that most apps are classified as suitable for children (76% suitable for users older than 3 years). However, I fail to find any app design tailored to fit children's needs (e.g., allowing parents to supervise children while using the app). These apps provide the same app content for both adult and children users. Besides, more than half of the apps do not provide age-appropriate privacy policies. E.g., the policy contents are inconsistent with the age rating claim on the app marketplace. E.g., 58% of apps claim to restrict users to a specific age group, but their marketplace age rating includes the restricted age group.

There is a lack of evidence base of current depression apps' statement. More than half of the apps (18/29) have claimed that their app design are based on scientific theories. However, there are no evidence for proving these claims. Besides, it is unclear if these apps can actually deliver the interventions as they claimed to offer. Moreover, the evidence of app efficacy is mostly absent. For example, only 2 of 29 apps provide direct evidence (i.e., peer-reviewed scholarly work) for their effectiveness in reducing depressive symptoms. This may indicate that many currently available depression apps fall short of following ethical principles in developing digital products. For instance, the fact that 59% (17/29) do not mention the involvement of mental health professionals in their design (see appendix D) indicates that these apps fail to follow the Guideline 2.6, as: "(developers should) perform work only in areas of competence" in ACM Code of Ethics and Professional Conduct [189].

Some top-ranked depression apps are poorly designed and may induce harm to users. Healthcare apps are sensitive by nature. Poorly designed app content may cause a potential risk of harm. Users with depression are especially vulnerable, with some at risk of self-harm or suicide. Exposing such vulnerable users to negative content (e.g., contents that express a sense of hopelessness,

despair, or even death) may trigger even stronger negative behaviour (e.g., self-harm). This is worrying as I have identified 2 reviewed depression apps that provide potentially disturbing content without safeguarding procedures such as prompting users to contact emotional crisis helpline. This includes quotes capturing negative thinking (e.g., "have you ever feel like not existing anymore"), or images with themes related to death. Exposure to such contents which may inducing content-viewers' at-risk behaviour. These 2 apps are highly rated on the marketplace (i.e., review score of 4.4 and 4.6 out of 5). Therefore, they are likely to be used by users with depressive concerns. The risk of using such apps is not mentioned either in their marketing information page or in app content.

Many depression apps are designed without strategies to safeguard users. Most of the top-ranked depression apps (21 of 29) do not have information for handling or preventing the sick of suicide. This is concerning given that depression may lead to serious consequences such as suicide, and safeguarding strategies are therefore needed. From the other 8 apps that provide safeguarding strategies, I found that most apps (5 apps) provide information on accessing external support services (e.g., helpline), or suggest users to contact local emergency services (2 apps). 1 app allows users to form a personalised safety plan for handling crisis.

2. **Limitation of current depression apps and ways of improving their design**

2.1 **The design of depression apps needs to protect users.** Given the increased vulnerability of depressed individuals, I argue that designers of depression apps need to take the vulnerability of app users into consideration, and to include strategies for safeguarding users. For instance, while designing apps for assisting users' emotional expression, designers need to include strategies for protecting users from consuming potential negative content provided in app, such as limiting views of these contents. This is because such apps may involve content that can trigger users' negative mood, rumination or even induce emotional harm. Besides, the tracking functions of depression apps should also be carefully designed to minimise the risk of triggering the vivid recall of the emotional memories. This is because recalling emotional memories may be potentially risky to individuals with depression by triggering negative emotions or even rumination, and track records such as thought diaries includes predominantly negative contents. Moreover, apps for users with depression should provide information for immediately accessing mental health support if users are at risk.

2.2 **Depression apps should protect users' privacy by improving the quality of apps' privacy policies (improve readability and appropriate to target users' age).** Prior research indicates the prevalence for healthcare apps that sell users' data to technology companies [181, 167, 195]. Users are often not aware of the risk of having their private data exposed to others [181, 98]. This is worrying given the sensitive and personal nature of healthcare app data. Our results show that apps are mostly rated as suitable for children and adolescents in the marketplace. Aligning with prior research, our results also show that apps' privacy policies are rarely adequate, easy to find, or readable to typical users. Only a few apps in the current UK market are following General Data Protection Regulation (GDPR) compliance [151].

I argue that app developers and marketplaces that host depression apps are responsible for users' privacy protection. This is especially important for ensuring users are fully informed upfront of the risk of having their data shared with third parties. This can be achieved by providing consistent and readable information in the app description and their privacy policy and making sure the privacy policy is easy to find.

2.3 **Improve users' engagement with depression apps.** Current depression apps face the challenge as high user attrition (normally defined as the number of app users leaving the app without completing the a course of treatment [54, 63]). Prior research has indicated a few strategies for increasing users' engagement, such as providing personalised intervention content, involving concepts from gamification, and allowing users to access social support while using the app. Our result shows that depression apps provide personalised intervention content to some extent. I can fully leverage the affordance of mobile phone and deliver more time-adaptive intervention content that are tailored to users' current state (e.g., thought or moods). For example, good practices already emerge from 2 apps reviewed in this study, which utilise an AI conversion chatbot (e.g., a live-chat experience simulated by an AI robot) and provide psychoeducational content that is relevant to users' recorded thoughts. With the affordance of mobile apps, more responses can be designed and delivered as give real-time response of users' input. This will make the app more personalised and interactive, and therefore more engaging to app users.

As overuse of mobile apps can also induce risk of harm to end-users [118], we should also note the potential risk of inducing app-addition while improving users' engagement to using mobile apps. Current digital provisions use various sophisticated methods to avoid creating addictive behaviour while engaging app users [84, 104, 119, 103]. It is important for future work to investigate into ways for users to engage depression apps in the most healthy manner.

2.4 **Provide progress visualisation that supports episodic memory recall**. Our result shows that current depression apps provide visualisation of training progress to motive users. Current progress visualisation is mostly presented in an abstract manner (e.g., short note in textual format), and it is difficult for users to retrieve specific memories from seeing the progress. I suggest simultaneously capturing memory cues with contextual information and integrate them with the record of progress. This could allow users to understand the value of the app for their wellbeing, and better motivate them throughout completing intervention activities. This can also work as a digital positive memory bank, where users can record and review a collection of achieved activities and gain a better sense of achievement.

4.2.2.3 Main contribution to the thesis

The main contribution of this work include:

1. Access current app functionalities for managing depression symptoms
2. Analyse the limitation of current apps for depression, and suggest ways for app designers to address these limitations in future practice
3. Explore opportunities to integrate app functionalities of D-ABMs to depression apps

Study 4 provides a comprehensive overview of the current marketplace of apps for depression. By identifying the common flaws of current depression apps, the study results enabled us to construct a checklist for future designers to avoid making the same mistakes when designing apps for depression.

4.3 Summary and Reflection

Four papers were published from the findings described in this chapter:

- Study 1 is published as a work-in-progress in *Proceedings of the 32nd International BCS Human-Computer Interaction Conference (HCI), 2018*. The full published piece is attached in appendix A,
- Study 2 is published as a full paper in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 2019*. The full published piece is attached in appendix B.

- Study 3 was published in *Annual Review of CyberTherapy and Telemedicine scientific journal to Cypsypsychology conference 2020.* The full published piece is attached in appendix C.

- Study 4 was published in *JMIR special issue, 2019.* The full published piece is attached in appendix D.

I summarised the key points extracted from the above four research papers, and wrote this thesis chapter with the aim of providing a rich understanding of how D-ABMs are treated by current psychology interventions (study 1-2), and how can these interventions inform the design of apps for addressing D-ABMs.

Through analysing the main mechanisms underpinning current treatments, the findings stress the importance of designing apps that are specifically tailored for end-users living with depression and its associated memory impairments. The works in this stage also led us to identify the requirements of mobile apps that can support ABM-based treatments effectively. This begs the questions of how to design features of ABMs-targeting apps that meet these requirements, which motivates the following studies in the following stages for answering research question 2.

Following this, the subsequent studies (study 3-4) provides an exploration into a combination of app functionalities that could be included in apps to address D-ABMs. I also explore the marketplace for hosting depression apps and suggest a few pitfalls to be avoided while designing apps for D-ABMs. This understanding can guide the future design of D-ABM apps that fit the best standards and requirements of depression apps.

Chapter 5

Translating the empirical findings into real-world HCI design practices

This chapter reports the process of generating the theory-based input materials (includ- ing persona cards, scenario cards, theory cards, as well as the design sprint workshop progress and instruction cards) for facilitating future designers and researchers to apply the empirical findings of the work I have conducted and reported in the previous chapters.

I have mainly conducted the work, including reading and synthesising the liter- ature's, organizing information. The work also involves collaborative input from Camille Nadal , as a co-author of the research project. Besides, Dr Muhammad Umair also contributed to the work The project was also conducted under joint supervision from Professor Corina Sas and Dr Gavin Doherty.

5.1 Overview

In this work, I mainly focus on D-ABMs and a wider (related) range of cognitive impairments in depression. Such D-ABM theories are mainly described in academic research papers, and have not yet been translated into accessible materials for designers. Designers need support to equip them with sufficient knowledge about D-ABM theories, and adequate skills for designing D-ABM supports. Lacking such design supports can be the reason why designers rarely incorporate them into psychology theories into their current design of depression apps.

The questions I seek to answer in this chapter is **RQ3: How can we facilitate**

the design process of apps for ABM impairments in depression? To answer this, I tested a self-developed design toolkit on a cohort of app designers. Development of the toolkit was based on the principles of translating the complex psychology theories in actionable format suggested by prior research works [64, 17, 105].

5.2 Designing the Toolkit

This section describes how I explored the key component of the design toolkit for bridging the theory-design gap of D-ABMs. This includes 3 steps: deciding theory foundation, distributing theories to toolkit design, and toolkit iteration.

5.2.1 Step 1: Deciding theory foundation of the toolkit

The theory base underpinning the toolkit triangulates both empirical findings obtained from the studies described in chapter 4, psychology theories around D-ABMs, and a wider range of cognitive impairments in depression.

Firstly, I developed two design goals based on the results generated in study 1:

> **Goal 1:** The app needs to support users to engage and record daily positive memories that are useful for ABM-treatments,
>
> **Goal 2:** The app needs to support users revisiting their recorded memories and in processing them therapeutically.

The goals highlight the importance for D-ABM apps to provide the function of a digital memory bank that can capture app-users' positive memories. This inspire us to identify theories that can encourage users to actively record positive memories in everyday life. From reviewing psychology theories that are effective in motivating users with depression concerns, I decide to involve goal-setting and planning theories in the design toolkit. (see table 5.1). Through reading the above literature, I then identified 5 themes (later referred as design contexts) of D-ABM apps, each with design challenges and revised design goals of this context (see table 5.2). The five unique design contexts describe five different stages of end-users creating and engaging with emotional memories through using the app. In each of the five contexts, end-users face different challenges that need to be addressed by the design of a D-ABM-focused app.

Key app requirements	**Draw from literature**
Support engaging and recording daily positive memories	Theories and interventions on helping individuals with depression to plan and perform positive activities. I.e., GAP (goal setting and planning) [49, 186, 128]
Facilitate revisiting the recorded memories and better process them	Theories and interventions for managing D-ABMs [86, 40]

Table 5.1: Design goals of the toolkit and their mapping of theories

Related theory	**Design theme**	**Design challenges**	**Revised design goals**
GAP	1.Goal setting 2.Plan setting	Decide feasible goals/plans that can benefit depression alleviation	Encourage app users to plan and engage in positive daily activities
D-ABMs, GAP	3.Memory recording (if achieve plan) 4.Memory recording (if fail the plan)	Engage users while engaging with positive-provoking activities.& Encourage app users to record positive memories	Avoid/ alleviate emotional distress while using the app
D-ABMs	5.Memory (progress) revisiting	Present recorded memories in a way that is safe and helpful for addressing D-ABMs.	Facilitate users to review and retrieve positive memories appropriately

Table 5.2: Mapping of design themes to psychological theories.

5.2.2 Step 2: Distributing theories into the toolkit design

I then distributed and combined the identified design goals, challenges, and the related psychology theories into the design toolkit. (See figure 5.1 and table 5.2). The toolkit comprises two parts: 1) a set of design cards, and 2) a description of the design procedure for guiding participants to use the design cards.

1) **Toolkit Part 1: The composition of design cards (figure 5.2)**

   Inspired by recent work [26, 28] on adapting academic knowledge to design practice, I choose design cards as the format for the design toolkit, as they are one of the most useful tools when bridging the gap between complex theories and design process [64, 17, 105]. The cards developed comparise:

   - **Persona cards (N=3):** The three persona cards feature textual descriptions of three fictional app-users living with D-ABMs. Each persona has unique demographic characteristics and needs.
   - **Scenarios (N=15):** Each of the 3 persona cards match with 5 scenario cards, which highlight how D-ABMs bring challenges to a person's daily life in each of the 5 design contexts (see table 5.2).
   - **Theory-informing cards (N=29):** The theory cards aim to present detailed descriptions of D-ABM theories and actionable recommendation for addressing the issues they pose. The identified depression-related challenges were evenly distributed into the design of the 3 personas and 15 scenarios. The detailed distribution description is illustrated in figure 5.2.

2) **Toolkit Part 2: Developing the guidance of using the toolkit (table 5.3)**

   I iterated the design of design sprint procedure, for the aim providing step-by-step guidance for participants to use the cards. The design sprint procedures are generated based on prior research practices in design sprint [28, 26, 106]. There are 10 steps in the design sprint, each step involving specific action points, design goals and deliverables. The design sprint lasts around 120 minutes and ends with participants sharing their feedback on the workshop. The design outcome is textual app features written by participants.

5.2.3 Step 3: Toolkit iteration

After generating the 1st version of the design toolkit, I piloted it with 4 experts (comprising 1 psychology practitioner and 3 HCI designers). I then modified the materials and workshop procedure based on their feedback.

Demographics of personas	Mark	Alice	Arthur
	Male Middle age (working professionals)	Female Young	Neutral Young (20-30)
	Very busy	Low self-esteem (afraid to do something)	Low motivation (does not feel any emotion, not even the experience of fun)
	He has too demanding goals, try to be perfect. (But it's hard!)	Have avoidance goals (e.g., I don't want to ..), instead of approach goals (e.g., I want to ...)	He/she only has blur, non-specific life goals (e.g., want to be happy without clearly picturing why)
Goal setting	He has too many goals, try to achieve them all, but it's impossible to balance	Have self-concordant goals. (e.g., work a lot to achive career success, go to gym everyday, and spend time taking care of kids).	He/she has goals but doesn't believe these goals are achievable.
Plan setting	He makes unrealistic plans. Having overly high standard on himself	She cannot make goal-achieving plans. Also have no confidence in believing herself to perform the plan.	He/she makes general plans because does not want to push her/himself too hard (however the plans are too vague to perform or measure)
Plan performing - success	He wants to celebrate happy memory, but find it hard to record them (not having enough time) He doesn't celebrate happy memory. Even if him did something good (i.e., act on a planned action), he/she will try to supress themselves from feeling good. (e..g. "it's not big deal, nothing to celebrate about")	She wants to celebrate happy memory, but find it hard to record them. (Example: even if she remembers to take pictures, she never revisit [illegible]) She doesn't celebrate happy memory. Even if him/her did something good (i.e., act on a planned action), he/she will try to supress themselves from feeling good. (e..g. "it's not big deal, nothing to celebrate about")	He/she experiences motivation, sometimes just cannot see the point of doing anything He/She doesn't celebrate happy memory. Even if him/her did something good (i.e., act on a planned action), he/she will try to suppress feeling good. (e..g. "it's no big deal, nothing to celebrate about")
Plan performing -fail	He doesn't have time for planned actions. He finds himself easily losing interest and confident to continue performing the plan, even if just failing one single action.	She has negative predictions of almost everything and avoids situations or even planned actions. She can easily start negative-biased OGM when failing a planned action.	He/she constantly feels low motivation and skips plans because don't know the plan of doing it. He/she tends to start negative-biased OGM when failing a planned action.
Others	He doesn't remember life achievements enough.	Don't remember life achievements enough. Start comparing past happiness with current sadness, then start negative-biased OGM	Don't remember life achievements enough. Start comparing past happiness with current sadness, then start negative-biased OGM

Figure 5.1: A screenshot of the table I used for distributing different D-ABM related issues in each personas and design contexts

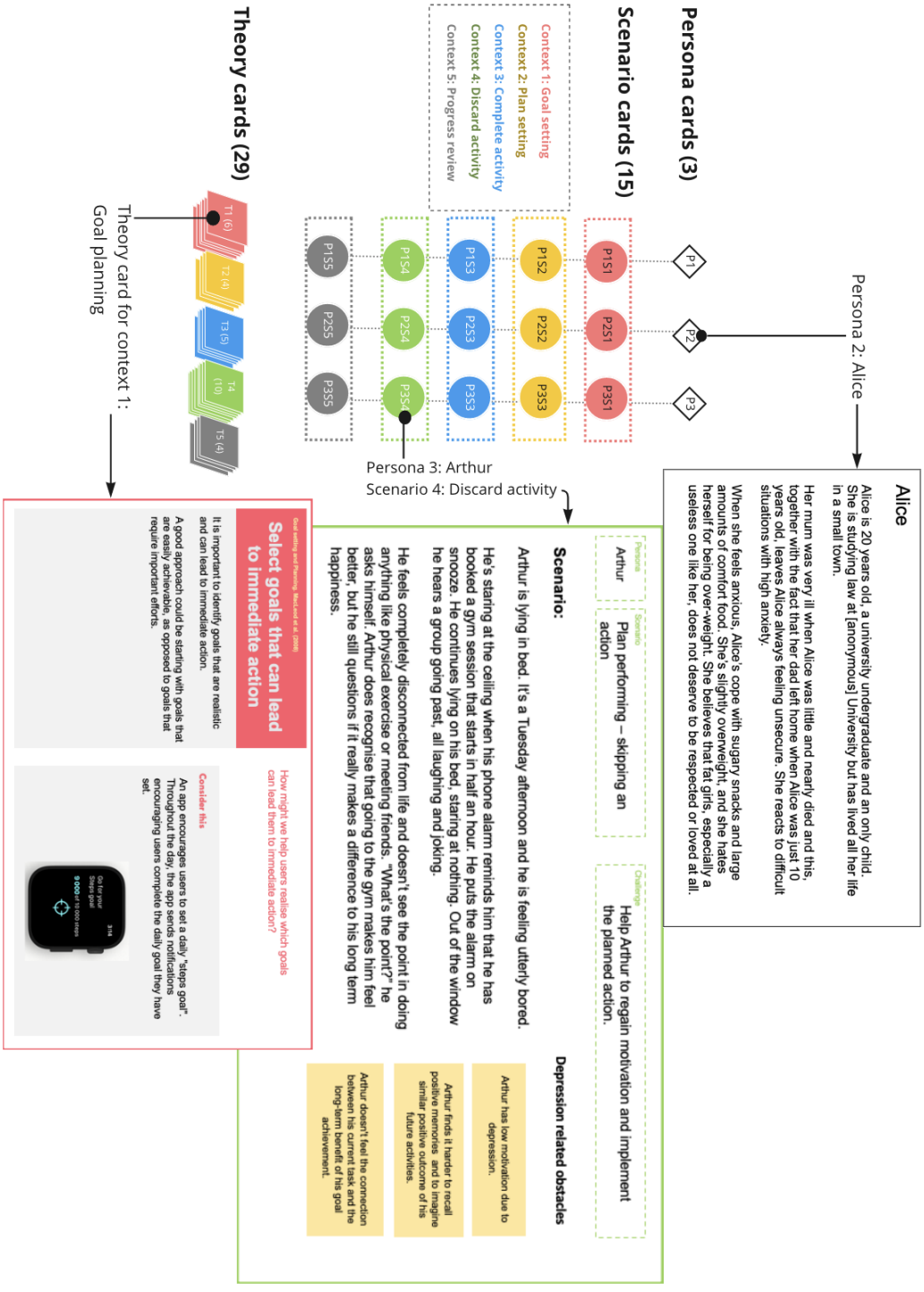

Figure 5.2: Overview of the content of design cards and how they are allocated to different research contexts.

Steps and goals	**Input material**	**Deliverable**
Step 1: Understand persona& scenario Step 2: Imagine app features	Persona cards Scenario cards	1.High level digital solutions (textual) 2. Concrete app features (textual)
Step 3: Create alternative user journey	User journey cards	Imagination users' life after introducing the digital app
Step 4-5: Group discussion	-	Teams merging all app features into initial app features (app_v1)
Step 6: Link theory with user journey	Theory cards	-
Step 7: Update app features	-	Modified app features (app_v2)
Step 8: Reflect ethical issues Step 9: Address the risks	List of questions (see full draft in appendix E)	Modified app features (app_v3)
Step 10: Feedback	List of questions (see full draft in appendix E)	Feedback of materials and workshop procedure

Table 5.3: The design sprint procedures

5.3 Evaluating the Theory-informed Materials

5.3.1 Study deployment

Step 1 - Evaluate: I deployed the design tool with 15 participants in 5 design sprint workshops to evaluate its usability and effectiveness. These 15 participants are experts in HCI design and had no prior experience and knowledge about D-ABMs or depression. During the workshop, I asked participants to use the design toolkit with the goal of designing apps for supporting users with D-ABM management difficulties.

Step 2 - Feedback: After the workshop, I conducted one-to-one follow-up interviews with each participant to collect individual feedback about the design toolkit. The interview was conducted online over telecommunication software (MS Teams).

Step 3 - Analysis: The study results are drawn from the data collected from both the workshop and the follow-up interview. To understand if and how the design toolkit can support design activities, I recorded the design ideas generated in the workshop, with a focus on if and how design results linked to the presented design cards. To understand participants' experience of and feedback on the design toolkit, I also audio recorded each interview and transcribed them. I then applied a thematic coding technique (following the Braun and Clarke approach [25]) to analyse the data collected from each interview session.

5.3.2 Findings

I now outline the findings in two parts: 1) the benefits of the design cards, 2) the limitation of design cards and ways to address these.

5.3.2.1 **The benefit of theory-based materials in design activities** The design cards support participants to understand users living with depression and its associated memory impairments in the following ways:

Persona and scenario cards can help designers to better understand the complex needs of depression, foster empathy, and tailor realistic solutions for solving their issues: With the help of D-ABM tailored persona and scenario cards, participants can have a more in-depth understanding of individuals with depression. For instance, participants commented that the fictional persona presented in the toolkit feels *"real enough"* for the designer to develop an emotional attachment with the persona. This fosters participants' empathy towards individuals with depression, which then leads to better design.

D-ABM cards help participants to better generate realistic digital solutions to solve users' individual obstacles: According to participants' feedback, the D-ABM tailored materials can describe the specific needs of the target users. This is helpful for participants to narrow down specific user problems to address, and to tailor the solutions based on users' personal preferences. Participants preferred the D-ABM tailored materials over traditional ones, because the latter materials can provide the detailed, personal description of different aspects and symptoms of depression. According to the participants, in contrast with D-ABM tailored materials, other design support tools mainly provide abstract descriptions such as *"he is feeling like x or y"* (P5), which can be hard for participants to relate to.

The design cards can make depression-related theories more accessible: Participants reported that using theory-informed persona and scenario cards was helpful for them to understand users' needs and the complex depression underpinning these needs. Theory cards also made psychological theories more accessible, as they provided simplified explanations and vivid examples to communicate complex and abstract D-ABM-knowledge from the psychology literature. Participants highlighted elements that were particularly helpful in supporting their understanding of D-ABM theories (see an example of theory cards in figure 5.2, bottom right) such as,:

- The thought provoking question that led to reflection (top right of theory cards),
- The technical example which provided a vivid showcase of how the theories could be translated into designs (bottom right of theory cards).

Participants acknowledge that theory cards could give them (as novice designers to depression) a sense of confidence, and make them feel they were better able to understand and leverage validated theories for their designs.

The design cards (persona, scenario, theory cards) can complement each other, for better guiding designers through their design activities: Participants reported that the different materials worked well together, and provided for the following reasons:

Firstly, the materials were presented progressively during the design workshop, which allowed participants to understand the complex D-ABM theories step-by-step. More specifically, the persona cards provided a general overview of depression, whereas scenario cards provided a more detailed description of how D-ABM related to issues that impact on an individuals' life. Additionally, theory cards educated participants about concrete treatment techniques for addressing D-ABM related issues that featured in the persona and scenario cards.

According to the feedback, working with different materials engaged them through different steps in the design workshop procedure. Participant quote: *"the process is fun, it's like playing a jigsaw game"*.

Moreover, the design materials helped elicit ethical considerations in mental health app design. For instance, one participant indicated that theory cards *"... (provides) a new way to look at the (ethical issues) in a wider context"*. The ethical discussion (see table 5.3, step 8-9) also helped participants to review their app features in the light of ethical concerns.

5.3.2.2 Overcoming the limitations of design cards

Balancing content complexity and readability: participants express concerns that sophisticated details of complex psychology theories might be lost for ensuring the read-ability of translational toolkit. However, some participants also worries that having the design cards providing too much information could be over-whelming for participants to digest. For instance, P1 noted that they were concerned that the complex D-ABM theories might be over-simplified in the design cards, which may affect participants' trust in the materials. In addition, due to some missing details about D-ABMs, some participants said that they experienced difficulties in understanding D-ABM-related user issues fully. For instance, P3: *"depression hits so many people in different things, so we need to know as much detail about how to deal with- the design as possible"*. However, some other participants also raised concerns as there was too much content present in the materials. As P2 mentioned: *"there was a lot of information... We were not sure where to start reading"*. As a solution, while presenting such translational design tools, we should clarify the limitations of such materials. I.e., they can only condense part of D-ABM-related theories. To balance the simplicity and complexity of card design, providing materials in an interactive format can also be helpful. For instance, we can imagine providing the design cards in form of Gantt chart, interactive calendar, or chatbot. In this way, users can request more details when they need them.

Additionally, it is important to develop strategies to avoid discomfort when participants are building empathy with their target users (i.e. individuals living with depression). Despite of the benefit of understanding target users' emotional experience, overly-exposing participants to persona's experience might be emotionally challenging [144]. To avoid potential risk of harm, we need to consider mechanisms for protecting participants' emotional well-being, especially during the delivery of D-ABM materials. For instance, we can create a sense of distance to safeguard the emotional well-being of the participants while empathising with their personas. P2 suggested that one way is to selectively present materials according to participants' own demographic characteristics

(e.g., present female persona to male participants). Additionally P8 mentioned that the absence of a picture in a persona was a good way that prevented him/herself from experiencing vivid negative emotions while portraying the end user.

Balancing tensions between group and individual activities: Some participants like working in teams, some participants suggested spending more time engaging in individual-based work. Most participants (7 out of 10) appreciated having both individual tasks and group tasks. Half of the participants were particularly in favour of group tasks, which allowed them to work with multiple personas. They reported that discussing different personas helped them reflect their own design. P3& P1: *"(Being exposed to more personas might help) . . . get a better idea of what depression could look like for different people''*.

However, 2 participants thought working with more than one persona was overwhelming. For instance, P7 mentioned that the information can be too much for: *"person who is not a psychiatrist or without similar background"*. Additionally, P1 expressed similar idea: *"not all solutions might work for all of those people (persona)"*. This is agreed by P5: *"stepping too far away from any specific issue and maybe not addressing something"*. Additionally, 2 participants experienced difficulties in group communication because they held different understandings from their group partners of the psychology terminology being presented. Therefore, it is important to balance the group and individual activities when designing workshop activities. Introducing a moderator who understands both D-ABM theories and HCI design can help facilitating the group discussion.

Balancing the openness and focus of design space: Some participant thought the design tools were restricting their creativity, e.g. P9: *"(the detailed user obstacles) stop participants making own assumptions about the persona"*. However, some other participants also acknowledged the importance of narrowing the design space down. P6: *"if you don't put constraints, you have a lot of risks to do something bad."*. Besides, some participants perceived the technological example of each theory card promoted certain types of digital solution. For instance, P3: *"if you had got these theory cards out earlier, then we would have gone: 'Right well, let's just design an app with motivation and that smartwatch"'*. Participants also pointed out that these examples are not necessary for experienced designers, as they can easily form their own solutions. Besides, some participants feel like the technical examples are enforcing technology itself, such as (P3): *"not everything can be solved by technology"*.

To balance the openness of design space, most participants noted the benefit of presenting theory cards at a later stage (i.e., after participants generate initial designs). P8 considered that the theory cards were more helpful as a 'validation' tool, to back up or challenge existing design ideas. To avoid enforcing unnecessary digital designs, participants suggested encouraging future designers to think beyond the design. For instance, during the ethics discussion (step 8-9), future designers can be encouraged to also reflect on (P3): *"Is it really important to have the technology in the first place?"*

For this, participants suggested some improvement, which especially includes targeting the technological example on theory cards. For instance, P9: replace the technological examples with *"real-world examples",* and P3: *"(to also provide) non-technical solution that draw on the presented theories"*. Additionally, P6 suggested replacing the specific technical examples with less concrete design guidelines, which can facilitate the design process without overly restricting designers' creativity.

5.4 Contribution and Relationship to Overall Thesis

The main contribution of this work is an exploration of how to best facilitate the design process of D-ABM apps. This includes:

1. Designing a toolkit that translates complex theories about D-ABMs to participants who are new to depression (i.e., designers who have little prior knowledge about D-ABMs or depression).

2. Evaluating the design toolkit with participants as HCI designers and researchers, collecting and analysing toolkit-users' feedback regarding their effectiveness and usability.

3. Generating design suggestions to guide future development of the translational materials (e.g., toolkit) for bridging complex theories and actual HCI design practice. This can be particularly helpful in supporting novice designers to quickly understand and leverage complex theories into app designs.

Additionally, the design tools generated in study 5 can be used for supporting future design of D-ABM apps. This also provides an insight of how to support future design activities with the empirical findings generated in study 1 and 2. Compared to prior literature, our design tool opens up new design opportunities for incorporating complex domain knowledge (e.g., D-ABMs) in HCI design.

Chapter 6

Discussion and Conclusion

6.1 Revisiting research questions

This section revisits each research questions and summarise how were these questions being answered by each of the five studies in this thesis.

6.1.1 Research question 1: What can we learn from best practices in ABM-based interventions in depression?

This question was answered through the practical contributions from study 1 and study 2, which provided rich understanding of users' requirement of D-ABM apps, informed by the current best practices.

RQ 1.1 How are D-ABMs being treated by current psychological approaches (both in theory and in practice)?

Study 1 formed the foundation for this thesis work, providing an overall understanding of theories around D-ABMs and the key mechanism of the latest theory-grounded, D-ABM targeted interventions. In particular, through study 1, I identified:

1) The specific memory impairments that are useful to be addressed during D-ABM interventions, namely **negative bias, OGM**, and **rumination**,
2) The key intervention procedures, and their principal mechanisms for addressing each of these targeted D-ABMs.

Moreover, the understanding gained from study 1 motivated study 2, which further explored other approaches beyond theory-based interventions. Study 1

also informed the conceptual framework that guides the data analysis of study 2.

By exploring approaches that are applied from a wider range of clinical practice for depression, study 2 provided a more enriched understanding of how D-ABMs can be mitigated by various of types of depression interventions. The contribution of study 2 enriched the answer of RQ 1.1 by:

1) Building on the understanding of D-ABMs and their interventions gained throughout study 2, I identified the three main **D-ABMs** to be targeted: **negative-bias, OGM,** and **Reduced positivity**.
2) By conducting an in-depth interview study with experts on depression, in study 2, I gained a richer understanding of therapists' opinions, experiences, and incentives behind their approaches while treating D-ABMs,
3) By explored how D-ABMs are addressed in a wider range of practical approaches (in both clinical and experimental setting), study 2 provided a comprehensive understanding of current best practice in addressing deprssion associated memory impairments.

Based on the answer of RQ 1.1, the combined findings of study 1 and study 2 informed the generation of key requirements and design requirements for apps that can support D-ABM management.

RQ 1.2: This contributed to the answer of **RQ 1.2: How can current psychological approaches (from laboratory and therapeutic practice) inform the design of mobile-based technologies for D-ABMs?**

By revealing the main mechanism of the current D-ABM interventions, study 1 and study 2 offered the following contribution to inform future designs of D-ABM apps (Details of the design suggestions can be seen in the following section in this chapter 6.2.1):

- A list of requirements that need to be met in the design of D-ABM apps (e.g., D-ABMs) for supporting users living with depression and its associated memory impairments,
- Identification of the principle therapeutic mechanisms that can address users' D-ABM specific life difficulties, which can lead to digital features guide to inform future app design.

These design requirements guided the data analysis of study 3 and study 4, which aimed to explore current app features that are suitable to meet the above

requirements, and how to leverage these current app features to address D-ABMs, following the above identified principal therapeutic mechanisms. The findings also informed the generation of a design toolkit, which was used in study 5 for exploring the best design method for designers to quickly to understand D-ABM related theories and the current best approaches, and draw design ideas on them.

6.1.2 Research question 2: How can we best design mobile apps for D-ABMs?

This thesis answered RQ 2 from two perspective:

1. Study 3 and 4 explored a list of the current features that can be leveraged for building D-ABM apps that meet the identified requirements,

2. Study 5 investigated the best way to design approach for generating mobile apps that can meet the identified requirements

RQ 2.1 The findings of study 3 and 4 contributed to the answer of **RQ 2.1: Are there existing applications with features that are suitable to address D-ABM impairments? What are their gaps, and how to improve them?**

Study 3 first assessed current digital app functionalities that can be added to D-ABM apps. By identifying suitable digital app functionalities and analysing their strengthens and limitations, study 3 identified the design opportunities of combining and tailoring these app functionalities for building D-ABM apps.

Study 4 then assessed current app functionalities and design features that are required for global depression management. This is to make sure that apps with D-ABM features, besides mitigating D-ABM impairments, can also be sufficient in managing depression. I also explored if and how D-ABM app features can be seamlessly integrated into the overall design of depression apps. By analysing the limitation of current apps for depression, study 4 suggested ways for app designers take consideration while designing depression apps.

Combining the findings generated in study 1 and 2, study 3 and 4 produced a comprehensive design implications for guiding the design of D-ABM apps that are user-friendly, effective, and safe for end users living with depression. Details of the design implications can be seen in section 6.2.1).

RQ 2.2: To support the design process of apps that meet the requirements of D-ABM apps, the contribution of study 5 answers **RQ 2.2: How can we facilitate the design process of apps for D-ABMs?**

Study 5 developed and evaluated a method for facilitating D-ABM app design, by using a D-ABM tailored toolkit. I designed this toolkit to translate the complex theories about D-ABMs for designers who are new to depression, and have little or no prior knowledge or experience in addressing D-ABMs. Through deploying the D-ABM tailored toolkit to HCI design experts, and investigating how the toolkit helps the design of D-ABM apps, I was able to evaluate the effectiveness and usability of the design method in supporting future D-ABM apps. I also generated a list of design suggestions to guide future design of apps that need to be designed base on complex theories.

Extending prior research [28, 26], study 5 opened new design opportunities for incorporating complex domain knowledge in HCI design. This can be particularily useful in early stages of the user-centred design (UCD) cycle, by quickly equipping non-expert designers with knowledge of design-required knowledge. By doing so, such design method lowered the barrier of designing apps for users with complex needs, and bridged the long-lasting theory-practice gap in the domain of HCI in mental health [22, 28, 83, 93, 165].

Study 5 also provided an insight of how to support future designers to understand and utilise the empirical findings generated in this thesis (particularily study 1- 4 in chapter 4). The design tools generated in study 5 can also be used for supporting future design of D-ABMs apps.

6.2 Design Implications

6.2.1 Implications for guiding future D-ABM app design

Study 1 and 2 both indicated that a D-ABM app need to meet the following requirements for ensuring their effectiveness:

- Mobile apps for addressing D-ABMs need to target three memory impairments: negative-bias, OGM, reduced-positivity.
- D-ABM apps need to translate these therapeutic components:

  1) **Address negative bias**: to support clients in disengaging with negative memories, and the negative emotions associated with these memories. This can be conducted through analysing the over-generalized negative memories in detail, breaking negative thinking patterns, or helping service users improving abilities in generative retrieval of specific episodic memories. Some approaches can also assist clients in retrieving specific memories in detail and analyse them in a more concrete manner.

2) **Address OGM**, to help clients in enhancing the ability in retrieving specific memories (especially in response of emotional word-based cues). Such approaches normally come with a scaffolding process to ensure clients are fully concentrated on retrieving their memories, instead of being distracted by rumination.
3) **Address reduced positivity**, to increase clients' abilities to retrieve positive memories and associated positive emotions, and eventually help them generate a more positive self-image.

Base on the design requirements generated in study 1-2, and the best combination of current features identified in study 3-4, I was able to finalise the design implications for D-ABM apps.

- **First, it is important to build a positive memory bank that contains cues of end-users' everyday memories.** Such digital memory banks can be used in the long-term to register positive memories across users' lifespans. These recorded positive memory cues can help users to challenge the negative self-presentation that are associated with depression.

  Such digital memory banks also need to provide novel memory cues that are tailored for D-ABMs (study 2, study 3). To address **reduced positivity** (study 2), study 3 identified the design opportunities to provide enriched cue content to support sufficient memory recall with vivid contextual details. For instance, by encouraging users to record personal cues with activity logs, or to present the cues with rich contextual information in forms such as pictoral, voice recording, or mood logs with annotations. Moreover, to address the **reduced positivity** and **negative bias**, the findings suggested that D-ABM apps need to provide multimodal cues that improve the quality of enriched positive memory recall (study 1, COMET). Inspired by current apps in providing textual templates for assisting users' memory recording (study 3), another helpful method is to encourage users to record enough details in the memory cue (e.g., who, where, what) is to provide template to assist memory recording. This is particularly important for managing **negative bias** and **reduced positivity**.

- **Additionally, D-ABM apps need to be particularly designed for addressing ABM impairments instead of EM impairments.** This means that D-ABM apps function more effectively when not directly presenting the specific memory cues with enriched details to users, but instead when they present memory cues in a rather generic format to encourage users to practise their own abilities in generative memory retrieval. This is because the detailed memory cues with vivid and enriched contextual information normally trigger direct EM retrieval, which has little therapeutic benefit to users with depression.

Additionally, recollecting emotional memories through direct retrieval process may involve the risk of rumination, which can potentially worsen users' current mood (study 2). Informed by the result of study 3, mobile apps can access users' current moods and provide app features that tailored by users' current mood. Additionally, to avoid users' negative mood affecting their previous positive memories, it is important for D-ABM apps to provide safeguarding strategies. For instance, when users are experiencing strong negative moods (study 2, study 4), it is best to suggest mood regulation tasks to users before retrieving memories that may trigger emotional response.

As study 2 indicated, adding scaffolding support while users retrieving memories from these generic memory cues is important. This is to ensure service users are concentrating on the memory retrieval and reduce the risk of rumination hijacking users' cognitive resources (inspired by Such features are particularly helpful in addressing **OGM**.

- **With enriched memory cues registered in memory banks, apps can provide personal training content that also translates other therapeutic approaches for mitigating D-ABMs.** For example, providing smart machine-human conversation could aid users' smart reflection on negative memories (study 1, study 3), as well as supporting reinterpretation and imagination (study 1, inspired from CBM-I) using edited memory cues from the memory bank.

  Such features can help end users with depression to build a more positive sense of self to against the natural negative self-image that associate with D-ABMs. Mobile apps that meet the above requirements could have huge potential for addressing the increasing demand for depression interventions, such as clinical interventions and self-help strategies, and support the alleviation [**Kohler˙2015**, 39, 86].

6.2.2 Safeguarding users while designing mental healthcare apps

Prior work has indicated that using mobile apps for managing depression can raise some ethical concerns [195, 198, 167, 124]. It is therefore important that such apps provide evidence on the **effectiveness, safety,** and **confidentiality** before reaching end-users in need [156, 195, 198].:

Users living with depression may face potential risk of harm by using poorly designed mental health apps [156, 181]. Findings of study 2 stressed the importance for D-ABM apps to safeguard their users. For example, viewing emotional memories can be problematic for users living with depression, as this may leads to worsening

users' present negative mood, induce rumination, or even depressive symptoms [110]. This is because when individuals are experiencing negative moods, viewing past happy memories can trigger ruminative response (e.g., comparing current difficult situation with the past, and feel that good things will never happen again)) [39, 45, 72]. When memory technologies present users with vivid, specific episodic memory cues (e.g., pictures), these cues induce direct retrieval which, as an effortless process, can easily be hijacked by rumination [39, 45], which is as a challenge posed by D-ABMs, as it involves difficulties for one to disengage from the ruminative thoughts (study 1, study 2). This highlights the importance of D-ABM app designers providing interactive design solutions that follows the ethical principle of nonmaleficence [14].

D-ABM apps need to safeguard users by preventing rumination while using the apps. For instance, findings of this thesis (study 1, 2) stressed the importance for D-ABM app design that can access users' current emotional state and adapt the retrieval of positive memories accordingly. For example, such apps can simply ask users to self report their mood state (e.g., by selecting between different emoticons or different text-based options), and provide content adapted to users' current mood. There are several scaffolding assisting features can be provided by D-ABM apps for users to challenge their current rumination thoughts. For instance, since users with depression tends to spawn rumination while revisiting emotional memories when they are in sad mood [86, 39], apps that target these users should safeguards for users from potentially emotionally provocative content (e.g., limit viewing pictures of a deceased friend, or avoid viewing any memories that related to users' negative self-thoughts).

Good examples can be found in 2 apps (study 4), which provide filters to automatically cover negative keywords within app-provided content and to offer a pop-up window with free psychological counselling helpline every 3 times when users choose to reveal the hidden negative words. Since depression at severe level can induce risky behaviour (e.g., self-harm or suicide), another important feature of D-ABM apps is to provide direct access to professional help (e.g., helpline for mental health crisis or suicide prevention) for protecting users in immediate danger.

Additionally, to further challenge the ruminative thinking patterns, we can imagine D-ABM apps to help users building a more balanced perspective on life including both positive and negative experiences. For instance, to prompt users practise their abilities in revisiting and re-experiencing past memories that can work as a counterexamples of their ruminative thoughts.

Besides ensuring efficacy and safety, safeguarding sensitive users' health-related data is another mandatory item to be taken into consideration when designing apps for mental Health. Aligning with prior academic reviews of mental health apps [71, 170], I have found that there are limited guarantees that top-ranked depression apps protect users' sensitive health information (study 4). The finding of study 4 indicated a common issue of current depression apps is providing questionable data ownership.

For example, although most apps claim to follow GDPR, most apps fail to provide access for users to completely delete data if they wish to.

In line with prior research [150, 170, 209], in study 4 I found that the regulation of such apps regarding safety and data privacy remain inadequate [150, 209]. In addition, although most of the apps reviewed were free to download, many come with in-app purchase for additional features or advertisements. I have also found that more than 80% of the apps using advertisement declared that they share users' data for commercial purposes. However, these information are not highlighted in the privacy policy, and are written in a style can be difficult to be comprehended by typical users, and no statement relating to this could be found on app marketplace description.

Such a statement would support users make an informed decision at the point of downloading the app. Missing such information is even more concerning given that prior studies have already found that many mobile apps rely on selling data as part of their business plan, which put users under the risk of having their privacy compromised. Prior studies [150, 209] have reported a high prevalence of health-related apps selling users' data to third parties e.g., lottery companies.

Responsibilities lie both with the developers of depression apps and the app market that hosts them to safeguarding users while using D-ABMs apps. Our findings, aligning with prior research [150, 170, 209], highlights the the responsibility of developers for both depression apps and the app marketplaces that host these apps to mitigate the above ethical risk . For instance, it can be arguable that developers of mobile app marketplaces are responsible for regulating depression apps and ensure app developers to:

1) Present careful design that followings ethical principle (e.g., nonmaleficence and beneficence),

2) Allow users to quickly access to resources if in immediate danger (e.g., experiencing strong negative emotions or even suicidal ideations),

3) Upload a privacy policy with consistent content with their other claims on the marketplace,

4) To communicate users upfront of the risk of having their often-sensitive data shared with third parties on the marketplace.

6.3 Limitations

This thesis focuses on gathering empirical findings to guide the design of apps to address memory-associated memory impairments. Since the result of this thesis draws on data gathered from each of the studies, some limit may resources in terms of

the enrichness of data sample that gathered from the studies in this thesis. More specifically:

1) In study 1, the data were gathered from prior literature about D-ABMs. This means this thesis focuses on interventions with evidence provided before 2017. Since the research works in the psychology domain develop very fast, new interventions may emerge and leads to novice design ideas for translating these new therapeutic approaches.

2) The data in study 2 are only collected from certain domain experts (e.g., CBT, psychologists, therapists). Experiences from experts from other subgroups of clinicians (e.g., mental health support worker, sport and Exercise psychologists, educational psychologists) might have been overlooked.

3) The digital features found in app marketplace (study 3 and 4): App iterate too fast, the studies conducted in 2019 may not suit the app marketplace right now.

With acknowledgment of the limit due to fast-paced intervention and digital technology development, I encourage future designers and researchers to combine results of this thesis with more up-to-date research and practice activities for gaining a comprehensive overview.

Additionally, study 5 focused on how the self-generated, theory-informed materials were used by the participants as HCI researchers and designers without background in psychology. Although the I may argue that the findings of study 5 achieved the aim of demonstrating the effectiveness of the materials, I could imagine further improvements of this study. For instance, a more rigorous evaluation session would have helped develop evidence base of the design ideas generated by the participants. Such evaluation sessions can be conducted as a follow up workshop session, involving domain experts such as psychologists to elaborate and validate the materials, and analyse their feedback and design ideas.

This would help to produce personas and scenarios that are as realistic as possible, and to reduce the burden on researchers when putting together the theory cards. Additionally, engaging the design process with psychology experts can further ensure relevant theories are being accurately and sufficiently transferred to the design cards.

Therefore, I suggest future work to engage non-designers, such as clinicians or end users with lived experience of depression. As having their input and feedback can further improve the clinical validity of the the design artifacts generated from the workshop (i.e., app features), as well as the design method.

6.4 Future Research

There are several options to further this research work. In this section, I will discuss possible future research ideas.

6.4.1 Design and evaluate the usability, efficiency, and safety of D-ABM app

This thesis work explores and presents design implications for future developers to generate apps for addressing D-ABMs. Besides building apps for addressing D-ABMs, I also expect future designers to proceed with designing, developing, and evaluating these D-ABM apps. This is because although the app functions are generated from evidence-based therapeutic components, there is no guarantee that the combination of these components can transfer the clinical effectiveness of the original interventions.

Additionally, there are many differences in the mode of delivery of interventions, such as frequency, context, concentration on the intervention. All these differences may impact the effectiveness of the intervention [209]. Therefore, I suggest future app developers to perform rigorous evaluation studies.

Moreover, I would suggest future HCI researchers to investigate the effectiveness of each feature suggested in the implication. This would assist in figuring out which features are the most (and the least) effective in D-ABM apps while coping with depression, and whether these features are being presented in the best way. For instance, evidence from Randomized Controlled Trials (RCT) is considered as a golden standard for backing up clinical interventions [169]. Future research into D-ABM apps should therefore consider performing RCTs to identify the key ingredients (e.g., compares a packaged intervention to TAU), and then evaluate the effectiveness of each ingredients of the intervention (e.g., having each arm of the RCTs with each arm testing one feature of D-ABM app design). Usability studies could also be conducted for testing the efficiency and safety of the combination of all therapeutic components suggested in this thesis.

6.4.2 Informing designs beyond D-ABMs

This thesis work focuses on investigating best design of apps that address D-ABMs, which is one of many impairments that associate with depression. For instance, besides D-ABMs, there are other cognitive impairments such as negative information processing [72], reduced cognitive flexibility [85], or negative cognitive bias [39, 130]. These depression-associated impairments can all contribute to the development of depression symptom and require tailored design for addressing them. I would thus

encourage for future works in investigating these impairments and take them into consideration while designing depression apps.

Additionally, By stressing the importance of tailoring mobile systems for users living with depression, the thesis work also sensitises HCI researchers to the limitations of current memory technologies. I would expect this work can encourage future designers to engage with the less explored design space as memory impairments in mental health conditions. By doing so, I could imagine novel classes of memory technologies might be developed fitting the needs of users living with alternative memory impairments such as those found in people with anxiety, PTSD, or other conditions.

6.4.3 Designing for users whose voices are suppressed

An essential component in the UCD design process is to understand the end users' personal experiences and needs [36].

In this thesis, I explored ways to help HCI designers' gain a better understanding of end users' struggles and needs associated with D-ABMs that will help them generate the most suitable app design based this understanding. I explored design cards as a material to translate such knowledge to designers. Such methods can quickly equip designers with sufficient understanding of users and relevant domain knowledge, without actively involve individuals living with D-ABMs (study 5). This can be helpful for designers to understand users who can be challenging to access.

For example, such translational materials can help designers in the mental health domain, especially in engaging users living with mental health conditions in early stage of HCI research or very exploratory design work is often a challenge [138, 53]. This is because such service users are living with complex conditions, and it requires throughout procedures to safeguard such service users [20], clinicians and researchers [144, 58] during research and design activities:

1) It can be emotionally taxing for designers and researchers to work with such a vulnerable group, especially when they directly engaged with participants' sad stories, distress, or over-whelming negative thoughts [171, 144].

2) Involving designers to materials that express highly negative emotional content may evoke designers' own negative mood response. This is supported by several participants in study 5 who remember their own life frustrations from reading their personas' stories. Such process may involve potential risk of affecting both designers' and service users' mental well-being [144], and the complex procedures for safeguarding both parties during fieldwork [58], such as to provide regular debriefing sessions within the research team [76].

Traditionally, to gather understanding of users, HCI researchers utilise methods such as in-depth interviews, participatory design workshops, or focus groups with either service users or domain experts [68, 138, 166]. The process can be highly time-consuming and expensive for HCI design practitioners to start engaging in the mHealth design area. Additionally, due to the lack of experience and knowledge working with participants in need, novice designers can be less sensitive in the safety, which can cost extra burden to both participants and the designers. Our findings (study 5) indicate that compares to the traditional methods (e.g., co-design workshop), using theory-informed design materials can help HCI designers to acquire basic domain knowledge in a cost-efficient manner, and help them maximising their resources in involving end users living with mHealth conditions only when necessary.

Moreover, I see the potential for the use of theory-informed design cards to lower the barriers for designers to access end users in sensitive settings beyond mental health. For example, Taghreed et al., [5] introduced scenario cards that co-created with end users in sensitive settings (i.e., women living in a culture impeding their self-expression). Honary and colleagues [88] designed video stories to present the lived experience of users with severe mental illness, and provided a framework for designing digital tools for translating their experiences without directly engaging them to the researchers.

Similar to these two studies, the theory-informed design cards used study 5 also show positive results in translating the lived experiences of target users, which helps designers to design relatable, accessible, and ethical digital content for addressing end users' needs. I see the potential for deploying the design approach with theory-informed cards for a wide range of user's groups, especially those who live in sensitive contexts and can be extremely challenging to access. For instance:

1) Users living with severe mHealth condition (e.g., suicidal ideation or self-harm [81, 199, 114]),

2) Users with difficulties in expressing their thoughts (e.g., users living with conditions such as Alzheimer or Alexithymia, or users experience language barriers to articular themselves to others),

3) End users living in sensitive settings beyond mental health, such as living in sensitive and critical environments (e.g., women living in a culture impeding their self-expression)

6.4.4 Supporting clinical interventions with the findings

The rising mobile device ownership provides an opportunity to lower the barriers for accessing mental health supports, raise awareness of mental wellbeing, or sharing

reflections on mental health concerns with peers. Compares to traditional clinical interventions, mobile apps can deliver interventions with less restrictions regarding location, cost, administrative burden, and stigma. D-ABM apps thus have a huge potential to reach a large number of service users in need, which is particularly promising for users who are less likely to seek for face-to-face interventions. Besides, D-ABM apps can provide depression interventions with personalized training content, which increase the usability and users' engagement of the intervention (study 2). Therefore, I can imagine integrating D-ABM apps with clinical intervention (e.g., as homework between intervention sessions). Additionally, the D-ABM app can help users collect self-relevant materials, which can help clinicians to gain better understanding of their clients, and potentially make later intervention sessions more productive.

Furthermore, mobile devices can also make the engagement with interventions feels simple, efficient, and less burdening. This helps maintain users' incentives to continue and complete the intervention [56]. If used in long-term, memory app with D-ABM related features can work as early-intervention and to mitigate the risk of depression from developing.

Appendix A

Published pieces: Exploring Memory Interventions in Depression through Lifelogging Lens

Exploring Memory Interventions in Depression through Lifelogging Lens

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Depression is a major affective disorder with significant socio-economic cost. Distinctive autobiographical memory impairments in depression include overgeneralization, negative-bias, and repetitive negative thinking. A few psychotherapeutic interventions have been purposefully designed to address these impairments, albeit they benefit from limited technological support. This paper reports an analysis of four memory-based interventions proven effective in the therapeutic practice targeting depression. We also explored the memory impairments addressed by these interventions. Our findings led to three design implications for digital tools in this space. We suggest the value of supporting enriched positive memory recall, negative memory reappraisal, and future episodic imagination.

Memory impairments, depression, overgeneralization, negative bias, rumination, lifelogging technologies

1. INTRODUCTION

With significant social and economic costs, depression is a major affective disorder impacting over 300 million people worldwide (WHO, 2012). Depression influences cognitive functions leading to distinctive memories impairments (Köhler et al., 2015). People living with depression have overgeneralized autobiographical memories with a strong bias towards negative events (Dalgleish et al., 2014). Several interventions have proven effective in addressing such memory deficits in depression (Table 1). These consist of Memory Specificity Training (MEST) (Raes et al., 2009), Concreteness Training (CNT) (Watkins et al., 2012), Competitive Memory Training (COMET) (Korrelboom et al., 2012) and Imagery Cognitive Bias Modification (CBM-I) (Holmes et al., 2013).

Most HCI research on depression has focused on developing computerised cognitive interventions, such as online Cognitive Behavioural Therapy (CBT) (Coyle et al., 2007 and Doherty et al., 2012). Limited work, however, has explored how memory technologies could support memory-related cognitive challenges in mood regulation, especially for preventing and alleviating depression. This is surprising given that lifelogging technologies could capture and effectively support autobiographical memory retrieval through records of pictures, audio, or affective states of memories (Van den Hoven et al., 2008 and Sellen et al., 2010). This paper explores four psychotherapeutic interventions for memory impairments in depression and the feasibility of augmenting them with digital tools (Table 2).

2. RELATED WORK

2.1. Mental Health in HCI

Much HCI research has explored prevention, detection and treatment of mood disorders, with a focus on emotional and behavioural responses. For example, social media has been used to detect depression (Tsugawa et al., 2015), while digital affective diaries (Konrad et al., 2016) and expressive writing method (Pennebaker et al., 2017) have been developed to support monitoring and reflecting on one's experience. Technologies have usually been intended as aids for traditional therapeutic

Table 1. *Four interventions targeting memory impairments in depression*

Intervention	Main procedure	Addressed memory deficits
Memory Specific Training (MEST)	*Guided by trained therapists, this intervention presents a series of cue words, and asks people to retrieve as many specific memories as possible*	*Overgeneralization*
Concreteness Training (CNT)	*This intervention requires people to repeatedly imagine the sensory details, warning signs, and actions related to difficult events and to reflect on them in a concrete manner.*	*Overgeneralization, rumination*
Competitive memory training (COMET)	*This intervention asks people to identify a positive self-identity, enrich it iteratively and practice such imagination over several sessions.*	*Rumination, negative bias (negative self-image)*
Imagery Cognitive Bias Modification (CBM-I)	*This intervention asks people to imagine themselves involved in prescribed scenes. The scenes start ambiguously and are resolved positively.*	*Negative bias (future-oriented scenario)*

interventions, harnessing the potential of augmented reality (Wrzesien et al., 2015), interactive games (Coyle et al., 2011), or multimedia positive self-portraits (Mynatt et al., 2001). More specifically regarding depression, HCI work has focused on online CBT (Coyle et al., 2007 and Doherty et al., 2012) for delivering digital training content. Limitations of these approaches are twofold. First, they have focused mostly on the affective and behavioural aspects of mental health and less on its cognitive aspects. Second, the few studies exploring cognition-based interventions in depression, such as online CBT, have employed technologies with limited interactivity, personalisation, or user engagement (Doherty et al., 2012).

2.2. Memory Technologies

Much HCI work has explored the value of lifelogging technologies in memory augmentation, by supporting memory capture and retrieval. Such technologies harnessed wearable sensors including, for example, SenseCam (Hodges et al., 2011), narrative clip (Viet Le et al., 2016) or biosensors (Sas et al., 2013) to cue retrieval of autobiographical memories. Such exhaustive and multimodal capture underpins the effectiveness of lifelogging technologies in addressing memory impairments (Sas et al., 2015). Lifelogging tools have also been explored in relation to progressive neurological disorders, which lead to significant memory impairments, such as Alzheimer's disease and dementia (Harvey et al., 2015, Allé et al., 2017 and L. Lee and K. Dey, 2008).

However, unlike other conditions involving memory challenges, memories of people living with depression are not necessarily impaired but rather difficult to access from the autobiographical memory structure (Conway, 2005). As Conway identified in his autobiographical memory model, the accessibility of specific episodic memories depends on one's working self, which is a complex set of self-images and active goals. Difficulty in memory retrieval is an important marker of depression (Dalgleish et al., 2014). Such difficulties consist of overgeneralized memories leading to biased interpretation and imagination of future events, as well as negative-biased memory retrieval. More specifically, people with depression have unique difficulties in retrieving specific episodic memories. They have a high tendency to truncate their memory-searching process and only recall overgeneralized memory in a negative tone, with a low level of specificity (Williams et al., 2007). Another distinctive memory impairment in depression is that negative memories are faster and richer to retrieve, while positive ones are slow and difficult to retrieve, less vivid and low in emotional response (Dalgleish et al., 2014). Thus, people living with depression may benefit little from simply reviewing sensory details of their memories prompted by lifelogging-based cues. They require a rather complex process to enhance their abilities in recalling and reflecting on their memories, to re-experience positive emotions associated with their happy memories and disengage with the negative emotions from their sad memories.

3. METHOD

Our study consists of an analysis of the four identified memory-based interventions proven effective in alleviating depression in lab settings. The selection of the four interventions: CNT (Watkins et al. 2012), MEST (Raes et al., 2009), COMET (Korrelboom et al., 2012), and CBM-I (Holmes et al., 2013) is based on the findings of a recent meta-analysis of autobiographical memory based interventions for depression (Hitchcock et al., 2017). Our analysis aims to reveal the main cognitive challenges addressed by these interventions, in terms of the cognitive abilities targeted by each intervention, especially for coping with emotional events and memories. The aim is to explore if and how lifelogging tools could better support these interventions.

***Table 2**. Four interventions and their potential of integrating with lifelogging technologies.*

Intervention	The key value to memory abilities	Input		Output	
		Current	*Lifelogging-augmented*	*Current*	*Lifelogging- augmented*
MEST	*Enhancing specific memory recollection*	*Emotional cue words*	*Bank of emotional memory cues*	*Verbal discussion*	*Visualize a bank of recollected specific emotional memories.*
			Personalized emotional cues		
CNT	*Reviewing memories and change viewpoint*	*Audio training& first-aid relaxation guide*	*Bank of negative memories to be analysed*	*N/A*	*Identify user's negative thinking pattern. Detect and offset rumination from an early stage*
			An interactive guide for reflection on negative memories		
COMET	*Enhance positive memories recollection, build a positive self-image*	*Self-generated materials*	*Bank of positive memories across the lifespan*	*Imagery positive self-image*	*Visualize an ideal self-image with enriched sensorial details.*
CBM-I	*Enhance positive current/ future imagination with everyday scenes.*	*Neutral scene via audio or pictorial materials*	*Personalized ambiguous scenes from "editing" users' everyday neutral scene*	*N/A*	*Visualize users' imagination as training result (e.g. painting).*

4. FINDINGS

4.1. The Challenge of Recollecting Specific Episodic Memories

MEST and CNT both pointed out that people living with depression suffer from categorical memory recollection in a negative tone. The overgeneralization process stops individuals from reflecting on what had happened, but instead keep processing abstract negative memories. Overgeneralization, as an indicator of depression, could persist even after remission from depression and potentially contribute to the next depressive episode. As an intervention specifically targeting this cognitive vulnerability, MEST trains participants' ability to retrieve specific episodic memories in detail. It provides word-based cues associated with different emotional valence, to break people's categorical negative thinking. CNT trains participants' abilities for reviewing specific negative memories and for re-evaluating them to mitigate against overgeneralization.

4.2. The Challenges of Building a Positive Self-image

People living with depression tend to have negative views of their lives, keep revisiting their negative life events, and feel like only bad things happened in their life. The negative-biased view contributes to their negative self-image, as pointed out and addressed by COMET. According to Conway's autobiographical memory theory (Conway, 2005), people evaluate and interpret their present and future scenarios by retrieving relevant memories. Therefore, as addressed by CBM-I, people who hold a negative view of their lives tend to interpret events in a consistently negative way, which contributes to their low motivation and hopelessness. During COMET intervention, participants first identify negative self-identity and imagine an incompatible positive self-identity. They then strengthen this positive self-image by progressively adding verbalisation, body postures, background music, and facial expressions. CBM-I exposes participants to neutral scenes, presented acoustically and visually, and asks participants to imagine a vivid positive ending to the described neutral scenes. This intervention also engages people in positive imagination.

4.3. The Challenge of Disengaging from Negative Thoughts

Due to cognitive weaknesses such as negative bias and overgeneralization, people living with depression have difficulties in disengaging from repetitive negative thoughts. CNT supports people to review and reflect on specific difficult events and analyse the triggers of negative emotions. This intervention also encourages participants to explore alternative solutions and to alter the viewpoints of their upsetting memories. COMET trains participants' ability for retrieving positive memories as alternative material against negative thoughts. The increased accessibility of positive memories could reduce the possibility for negative memories to hijack one's cognitive resources.

To summarise (Figure 1), these findings indicated that memory-based interventions could benefit from lifelogging technologies. Key here is to identify the right cue content, which should (i) address negative bias (Dalgleish et al., 2014), (ii) address the identified challenges of the above interventions, and (iii) leverage the potential of lifelogging tools to enable personalized, self-tailored and more engaging interventions (Doherty et al., 2012).

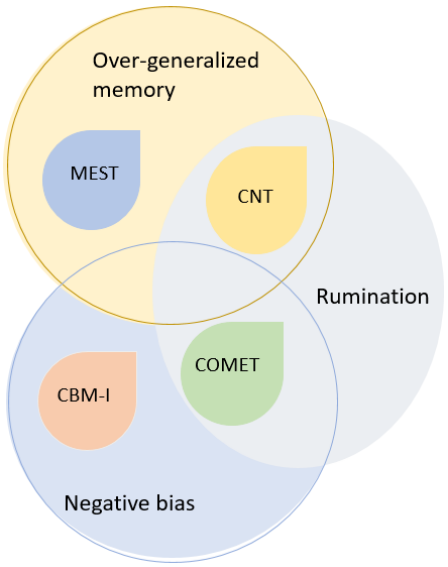

Figure 1. *This figure illustrates target symptoms of each intervention: MEST and CNT target overgeneralization. COMET and CBM-I aim to reduce negative bias, while CNT and COMET aim to reduce rumination.*

5. DESIGN IMPLICATIONS

5.1. Supporting Sensory Rich Positive Recall (Challenge 1, 2)

As pointed out by MEST and COMET, people living with depression face difficulties both in retrieving positive memories and in reliving associated positive emotions. They tend to have insufficient positive memories to build a confident self-concept against their negative one. Therefore, one can think of new tools for capturing and archiving positive events across the lifespan. Such a multimodal bank of positive memories, captured through biosensors could be deliberately tagged with sensorial contents, for example, audio, visual, or haptic, close to the

moment of encoding. Such a positive memory bank has the potential to contribute to vivid positive self-imagination. It can also strengthen people's memory processing abilities, especially the encoding of positive episodic memories. This in turn can safeguard people from the offset of depression.

Unlike generic cues used in MEST intervention, this positive memory bank, with enriched personal memories could provide powerful self-relevant cues (Sas, 2018) simulating the memory-encoding context, which also harnesses the context-dependent quality of memory for better recall when the contexts of encoding and retrieval are similar (Tulving, 1973). Personalized training modules, as pointed by previous online mental health intervention research (Doherty et al., 2012) is also important for user engagement. In addition, a bank of positive memories could support the visualisation of users' training progress and provide them with a sense of achievement.

5.2. Supporting Reflection on Negative Memories (Challenge 3)

The above interventions point out a design space for supporting reflection on mood journal. As previous HCI studies about mood journals revealed (Konrad et al., 2016 and Hollis et al., 2017), simply reviewing previously written memories is not enough for mood regulation. Designers of such systems also need to consider the mood dependent context and human memory weakness (Sellen and Whittaker, 2010). For example, findings from mood journal studies (Konrad et al., 2016) have shown that reflecting on positive memories in sad moods could potentially taint the happy memories and induce joy-killing thoughts. Findings also indicated that revisiting negative memories from digital affective diaries (Hollis et al., 2017) contributes little to both momentary and long-term mood improvement, although it has proven effective in pencil and paper based studies (Pennebaker et al., 2017) for inducing re-appraisal, self-distancing and wellbeing.

Thus, it would be useful to support users to reflect on their memories in a more structured manner by replacing their previous free-style of reflection. For example, CNT inspires a design opportunity for a novel interactive system that explicitly facilitates reflection and sense-making, by integrating natural language processing techniques such as conversational agents for guiding such reflection in a concrete style. If used along the lifespan, the system may allow early identification and correction of negative thinking patterns. The system is promising for detecting negative thinking patterns at early stages of rumination. Such a system could thus offsetting the negative influence of recalling traumatic events, and potentially preventing the depressive episode to set off.

5.3. Supporting Positive Reinterpretation and Imagination (Challenge 2)

Our findings indicate the value of CBM-I training in supporting the positive interpretation of generic ambiguous events. As suggested in HCI mental health research (Doherty et al., 2012), personalisation is key to user engagement. We can thus think of exploiting lifelogging technologies for collecting self-relevant everyday neutral events or "editing" anticipated ambiguous future events to train positive interpretation. For example, when users want to reflect on an emotional event, the system could remove the colour of a captured pictorial cue and ask users to i) colour the picture themselves, and then ii) draw an imaginary positive ending of this ambiguous scene. This process, inspired by mandala colouring as art-therapy (Palmer et al., 2014) could lead users to an engaging future-oriented positive imagination practice. Authoring tools can also be envisaged to assist people in capturing their interpretation of such events over their entire lifespan. Users could thus pay more attention to their everyday scenes and be more engaged in the present (Keyes, 2014).

We argue that technologies such as lifelogging are well suited to address the negative bias in depression. However, more effort should be put in leveraging potential of such technologies to address overgeneralized memories, especially identifying positive memories as material to guard against negative overgeneralization. In addition, identifying neutral events to train positive interpretation could also have great potential in addressing memory impairments in depression.

6. CONCLUSION

This work explores the potential of lifelogging technologies to support memory-based interventions in depression. We report an analysis of four such interventions. Findings identified the cognitive challenges targeted by each of them, as well as their training procedures, materials and main limitations. We employed a "lifelogging lens" to this analysis and identified three design implications addressing the challenge of negative bias of memory retrieval and interpretation in depression.

7. ACKNOWLEDGEMENT

This work has been supported by AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 Marie Skłodowska-Curie GA No 722022.

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Appendix B

Published pieces: Exploring and designing for memory impairments in depression

Exploring and Designing for Memory Impairments in Depression

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ABSTRACT

Depression is an affective disorder with distinctive autobiographical memory impairments, including negative bias, overgeneralization and reduced positivity. Several clinical therapies address these impairments, and there is an opportunity to develop new supports for treatment by considering depression-associated memory impairments within design. We report on interviews with ten experts in treating depression, with expertise in both neuropsychology and cognitive behavioral therapies. The interviews explore approaches for addressing each of these memory impairments. We found consistent use of positive memories for treating all memory impairments, the challenge of direct retrieval, and the need to support the experience of positive memories. Our contributions aim to sensitize HCI researchers to the limitations of memory technologies, broaden their awareness of memory impairments beyond episodic memory recall, and inspire them to engage with this less explored design space. Our findings open up new design opportunities for memory technologies for depression, including positive memory banks for active encoding and selective retrieval, novel cues for supporting generative retrieval, and novel interfaces to strengthen the reliving of positive memories.

CCS CONCEPTS

• Human-centered computing • Human-centered interaction (HCI) • Empirical studies in HCI

KEYWORDS

Depression; memory impairment; memory technologies; cues

ACM ISBN 978-1-4503-5970-2/19/05.
DOI: https://doi.org/10.1145/3290605.3300740

ACM Reference format:
Chengcheng Qu, Corina Sas, Gavin Doherty. 2019. Exploring and Designing for Memory Impairments in Depression. In *2019 CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland, UK.* ACM, New York, NY, USA. Paper 510, 14 pages. https://doi.org/10.1145/3290605.3300740.

1 INTRODUCTION

Depression is a condition with significant social costs which raises significant challenges both for interventions used in clinical settings and for support provided in daily life. While depression is primarily known for the dysregulation of affect, it is also characterized by cognitive dysfunction including memory impairments such as *negative bias, overgeneralization* and *reduced positivity* [13,25].

While most HCI research on memory technologies has focused on episodic memory impairments such as those associated with dementia, less work has focused on building technologies for autobiographical memory impairments to help people living with other mental disorders such as depression. Memory impairments in depression are however fundamentally different; their effect is felt not through the loss of episodic memories, but rather difficulties in the retrieval of episodic memories through higher levels of autobiographical memories such as general events and lifetime periods. Another distinct body of work explored computerized interventions for depression such as online Cognitive Behavioral Therapy (CBT). Such interventions address memory impairment, not as the main focus, but rather through a subset of psycho-educational materials concerned with negative thinking patterns, and tools for tracking mood [9,10,17], which provide limited support for the distinctive autobiographical memory impairments associated with depression. Our work aims to bridge these two strands of work to contribute to the design of novel classes of technologies that specifically address memory impairments in depression. We argue that understanding the specific memory impairments in depression, and the new range of challenges they pose, offers a rich opportunity to extend HCI research on

memory technologies in new directions. This paper is an initial step towards exploring this space and focuses on the following research questions:

1. How are memory impairments in depression addressed through tailored interventions used in clinical and neuropsychological practice?
2. What is the role of materials in these memory interventions and how are they employed in therapeutic practice?
3. How can therapeutic memory interventions for depression inform the design of novel memory technologies?

To address these questions, we report on interviews with ten experts working in clinical and neuropsychological practice with people living with depression. This includes four neuropsychologists, for whom memory impairments will form a larger part of treatment, as well as therapists from other backgrounds, for whom memory impairments will form part of a wider treatment strategy. The main contributions of this work include a richer understanding of how memory impairments in depression are addressed in clinical practice and design guidelines for new memory technologies for people living with depression. The paper's contribution is threefold: (i) sensitizing HCI researchers to the limitations of current memory technologies, (ii) broadening their awareness of memory impairments beyond those associated with episodic memory recall, i.e., unlike ageing or dementia, other conditions such as depression or PTSD do not involve impairments of episodic memory recall [60], (iii) inspiring HCI researchers to engage with this less explored design space for developing novel classes of memory technologies to address alternative memory impairments such as the ones in depression.

2 LITERATURE REVIEW

2.1 HCI Work in Depression Treatments

The last decade has witnessed a massive growth of HCI work on affective health [48]. In particular, HCI work on depression has considered a range of systems aiming to support detection of depressive symptoms, management of short-term negative emotions, tracking of depressive symptoms, and online management of depressive symptoms over the long term. Work on diagnosing depressive symptoms has focused on analyzing online daily activities (e.g., Reddit [3,6], Twitter [5,58], Instagram [37]) to detect depression (e.g. postpartum changes [5], suicidal ideation [6], self-disclosure [3], severity of depression [58], and mental health issues in general [37]). Another strand of relevant HCI work has looked into interactive devices for guiding mindful practices [14] to reduce high-intensity negative emotions in the short-term [4] or tracking depressive symptoms [38]. This body of work builds on positive psychology [29], utilizing lifelogging technologies [29] to better support coping strategies through expression [43] or increased social communication [61]. Retrospective self-tracking is itself subject to a number of sources of bias [18].

In addition to tracking, the design of computerized psychological treatments for depression has been explored by HCI research [10]. Such interventions tend to include psychoeducation sessions, requiring users to complete a number of achievable goals [9]. These online mental treatments are often based on highly structured and goal-oriented psychological treatments such as CBT or Solution Focused Therapy (SFT) [9]. It has been argued that the structured nature of the content of these interventions, and the goal-oriented user journey make them more amenable to delivery via computer [10]. However it is important to also note that at present CBT is one of the most evidence-based and widely used approaches in both the clinical context and in internet-delivered therapy [10,17,47] and is currently as one of the first-line treatment options for mild to moderate depression, especially in the UK [17].

An important challenge for e-Health programs such as online CBT is the rate of attrition [20]. To improve user engagement, Doherty and colleagues [17] suggested a number of strategies including delivering more personalized and multimodal content, such as by allowing users to tailor their preferred treatment path. Accessing information through other modalities such as video [9], games [2,9,11], or conversation with embodied agents [22] has also been suggested, especially to increase young people's engagement with their treatment for depression.

While current computerized depression treatments are primarily based on highly-structured interventions, other unexplored possibilities include free-form interventions which build on people's life-narratives [9]. Coyle and colleagues [10] suggest approaches which focus specifically on clients' sense of self, and how they construct the narrative of their life stories with the aim of changing thinking patterns to alleviate depression. In addition, it has been suggested that the design of computer–aided systems for clinical treatment should support a broad range of therapists, treatment settings, and clients [9]; there is thus an opportunity to support a range of person-focused therapies by addressing common factors in depression.

Another challenge faced in the design of computerized systems is that as the treatment is associated with their

illness, users may stop using the system after they feel like their depressive symptoms have improved [17]. However, quitting treatment early may mean that some cognitive impairments remain and raise the risk of relapse [13]. An interesting possibility is to investigate solutions, which can be used inside or outside of treatment.

All the above issues motivate the exploration of new technologies for the treatment of depression, with less focus on linearly-delivered training content, and less dependence on text and reading skills. This requires that the technology involve more of the client's self-relevant materials and have a less explicit framing as "treatment for depression", but instead aim to raise the resilience of people at risk of depression.

2.2 HCI Work in Memory Technologies

Memory technologies have mostly focused on addressing episodic memory loss within non-clinical populations or of people with dementia. In particular, lifelogging technologies capture episodic memory to support later retrieval [26,52], reminiscence [16,51,53,56] or mood regulation [31]. HCI work supporting memory in dementia [1,24,35,36,50] has explored lifelogging technologies such as SenseCam to capture episodic memories and support episodic retrieval through the autobiographical memory system [49].

2.2.1 Systems supporting capturing and organizing cues for EM. Episodic Memory (EM) contains highly detailed sensorial information regarding specific life events, which can either decay quickly or become integrated within the autobiographical memory system from where they can be vividly retrieved [7]. With the help of modern memory technologies (such as contextual sensors and massive digital storage techniques [54]), people can record more and more sensorial memory cues (e.g., visual cues with camera [26,30,52], or verbal cues with microphones [16]) to support episodic memory in everyday life. However, such technologies can generate a huge number of memory cues, which are impractical for users to review and directly make sense of (e.g., 1500 images a day [30]). Thus, Sellen and colleagues [54] suggest selectively capturing episodic events for addressing particular memory impairments. Some researchers suggest filtering valuable memories at the moment of capture, either automatically (e.g., by filtering memories with high emotional arousal [52], or via user selection (e.g., self-crafted memory cues [50]).

As episodic memories cues accumulate over time, a framework is required to organize and represent captured cues. Recording captured memory cues and constructing them in a narrative representation is a method that works well with users' preferences and natural habits [44]. Such work includes narrative diaries of everyday events, modalities of cues include video summaries or animations [30], bio-sensing data [55], or combined multimedia memory cues [42].

2.2.2 Systems supporting cue-based remembering through AM. Autobiographical memory (AM) is the "remembered self" across the lifespan, which provides a long-term framework for episodic memories. Current memory technologies predominately support user needs in directly accessing episodic memories through the AM system, by representing memory cues that explicitly target specific episodic memories [26]. Such supports in direct retrieval could benefit people with memory loss problems, to reconstruct forgotten memories for later reminiscence [56], memory sharing [32], emotion regulation [31], or alleviating dementia [35]. However, presenting users with captured memory cues does not necessarily mean they can remember successfully. The captured cues are just collections of data for assisting the remembering process, but not the process itself. As stated in [27], remembering is a process of re-construction within the self-memory system and retrieving specific memories based on users' current beliefs. The retrieved memories will always be altered by people's current dominant self-beliefs, and their current interpretation of the memory. Van den Hoven and colleagues [27] further suggested that AM technologies should be flexible in presenting memory cues for supporting memory retrieval.

We see from the above that work on memory technologies has mainly focused on episodic memory impairments (i.e., memory loss in dementia or forgetting). Qu and Sas [45] have started to introduce autobiographical memory training for depression to the field of HCI and called for future work in advancing memory technologies, however, HCI research has not widely addressed several important aspects of autobiographical memory impairment, and in particular how people's dynamically-changing sense of self can distort their ability to remember. These complex impairments arise in a variety of mental conditions, including autobiographical memory impairments in depression, and flashback trauma memories in PTSD.

2.3 Memory Impairments in Depression and Memory-Based Interventions

2.3.1 Autobiographical memory and self-identity. Retrieval through the Autobiographical Memory System (AMS) involves the autobiographical knowledge-base and people's self-identity [8]. The former contains memories across the lifespan at three levels of abstraction (Fig.1): lifetime

periods (highly semantic), general events (part semantic, part episodic), and episodic memories [7,8] while the working-self [8] involves information about self-identity, and is critical for accessing each episodic memory. The AMS supports two modes of retrieval: generative retrieval and direct retrieval. Generative retrieval is a memory searching process involving one's self-identity. As shown in Figure 1, the generative memory-searching process starts with a cue activating the retrieval mode, accessing and evaluating memories at all three memory levels, and elaborating the search-cue iteratively, until a matched specific memory is reached. Direct retrieval is triggered through cues with direct links to specific episodic memory, with less involvement of self-identity.

Consistent findings in psychology have shown that people living with depression have three distinctive AM impairments (Figure 1): *negative bias, overgeneralization,* and *reduced positivity* [13,25]. These memory impairments mainly disrupt the generative retrieval process. Several memory-based interventions [19,34,46,57] have been designed to address such memory impairments in depression [25].

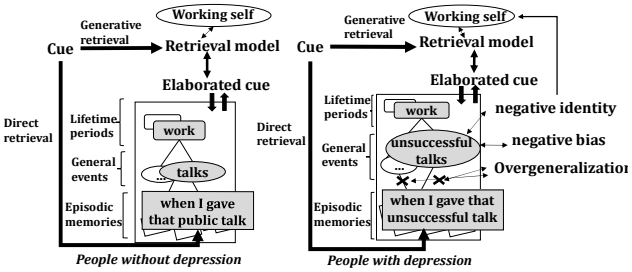

Figure 1. Memory retrieval in people without depression (left), and with depression (right)

2.3.2 Three memory impairments in depression and targeting interventions. Psychological work has identified three memory impairments in depression [13]: *negative bias, overgeneralization,* and *reduced positivity* and four main tailored interventions [25]. Concreteness Training (CNT) trains people's ability to look back at specific events in a concrete manner to reduce *negative bias* and *overgeneralization.* Memory specificity training (MEST) trains people's ability to retrieve episodic memories to address *overgeneralization.* Competitive Memory Training (COMET) trains the ability to retrieve positive memories for building a positive identity for addressing *negative bias* and *reduced positivity.* Cognitive Bias Modification-Imagery (CBM-I) trains people's ability to cope and practice positive interpretation through imagination for addressing *reduced positivity.*

Negative Bias [13]. Research has shown [13] that people with depression tend to have negative self-identity, which contributes to *negative bias.* They tend to pay attention to negative materials or to interpret vague scenarios in a negative manner, which leads to the retrieval of a larger number of negative memories compared to the non-depressed population. This process strengthens the access path of negative memories from the memory system making negative memories easier to retrieve and positive ones harder to retrieve. As time goes by, the imbalanced remembered self (AM) continues to fuel a stronger negative self-identity. Several memory interventions have been developed to address *negative bias* [25], including COMET [34] and CNT [19]. While COMET helps clients to construct a positive self-image to guard against the negative one, CNT helps depressed clients to disengage with their retrieved negative memories by analysing them in a concrete manner.

Over-generalization [12,13]. People living with depression have difficulties in accessing both specific episodic memories, and their details through the generative retrieval process. As shown in Figure 1, the memory search process starts from accessing the higher levels of AMS such as lifetime periods and general events. Unlike non-depressed individuals, people with depression tend to finish the search process before reaching the episodic memory level. In addition, as mainly negative memories could be retrieved due to *negative-bias*, the retrieved abstract, negative memories further contribute to an abstract and negative life summary; "My life is a total failure". People with depression do not have problems with the direct retrieval of episodic memories, as their memories are not lost, but simply harder to access [59]. As described in [25], MEST [13,46] and CNT [19] are interventions addressing overgeneralization. MEST helps users enhance specific memory retrieval with emotional word-based cues, while CNT help them retrieve details in their specific negative memories and analyze them in a more concrete manner.

Reduced Positivity [13]. Due to their negative self-image, positive memories of people with depression are less vivid and emotionally-intensive, so they contribute little to users' mood even when retrieved successfully [13]. In addition, as depression draws attention to negative material, fostering rumination and negative mood, it can also contribute to worsening of mood while reviewing positive memories. Apart from clinically depressed people, healthy people with low mood [33], or history of depression [15] also face this risk. As suggested in [25], COMET [34] helps users build positive self-image by repeatedly imaging

positive experiences or retrieving positive memories, while CBM-I [57] helps users to practice positive interpretation of neutral scenarios.

These three memory impairments, as indicators of depression, may persist even after a depressive episode is resolved, contributing to the next one [13].

3 METHODOLOGY

We conducted semi-structured interviews with ten experts in clinical or neuropsychological practice, with at least six years of experience of working with people living with depression. The study aimed to explore their practices of addressing memory impairments in depression. Participants (eight female, two male) have on average 15 years of experience (range 6-30) in working with their clients living with depression. Seven participants have expertise in CBT (P1, P2, P3, P4, P8, P10), two are neuropsychologists with expertise in memory training in depression (P5, P9), and two have expertise in both CBT and memory training in depression (MEST) (P6, P7). Five participants have Ph.D. degrees in Psychology, four have postgraduate degrees (MA, certificate, diploma) in psychotherapy, while another one has a BSc degree in psychology. Six participants were from the UK, while the other four were from Belgium and the Netherlands.

Participants were recruited through email advertisements from CBT associations and an online database of clinical practitioners and researchers. The semi-structured interviews were carried out individually through phone or Skype calls. During the interviews, we asked participants about their practice and how they addressed memory impairments in depression. We also asked about their challenges in conducting the treatments as well as engaging treatment-recipients. Interviews lasted about an hour, were audio recorded and fully transcribed.

Data analysis involved hybrid coding which ensured that themes were partly grounded in the literature and partly derived from our findings, offering the advantage of balancing the knowledge of existing theory with the sensitivity to theoretical novelty. The first author completed the interviews and the initial coding. Questions in the interview include: (regarding overgeneralization) "Have you worked with clients with overgeneralized memories?", "Have you tried to address this overgeneralization problem, if so, how?" This strategy was part of the hybrid approach [21], integrating the framework from the literature with accounts of the work practices of individual therapists.

Data analysis took over three months, engaging all authors through weekly meetings where the codes with quotes were shared, discussed, and iteratively revised until agreement was reached regarding the final list of codes and their definitions. A conceptual framework developed from literature supported deductive coding, i.e., impairments such as overgeneralization, negative bias, reduced positivity, or memory processes such as encoding or retrieving. These were refined as new codes emerged, i.e., approaches such as encoding positive memories or retrieving negative memories.

4 FINDINGS

In this section, we discuss the *clinical approaches* used by participants to address the three key areas of *negative bias, overgeneralization,* and *reduced positivity.* We report them together with what *type of memory (i.e., negative or positive)* these approaches apply to, as well as which *memory processing stages* are targeted by each approach. We then conclude this section by reviewing specific materials that these clinicians used in their practice to support people managing depression.

4.1 Approaches Addressing Negative Bias

Negative bias refers to the pervasive negative-tone of depressed individuals' life-narrative, which is due to their preference for paying attention to negative materials and negative interpretation. People living with depression also tend to retrieve negative memories much faster and easier compared to positive ones [13,25]. Negative memories with high-accessibility (and positive memories with low-accessibility) further enhance the negative perspective of their life-stories as well as increasing the likelihood of rumination.

We identified several approaches from both clinical and neuropsychological practices to address the above problems, including reducing the negative effects of retrieved negative memories and increasing clients' ability to encode and retrieve positive memories.

4.1.1 Analyze and learn from negative memories. Both CBT therapists and neuropsychologists help their clients to analyze negative memories to support disengagement. These approaches aim to make negative memories less negative, and their emotional meaning easier to be disengaged from in future retrieval. The quotes provided in this section are illustrative of the common themes identified. Findings suggest two ways of supporting analysis and reflection on negative memories. Some therapists directly inform their clients about their problematic thinking style, P8 (CBT therapist): *"the thinking errors [could be] jumping to conclusions, thinking more negatively towards yourself and other people, or you are*

harsher on yourself then you are to other people". Another approach is to provide detailed scaffolding questions for guiding clients in analyzing and learning from their retrieved negative memories, P1 (CBT therapist): *"they need to learn what is it that creating the negative experience? What is that about? Is that about the type of people they attract? Is it something about them, which causes these things to go wrong? They will need to explore that, and then they might do differently in the future"*. This quote provides evidence of therapists' effort to encourage identification of unhealthy thinking patterns, to support disengagement from negative memories, and future healthier emotional or behavioral responses.

4.1.2 Reframe clients' negative interpretation and emotional response and encode reframed memory. Another approach for reducing the negative effects of negative memories is found in both clinical and neuropsychological practices. P5 (neuropsychologist) gave an example of a possible approach based on the Cognitive Bias Modification methodology [57]: *"for example, imagine 'a cup of coffee behind a rainy window'. The depressed persons' standard interpretation would be 'I feel isolated', but the alternative interpretation would be: 'it is a lovely afternoon, we are enjoying a lovely cup of coffee'. So you [could] expose clients to this kind of negative [mental] images, and then align them to interpret the meaning of these images [and reframe them more positively]"*. We also found similar approaches for reducing negative-biased interpretation through reframing negative memories mentioned by P1: *"a client [was] upset because [her] friend had a job she was also applying for, and she thinks it is unfair. However, I prompted her by saying: 'okay you told me that you are upset and worried about this, but is there another way of viewing it?' That could offer them [options to reframe their interpretation] and view the situation differently; [so that they could] reframe their emotion response and feel more positive about it"*.

The idea of this reframing process is to help clients to both reframe their memories less negatively and to encode the reframed memories in their memory system. As these negative memories could be less negative if retrieved in the future, depressed clients could disengage from these memories more quickly and easily over time.

4.1.3 Encourage switching attention from rumination to retrieved memory itself. Depressed individuals have a higher tendency to avoid retrieving details of their memories and rather distract themselves through rumination [13]. An approach for addressing this problem was mentioned mostly by neuropsychologists delivering a memory-based intervention (MEST) [46]. Three neuropsychologists (P5, P6, P8) mentioned their approach in guiding the clients to focus on the memory itself until it is successfully retrieved with as many concrete details as possible. For example, P7 (clinical MEST therapist): *"sometimes clients do start to ruminate about their negative memories. Then [as a therapist], you say, 'OK, I guess it's very difficult for you. However, just think about this family dinner and let us see what details are in there'. Therefore, you distract them from 'thinking' about the memory, by retrieving details of that memory"*. This illustrates an approach for disengaging from rumination by encouraging clients to fully engage with the memory retrieval instead of allowing their attention and cognitive resources to engage in rumination.

The low-accessibility of positive memories for depressed individuals also contributes to a negative-biased and unbalanced life-perspective. Therapists thus suggest building a stock of positive memories to help and encourage clients to encode positive memories over time, as a process of enriching the collection of retrievable positive memories. Such positive memory banks could also help users to increase their positive memory retrieval and thus create a balanced view of life-perspective. We have identified three strategies based upon positive memories:

4.1.4 Encourage active behaviors for encoding positive memories. If clients cannot draw from a rich collection of positive memories, therapists would bypass the choice altogether by creating opportunities for positive events and encouraging their purposeful encoding. For example, within the treatment, several therapists deliberately introduce specific activities such as arts and crafts that are likely to induce positive emotions and encourage clients to actively encode them as positive memories. P2 has mentioned her approach as: "*I help them trying to retrieve the positive memory of the treatment [...] we are trying to get (clients) to realize that they are making gains right now*". The above findings suggest opening up new design opportunities to better support such cue creation. P10, a CBT therapist, has also mentioned: "*I guide users to create artworks in the treatment, so my clients can take them back home and retrieve the happy moments in the treatment*". This quote indicates the important value of a tangible cue of a positive activity, which can trigger later positive memory retrieval.

While positive memories can be created as part of the treatment, they can also be made within clients' everyday life, since negative bias impairs depressed individuals' abilities to pay attention to positive materials. P2 describes this process as: "*(they feel like) their whole life is always negative, it's hard for them to realize that positive things can happen, or even that positive things are happening currently*".

CBT therapists thus encourage their clients to increase their ability to be present and pay attention to current positive events and to encode such memories in specific detail for easier later retrieval. For example, P3 (CBT therapist) mentioned: *"[I use techniques, [for] pointing out things that [clients] are grateful for in the present moment, or things they do that nurture them, to balance the things to displease them".* P3 encourages clients to take notice and encode all daily emotional events: "*encouraging clients to notice positive things happening in their life, unpleasant things as well as the difficulties, could tackle their overgeneralized autobiographical memories".*

4.1.5 Encourage positive memory retrieval to disengage from rumination. We found a prevalence of this approach in both CBT therapies and neuropsychological treatments. For example, P4 has mentioned his approach of using clients' positive memories to help them disengage from rumination: *"I use his past successes [to help him] feel balance and distract him from his pre-worry about his physical health".* P6, as a neuropsychologist with background in CBT, also suggested the importance of having available positive experiences for depressed clients to engage with and to distract from negative thinking: *"the most important thing for clients to shift their bad habits of negative [ruminative] self-thinking, thinking […is to] have enough positive collectible experiences where they do manage to disengage from that ruminative thinking and to experience, [and] shift their attention or focus to something else".* An interesting outcome is that although these memories could be cued through modalities other than words, findings indicate limited visual or tangible materials being used to facilitate positive memory retrieval.

4.1.6 Encourage positive memory retrieval to create a balanced view. Therapists (both neuropsychologist and CBT therapists) further mentioned the importance of a positive memory bank for increasing clients' ability to retrieve such memories and to build a more balanced view of life. For example, P5 (neuropsychologist) suggested: *"[positive memory bank is useful], as they [clients] can thus look back and say 'well no, I am not always a failure in my life, not everyone in my relationships rejected me' ".* P2 (CBT therapist), has also agreed the value of a positive memory bank in promoting balanced life-review*: "[addressing negative bias is about] get them to see balance, challenge their negative thoughts, so […] having them describe the situations in the past that have gone better is more powerful than just say 'everything will be alright' ".*

Other CBT therapists also suggested a positive memory bank by providing illustrative examples of its value, P1: "I let them feel balance about their life, so they feel like 'something good happened' […] I do have the capability to have good experience in a relationship […] because it had happened". P4 also mentioned using positive memories as a counterexample to break clients' negative life perspective: "I pick out some of the [past] successes […] so he was able to acknowledge [that he is not a failure as he thinks]". P5 further suggested that such a positive memory bank could help clients to practice and improve their abilities in positive memory retrieval: "this kind of bank of memories, with much enriched contextual details, could help [them] to increase (the accessibility of) these memories with creating more memory traces [for retrieving them]".

4.2 Approaches Addressing Overgeneralization

People living with depression not only tend to retrieve their past in a negative manner, but also do so in an overgeneral style. Overgeneralized memory, as a cognitive marker of depression, refers to the cognitive dysfunction affecting the retrieval of episodic memories and their details [12,13,46]. *Negative bias* and *overgeneralization* reinforce each other and contribute to a profound negative life summary and self-perception (an example given by P4: "*my whole life I have struggled"*) and of the world as in the example provided by P1: *"all my relationships failed".*

4.2.1 Training clients' ability to retrieve specific memories through the generative retrieval process. This approach is mainly applied in neuropsychological treatment. Neuropsychological interventions [25,46] aim to reduce negative overgeneralization by training clients' ability to retrieve episodic memories through the generative retrieval process (section 2.3). Training the generative retrieval process consists of supporting clients to move from high-level autobiographical memories such as lifetime periods, and general events towards retrieving specific-level episodic memories. Generative retrieval is mostly prompted by what we identify to be new types of cues: generic, and word-based. For example, in neuro-psychological memory-based treatment (MEST [46]), clients practice memory retrieval with emotional word-based cues, such as "successful" or "disappointed". Such cues should be generic rather than specific to ensure that only the generative retrieving process is activated, rather than direct retrieval usually cued by photos. Cues also have to involve certain emotional valence (neutral, negative, positive), as depressed people experience more severe difficulty in memory-searching from emotional cues [46]. As described in the MEST protocol, MEST therapists trigger clients' memory retrieval through standardized word-based cues, such as "enthusiastic" (positive cues), "telephone" (neutral cues), "stressed" (negative cues). Once clients come up with a memory (the first attempts are normally not specific

enough), therapists then guide them to retrieve more specific details through scaffolding questions, until a specific episodic memory (normally an event that has lasted for less than 24 hours) is retrieved. We consider further this scaffolding process below.

4.2.2 Providing scaffolding to help generative retrieval. This approach is usually takes place in MEST training. It aims to scaffold clients' generative retrieval process and help them address their inability to access episodic memories. For example, P6 (neuropsychologist specialist in MEST): *"when the client starts with 'I am never happy', [then I will say] 'Can you think of a time when you felt happy in the past?' 'When I went on vacation' 'OK that's a little more specific' [so this is how] you help your clients to work through that hierarchy: from vacation to the trip to the seacoast, and then to a specific trip to the seacoast which lasts a week. Then I ask and challenge the client to come up with a specific day or event or moment in that one-week trip to the seacoast".* P6 also suggests leveraging social support particularly though group intervention *"the nice thing [of working in a group] is that not only [the] trainer is challenging the clients, the clients are also challenging each other".*

4.2.3 Training abilities in retrieving details of specific episodic memories. This was mentioned by neuropsychologists as focusing on in-depth specific memory retrieval after their clients identified and retrieved a specific, episodic memory successfully, P6 *"when [clients] come up with specific memories, we challenge them to come up with extra contextual sensory perspectival details, with their specific memories".* One neuropsychologist further provides suggestions of how she would use such a guiding process within a mobile application: *"[The app would] train participants to retrieve positive events and retrieve them fully detailed, by asking users to describe details of those events: normally at least 15 details".* P8, as a CBT therapist utilizing behavior activation who also acknowledged the value of MEST training, has put effort in integrating MEST elements into her CBT treatment. In this respect, she suggested positive immersion in the retrieved memory, and its specific details: "*[…] close your eyes, and imagine this [experience], imagine it, and pause with this, and feel […] I expose them [clients] to their positive feelings, make them open up and let these feelings enter their system".*

4.2.4 Encourage retrieving positive memories to break negative thinking style. This approach was specifically found in CBT therapies in training overgeneralization (more than half of the interviewed CBT experts). As in treating depression, traditional clinical treatments such as CBT emphasize changing negative thinking patterns due to negative-biased overgeneralization, therapists thus predominately address *overgeneralization* by driving clients directly to specific positive memories. They also use positive memories that are retrieved by the clients as counterexamples for breaking the over-generalized thinking style and negative life summary. Findings indicate two ways of triggering positive memory retrieval. Some CBT therapists trigger it with simple questions by directly challenging clients' negative thinking, P2: *"really? Don't you have any positive memories? Is that true?"* or P1: *"so are you saying that you never get enjoyment out of doing things?"* These quotes illustrate therapists' efforts to make clients realize the problem of their negative, overgeneralized thinking, and start retrieving positive memories. The second method for triggering positive memory retrieval consists of guiding the clients to retrieve specific life events that are generally enjoyable, P1: *"maybe […] there was a time that you have experienced a good relationship?"*, or bring awareness to such positive memories as reflected directly in clients' accounts during the treatment, P8: *"when he was describing what happened at work when I heard something good […] I stopped him".* CBT therapists also mentioned the value of knowing clients' background as a way to better prompt this retrieval process, P2: *"[if I know their background well] I would say 'what about the day when you got married?' or 'How about the day when your kids were born?'".*

4.3 Approaches Addressing Reduced Positivity

As suggested by [13], even if depressed individuals can successfully retrieve a positive memory, such memories are less vivid and emotionally-intensive, impeding depressed individuals from experiencing the positive emotions associated with it. We report three main strategies identified for addressing this problem.

4.3.1 Helping reconstruct, visualize, and retrieve associated positive emotions of positive memories. Both neuropsychologists and CBT therapists mentioned this approach. It consists of first helping clients to retrieve many details of specific positive memories, P9: *"just think of an event […] imagine it including some of the details, for example […] what happened exactly, […] as well as how they were feeling […], in 5 to 15 details".* The second step is to help clients through scaffolding questions to retrieve positive emotions associated with these memories, otherwise, as P8, a CBT therapist described, their clients would just "*jump over it".* This step focuses on positive emotions, as such memories are important in helping depressed individuals to experience rather than avoid

specific memory details [13], P8: *"so it is using the image vividly, and feel what he [client] feels at this moment. To open up and to let it enter the system"*. The most used scaffolding questions include, P8: *"when I heard something good, [like a compliment or nice interaction] I stopped him and instead of [let him] just going over it, I asked him to do some imagery [and] stand still to feel the feelings or imagine the situation again"*. P8 further illustrated details of her scaffolding questions to support reliving this memory: *"[I] say 'close your eyes, and imagine this experience. Imagine it and, pause with this, and feel.' So [the process] is using the image vividly and feel what he feels at this moment. To open up, and to let it enter the system"*. This quote illustrates the value of slowing down and paying attention to a positive memory, which opens up new design opportunities supporting a rich reliving process.

4.3.2 Enhancing retrieved positive memories with a positive cognition model, and help encoding reframed positive memories. This approach was suggested by a CBT therapist, P3. She reported her efforts to enhance these positive memories by integrating a positive cognition model with these memories [23], helping the clients to encode enhanced positive memories in their memory system: *"[I] encourage users to encode their memory holistically. Get clients retrieving things that they are grateful for […] and encourage them to use the CBT model to break these moments down, create an emotional memory [that] involves emotion, cognition. So whenever you retrieve this positive memory, not only you will retrieve the memory itself, you will also retrieve the full [CBT] model behind it"*. As indicated above, this approach aims to lead clients to repeatedly retrieve their positive memories to encode future positive memories in a holistic manner.

4.3.3 Utilizing positive memories to build better self-identity. More than half of the interviewed participants mentioned the importance of boosting users' self-identity. Some therapists specifically identified their approaches of utilizing positive memories for this purpose, P1: *"I use that [positive memories provided by my clients] to help them feel a bit more confident about themselves, like, "you know, you do have the capability to have good experiences in a relationship […] because it had happened once"*. However, such an approach for boosting self-identity is currently supported only by verbal conversations, with limited efforts focused on capturing these powerful positive memories linked to one's sense of identity.

We argue that purposefully encoding these emotional events as they occur during the therapeutic session can later provide valuable cues for key positive memories weaved in one's sense of self.

4.4 Clinical Usage of Materials

Study findings indicate that current depression treatments are predominantly based on conversations. Some therapists use standardized materials in their treatments, such as printed paper of the ABC worksheet [62] and feelings wheel [63] in CBT (P2, P3) or word-based cues in MEST training (P6, P7). Other therapists select materials that may cue their clients' positive past experiences. For example, P4 uses songs and visual objects to remind his clients of significant life events, integrating materials that are relevant to each specific client's background. In most case, therapists are the ones to provide training materials, but occasionally clients' written diaries are also employed as part of the treatment (P3, CBT and P6, P7, MEST).

4.4.1 Self-relevant materials. P4 specifically mentioned the value of self-relevant materials, for example, as visual cues: "things that could trigger a retrieval, like photograph albums […] an old dictionary or an old textbook. (They could) unlock other memories […] Once I used some normal computer magazines from the 1990s, because a client was working in the IT industry [during that time], [it's the type of magazine that] you could have bought in any stores". P4 also utilizes the audio cues such as songs: "you could almost consider that as a signature. These are a personalized set of stimuli or triggers [One time I played an old song in front of my client] when the music came, because they are her brothers' favorite artist, she suddenly felt herself upset [for feeling the time spent with him] as quickly as it started." From a CBT perspective (P4), that's: "something that is worth the grasp and makes her reflect on this retrieval". These quotes illustrate the importance of vivid visual and audio cues, as specific memory cues could trigger rich sensorial direct retrieval [8,27]. One concern is that such sensorial memories could worsen clients' mood with potential harmful impact, and care should be taken in designing and using them with clients.

Some CBT therapists also asked clients to write diaries, mostly on paper, as material to trigger retrieval in the next training session, P3: *"and we used a lot of stories to illustrate that it's not always the case, and the diaries show what he feels for sensing"*. Neuropsychologists also mentioned written diaries as important part of MEST training, P6: *"the diary is just on a piece of paper, within the support group, they help each other inside […] If they do it as homework, they will write them down, or they talk about it during the training session or in a group interventions context"*. Interestingly, no participant mentioned helping their clients to collect and store these individual notes into a diary notebook for later retrieval.

4.4.2 Standardized materials. Other self-relevant materials include self-generated personal triggers from general training materials, such as the feelings wheel [63] mentioned by P3: *"(I) let clients identify triggers [such as] pleasant and unpleasant triggers. Then I get them to validate the feelings they noticed. After that, I let them realize where they identify in the body, and then get them to notice the input, and then help them to cope with the next step".* P2 also mentioned using paper-based ABC worksheets [62] to help her deliver cognitive behavior therapy. The idea of these standardized materials is to trigger clients' personal feelings of thoughts.

MEST [46] also uses a list of standardized word-based cues for helping clients practicing generative memory retrieval, usually from neutral word-based cues to more challenging positive word-based cues. MEST also utilizes negative cue words for training clients' cognitive flexibility in memory retrieval, especially in disengaging from rumination [39].

5 THEORETICAL IMPLICATIONS

We now revisit our research questions and identified limitations from prior work we reviewed earlier. We highlight the findings, especially regarding strategies and materials from current therapeutic memory interventions. We hope to inspire and inform the design of technologies to better address memory impairments in depression.

5.1. Tailoring Depression Technologies

As suggested in prior research [9,17], computerized depression interventions, especially online CBT platforms are mainly concerned with the delivery of pre-designed psychoeducational content. While they can incorporate a variety of more interactive exercises, these platforms currently involve limited self-relevant materials from users' life narrative. In order to fully realize the potential of technology for mental health treatment, researchers have called for more exploration of support for person-centric interventions [10]. Such an approach would involve more free-form interventions that build on users' life narratives and focus more on users' sense of self. This can include memory based interventions.

Researchers have also suggested utilizing more personalized and multimodal content to improve users' engagement [17], which further supports the inclusion of self-relevant materials.

Regarding self-relevant materials used in therapeutic memory interventions, we found that clinical approaches mainly use standardized training materials, while some therapists utilize sensorial materials to trigger emotional responses associated with certain memories. However, these specific cues may come with a potential risk of harming clients by triggering strong, negative feelings that are, described by P1: "*too painful [for clients] to even talk about*". Other clinicians utilize users' written diaries as part of training, but do not use them for tracking the effectiveness of the treatment.

5.2 Tailoring Memory Technologies

As suggested in prior research [27,54], memory technologies should be designed to strategically address users' memory impairments and support related memory functions, but we know little about how these can be achieved for people living with depression.

Previous work suggests that most memory technologies focus on supporting memory impairments at EM level by triggering direct retrieval (e.g., episodic memories, lost or forgotten [16,26,30,35,52]). This, however, is not a memory impairment associated with depression [59]; depression is associated with three distinctive impairments at AM level [13]. Building on this knowledge, several recently developed psychological interventions provide an interesting starting point and potential context of application for the development of new memory technologies [25]. We have presented findings on how approaches from both clinicians and neuropsychologists address each memory impairment in their work with people living with depression. We have found that: 1) For negative bias, clinicians appear to use approaches focused on improving clients' ability to retrieve both positive and negative memories, reframe negative memories, as well as encode both newly generated positive memories and reframed negative ones. 2) For addressing overgeneralization, neuropsychological approaches mostly help clients to improve their ability to retrieve episodic memories with enough specific details, while CBT therapists address negative-biased overgeneralized thinking (e.g., breaking a negative thinking pattern) by improving clients' ability to retrieve positive memories opposing their negative thinking. 3) Reduced positivity was addressed by increasing clients' ability to retrieve positive memories, fully relive and enhance them, and to encode these enhanced memories for later retrieval.

6 DESIGN IMPLICATIONS

We now discuss the design opportunities for addressing the identified gaps in prior research on memory and depression technologies based on the findings of this study. We will

specifically identify the key challenges associated with each memory impairment in depression: *negative bias, overgeneralization* and *reduced positivity*.

6.1 Positive Memory Banks for Active Encoding and Selective Retrieval

Our findings indicate the significant and pervasive use of positive memories for addressing all memory impairments in depression. However, an important outcome is that the value of these positive memories is associated less with their retrieval and more with their active and purposeful encoding. For example, clients are encouraged to notice and record positive daily events, marking progress as their treatment progresses, as well to plan and engage in pleasurable events. Clinical practice, however, provides limited support for the capture and materialization of these memories. We can think of novel classes of memory technologies to purposefully support *active encoding* by identifying positive affective experiences, prompting more elaborate encoding, and rewarding the growth of these positive memories as a powerful resource to draw from in the future. Precious moments are perhaps fewer and further apart for people with depression, and hence it may be valuable to prompt their encoding. Thus, biosensor-based interfaces could offer new exciting opportunities in this space. In a critique of the total recall enabled by lifelogging, memory technology researchers have called for the importance of *active* curation, i.e., active process of annotating memory records [28]. With respect to depression, our findings further emphasize the importance of active or purposeful user engagement by extending it earlier in the memory process at the encoding stage.

Our findings also emphasize the importance of selective retrieval of positive memories, an aspect less recognized in HCI memory work. Previous findings have shown that retrieving positive memories can be problematic for depressed clients [13,15] who at the time of retrieval are experiencing negative moods, as it can trigger rumination [41], and comparison with one's past thus worsening the present negative mood [33].

We argue for the importance of novel technologies that can adapt the retrieval of positive memories to the current emotional state of the user and particularly address rumination. For example, we can imagine technologies that prompt people to identify and retrieve positive memories as counterexamples for ruminative thoughts. In turn, this can support a more balanced perspective on life including both positive and negative experiences, and increase the accessibility and value of positive memories for breaking ruminative thinking patterns. We can also think of novel memory technologies that can address the challenge of direct retrieval which, as an effortless process, can easily be hijacked by rumination [13,15].

6.2 Novel Cues for Supporting Generative rather than Direct Retrieval

Our review of the psychological literature indicates that memory impairments in depression disrupt the generative retrieval process [12,13,59]. Therefore, people living with depression may benefit more from interventions and technologies supporting generative retrieval rather than those supporting their unimpaired direct or cue-based retrieval [59]. In other words, the main challenge for people living with depression is accessing the episodic memory level within the autobiographical memory system rather than remaining stuck at the lifetime periods or general events levels. If they successfully overcome this challenge and manage to access an episodic memory, they have fewer difficulties recalling its specific details through traditional cue-based, direct retrieval. As a result, people living with depression not only benefit less from the types of cues usually explored in memory technology research, but such cues can also be counterproductive: by prompting direct retrieval these cues interrupt the generative retrieval, depriving them of the opportunity to practice the latter process (which has been shown to have positive effects in alleviating depression [25,46]).

Most technology-based cues, and in particular those captured through lifelogging technologies, record episodic events, and therefore support direct retrieval. However, people living with depression need a new type of cue to prompt generative retrieval. The main source of information we have found regarding the construction of such cues is provided by the MEST intervention where generic cues, often word-based, are used to support it. Interestingly however, we have seen therapists' efforts to augment such cues with content relevant for their individual clients such as magazines from the 1990s when the client was working in the IT industry. We argue that such important cues can in fact be supported by technology, as long as their content remains generic, i.e., about lifetime periods or general events, rather than specific. i.e., about episodic memories. For instance, we can imagine new techniques for integrating, summarizing, or visualizing technology-captured episodic cues into high-level representations of general event or lifetime periods within which the specific episodic content remains unrecognized.

We can also imagine new techniques for identifying among one's lifelogging data ontologies of objects inferred from distinct yet related episodic events, which can be used to construct cues for generative retrieval. This would imbue

these cues with much needed self-relevant content. Or we can think of such cues for generative retrieval as consisting of meta-data of captured emotional episodic events. The study also suggests opportunities for improving generative retrieval by augmenting these cues with scaffolding questions. One can imagine conversational agents [22] guiding memory search towards the episodic level of AMS.

6.3 Novel Interfaces Strengthening the Reliving of Positive Episodic Memories

We have already discussed the importance of selective retrieval of positive memories while accounting for people's current emotional states, and that in negative moods, such retrieval should be carefully leveraged. In contrast, the moments when depressed people experience neutral or positive moods can be fully leveraged for prompting retrieval of positive memories. In addition, the study indicates that such positive memories are not only difficult to access but they also are less vivid and experientially embodied. Such insights open up new design opportunities for memory technologies. We can imagine novel, rich, expressive and multisensorial interfaces that could strengthen the *felt-life* quality [40] during retrieval of one's positive memories. In turn, such increased reliving could further strengthen positive self-identity.

6.4 Introducing Tailored Memory Technologies to Online Intervention Platforms

Our previous discussion argued the importance of introducing self-relevant materials to online intervention platforms for treating depression. The study also revealed how clinicians apply self-relevant materials such as emotional memory cues within interventions. An opportunity exists for more person-centric online platforms for treating depression, which integrate memory systems specifically tailored for depression and provide materials from users' life narrative. In addition, a positive memory bank, which helps users to track positive memories, could provide a visualized training progress and a sense of achievement, and thus help increase user engagement with the intervention.

7 CONCLUSION

Our study explored three memory impairments in depression, namely *negative bias, overgeneralization,* and *reduced positivity*. By interviewing 10 clinical and neuropsychological experts, we identified effective approaches for addressing the challenges of these impairments; approaches grounded in both theory and clinical practice. Our findings open up new design opportunities for memory technologies tailored to the needs of people living with depression. These include positive memory banks for active encoding and selective retrieval, novel cues for supporting generative rather than direct retrieval, and novel interfaces to strengthen the reliving of positive memories.

ACKNOWLEDGMENTS

This work has been supported by AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 Marie Skłodowska-Curie GA No 722022. The research of Gavin Doherty is supported in part by Science Foundation Ireland grant 12/CE/I2267 to the Adapt Centre.

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Appendix C

Published pieces: Reviewing and evaluating mobile apps for memory impairments in depression

Reviewing and evaluating mobile apps for memory impairments in depression

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Abstract. Depression is a major affective disorder that influences autobiographical memory processing abilities. Mobile phones hold great potential for delivering effective self-help treatments for addressing such issues. This work explores apps that support users' everyday challenges associated with depression and memory processing and highlighted the current supported functionalities, which could be used to inform novel functionalities tailored to address depression-related memory issues and consequently mitigate depressive symptoms.

Keywords. Depression, mHealth, mobile apps, review

1. Introduction

With significant socioeconomic costs, depression is a major affective disorder impacting over 300 million people worldwide [13]. Addressing this raises significant challenges, both for providing clinical interventions and everyday self-care strategies [11]. Scholarly work has explored mental health interventions [4] more broadly. In addition, mobile phones hold much potential to scale up the provision of interventions that target depression most often structured psychological interventions [7]. Researchers, however, have called for the importance of also exploring additional interventions such as those building on users' life-narratives [2]. The latter are promising because they particularly target memory processing issues associated with depression [10]. Recent studies have shown depression is associated with a few distinctive autobiographical memory processing dysfunctions [3, 10], over-generalized, negative-biased memory retrieving, and difficulties in encoding and retrieving positive memories. Prior studies have suggested a design opportunity for mobile applications to reduce depressive symptoms by helping users improve their self-memory processing abilities [3], especially for assisting purposeful encoding and retrieving positive memories [10], enhancing the positive affect of retrieved positive memories, and alleviating rumination from negative memories [10]. These findings call for further work on memory technologies for assisting people's memory processing and their specific impairments in depression [10]. This work aims to identify key functionalities of currently available, top-rated mobile apps with the potential to address memory impairments in depression. Future work will focus on evaluating their effectiveness in addressing memory impairments in depression, and on the provision of guidelines for advancing current apps.

2. Method

App reviews have been increasingly used to explore the design space of commercial apps [9]. The review was carried out on two major mobile app marketplaces: Apple (iTunes), Android (Google Play) in Spring 2019. For retrieving the apps for depression, we used the keyword "depression". For retrieving apps for memory processing, we used the following keywords: "diary", "mood tracker", "mood memory", "journal", and "daily event" to capture apps that support recoding and retrieving of daily emotional events. We used a script [5] to extract all apps yielded from searching each of the keywords on app searching engines. Initially, we retrieved 482 depression apps and 3119 memory apps. We then filtered these two sets of apps separately, by excluding apps that: 1) have less than 100 reviews, 2) are in irrelevant categories, 3) do not mention keywords such as "depression", "diary" or "mood" in either title or description, 4) are not accessible at the time of selection, 5) had average user review scores lower than 4.0 (out of 5.0). This resulted in 34 memory apps and 35 depression apps that meet the inclusion criteria. After removing duplication, 20 apps were finally selected for further evaluation (see Appendix), which includes 7 apps yielded from searching memory-related keywords, 9 apps from depression keywords, and 4 apps yielded from searching both keywords. The first author extracted descriptive characteristics of the apps from the information provided on the marketplace (e.g., price, review score), and has used all apps on an iPhone and a Xiaomi phone to extract the functionalities and iteratively revise the codes.

3. Results

3.1. Apps providing therapeutic functionality for treating depression

Mood tracker is the most common therapeutic functionality employed by 75% of the apps (15/20). While one-third of apps provide solely mood tracking (30%, 6/20) function, most apps (60%, 9/15) support mood tracking integrated with other functionalities. Of these 9 apps that provide mood tracking as an assistive tool for depression interventions, 27% (4/15) provide mood tracking for assisting CBT as their main intervention for depression, however, such apps mainly allow users to record their mood and thoughts, as well as to log their daily activities that trigger their moods. Another 20% (3/15) apps allow users to track moods during prompted activities, while 2 apps combined mood tracking with drugs or pain tracking (e.g., Pain Diary). In addition, apps that solely provide mood tracking function aim to alleviate users' depression by revealing their mood swings and factors that affect their mood (such as exercise or drugs), as well as by reinforcing daily habits that lead to positive emotions.

Thought diary is another popular therapeutic functionality that is provided by 65% of the selected apps (13/20), with 23% of the apps (3/13) solely provide thought diary function for treating depression and assisting users' memory processing. We found interesting mechanisms for alleviating depression from CBT apps (31%, 4/13), which allow users to record their thoughts for understanding the underlying negative thinking patterns and for challenging them. In addition, another 4 apps combined thought tracking with mood tracking, whereas 2 apps allow users to record their thoughts during mindfulness practice (Mindfulness daily, Pacifica).

Positive activities such as healthy ones targeting mindfulness, exercising, sleeping and eating, and those for encoding positive daily events were also popular therapeutic

functionalities provided by our selected apps. 35% of the apps (8/20) encourage users to engage in healthy activities such as meditation (50%, 4/8) or other activities (50%, 4/8) such as drinking water. Another 33% (4/12) encourage users to find and record daily positive events, and record gratitude in journals.

3.2. Apps functionalities for assisting memory processing

We found textual templates provided by most of the apps (75%, 15/20) for guiding users' recording process, and in particular 15 apps supporting mood tracking, 69% (9/13) apps supporting thought tracking, and 93% (13/14) apps tracking the completion of positive activities. Surprisingly, we found that one-fifth of the thought tracking apps (23%, 3/13) do not provide such templates for recording users' input, albeit 2 of these apps specifically claim to assist emotional writing and to encourage gratitude (Chronicle, Gratitude Journal 365). However, such apps fail to provide specific guidance on how users could tackle depressive thoughts captured in their recorded thoughts. For activity tracking, only one app does not provide a template, as this app automatically logs users' achieved activity (i.e., in-app meditation). In addition, most templates are static and generic, which guide users to select their current mood from a set of provided emoticons, then record annotations or notes by either selecting textual tags or entering text. Good practices for improving users' engagement during recoding were found in 2 apps that deliver templates during users' conversation with AI robots (Wysa, Youper).

All of the 15 mood tracking apps provide templates to log users' mood with general cues (i.e., emoticons or texts). Within such apps, 80% (12/15) also allow users to record personal cues through short textual notes (33%, 5/15) or more enriched information (47%, 7/15). For instance, for proving more enriched contextual information of the mood log, 1 app (Happify) allows users to attach a photo to each mood logs, and another 2 apps allow users to track changes of their mood before or after of their mindfulness practice (Mindfulness Daily, Pacifica - Stress & Anxiety). Most of the selected apps (92%, 12/13) allow users to collect enriched, personal thought record, albeit a fourth of them (25%, 3/12) only record a short note, and 1 app (Youper) does not provide access to users' thought record. Besides 2 apps as exceptions (i.e., Happify that allows attaching photos, Pacifica that allows voice input), all these apps collect and present users' thoughts record in textual format. The logs for more than half of the apps (71%, 10/14) are pre-defined, thus with no cues to support later specific memory retrieval of users' memories during mindfulness practice. Only 4 apps allow users to encode notes as cues, to support later recall of their positive memories.

4. Discussion

Prior work suggested the importance of depression apps to provide functionalities for encouraging users to actively engage and record positive events [10]. We found that although 70% (14/ 20) apps offer functionality that supports users to engage in positive activities, their activity logs are mostly pre-defined, thus with little cues to support later memory retrieval. We thus call for more enriched content for app-assisted activity logging. For instance, we found 4 apps providing good such examples by allowing users to input textual thought (e.g., MoodKit), or attach photos (e.g., Happify) in their activity logs. In addition, although purposeful planning of positive activities is both beneficial

for activity engagement and effective in treating depression [12], most apps fall short of providing a specific goal and plan for the prompted activities. We only found 3 apps that allow users to set goals by providing target activities (Moodkit, Fabulous). Our finding revealed that the selected apps solely rely on users' own ability to engage with the prompted activities, which suggest potential for future apps to provide further assistance to help users if they disengage because of low motivation or avoidance tendency [10].

Besides, the finding suggests the opportunities of supporting enhanced positive memory processing with enriched content and multimodal cues. Most of the apps support users for tracking at least one aspect, such as moods, thoughts, or daily activities. The tracked data is beneficial, as it can work as memory cues to support users' later recall. However, such recorded content tends to be generic, with no or little users' personal input, which may fall short of supporting users' memory recall. For instance, 64% of the activity tracking apps and 33% of mood tracking apps only support generic or brief logs, with limited uniqueness and therefore cue efficiency [1]. We thus suggest that apps for assisting memory impairments in depression should collect and present more enriched, if possible multimodal content for enabling later memory recall. As highlighted by memory research [6], it is vital to collect contextual information such as activity, spatio-temporal content, or people involved in a specific event, to support recall. While such content is essential [6], it may be challenging for users to generate sufficient cueing information (e.g., who, where, what) without assistance. Therefore, it is beneficial to provide templates for guiding users through the recording process, for which good practices have started to emerge. Good practice has found in 36% (5/14) apps that provide templates for recording users' more enriched content besides activity logs.

Additionally, as depression is often associated with cognitive dysfunctions, including difficulties in vividly and experientially retrieving positive memories [3]. Prior studies [10] suggested that memory technologies for addressing impairments in depression should provide enriched and expressive cues to assist retrieval, while multimodal cues may better support multisensory engagement, and thus specifically beneficial for memory retrieval. Our findings reveal that the selected apps mainly support data in textual format and rarely support cues in other modalities (i.e., only 3 apps support pictorial cues, 1 app supports voice input). We suggest that apps for treating memory impairments in depression could consider further leverage the affordance of digital devices to for multimodal cues (e.g., visual cues or sensorial cues such as odour or taste).

We would like to emphasize the importance of apps for depression to offer selective retrieval of emotional memories according to users' current mood. Previous findings indicate that viewing material associated with negative memories, when users are in sad moods, can trigger rumination increasing the risk of harm [10]. Our findings revealed that, although 2 out of 20 apps access users' mood while using the app (Happify, Pacifica), no app filters the recorded content which can act as memory cue according to the negative valence and users' current mood. In addition, only 4 out of 20 apps support users to search or selectively view the recorded memory cues through keywords, while no app enables users to filter the recorded memory cues based on their valence.

5. Conclusion and future perspectives

This work explores the potential of mobile apps to support users' memory processing in depression. Our study is the first to explore the shared functionalities of the two types of selected apps: those for depression and for memory processing. Future work will focus

on the evaluation of these apps, and recommendations for guiding the design of memory technologies for depression. Our finding suggests that developers of apps for memory impairments in depression need to better support users to actively plan and engage with positive activities, as well as to purposefully encode cues with more enriched content for later retrieval of such positive memories. In addition, the analysis of app functionality provides new insights into opportunities for mitigating harm by safeguarding users' during low motivation, and selectively retrieving emotional memories during sad mood.

Acknowledgements

This work has been supported by AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 People Programme under Marie Sklodowska-Curie grant agreement number 722022. The research of GD is funded in part by SFI grant number 13/RC/2106 to the Adapt Centre.

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Appendix D

Published pieces: Functionality of Top-Rated Mobile Apps for Depression: Systematic Search and Evaluation

Review

Functionality of Top-Rated Mobile Apps for Depression: Systematic Search and Evaluation

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Related Article:
This is a corrected version. See correction statement in: http://mental.jmir.org/2020/2/e18042/

Abstract

Background: In the last decade, there has been a proliferation of mobile apps claiming to support the needs of people living with depression. However, it is unclear what functionality is actually provided by apps for depression, or for whom they are intended.

Objective: This paper aimed to explore the key features of top-rated apps for depression, including descriptive characteristics, functionality, and ethical concerns, to better inform the design of apps for depression.

Methods: We reviewed top-rated iPhone OS (iOS) and Android mobile apps for depression retrieved from app marketplaces in spring 2019. We applied a systematic analysis to review the selected apps, for which data were gathered from the 2 marketplaces and through direct use of the apps. We report an in-depth analysis of app functionality, namely, screening, tracking, and provision of interventions. Of the initially identified 482 apps, 29 apps met the criteria for inclusion in this review. Apps were included if they remained accessible at the moment of evaluation, were offered in mental health–relevant categories, received a review score greater than 4.0 out of 5.0 by more than 100 reviewers, and had depression as a primary target.

Results: The analysis revealed that a majority of apps specify the evidence base for their intervention (18/29, 62%), whereas a smaller proportion describes receiving clinical input into their design (12/29, 41%). All the selected apps are rated as suitable for children and adolescents on the marketplace, but 83% (24/29) do not provide a privacy policy consistent with their rating. The findings also show that most apps provide multiple functions. The most commonly implemented functions include provision of interventions (24/29, 83%) either as a digitalized therapeutic intervention or as support for mood expression; tracking (19/29, 66%) of moods, thoughts, or behaviors for supporting the intervention; and screening (9/29, 31%) to inform the decision to use the app and its intervention. Some apps include overtly negative content.

Conclusions: Currently available top-ranked apps for depression on the major marketplaces provide diverse functionality to benefit users across a range of age groups; however, guidelines and frameworks are still needed to ensure users' privacy and safety while using them. Suggestions include clearly defining the age of the target population and explicit disclosure of the sharing of users' sensitive data with third parties. In addition, we found an opportunity for apps to better leverage digital affordances for mitigating harm, for personalizing interventions, and for tracking multimodal content. The study further demonstrated the need to consider potential risks while using depression apps, including the use of nonvalidated screening tools, tracking negative moods or thinking patterns, and exposing users to negative emotional expression content.

(JMIR Ment Health 2020;7(1):e15321) doi: 10.2196/15321

KEYWORDS

mobile apps; depression; review; ethics; mHealth

Introduction

Background

Depression is a major affective disorder with significant socioeconomic cost [1], affecting over 300 million people worldwide [2] across the life span [3]. However, access to treatment is problematic [4] given the acknowledged barriers such as high treatment cost, time constraints [4], geographical location [5], and stigma [4-7]. With over 90% worldwide penetration [8], mobile phones have significant potential to scale up the provision of interventions targeting depression [9]. They are especially useful to reach users who do not normally seek professional support, such as adolescents [10]. Prior work has already indicated a high user acceptance and effectiveness of mobile-delivered interventions for depression [11,12]. The number of mobile apps available on marketplaces offering treatment for depression has also been growing rapidly [9,13].

The apps available on mobile phone marketplaces provide access to a range of interventions targeting depression [14-16], which people can select and download to fit their needs [17]. Yet, users acting independently can only select apps based on information that is available at the point of download, ie, popularity, user ratings, or app descriptions provided on the marketplaces. Evidence for supporting assessment of the quality of an app, ie, structured description of its main features, evidence-based functionality, and potential risks, is not reflected in user ratings of apps [18,19]. Additionally, marketplaces do not require app developers to provide such information [20,21]. As a result, concerns have been raised regarding the lack of an evidence base for mental health apps [15,19,22] and poor regulation of the major mobile marketplaces [23-25] hosting them. Prior work [26] has also suggested the importance of having controlled clinical trials to determine the efficacy of new therapeutic treatments. In this newly established field of mobile health (mHealth) apps, most apps claim to be informed by evidence-based treatments rather than presenting rigorous evaluations of the app itself.

Besides efficacy, understanding patients (eg, their characteristics, needs, and behaviors) is also key for improving the uptake of apps [26,27]. Most human-computer interaction (HCI) studies on understanding [28-30] or supporting depression have focused on designing and evaluating mobile technologies in research contexts rather than marketplaces [31-33]. Scholarly work has also called for the evaluation of commercial apps for depression to support the effective development of the rapidly growing market of commercial apps [10,13,15]. However, such evaluations tend to focus in isolation on specific aspects such as ethics [34] and safety [35] or on specific interventions such as cognitive behavior therapy (CBT) or acceptance and commitment therapy (ACT) [10,19]. Moreover, previous evaluations tend to analyze app information from marketplaces without the actual experience of using the apps [15].

Objectives

This paper addresses these limitations by focusing on a broader range of interventions and functionality of the top-rated apps for depression. Thus, we focused on the following research questions:

1. Which are the key functionalities of the top-rated apps for depression available on iPhone OS (iOS) and Android marketplaces?
2. Is this functionality described and delivered in a way that supports user privacy and safety?

Methods

Overview

This paper focuses on apps selected in spring 2019 from 2 major marketplaces, iOS and Android, whose analysis triangulates (1) reviewing app ratings on marketplaces to identify the top-rated apps for depression, (2) reviewing app descriptions on marketplaces, and (3) experimental evaluation through author interaction with the apps as expert HCI researchers [36,37].

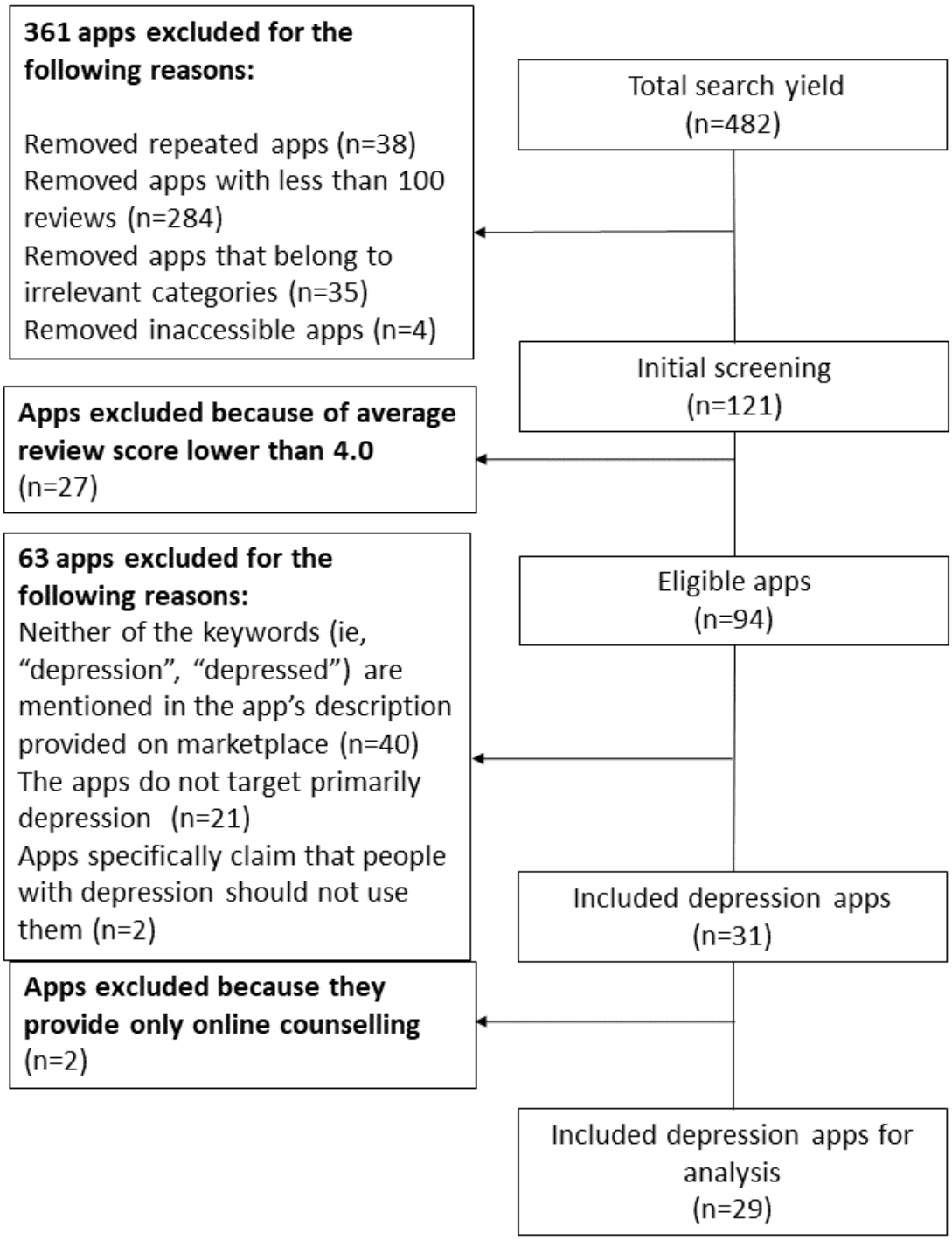
App Selection

We now describe the selection process (Figure 1). The apps were initially identified through the 2 keywords “depression” and “depressed” entered into App Crawler and Google Play search engines. A script was used [38] to extract all the apps shown in the search results. The script automatically downloaded information for each app from its marketplace, including name, category, marketplace description, price, review score, and number of reviewers. This resulted in 482 apps, and after removing duplicates, 444 apps were included in the later selection.

The strategy for app selection outlined in Figure 1 aimed to include top-rated publicly available apps targeting primarily depression. From the initially identified 444 apps, we excluded those that (1) had less than 100 reviews; (2) were inaccessible at the time of selection; (3) belonged to irrelevant marketplace categories such as social, casual, business, news, or book; and (4) had average user review scores lower than 4.0 (out of 5.0). The application of these criteria on the initial set of 444 apps resulted in 94 apps for consideration.

From these apps, we further excluded those that did not focus primarily on depression by employing the following criteria: (1) the words “depression” or “depressed” do not appear in the app’s title or marketplace description of the app, (2) the primary target is not depression (eg, yoga tracker), and (3) their marketplace description mentions that people with depression should not use the app. These criteria led to 31 apps, from which we further excluded 2 more apps as their functionality was limited to the provision of therapy sessions to be purchased in-app. The remaining 29 apps were analyzed in this review (see Multimedia Appendix 1).

Figure 1. App extraction progress.



Data Extraction

Descriptive characteristics of the apps were extracted from the information provided on the marketplace. These included *category*, *costs*, *target audience*, whether they claimed to be *evidence-based* (including explicit scientific underpinning and clinical input), and data supporting analysis of ethical aspects such as the *privacy policy*.

To extract data on app functionality, between June and October 2019, 2 rounds of experimental evaluation [36,37] were used in which the authors as HCI experts interacted with the apps using both Android and iPhone mobile devices (ie, Samsung tablet and Xiaomi phone for Android apps and iPhone for iOS apps). The entire set of apps was evaluated by 2 authors (CQ and CD), and 21% (6/29) of the apps were evaluated by all authors. The coding scheme was iteratively revised until agreement was reached among all the coders. The coding

process was hybrid, integrating both deductive and inductive coding. Informed by prior work on the classification of mHealth apps [14], the deductive codes consisted of 3 main types of functionality of depression apps: screening, tracking, and provision of interventions (Table 1). The inductive coding [39] allowed the identification of specific subcodes under each of the main functionality described above. For instance, the screening function was broken down into subcodes such as symptom monitoring, self-diagnosis, and basis for personalization.

Table 1. Main codes and subcodes from functionality's evaluation.

Functionality type and subtype	Definitions
Screening	
Monitoring symptoms	The screening function is provided for monitoring depression symptoms during intervention
Self-diagnosis	The screening function is provided for self-assessment of depression
Basis for personalization	The screening function is provided as a basis for personalized intervention
Tracking	
Tracking thought patterns	The tracking function supports the tracking of thought patterns
Tracking mood patterns	The tracking function supports the tracking of users' mood patterns
Tracking behavior as the intervention progresses	The tracking function is provided for monitoring progress in following the intervention, including users' adherence to the intervention
Tracking depression symptoms	The tracking function is provided for monitoring symptoms
Intervention	
Thought diaries	The intervention is provided to help users identify and challenge their negative thinking patterns
Psychoeducation	The intervention is provided as psychoeducational content
Mindfulness	The intervention is provided to help users improve mindfulness
Behavioral techniques	The intervention is provided to motivate and guide users to perform positive behaviors
Mood expression	The intervention is provided for users to express their emotions
Other	The intervention is provided as emotional regulation strategies other than mindfulness

Results

Overview

The description of findings is organized into 3 parts. The first outlines a broader picture focusing on descriptive app characteristics (eg, categorization). The second part covers ethical considerations. The third part looks in more depth into specific functionality such as screening, tracking, and provision of interventions.

Descriptive Characteristics

This section describes the characteristics of the selected apps, for example, the main categories under which depression apps are classified on marketplaces, their target audience, costs, evidence base, medical disclaimer, and whether involving of clinicians' guidance while using the apps.

Categorization

The 29 apps reviewed in this study belong to 3 categories used to describe apps on the marketplaces. The most popular category is health and fitness (18/29, 62% apps), followed by lifestyle (4/29, 14% apps) and medical (7/29, 24% apps).

Targeted Audience (Age Group)

An important finding is that app marketplaces rate all apps as suitable for nonadult users (Multimedia Appendix 2). Most of the selected apps were classified as being suitable for children from preschool age: 76% (22/29) of apps were rated for those older than 3 years, 3% (1/29) for those older than 4 years, 7% (2/29) for those older than 12 years, 3% (1/29) for those older than 16 years, and 10% (3/29) with parental guidance.

However, only 41% (12/29) of the apps provide a privacy policy intended to protect children's data. Half of these privacy policies (7/12, 58%) claim to restrict users to a specific age group, albeit this approach is inconsistent with the app's age rating on the marketplace. For instance, one app (A8, see app_ID in Multimedia Appendix 2) states in its privacy policy that the app does not provide services to users who are younger than 18 years; in contrast, it is rated on the marketplace as Pan European Game Information (PEGI) 3. This may be because of a mismatch between age rating definitions oriented around the inclusion of material such as violent content, and health care apps that should have age restrictions because of the personal and sensitive nature of the content, with associated risk for harm.

In addition, all the apps apply the same design across all ages, and we did not find any customization for users who are children, such as involving in-app interactions to allow parents to collaborate or monitor their children while using the app [40].

Targeted Audience (Clinical Nosology)

All included apps claim to target users with depression. Most of the apps (20/29, 69%) represent *depression* as a lack of well-being (eg, feeling stressed or having low mood). Less than

one-fifth of the apps (5/29, 17%) actually represent depression as a mental disorder, whereas only 1 app (A18) employs Patient Health Questionnaire-9 (PHQ-9) [41] to assess the severity of symptoms. Another 14% (4/29) of apps do not claim to target depression as a disorder, yet employ validated tools for assessing users' depressive symptoms. Furthermore, none of the apps claims to target users with a specific level of severity (ie, mild, moderate, or severe depression).

Costs

An important finding is that although most of the apps (28/29, 97%) are free to download, at least some of their costs are covered either directly or indirectly by users (Multimedia Appendix 2). The direct costs consist of explicit charges for more advanced features, whereas indirect costs relate to users' forced consumption of in-app advertisements. In-app purchase was offered by 66% (19/29) of the apps, mostly as a subscription priced between US $3.99 to US $29.99 per month, or as paid online therapy sessions (US $35/hourly session over call, video, or chat, A11). Advertisements were provided by 34% (10/29) of apps, which raises privacy concerns. Of the apps with advertisements, 80% (8/10) stated specifically in their privacy policies that users' information, captured for instance through cookies, would be collected and shared with third parties, including advertisers or analytics providers. Only 1 app that offered advertisements claimed that users' data would not be collected or shared (A29), whereas another app (A7) did not provide a privacy policy in English. Only 17% (5/29) of apps that are free to download neither request in-app purchase nor provide advertisement. Only 1 app requires purchase (for US $4.99) before downloading.

Evidence Base

Developers of 62% (18/29) of the apps have specified a scientific underpinning for their app design, whereas another 38% (11/29) do not make such a claim (Multimedia Appendix 3). Almost half of the apps (14/29, 48%) claim to be designed based on validated psychological treatments (eg, CBT, ACT, dialectical behavior therapy, and mindfulness). The remaining 14% (4/29) are designed based on theories pertaining to gamification, hypnosis, and affirmations. However, only 7% (2/29) of the apps provide direct evidence in the form of peer-reviewed scholarly work on the efficacy of the app for reducing depression symptoms [42,43], whereas another 34% (10/29) of apps provide indirect evidence of efficacy of their underpinning theories without referencing any academic work. For instance, 8 apps (A3, A4, A5, A15, A16, A17, A18, and A28) are promoted as evidence-based therapeutic tools by claims that their design is grounded on evidence-based treatments (ie, CBT). In addition, 41% (12/29) are described as being designed with input from clinicians (eg, psychologists, psychiatrists, and therapists), whereas 59% (17/29) do not mention the involvement of mental health professionals in their design.

Medical Disclaimer

A medical disclaimer is presented in 66% (19/29) of the apps, outlining that the app is not a replacement for clinical treatment (Multimedia Appendix 3). However, 11 out of these 19 apps (11/19, 58%) only present this disclaimer in their terms of use policy, which is difficult to find and unlikely to be read by users. Another 35% (10/29) of apps do not provide any disclaimer on either marketplace or app's website. No app presented itself as an alternative to clinical treatment (ie, drug treatment or face-to-face psychotherapy).

Clinical Involvement

All apps are designed to be used independently and do not require professional guidance while using them (Multimedia Appendix 3). In addition, 5 apps (5/29, 17%) provide opportunities to involve health experts while using the app. Of these, 2 apps support access to coaching and counseling sessions as an additional intervention for a price ranging from US $29.99 per month (A27) to US $35 per hour (A11). The other 3 apps allow users to share their in-app data (eg, health tracking report) with their health care providers (A16, A22, and A24).

Ethical Considerations

This section describes the ethical considerations raised while reviewing selected apps.

Negative Content

Aligned with the concerns raised by prior work that apps with poor design present an increased risk of potential harm [15,44], the results show that 2 out of 29 apps are categorized as so-called wallpaper apps. Such apps support people, "reflecting the true nature of the pain and loneliness in [your] heart […] give permission to feel the way you do" (A12). We found that these 2 apps include images or quotes capturing negative thinking (eg, "Do you ever get in those moods where you just don't feel like existing," A12). Surprisingly, these 2 apps with potentially disturbing content are rated as PEGI 3 (A12) or PEGI 12 (A6) on the marketplace, which indicates that the apps' content merely includes bad language. As prior studies [45,46] have indicated, adolescents' exposure to negative content may trigger negative behavior such as self-harm. Therefore, there is a clear need to explore safeguarding strategies for protecting vulnerable users such as those at risk of self-harm or suicide, especially given that these 2 apps are highly rated on the marketplace, ie, between 4.4 and 4.6 out of 5, and are subsequently more likely to be selected for use, adoption, or appropriation [47].

Safety

Strikingly, despite the increased vulnerability of people living with depression, 72% (21/29) of apps do not provide any information for handling or preventing the risk of suicide (Multimedia Appendix 4). Only 28% (8/29) of apps provide such information; in particular, most of these apps (5/8, 63%) provide information on accessing suicide prevention helplines, counseling websites, or support services, whereas 25% (2/8) provide information advising users to contact local emergency services if in critical risk of harm. In addition, 1 app (A18) assists users in creating a personalized safety plan for handling crises.

Functionality Review

We now discuss the functionality of reviewed apps such as screening, tracking, and providing interventions.

Screening

A total of 9 apps offer functionality to screen for depression; their features are summarized in Multimedia Appendix 5. Almost half of the apps that provide screening functionality (4/9, 44%) aim to assess changes in users' depression symptoms during engagement with the app-provided intervention. Interestingly, despite the acknowledged benefit of personalization to support adherence [48], most of these apps (3/4, 75%) provide predefined psychoeducation articles upon informing users of their screening result, rather than tailored information for addressing particular issues identified through screening. All 4 of these apps employ the PHQ-9, a validated screening tool. An interesting outcome in this context relates to the frequency of the screening. Although 2 apps supported periodic repeated measures of users' depression (ie, apps suggest or limit access to the screening tool only once in a fortnight), another 2 apps instead allowed on-demand momentary screening of users' depression (ie, users can access screening tools as frequently as they want with no instructions regarding an appropriate frequency).

In addition, 33% (3/9) of the apps provide stand-alone screening functionality for self-diagnosis purposes. Furthermore, 2 out of 3 apps classified into this category provide only screening functionality (A29 and A24), whereas another app (A16) also provides mood regulation strategies in addition to screening as its primary function. The first 2 apps (A29 and A24) do not use validated screening tools and do not provide direct in-app links to professional help upon informing users of the severity of their screening results. We found that the other app (A16) enables the potential benefits of screening while avoiding harm, as it provides support for both psychoeducation and for discussing the diagnosis and its implications with mHealth professionals [15,19]. In addition, the app (A16) provides screening as the main functionality through the use of International Classification of Diseases-10 [49], a validated screening tool, and in-app links to professional support. A16 also allows users to generate a report of the screening result to show to their own health care professionals.

The other apps (2/9, 22%) provide a screening function to inform the delivery of personalized app content. One app asks users to self-report their disorder and symptoms (A19), whereas another app uses a questionnaire as a screening tool (A11), although it provides neither the source of this questionnaire and information on its validity nor evidence for the personalization of intervention. This app offers in-app purchase of online therapy sessions; however, this is not integrated with users' progress through the intervention or their screening results.

Tracking

Out of the 29 apps, 19 apps offer functionality for tracking at least one aspect such as *thoughts*, *behaviors*, *moods*, or *depression symptoms* (Multimedia Appendix 6).

Apps that track multiple aspects serve different purposes; 89% (17/19) of these apps support tracking to assist the provision of personalized intervention, ie, tracking *thought* changes for providing materials to apply within the intervention or tracking users' *behavior* for visualizing their progress and adherence to the intervention. Furthermore, 37% (7/19) of the apps support *mood* tracking for revealing their triggers and patterns. Another 26% (5/19) of apps support tracking of *symptoms of depression* through frequent use of screening tools, and 1 of these 5 apps (A16) tracks aspects such as thought changes, mood, or physical condition (ie, appetite, sleep) over fortnightly periods to generate the screening result.

Thought tracking is supported by 74% (14/19) of the tracking apps, mostly combined with mood tracking on the same data entry. Good practices for improving usability have started to emerge, for instance, in the form of templates for guiding users through the tracking process (available in 11/14, 79% apps). There is also an opportunity to explore alternative modalities for mood tracking. From the selected apps, we found that text is the most commonly employed modality for recording thoughts (14/14, 100% apps) and moods (9/14, 64% apps). Other modalities such as emoticons are being used to record moods tagged with thoughts (4/9, 44%), and scales are being used to record mood intensity (1/9, 11%). Opportunities also arise for better representing the thought logs, for instance, introducing searching or filtering functionality. Currently, all 14 apps present thought logs directly to users in chronological order without the option of searching them.

Of the 42% (8/19) apps that track user *behavior* as progress through the intervention, 3 apps automatically log users' adherence to the proposed usage goals for app-delivered intervention (eg, minutes spent on app-delivered meditation), whereas 5 apps track user's achievement of positive behaviors suggested by the app (eg, socializing with friends and drinking water). Apps for the latter purpose mostly require users to log their achieved activity themselves, whereas 1 app allows automatic tracking (ie, step count, A13). In addition, only half of the progress-tracking apps (5/8, 63%) provide a summary visualization of intervention progress (2 apps provide a graphical summary, eg, A11 provides a calendar view). Another 3 apps provide a textual summary (eg, A17 displays the total number of minutes of meditation, without providing a record of each specific meditation). The other 38% (3/8) of apps provide direct access to textual logs with no summary.

In addition, 37% (7/19) of the apps support the understanding of *mood* patterns through visualizations. Such apps often track moods alongside their triggering factors (available in 4 apps) or physical conditions such as headache (available in 4 apps); the aim of the former is to understand the reasons for changes in mood, whereas the latter aims to reveal the impact of physical conditions on such changes. Despite the clear purpose of supporting understanding articulated by developers, the representation of logged data does not easily support the understanding of data patterns. Even though a graphical view of mood changes over time is provided by all 7 apps, most of them (4/7, 57%) provide it separately from the graphical view of other tracked factors (eg, A14, A28, and A11 provide a graphical view of mood changes within a period and a textual representation of mood triggering factors). Another 3 apps (3/7, 43%) offer an integrated representation of changes in physical condition with changes in mood, which may make it easier to understand relationships between the two.

Furthermore, 26% (5/19) of the apps automatically track screening results for *symptom* monitoring. Most of these apps (4/5) provide only a textual review of screening results, in chronological order. Only 1 app (A28) also provides a graphic visualization of changes in screening results.

Interventions

Overall, 5 types of interventions were identified in the analysis (see Multimedia Appendix 7), reflecting a mixture of elements from psychological interventions, including *thought diaries, psychoeducation, mindfulness, scheduling positive behaviors,* and *others*. A distinct group of apps aims to support *emotional expression* rather than a particular psychological intervention.

Thought diaries are a common intervention employed by one-third of the apps (9/24, 38%). This intervention borrows from traditional CBT practice by providing instructions for identifying negative thought patterns and for challenging distorted thoughts. One approach to tailoring interventions is to employ guidance for challenging real-time tracked thoughts or emotions. Most of these apps (7/9, 78%) provide thought diaries as tailored interventions consisting of guidance for identifying and selecting personal challenging thought patterns to guide the writing of reflective diaries. Another 2 apps provide a generic template to guide thought diaries, rather than adaptive or personalized guidance.

Apart from thought dairies, another set of 9 apps (9/24, 38%) provide specific *psychoeducation* as an intervention. Findings suggest that 44% (4/9) of such content is provided to specifically fit users' depression assessment, whereas 56% (5/9) is nonpersonalized, generic content.

Mindfulness [50] is another popular intervention (11/24, 46%) as most of the selected apps include meditation (9 apps), grounding techniques (1 app, A26), or breathing guides (1 app, A2). Furthermore, 4 apps suggest a frequency of use for the intervention, eg, 1 meditation session per day (A1), whereas the others do not specify a frequency of use. In addition, 2 apps provide adaptive interventions (ie, meditation guidance) triggered by users' input (eg, during users' conversation with artificial intelligence [AI]–based chatbot, A27 and A28).

In addition, 17% (4/24) of the apps delivered interventions for *scheduling positive behaviors* (or behavior activation). Aligned with prior work, personalization [19,29] is a good design principle for engaging users with app-delivered interventions. Overall, 3 apps offer tailored intervention materials by allowing users to enter positive behaviors that they wish to schedule (eg, A15, A18, and A21), and another app (A11) provides a personalized monthly plan based on the results of the users screening measures. Other valuable design choices supporting engagement include offering peer support [19] during the intervention (1 app, A21) or using gamification for providing daily intervention goals and rewards [51] for completed activities (2 apps, A11 and A21).

A final category of apps is those helping users to *express their emotions* associated with depression (5/24, 21), either by sharing posts in online support groups or by individually consuming art-based materials. Of the 2 apps providing peer-supported mood expression, only 1 provides links to a 24/7 suicide helpline. Both apps allow users to filter posts: 1 app (A23) allows users to set filter words (eg, "suicide") to hide posts including such words and safeguard themselves from such content, whereas another app (A19) filters materials (ie, posts in the community) automatically and only shows materials that relate to users' self-reported disorder and symptoms. Apps that fall in the latter category (3/5, 60%) provide art-based content for expressing depressive moods, eg, wallpaper pictures with emotional quotes. However, an important concern is that none of the wallpaper apps provide any scientific background or features to support access to mental health services for users at risk of suicide or self-harm. Most of the content of these 3 apps are negative, and only 1 of these apps also provides some positive content, being also the only app that offers users the possibility of personalizing the quotes.

Another 3 apps provide *other* types of emotion regulation strategies, including positive affirmations (1 app, A25) or hypnosis (2 apps, A10 and A20). Customization of intervention material is available in 1 app (A25), which allows users to create positive affirmations and to audio record them.

Discussion

Principal Findings

This paper indicates that the current top-ranked apps for depression provide various features to benefit users across different age groups. The potential of this newly established marketplace is promising, especially for reaching subgroups of users such as adolescents, who are less likely to seek professional support offline and thus could benefit from appropriately designed mHealth apps. For this purpose, we discuss the need and opportunity for regulating the marketplace to safeguard users and to ensure a positive impact from the use of apps.

We begin by considering the ethical principle of nonmaleficence [52] within the top-rated apps for depression. First, a clearer definition of age restrictions on the marketplace could better support users in general and younger users in particular to select age-appropriate apps. We found age to be handled insufficiently and inconsistently in current commercial apps, given that the age ratings on the marketplace generally indicate the maturity of app content rather than the targeted users for the app, and we also found that these ratings were generally inconsistent with information regarding the targeted age group. This risk is further heightened by the conditions within the reviewed apps' privacy policies including the sharing of users' data with third parties for commercial purposes.

A recent systematic review of HCI work on affective health technologies also identified potentially harmful aspects of tracking apps such as the provision of negative mood or thinking patterns with insufficient professional support, inadequate screening, and insufficiently founded diagnosis claims based on tracked data [30]. With respect to communicating negative content, we see apps supporting the consumption of publicly shared emotional expressions of depression generated by others (A6 and A12). We further advocate that developers should consider the presence of negative content when selecting an age

rating on the marketplace, as consumption of such content may lead to harmful behavior among adolescent users.

In addition, this paper systematically reviewed and analyzed the apps' functionality. The result inspires recommendations to guide developers to further leverage digital affordances to mitigate harm, to deliver personalized depression treatments, and to track multimodal content. For instance, for apps that provide screening functionality, there may be a tendency to overclaim symptom screening informed by nonvalidated screening tools rather than using validated ones, eg, developers of A24 and A29 prominently state their apps' effectiveness in clinical practice on the marketplace but do not provide scientific validation for the screening tools employed. In addition, with regard to the increased vulnerability of depressed individuals, we find limited direct access to professional help when screening results are communicated to users. For instance, in general, 76% (22/29) apps do not provide immediate access to suicide prevention or online counseling helplines (Multimedia Appendix 3).

Safeguarding Users While Accessing and Consuming Negative Content

Risk of harm can be identified with respect to the viewing of strongly negative content from others within the emotional expression apps for depression. Our findings highlight strong ethical concerns around these apps. Although arguably beneficial for people creating it [53], such content might have a negative effect on those viewing it, especially given that depressed individuals have a tendency toward rumination [54]. We suggest that such apps should include safeguards for users viewing highly negative content. Moreover, developers of such apps could limit views of negative content, especially given that these 2 apps (A6 and A12) are also accessible to adolescent users, who are susceptible to engage in *problem* or *at-risk* behaviors [40]. One deployed strategy was to automatically cover negative keywords within app-provided content and to offer a pop-up window with free psychological counseling helpline every 3 times when users choose to reveal the hidden negative words (A23).

In addition, apps not specifically designed for children and adolescents, but with a child-friendly age rating on the marketplace, should consider introducing customizable designs for nonadult users. It has previously been suggested that providing support and treatment sessions with parents, teachers, and siblings should be seriously considered when administering treatment to children with depression [40]. Therefore, we suggest that designers of such apps should consider mechanisms to engage parental support or supervision while children or adolescents are using these apps.

An interesting issue with respect to apps supporting the tracking of mood and thought patterns is the unfiltered presentation of these data when predominantly negative content is being tracked. Apps tracking thoughts only provide access to tracking logs in chronological order, and this presents a 2-fold limitation. First, such visualizations can be browsed but not queried to retrieve a specific entry. Second, browsing such logs may trigger vivid recall when they capture negative content and may increase the risk of rumination [29].

Safeguarding Users While Selecting Age-Appropriate Apps and Sharing Private Data

The suggestions discussed in this section particularly target the developers of marketplaces hosting apps for depression. Previous findings suggested that the regulation of such apps regarding data privacy remains inadequate [25,32,35] and reported the prevalence of health-related apps selling users' data to third parties. Survey studies have also indicated that the general public is less inclined to share their health care data with technology companies [32]. The identified limitations of the privacy policies for the reviewed apps illustrate that these concerns can be better addressed; 24% (7/29) of the apps failed to provide any privacy policy in English or in a reliable source (Multimedia Appendix 2). In addition, aligned with prior studies [26,55], the current privacy policies may be difficult to comprehend by typical users. We, thus, call for developers to improve the readability of privacy policies and support the suggestion of making them easy to read at a sixth-grade reading level [26].

Another concern is protecting the privacy of users' health data and, in particular, the data of young people while using depression apps. First, more than half of these apps (24/29, 83%) fail to provide privacy policies that specify strategies to protect children's data (16/29, 55%). Second, our findings also show that although most of the apps are free to download, they normally come with in-app purchases for additional features or advertisements. Regarding advertisement, we found that 80% (8/10) of apps that use advertisements declare that they share users' data for commercial purposes.

All of the reviewed apps are rated as suitable for children and adolescents on the marketplace, whereas one-fifth (7/29, 24%) of the apps specifically claim to restrict access from young users. This finding demonstrates the need for developers of marketplaces that host depression apps to increase the transparency of their standards. For instance, Google specifies that [56] their age rating is not for describing the apps' target user group but rather for describing the minimum maturity level of content in apps such as violence, drugs, and profane language.

Surprisingly, however, no statement regarding data sharing or targeted users' age range could be found on the app descriptions in the marketplace to support users making an informed decision at the point of downloading the app. The age rating may be specifically misleading to parents when they are selecting age-appropriate apps for their children as developers only claim age restrictions in the privacy policy. We advocate a clearer definition and regulations for age rating of depression apps on marketplaces.

In addition, we argue that users should be informed upfront of the risk of having their sensitive data shared with third parties for commercial purposes. The prevalence of health-related apps selling users' data to third parties has been previously reported [25,35,57]. Thus, we argue for the responsibility on the marketplaces' developers to ensure consistency of privacy-related information in the app description on the marketplaces when compared with its privacy policy or to ensure that the privacy policy is included directly within the app.

Safeguarding Users While Screening for Depression

Prior studies [57] have reported the tendency of commercial depression apps to blur the line between depression as a lack of wellness or as a mental disorder, which aligns with our findings. In addition, none of the apps examined claim to target a specific level of depression severity. Although apps may potentially reach a wider range of users by following such a strategy, it may be more difficult to formulate appropriate safeguards for users whose depression leaves them with higher levels of vulnerability [57]. In addition, we found that most depression apps tend not to undergo a rigorous evaluation of their intervention components but instead rely on designing the app based on evidence-based theory [26]. Apps with insufficient evidence of efficacy present challenges as they may risk misinforming patients [57]. We advocate clear communication of the targeted user groups for mHealth apps and marketplace guidelines to match the required level of evidence for each app as well as the condition and risks of their specifically targeted user group.

App-based depression assessment is potentially valuable in supporting individuals with depression concerns to seek help and share their electronic health information with health professionals [15,26]. In addition, health data collected by users could support professionals' understanding of users' symptoms, which could support diagnosis and the delivery of clinical treatment. Despite these potential benefits, the top-rated depression apps reviewed seldom support this usage. Only 1 of 8 apps offered the option of generating reports of screening outcomes for sharing with mental health professionals.

Although PHQ-9 is the most used tool for depression screening, 3 out of 8 apps use nonvalidated screening tools, and information about screening tools and their scientific underpinning is seldom provided within app descriptions. We recommend that app developers use validated screening tools and provide basic information about the tools and their validity.

In addition, findings indicate that screening tools employing periodic repeated measures such as PHQ-9 [41] also tend to be used within apps during daily tracking. However, the latter may be better suited to more lightweight ecological momentary assessment measures [58] rather than depression diagnosis measures. We also found a few emerging practices addressing this concern by suggesting an appropriate frequency for screening or even limiting the frequency of access to screening tools (A16 and A28). Thus, we suggest that app developers decouple the use of periodically repeated measures such as PHQ-9 for the purpose of depression screening and the use of ecological momentary assessment for more frequent daily tracking of mood, thoughts, behavior patterns, and symptoms of depression [59].

Opportunity to Improve Apps for Depression by Leveraging Digital Affordances

An important challenge of mobile apps for depression is attrition [29,60]. Previous work suggested the value of personalization for improving users' engagement with apps [19,29,61] and the value of accessing social support [19] and involving concepts from gamification [51]. In the future, this may involve the provision of real-time adaptive personalization of intervention content to the tracked thoughts or emotions [59]. However, despite the potential of mobile technology to deliver personalization, apps supporting it are limited. Exceptions here include the use of AI chatbot conversational agents (A2 and A28) to respond in real time to users' currently recorded thoughts, instead of generic (not personalized) psychoeducational content. Personalization can also be extended to the schedule of activities within an app-delivered intervention. However, only 1 of the reviewed apps (A11) offered a personalized intervention plan based on users' screening results. There is an opportunity to better leverage digital affordances for personalization when designing apps for depression.

Findings also indicate that tracking within depression apps is focused on capturing users' mood patterns or thought patterns and their engagement with app-delivered interventions. However, these distinct types of tracked content are seldom available together in a single app. We argue for the value of simultaneously capturing both thinking and emotional content as these can support better encoding at the moment when an event occurs and better retrieval later [62,63]. We also suggest that integrating such tracked content with a record of progress through the intervention and completion of intervention activities could better allow users to understand the value of the app for their well-being. Such combined visualization could further support users' engagement and motivation to continue to use the app-delivered intervention.

Conclusions and Future Work

The rapid increase of mobile apps for reducing depression can benefit from a closer look and evaluation of the functionality such apps actually deliver and the potential ethical issues that they raise. From a systematic analysis of 29 top-rated depression apps on the major marketplaces, we suggest that developers of marketplaces should regulate depression apps to mitigate ethical risks, including missing, inadequate, or inconsistent privacy policies, ie, sharing data with third parties, child data protection, and safeguarding of vulnerable user groups. In addition, the analysis of app functionality provided new insights into opportunities for mitigating harm regarding the consumption of the negative content, unrestricted access by children (with related privacy concerns), and the provision of screening tools with less scientific validation.

Acknowledgments

This work has been supported by AffecTech: Personal Technologies for Affective Health, Innovative Training Network funded by the H2020 People Programme under Marie Sklodowska-Curie grant agreement number 722022. The research of GD is funded in part by SFI grant number 13/RC/2106 to the Adapt Centre.

Conflicts of Interest

GD is a cofounder of SilverCloud Health, a provider of supported online treatment, and has a financial interest in the company.

Multimedia Appendix 1

List of selected apps.
[DOCX File , 17 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Assessment of targeted audience and costs.
[DOCX File , 27 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Assessment of apps' evidence base.
[DOCX File , 18 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Assessment of Safety design.
[DOCX File , 19 KB-Multimedia Appendix 4]

Multimedia Appendix 5

Assessment of the screening functionality (9 apps).
[DOCX File , 21 KB-Multimedia Appendix 5]

Multimedia Appendix 6

Assessment of the tracking functionality (19 apps).
[DOCX File , 22 KB-Multimedia Appendix 6]

Multimedia Appendix 7

Assessment of the intervention functionality (24 apps).
[DOCX File , 23 KB-Multimedia Appendix 7]

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Abbreviations

ACT: acceptance and commitment therapy
AI: artificial intelligence
CBT: cognitive behavior therapy
HCI: human-computer interaction
iOS: iPhone OS
mHealth: mobile health
PEGI: Pan European Game Information

Edited by G Strudwick; submitted 01.07.19; peer-reviewed by U Hegerl, N Karnik; comments to author 04.08.19; revised version received 29.10.19; accepted 02.11.19; published 24.01.20

Please cite as:
Qu C, Sas C, Daudén Roquet C, Doherty G
Functionality of Top-Rated Mobile Apps for Depression: Systematic Search and Evaluation
JMIR Ment Health 2020;7(1):e15321
URL: https://mental.jmir.org/2020/1/e15321
doi: 10.2196/15321
PMID: 32012079

Appendix E

Published pieces: Investigating the Role of Theory-based Input Materials in the Design of Technology for Cognitive Impairments in Depression

Investigating the Role of Theory-based Input Materials in the Design of Technology for Cognitive Impairments in Depression

ANONYMOUS AUTHOR(S)

There is much interest in producing technologies to support people with depression. Depression is often associated with cognitive impairments, and a body of psychology research exists which provides guidance on addressing these impairments in clinical practice. While clinical psychology theories and findings can help in producing safe and effective technology products, these theories are rarely available to designers in ways that can meaningfully inform the design process. Our research explores ways in which research on cognitive impairments in depression can be presented to support HCI design practice. To this end, we developed a range of theory-based input materials (e.g., personas, scenarios, and theory-cards) and explored them in a series of design workshops with 15 HCI designers. We find that designers engaged well with the materials, and gained a clearer theory-grounded understanding of the cognitive impairments associated with depression and their implications for technology design. We further discuss the use of such methods to provide guidance without over-constraining designers.

CCS Concepts: • **Human-centered computing** → *HCI design and evaluation methods.*

Additional Key Words and Phrases: Depression; mHealth; Design process

ACM Reference Format:
Anonymous Author(s). 2018. Investigating the Role of Theory-based Input Materials in the Design of Technology for Cognitive Impairments in Depression. In *Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY*. ACM, New York, NY, USA, 21 pages. https://doi.org/10.1145/1122445.1122456

1 INTRODUCTION

Depression is a mental health condition known for its associated cognitive dysfunctions, including impairments in autobiographical memory processing (e.g., negatively biased, over-generalized memory recall) [13, 35] and difficulties in setting and pursuing life goals [17, 48, 78]. These cognitive impairments are mainly explored in the fields of neuropsychology, clinical psychology, and cognitive science, but do not constitute a main focus in HCI research for depression [68]. Mental health technologies not grounded in psychological theories raise concerns, especially in the commercial marketplace [60, 67, 76, 77] which has the potential of reaching millions of users [65, 67, 76]. Indeed, technologies that are not fully tailored to the needs and cognitive difficulties of individuals with depression might result in miscommunication of mental health knowledge [80] or inducing harm to end users by triggering negative mood or rumination [67, 68]. Efforts are thus needed to inform design practices in the mental health domain with relevant clinical knowledge [5].

The reasons for this research-practice gap are twofold. 1) Traditionally, *experts in design* and *researchers* have different requirements, skill sets, and goals. *Designer practitioners* seek to create usable products to address clearly defined user requirements. In contrast, *researchers* mostly produce recommendations, guidelines, or design implications [5, 23, 61]. These may influence requirements but such output is rarely formulated as requirements. 2) Empirical findings generated

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by *researchers* are rarely presented in actionable, ready-to-use format [6, 75]. Thus, they are more difficult to apply for *designers*, especially under time constraints [6]. In the domain of HCI, the boundary between research and design work is often blurred. HCI researchers have started to explore design methodologies to bridge the gap between psychology research and design practice by creating *theory cards* and employing them in workshops [8, 9]. However, prior works have mainly applied general psychological theories targeting healthy individuals, with less complex user requirements than people living with mental health difficulties [5]. There is thus a need to address the challenge of incorporating clinical theories into design practice, especially when designing for individuals with mental health conditions.

This paper aims to explore the extent to which theory-informed design materials can facilitate and inform the design process of technologies for depression. Specifically, we will address the following research questions:

(1) To what extent can theory-informed design materials (i.e. personas, scenarios, and theory cards) help HCI designers with understanding the needs of end users with memory impairments due to depression?
(2) To what extent can theory-informed design materials support HCI designers in leveraging the theories of memory impairments in depression to address the user needs?
(3) How do designers experience the theory informed materials?

We generated design materials - including personas, scenarios, and theory cards - that are informed by empirical studies on depression [66, 68] and its associated cognitive impairments [13, 17, 35, 48, 78]. We deployed the materials in 5 design workshops, conducted with 15 HCI designers, to investigate how the theory-based materials could support HCI designers in understanding user requirements and leveraging psychology theories for generating theory-grounded solutions. HCI contains a large body of work focusing on the role of end-users in the design of health technologies [12], and the authors fully acknowledge its importance. The present research takes on a distinct yet complementary design-focused perspective. Specifically, we draw attention to the long-lasting HCI problem which is the research-practice gap [5, 6, 8, 9, 18, 34, 37, 61] and introduce a design method that has the potential to help build evidence-based technologies better tailored for and more effective at managing mental health conditions. The objective given to participants was to design a mobile app to help individuals with depression mitigate depression-associated cognitive weaknesses and embrace positivity in everyday life (e.g., improve their planning skills and remember positive daily events). Our contribution is a suite of theory-informed materials for the communication of psychology theories to HCI designers, and guidance in the design process of mental health technologies.

2 LITERATURE REVIEW

2.1 The design of technologies for depression

The HCI community has carried out extensive work to address the issue of depression, through the design of technologies for diagnosis [14, 15, 50, 81], treatment [11, 12, 21, 70, 83], monitoring of symptoms [22, 53, 58], or for supporting greater empathy among mental health technology designers [74]. There has also been an increase in the number of commercial mobile applications targeting depression [65, 67, 76]. These mobile applications are available to download from marketplaces providing access to a range of interventions, in varies of contexts. As a result, such mobile apps offer the potential for scaling up the delivery of depression interventions to under-served populations in need [65, 67]. Applications developed with the close collaboration of healthcare professionals are assessed to make sure they follow specific standards and regulations before they are made available for public use [19]. However, many commercial online interventions delivered through mobile or web apps are not clearly evidence-based [67, 76, 77] and lack clinical evaluation, posing a risk for service users [67, 72]. Mobile applications for depression management may target users'

screening, symptoms tracking, or treatment [67]. Applications focusing on screening provide self-diagnosis using standard depression test questionnaires such as Patient Health Questionnaire [40, 43]. Depression symptoms tracking apps may help monitor users taking part in an intervention [45], or allow the self-monitoring of their moods, thoughts, or specific behavior patterns [31]. Depression applications make use of a variety of interventions, such as Cognitive-Behavioral Therapy (CBT) to re-frame thinking and organize unhelpful thought patterns [42], and positive psychology [79], but can also support psychoeducation [38] and emotional expression [3]. Another relevant category comprises mindfulness applications which provide guided meditation [55], or breathing exercises [32]. However, the above practices tend to be broadly informed by psychological theories but less so by the clinical psychology theories that are specific to the context of depression. The difficulties that designers experience in engaging with clinical psychology theories is due to patients' complex cognitive challenges, which no single theory can entirely address [68], and the context of use [5] into which the new technology is to be introduced. More efforts are thus needed to inform design practice with clinical psychology theories, by translating and communicating to designers both the depression-specific challenges and available theories for addressing them.

2.2 User requirements associated with depression-related cognitive impairments

As suggested in prior research [13, 35], individuals living with depression tend to live with a range of cognitive impairments such as having negatively-biased, over-generalized view of self, the world and the future, which are considered as universal symptoms of depression [13, 64]. Such individuals may find it diffcult to interpret everyday events in a positive way, and tend to think that positive events rarely happen to them [13, 35]. Consequently, individuals with depression tend to engage less frequently in potentially pleasant activities, which leads to less positive reinforcement [4, 82]. These avoidance tendencies can maintain the experience of feeling depressed and even worsen depressive symptoms. The above two cognitive issues, namely goal setting and planning difficulties [17, 48, 78] and memory impairments in depression [13, 35], are associated with the development of depression symptoms. Prior studies [13, 17, 35, 48, 78] have shown the importance of addressing these issues for improving service users' well-being and moderating depression.

Prior work on the design of memory assistive systems aiming to alleviate memory impairments in depression (i.e., over-generalization, negative-bias, reduced positivity) [13, 35] has highlighted the importance of encouraging end users to plan and engage in positive activities, and capture memory cues for building a positive memory bank to enhance life positivity [68]. Identifying key issues in goal setting and planning [48] and increasing engagement in potential positive activities could help in breaking the ruminative cycle, reinforce positivity in everyday life, and help address negatively-biased, overgeneralized memory impairments in depression [13]. Qu and colleagues [68] highlighted the importance of encouraging service users to plan and engage in positive activities to break the ruminative cycle, reinforce positivity in everyday life, and mitigate depression symptoms [13, 35, 68].

However, motivating end-users with depression to plan and engage in activities is another longstanding issue [78], as depression is also strongly linked to low motivation and difficulties in goal setting and planning [17, 48, 78]. Additionally, individuals with depression may be more likely to disengage from mental health interventions, as they may find it harder to feel a sense of progress towards their goals, and may set abstract goals that are difficult to achieve. Consequently, abstract goals are more likely to induce frustration and a sense of failure in daily disruption of plans [78]. Moreover, people with depression tend to link their sense of self-worth and happiness to the achievement of these abstract goals (i.e. "I will never feel happy unless I achieve this goal")[17, 48]. Additionally, highly abstract personal goals and plans may facilitate heightened rumination, and individuals who pursue more abstract goals appear to become stuck while trying to fulfill these vague cues. This triggers cycles of rumination (i.e. "why don't my plans ever work?") [17] and further

maintains depression. The skills of goal setting and planning [48] are essential for mitigating depressive symptoms and its associated memory impairments [13, 35, 49, 68], as sustained engagement in potentially positive activities could help break up the ruminative cycle and reinforce positivity [68].

2.3 Gaps between academic research and design practice

The difficulty of aligning technology design with established guidelines and principles has been a widely reported issue in mainstream HCI and User Experience Design practice [23, 75], such as introducing ethnographic findings to design practice [18]. However, the theory-practice gap is even larger in the domain of HCI for mental health [6, 8, 18, 34, 37, 69], due to the specific complex needs of target users [60, 67, 76, 77], and the expert knowledge needed to support them. The issue can be mitigated through interdisciplinary research involving HCI designers and health researchers or practitioners. However, even then, the gulf of language between the two disciplines may be problematic to bridge. Hence, more accessible means of translating relevant theoretical concepts into the design process are much needed.

Prior HCI work has identified the challenges faced by UX and interaction designers wishing to apply psychology-based or ethnographic study based resources in their design practice [8, 9, 18, 61]. For example, theories can support the selection of functionalities for a system and ways in which to implement them [34]. For instance, UbiFit [10] encourages end users to make specific and measurable weekly goals, informed by goal-setting theories [44]. Another common practice is to develop design guidelines from empirical work, in the form of design implications [23]. However, researchers have pointed out that design implications may not be sufficient to drive industrial application [6, 8, 23, 61], and may be difficult for practitioners to understand and use [6, 8, 23, 61]. Research has found that one of the main reasons why practitioners do not incorporate theories into their design process, despite being interested in doing so, is that academic findings are often presented in a way that is hard for practitioners to apply [6, 23, 61]. To fill this gap, other forms of materials supporting design, such as design guiding books [25] and strategy cards [9, 29, 30] have been proposed. Colusso et al. [9] further examined the feasibility of utilizing such theory-informing materials in HCI design practice by integrating them into the design process through design workshops. Existing research has used cards in the design process to introduce playfulness [46], support the game design process [16, 57], and more recently to communicate metaphorical descriptions of depression experiences and their postures [74].

However, prior research [8, 9, 25] primarily aims to apply general psychological theories (e.g., behavior change theories [9]) to non-clinical user groups. Therefore, there is an opportunity to extend these methods to present user profiles with complex needs and challenges. However, when designing healthcare systems for depression, communicating complex users' needs and requirements [5] is essential [12, 70] due to the specific challenges associated with mental health conditions. For instance, users with depression may experience difficulties in processing and retrieving positive memories due to depression-associated autobiographical memory impairments [13, 35, 68]. Overlooking these specific depression-related requirements may reduce the efficiency of mobile-based treatments for depression [67, 68] or even cause harm to service users making use of a product that was not specifically designed for them [68]. Therefore, it is essential to explore novel theory-informed methods to better support designers' understand the relevant psychology theories and the complex challenges of target users.

We see a continuous effort in the HCI community to embed general psychological theories within HCI design practice [8, 9]. However, HCI design and research for depression can benefit from leveraging complex knowledge, expertise, and perspectives in the domain of clinical psychology. To help further refine and explore methods for incorporating complex theories into design practice, we generated enriched theory-informed materials, including persona, scenario, and theory cards to support HCI designers' in-depth understanding of both target users and relevant psychology theories.

3 GENERATING THEORY-BASED INPUT MATERIALS

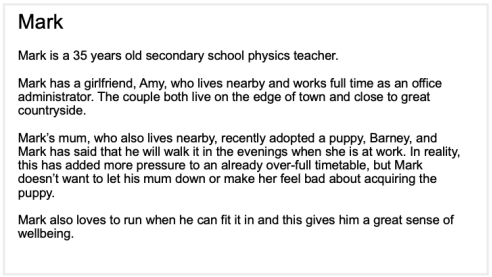

Fig. 1. Mark's Persona Card

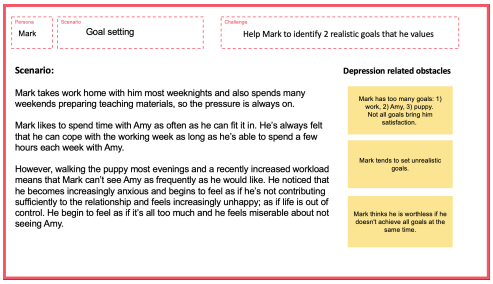

Fig. 2. Mark's Scenario Card (goal setting context)

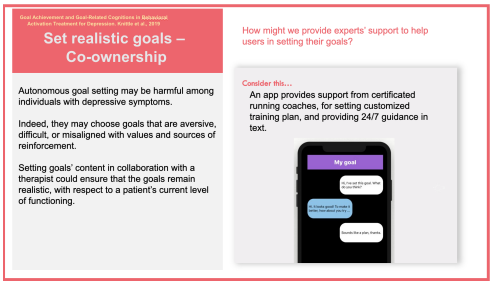

Fig. 3. Theory card (goal setting context)

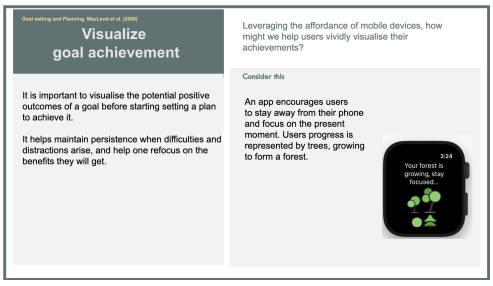

Fig. 4. Theory card (plan revisiting context)

Before describing the workshop procedure, we first explain how the theory-based input materials were generated based on academic research. Based on the literature review above covering depression associated cognitive impairments [13, 17, 35, 78], as well as engaging the first author's autobiographical experience of living with depression, we have generated materials for the following 5 design contexts: 1) goal setting, 2) plan setting, 3) plan performing - success, 4) plan performing - failure, and 5) plan revisiting. Author 1 distributed and combined these characteristics and key issues into three personas (see Table 1), and created five scenarios per persona - one for each design context. Each scenario highlighted the obstacles to help the reader focus on the depression-associated problems to be solved. For example, see persona Mark (Fig. 1) with its scenario for goal setting context (Fig. 2). Altogether, 15 scenarios were generated. Authors 1 and 2 iterated on the personas and scenarios with the help of a creative writer to produce materials that foster the reader's empathy. Additionally, a set of theory cards (see examples Fig. 3 & 4) were developed encapsulating the results of the selected literature around depression associated cognitive impairments. [13, 17, 35, 41, 48, 68, 78].

4 METHODS

The study aimed to explore the use of the theory-informed materials in a workshop to facilitate the design of technologies for depression. In this section, we provide details on the participants, workshop setup and procedure, data collection and analysis. The study was approved by the relevant university research ethics committee.

Design context	Key issues assigned to each persona (Mark, Alice, Arthur)	Summary of related theories
Goal setting	Setting goals that are unrealistic (Mark, Alice), vague (Arthur), not self-concordant (Mark, Arthur), or avoidance goals (Alice) [17, 48, 78]. Difficulties in having vivid, positive future prediction of goal achievement [17, 48, 78] due to negative-based, over-general life summaries and future interpretation [17, 48, 78] (Alice, Arthur).	Identify specific, realistic, valuable, self-concordant and approach goals that can lead to immediate action. Gain motivation from envisaging goals. [17, 48, 78]
Plan setting	Setting unrealistic (Mark, Alice, Arthur) or vague (Arthur) plans due to high self-expectations. Such plans are either too difficult to be implemented, or too vague to measure progress which can lead to frustration (Mark, Alice, Arthur). [13, 17, 35, 48, 78]	Set specific and realistic plans. Test plan with trials. Break down plans into small, specific steps. [17, 41, 48, 78]
Plan performing - success	Difficulties in fully sensing positive emotions while achieving planned milestones, but instead quickly habituate to the achieved goal, and feel the need to set higher and higher goals [17, 48, 78] (Mark, Alice, Arthur). Difficulties in linking current success to the long-term plan progress [17, 48, 78] (Mark, Arthur).	Maintain motivation by making accessible visualization of goal achievement, and maintain a sense of progress by allowing self-reward after achieving a planned action. [41, 48, 78].
Plan performing - failure	Rumination, frustration and negative self-conclusion due to difficulties to disengage from negative emotions from failing planned activities (Mark, Alice) [13, 35]. Skipping a planned action due to low motivation from negatively-biased self-overview (Mark, Arthur). [13, 17, 35, 48, 78]	Identify unanticipated obstacles and re-evaluate plans [17, 48, 78]. Maintain motivation: encourage small steps first [41], highlight achievements, empower effectiveness, or establish positive expectations [17, 41, 48, 78]. Break negative thinking pattern [17, 41, 48, 78].
Plan revisiting	Difficulties recalling positive memories, tendency to focus on the negative ones [13, 35] (Mark, Alice, Arthur). Rumination induced by revisiting positive memories while in current low mood could risk inducing rumination [13, 35] (Mark, Alice, Arthur). Tendency to beat oneself up or produce a negatively-biased life summary if high expectations are unmet [13, 35, 48, 78] (Mark, Alice, Arthur).	Collect positive memories for building traceable positive self [13, 35, 66, 68], and visualizing goal achievement [17, 48, 78]. Revisit memories that fit current mood [13, 35, 67, 68].

Table 1. Generation of personas anchored in psychology theories

4.1 Participants and workshop setup

We recruited 15 participants (11 males, 4 females) through mailing lists and advertisements in several universities. Participants were included in the study if 1) they had background knowledge of HCI (i.e., completed courses or were pursuing a degree in HCI), and 2) had no prior knowledge or experience working in the mental health field. All participants were over 18 years old. Of the 15 participants, 12 were enrolled as PhD candidates, 2 were academics with background knowledge in HCI, and 1 had completed HCI modules as part of a Bachelor degree and had prior experience in HCI research. Participants worked in the fields of engineering, sustainability, and virtual/augmented reality.

We conducted 5 workshop sessions where participants were assigned to groups of 3. Each participant attended only one workshop. Altogether, the workshop sessions covered 15 scenarios presenting the different life situations of the

3 personas (i.e., Mark, Alice, Arthur) in 5 design contexts (see table 1). Each group was assigned one context with three scenarios that we designed for. In the same group, each participant was asked to work with one persona and one scenario within the assigned context.

4.2 Workshop procedure

The workshop consisted of 9 steps. *Step 1*, each participant was given a persona card and a scenario card to read and highlight the parts that "made sense to them". This task aimed to engage the participants with the materials' narrative. The scenario also presented a list of depression-related obstacles, and participants imagined and wrote down high-level solutions to address these barriers. *Step 2*, participants translated their high-level solutions into concrete app features using sticky notes that they placed on the persona's journey. *Step 3*, participants created an alternative user journey with a technology including the features from the previous step. *Step 4*, each group engaged in a discussion where each group member explained their personas, user journeys, and app features. *Step 5*, group members merged their app features into one unique app. *Step 6*, group members picked together the theory cards relevant to their user journey and app. *Step 7*, each group used the the theory cards to reflect on their app features and could choose to update them. *Step 8*, each group discussed the possible ethical risks in their design, through questions inspired from prior research on digital design for mental health [67, 77, 84]. *Step 9*, each group could update their design in light of the ethical discussion. Each session lasted around 120 minutes and ended with participants sharing their feedback on the workshop.

4.3 Data collection and analysis

We collected and analyzed data generated from the workshop sessions (i.e., written notes), and follow up interviews with 11 of the 15 workshop participants (i.e., audio recordings). These individual interviews - held online - explored participants' experience in the workshop. A total of 701 minutes of audio was collected, with on average 1h per participant. One interview record was inaudible due to a technical issue. The other 10 audio recordings were transcribed by author 1, and analyzed following the Braun and Clarke approach to thematic analysis [7]. Hesitations, false starts, and cutoffs in speech are signaled by a dash (-); three full stops in a row (...) indicate editing of the transcript for brevity. The coding involved repeated readings of the transcripts by authors 1 and 2, and followed an inductive approach [26]. The codes were mapped out, revised and reworked in consultation between authors 1 and 2. Both authors iteratively produced the final analysis. In addition, author 1 captured the app features designed by the participants and grouped them by the five design contexts (see table 1). Author 1 then flagged the features that targeted a different use context than the one assigned to the participant, for example, participants who were given the subset of theory cards for plan revisiting but generated app features for plan setting. The author also flagged the features that were not covered by presented theories (e.g., a feature encouraging to leave time slots with nothing planned, in the context of plan-setting).

5 FINDINGS

In this section, we first discuss the role that theory-based materials play in the workshops sessions, how they complement each other in supporting the design process across the workshop activities.

5.1 Persona and scenario cards can help designers better understand the complex needs of depression and more emphatically design for the condition

This section describes the role that persona and scenario cards played in the workshop. We found that these cards supported designers' understanding of the condition, thus helping them generate better informed and emphatic designs.

5.1.1 Persona and scenario cards supports in-depth understanding of individuals with depression. Six participants (P1, P2, P3, P5, P6, P7) pointed out that the persona gave a realistic presentation of a potential user: "*there was enough detail to see it as a real person*" (P2) and " *I could imagine that this person really exists*" (P6). P7 commented that, as they got familiar with the persona card, it felt "real enough" to develop "*some emotional or attachment*" to the fictional user. Scenario cards, providing more detailed information than the persona cards, particularly helped this process (P1, P2, P3, P4): "*it helped me bring out what... is stopping Mark [the persona] from doing things... and how to realistically solve these individual obstacles*" (P4). P7 further commented "*[what] I've found from the scenario is what her [the persona's] problem is*" and "*how we can cope with her problem*".

Four participants mentioned that providing more information about the persona's preferences can support a better understanding of their target user. P5 mentioned the importance of a "*personal description of aspects of depression*", as opposed to short "*symptomatic descriptions*" which HCI designers usually have to work with. They further explained that giving "*really specific, issues that he [the persona] is currently facing because of his depression- as opposed to 'he is just feeling like x or y'*" influenced how they identified with the persona.

The persona and scenario cards supported designers accessing the specific needs of the target users, which allows the tailoring of mental wellbeing solutions [62], P3: "*it's useful to know the [persona's] likes and dislikes... it helps tailor a solution... [lists the obstacles on the scenario card] are good... to understand and what might work and what might not*". P9 further commented that the persona "*leads you down specific route of- 'Okay, this persona is predisposed to this way of thinking. And that's how it should help'*". Other participants (P4, P6, P7) suggested to add information about the persona's routine and relationship to technology. For example, P4: " *what are his preferences towards technology, towards the interfaces... what are his limitations when it comes to using the technology?*".

5.1.2 Persona and scenario cards helps foster empathy towards individuals with depression. Empathy is an essential tool for designers, helping them create solutions that are adapted to user needs [52]. Sharing similar experiences with the persona led four participants (P1, P2, P3, P5) to relate to the fictional user: "*someone I could relate to, it was something that could be situated in my living experience*" (P1). P1 further mentioned that sharing similar experiences helped them envision how they could help this person and facilitated the design process because "*you really understand the person you're designing for*". Participants also mentioned feeling empathy towards the user, especially for female participants who worked with a female persona. P2 suggested that the persona's demographic similarity might influence the degree to which designers can empathize with it:" *from their own [male] perspective, they wouldn't emphasize with it [the persona]*". This could be because when imagining end users, designers tend to be influenced by their own set of biases [59], P10: "*gender has an influence, for example, a scenario is completely different. And of course we have to think about the person's bias- as in my own bias*". This could explain why P3 suggested adding explicit gender information, although the personas employed gendered pronouns (she/he): " *I'm reading this and just assume [the persona] male ... I think being explicit with (gender) is useful [...] to make sure that we're [...]moving away from our own biases*" .

5.1.3 Persona and scenario cards can help with designing for complex needs. Depression is a complex issue and requires drawing design decisions on clinical psychology [68], or involving domain experts during design [67]. In this workshop, we explored how the theory-informed materials complement one another and helped designers challenge their pre-conceptions, as a first step to build their understanding of depression in design practice. Over half of the participants (P1, P2, P3, P4, P7, P9) mentioned that the theory-informed materials helped them understand their user's needs, and particularly their complex depression underpinning. P1 further explained how the theory-informed personas helped them understand how the persona felt " *but also why she felt that way ... you're not just describing 'she has anxiety'... but*

also like the whole backstory of why, how, she became so stressed". Participants further highlighted how the materials impacted their mindsets for the design practice: "*[the scenario] puts you in the right frame of mind for (pause) when you're going on to thinking about specific issues that they [the users] face because of their depression*" (P5). In addition, theory-informed persona and scenario cards supported participants' immersion into an unfamiliar design context, P9 describe reading the materials as: "*a way of putting yourself in perspective for the user that you might otherwise not put yourself in that position*". Consequently, designers might put more effort in designing for effective solutions, P6 "*to make sure that the design solutions that you come up with are also really solving the problem"*. Five participants mentioned how the theory-informed persona cards helped them understand depression and embrace its complexity: "*my view towards depression was completely useless before this, because (pause) you know (pause) it was not that simple*" (P4).

When discussing the scenarios, four participants (P1, P4, P8, P10) reported that the cards presented complex content in a clear and "*easier to digest*" manner (P4). More than half the participants (P1, P3, P4, P5, P9) stated that it helped them understand the roots - "*what was really causing the problem*" - and the " *symptomatic manifestations*" (P4) of depression. P5 further appreciated "*a more personal description of aspects of depression*" as "*it went into lots of detail, about how his [the persona's] specific issues with depression manifested*". P9 further explains: "*you can see how this potential user responds to certain situations, certain stimuli... the way the thought processes work... I feel like gives a more rounded picture of user*". Participants said the depression-related obstacles highlighted that the scenario card "*helped a lot with understanding the problem*" (P1) and *"helped me understand and re-confirm that what I understood about (persona) was correct."* (P4). Particularly, they appreciated the clear summary given by the depression-related obstacles on the scenario cards: "*on one hand you have the more elaborate description and on the other hand, you have the very specific problems*" (P1).

5.2 Theory cards can equip designers with relevant specialist knowledge by making clinical psychology theories more accessible

Findings indicate different roles of theory cards such as increasing the accessibility of relevant psychological theories, supporting participants' understanding of depression, and providing a sense of confidence in the materials' validity.

5.2.1 Theory cards make psychological theories accessible. Participants agreed that the theory cards sufficiently condensed the literature on depression-associated cognitive impairments [13, 68, 78] and relevant psychological interventions [78]. For instance, (P9): "*It's a very clear way of see[ing]- the scientific literature*", and (P5): "*A lot of the key bases were there and everything was really nicely summarised ... they covered a wide range of approaches that you could choose [from]*". Additionally, 8/10 participants reported that the theory cards made psychological theories 'very accessible' by de-complexifying the abstract concepts, P1: "*It builds on something that is complex and theoretical but... it makes it quite easy to understand for us ... I can just read it quite quickly and then understand what the theory means*". Several participants particularly highlighted the importance of having theory cards that are tailored for *them* - as designers without previous experience in the domain: "*I'm not a psychologist, but I could understand what they were talking about*" (P6), and P4: "*I'm not an expert in psychology domain ... Knowing the psychological effect of this particular item ... is something that is (pause) knowing that is a good thing for me*" (P4). The thought-provoking questions on the theory cards (see figure 3 & 4, top right) further supported designers' understanding. P6 described them as 'standards' and 'design guidelines' that "*make you understand even better what is a good solution or what is a bad [one]*".

Five participants (P1, P2, P3, P5, P9) mentioned that the technical example provided on each theory card (see example in figure 3, right bottom) supported the understanding of theories: "*the example is the best bit ... it summarized everything really well*" (P5), and worked as a visual cue while navigating through the cards (P3). Moreover, providing technological

applications of the psychological theories made participants aware of existing solutions, P4: " *what is available out there for me to choose [from] and suggest, rather than just coming up with my- ideas from- the ground.* " Aligning with prior work [9], the examples also helped them prototype solutions as they made it "*even easier to understand exactly how do you translate this theory [in]to an actual application*" (P1) and they helped "*think about how technologies have [been] designed for these issues*" (P3).

5.2.2 Theory cards skill up designers to address depression. Three participants reported that the theory cards helped them build skills to design for depression: "*reading the theory cards made me feel like I was better equipped to solve the issues of the persona*" (P1). One quote suggests the need for materials to guide designers of mental health technologies: "*if you just tell me 'this person has this problem, can you help design from the basic?' then I wouldn't know*" (P4). Also mentioned was the importance of theory cards for guaranteeing designing for nonmaleficence: "*[the theory cards] really helped to, not make mistakes that others have made before... It helps you to take all these standards into account*" (P6).

Five participants (P1, P3, P4, P5, P8) reported that they enjoyed learning about psychological theories. P1 explains: "*I actually liked this part, a lot, because I felt like reading the theory cards, made me feel like I was better equipped to solve the issues of the persona*". P4 continues: "*I was presented with a problem that I wasn't aware of very muchI was very curious about what we could be designing, what I could learn from this*". Additionally, P7 realised that a theory card "*can be useful for more than one situation*", showing that they understand that a psychology theory might apply to different contexts.

5.2.3 Theory cards for providing a sense of materials' validity. Three participants highlighted the importance of having evidence-based materials to work with: "*what is really good about them is that they build on actual, like, psychology theory which is something that as designers, we don't have a background in*" (P1), and: "*I find it interesting to just see how the solutions are based in- actual scientific evidence*" (P8). Confidence in the materials was also supported by the presence of a literature reference on each theory card: "*it was quite nice that it had a very solid relationship to literature... it does give a lot of confidence in the validity of the card*" (P5).

5.3 Theory-based materials complement each other in guiding designers through design iterations

In this section, we report how the theory-based input materials (i.e., persona, scenario, and theory cards) complement each other in guiding the overall design process, and opening new design considerations during the design iterations.

5.3.1 Presenting materials in different design stages guides and engages designers through design iterations. Five participants (P1, P3, P6, P7, P9) mentioned that the personas and scenarios worked particularly well together - "*the scenario was built upon a picture of that persona*" (P3) - that they were "*equally important*" (P7), and "*both work well with the theory card*" (P6). P5 further explains that the persona card "*gives you a kind of higher level overview of the person, and touches on some of the problems that they face*" and the scenario card specifically shows "*how their depression manifests for them personally*". Half of the participants reported that the materials provided helpful guidance to design for users experiencing depression. The depression-related obstacles (scenario card) were perceived particularly helpful as they "*give me a sense of direction as to what I need to do*" (P10) and "*highlight things that you need to look for (and) design for*" (P3). The theory cards were also deemed helpful as they "*provide the knowledge behind what we should design for*" (P2). Together with the scenario, the theory cards helped participants (P2, P3, P8) reflect and (un)validate their initial design solution: "*can my feature make sure that Mark [the persona] overcomes this obstacle? Does it relate to what has been found in psychology? So, if I can answer yes, then my features are probably correct*" (P8).

The theory cards were introduced at *step 6* of the workshop procedure, where designers were asked to pick the cards they think were relevant to their scenario, use them to reflect and iterate on their app features. Four participants (P1, P5, P8, P10) reported that the depression-related obstacles on the scenario card were particularly helpful to select relevant theory cards, P1: "*you can clearly see that you can use some of these [theory cards] to solve the problems in the scenario*", and P5: "*I'd be looking back at my depression related obstacles and ethical risks, and then trying to find solutions to those things through the theory cards*". Participants also reported how trying to match theory cards with the scenario supported their engagement in the design exercise: "*when checking between the theory cards and depression related obstacles, they were written in kind of such a way that it felt almost like putting jigsaw pieces* " (P5).

In addition, participants learned new design strategies to address depression challenges. For example, P2 mention that the 'address negative thinking' card suggested a the use of a diary, and that they: " *eventually had something like a memory-based diary as well. It made me realize 'okay negative thinking can be addressed by this strategy'* " (P2).

5.3.2 The combination of design materials can help elicit ethical considerations during the design process. User-centered design is by definition an iterative process [1]. According to P5, the theory cards supported iterations by opening new design perspectives: " *after reading through the cards, more often than not, it would kind of open up a new perspective, it would be something that I hadn't considered previously*" and would also provide "*a way to kind of look at the big wider context*" (P5). The ethical discussion introduced in the final iteration especially helped participants review their prototype in the light of ethical concerns. Most participants (P2, P3, P4, P5, P6, P7) reported that this discussion lead to a change in their initial design: "*more often than not, they'll be like an issue that comes up that you didn't think about, and then you'd be thinking about your design and being like 'Oh, well, let's change that, to reflect that kind of thing'*" (P5). P5 added that the groups would have benefited from more guidance to focus less on 'privacy and data' and more on "*complex ethical issues relating to their depression*". P3 stressed that "*not every designer will be thinking about ethical issues from the beginning*", showing the importance of introducing a discussion around ethics at early design stage. P7 pointed out that "*it is a further understanding of the problem*" and stressed the fact that not considering ethical issues might result in losing end users. Going further for non-maleficence, P4 highlighted the importance of knowing the regulations in place or to also provide examples of bad practices in the theory cards, so that they know *"things that we shouldn't do"*. Two participants suggested involving clinical psychologists to validate the usefulness of the prototypes (P4) and addressing any ethical problems (P6).

5.4 Feedback and reflection on the materials and design activities

We report designers' perceived tensions while working with the input materials in the workshop sessions. We also report designers' suggested improvements for balancing the presentation of enriched, empathetic information without overwhelming designers, and for shaping the design space with input-materials without limiting designers' creativity.

5.4.1 Balancing content complexity of theory-based materials is necessary but can be challenging. P1 warns that translating complex problems into a list of obstacles might appear "overly simplistic". This suggests that, in an attempt to simplify users' needs, we might affect designers' trust in the materials. Participants acknowledged the limitations of the cards as they can only condense parts of the depression-related psychological theories. Sometimes, they found it difficult to fully understand the users experiences with depression due to the missing details: "*it's hard to design for something you don't really know ... depression hits so many people in different things, so we need to know as much detail about how to deal with- the design as possible*" (P3).

Conversely, providing too much information can be overwhelming. Two participants (P1 and P2) raised concerns about the amount of content presented: "*there was a lot of information... I wasn't sure where to start reading*" (P2) and "*you have the risk of being overwhelmed- because you need to read too much*" (P6). P2 suggested to "*make clear what each section of the cards mean*" and give more time with the theory cards to allow informed design decisions. A quote from P10 further implies the difficulties of building an understanding of theories in a short period of time, as they comment that the "only thing" they took away from the workshop was: " *if you think of the negative events, it's harder to do things mentally... and that depressed people tend to think more of the negative events*".

Presenting materials in interactive format could be one solution. This coincides with previous work [71] highlighting the *design power* of persona creators when deciding which information to include in a profile. Solutions were elicited to make the personas more interactive and thus allow HCI designers to get a more detailed understanding of the user. P7 suggested multi-modal formats, where more information is available but easily readable "*like Gantt chart, or calendar* ", or "*a couple of minutes' video... with some sound, it can be more attractive*", while P6 mentioned the possibility of "*asking questions*" to the persona through a chat box.

5.4.2 Emphatic connection can help the design process but can cause discomfort to designers. Two participants (P3 and P8) reported the difficulty of designing for depression and how it can affect designers: "*depression is so personal and difficult, isn't it? And everyone's got someone that has probably dealt with mental health issues in their life... It becomes a lot more loaded with feeling and emotion, and that you don't want to get it wrong* " (P3). To prevent designers from experiencing discomfort, P3 suggested: "*I probably wouldn't use the term 'depression'. I'd probably focus on the underlying things that cause depression, like the self-imposed tasks. Then, designers can relate to something very obvious, that's easy to design for* ". Similarly, other participants also mentioned that feeling too close to a persona's experience might create discomfort in the designer: "*it is good that I can relate to her [the persona], but not too much*" (P1). Choices within the design materials may increase/reduce empathy or the sense of distance. These includes the selection of demographic characteristics: "*I felt more comfortable reading about a male perspective because I feel a bit more distant from them as I'm a female*" (P2). A participant (P8) also mentioned that the absence of a picture in the persona kept them from experiencing vivid negative emotions while portraying the end user.

Additionally, a majority of participants mentioned the usefulness of highlighting the parts of the persona card which they related to, as it helped them empathise with the fictional user. However, P2 reported feeling uncomfortable as the activity was "*exposing in a way... everyone else could see what I was doing*". For that reason, they refrained from highlighting parts that might reveal "*something personal about you in a way... I didn't feel comfortable having that topic [family situation] in the conversation whatsoever*". As a solution to mitigate the perceived stigma, P2 suggested to keep the result of the highlighting private, or only share with the workshop facilitator. This highlights the fine line between encouraging empathy towards end users, and triggering discomfort.

5.4.3 Tensions can emerge between group and individual activities. Most participants shared positive feedback on the sequence of activities. 7/10 participants (P2, P3, P4, P5, P6, P7, P10) appreciated switching between individual tasks and group tasks : "*I wouldn't be designing the interface on- my own alone. There is always a problem with doing things on your own. It was- good to have the thoughts of other people*" (P4), and reported that beneficial for them to work both individually and as a group, as discussing the other personas helped them reflect on their own: "*it was a good reflective exercise in that sense*" (P5). "*talking to others makes you talk about the work that you did, so it helps you to articulate and understand it better*" (P10). However, P1 and P7 mentioned the difficulty to an efficient communication in group conversations about design, especially when various terminologies are used (e.g., psychology vs engineering).

When discussing methods to design a solution for a specific user group, half of the participants were in favour of working with multiple personas. P9 highlighted that during the workshop, they were presented with the personas of the other group members, they felt that "*it would have been useful to work with all three personas*" (P9). Being exposed to more personas might help "*get a better idea of what depression could look like for different people*" (P1) and design for users "*who might have different problems*" (P6). P9 comment's "*the more scenarios you have for a persona, the more believable it becomes* " suggests that showing a broader range of life-like situations for each persona would help perceive them as realistic users. P7 and P10 point out that working with more than one persona might be overwhelming, especially for "*a person who is not a psychiatrist, or don't have that sort of education*" (P7). Other participants mentioned that "*not all solutions might work for all of those people*" (P1) and that there was a risk of "*stepping too far away from any specific issue and maybe not addressing something*" (P5). P3 suggested introducing the different personas iteratively to facilitate the task for designers. However, generalising a solution to an entire user group didn't seem straight forward for the designers, as P9 explained they were: "*quite (pause) afraid of this task, because I feel like in the realm of mental health, you need sort of very laser focus on what the particular problem that you're trying to address*".

5.4.4 Input materials can help shape the design space, but they may also limit designers' creativity. In the workshop, we presented input materials to the participants with the aim of communicating complex user requirements and available psychological theories. The materials have also shaped the design space and process, particularly each subset of theory cards which targeted a specific use context (e.g., goal setting). Indeed, P6 felt that they narrowed the design space, but "*if you don't put constraints, you have a lot of risks to do something bad. With these theory things [cards], you limit the design space to things that work*". Although some participants suggested that the materials restricted their creativity - "*while it [the scenario] sorts of guides designers in a way, it's also... restrictive... you stop designers making assumptions about the persona* " (P9), other reported the opposite. Indeed, it was mentioned that the materials helped get a grasp of the 'wider context', and broadened the designers' own range of ideas, for example as they introduced "*a lot of things on those cards that I wasn't familiar with"* (P5).

Some participants designed *beyond* the materials. This includes the generation of app features that were not covered by the design materials and that did not fall under their assigned design context. For instance, one group generated app features such as "*encourage downtime*" and introduce new goals if the user has become " *obsessed with the old ones*", both addressing requirements which are not covered by the input materials or the academic research that the materials draw on [17, 48, 78]. Besides, one group assigned to the context of goal setting produced app features relevant to the context of progress review (e.g., a chatbot identifying negative patterns in the user's actions towards the goal).

The technological example on each theory card was sometimes perceived as an enforcement of certain digital solutions: "*they limit your imagination, and they don't... let you explore the design space*" (P6), or as an enforcement of technology itself: "*not everything can be kind of solved by technology... I don't know enough about designing for depression... I'd relate more to about my own perception of how I might want to deal with mental health issues... I would struggle to fix that with technology*" (P3). This highlights that, when lacking knowledge on the user's challenges, designers might rely on their own personal experience to design a solution. To broaden the design space, P3 suggested providing examples of '*technology non-use*' and highlighted the importance of an ethical discussion "*beyond the design itself, like, whether it's important to have the technology in the first place*". Finally, a participant pointed out that these examples might not be necessary for experienced designers, but could be "*quite useful to discuss with the experts in psychology*" (P4), probably as it might help them visualise the possibilities technology offers.

Most participants suggested presenting them at a later stage to encourage designers reflect on and challenge existing design solutions. Indeed, three participants argued that this would prevent using the theory cards as 'requirements', and prevent the examples from overly narrowing the design space: "*if you had got these theory cards out earlier, then I would have gone: 'Right well, let's just design an app with motivation and that smartwatch'*" (P3). P8 suggested that the theory cards were more helpful as a 'validation' tool, to back up or challenge existing design ideas. However, P9 felt that it was difficult to consider new design ideas with the theory cards in hand, as if they come up with an idea: "*it'll probably be disregarded*". To mitigate this limitation, P9 suggested replacing the technological example by a 'real world example' to not impact on designers' creativity. Alternatively, P6 suggested replacing technological examples with design guidelines to facilitate the design process and avoid having to "*extract these guidelines from the concrete example* ". Although most participants favored introducing the theory cards later in the design process, P1 would have preferred working with them before the first ideation, as they felt that "*it didn't have as much impact in me on the design process*". These comments highlight the complexity of introducing the theory cards 1) at early design stage without overly constraining ideation, or 2) later on to reflect on an existing design and challenge it when necessary.

6 DISCUSSION

We now revisit our research questions and discuss the implications of our findings.

6.1 Including theory-based persona and scenario cards in the design process can help deepen designers' understanding of end-users' needs and context

HCI researchers are increasingly engaging in design for users experiencing depression [72]. When designing healthcare systems for depression, communicating complex users' needs and requirements is essential [5, 12, 70] due to the specific challenges associated with mental health conditions. However, individual experiences of people affected by depression are not easily accessible and designers often struggle to understand their specificities [54]. Prior work has called for adapted personas and scenarios that draw on vignettes from ethnographic work [9, 23] to ensure that designers can better understand the design context [9], suggesting that literature-based personas and scenarios are powerful tools to bridge the gap between theory and design practice. Our work adapts and extends the identified issues by introducing theory-based personas and scenarios to further explain complex user requirements associated with depression. In this study, we generated personas and scenarios based on the literature to assist designers in understanding their target users' special requirements and to encourage empathy towards them. Our findings show the usefulness of theory-based persona and scenario cards to improve designers' understanding of users' needs and challenges associated with depression (P1, P3, P4, P5, P6, P7, P9), and allow them to "see through the eyes of the potential user". Participants also reported a greater sense of empathy towards the users and their daily challenges thanks to the persona cards.

Furthermore, designers becoming aware of their shared experiences with the end users can further facilitate empathy building. Designers who identified with the persona stressed the important role it played in their engagement with the prospective user. As highlighted by two participants (P1, P5), describing the symptoms of depression is important, but detailing their impact on people's life is essential to gain a better understanding of their needs and start developing a strategy to address them. Specifically, theory-informed personas and scenarios included a description of realistic situations in which depression affected one's daily activities. Adding information on the persona's preferences (e.g., use of technology, social life, etc.) was also seen as a potential means to support further tailoring of the solution to the user.

Finally, personas and scenarios specified use contexts and requirements, while supporting designers' reflection around the psychological mechanisms at play in the users (e.g. cognitive impairments). Thus, designers were better guided to produce more adapted designs.

In addition to facilitating a deep understanding of experiences with depression, design materials should also support the (in)validation of designers' assumptions. Indeed, some participants stated that the materials helped them correct their preconceptions about depression, often simplistic, and acknowledge the complexity of the condition. For this reason, we argue that design materials should aim to use specific descriptions of depression symptoms, and avoid generic formulations like "he felt depressed".

6.2 Theory cards may work best if introduced in an iterative and incremental fashion

Although understanding real user problems is key when designing for depression, only presenting persona and scenario cards might not be enough for equipping designers for conditions as complicated as depression. In the workshop sessions, we first introduced persona and scenario cards, for designers to draw initial design solutions base on their understanding of users' needs and problems. At this stage, we found some designers pointed out their concerns regarding their lack of experience in the mental health domain, while acknowledging the complexity of depression.

We then introduced 29 theory cards, generated from the academic literature on cognitive impairment in depression, including memory impairments [13, 35, 66, 68] and goal setting and planning difficulties [17, 48, 78], and designers to iterate their original design solutions accordingly. We found the theory cards particularly useful for complementing the theory-based persona and scenario cards, as most designers felt better equipped to design for depression after reading the theory cards, and two mentioned the cards helped them validate their design ideas. Besides, we found theory cards can be leveraged to iterate on existing design and further enrich designer's understanding of depression. The depression-associated challenges on the scenario card were deemed particularly useful to select relevant theory cards, with participants (P2, P5, P7) mentioning that they were searching for and selecting theory cards with solutions that fitted the design problems highlighted in these obstacles. We also found that a sense of confidence in the validity of the theory cards can be provided by the presence of peer-reviewed references supporting the theories presented.

In addition to the role of theory-based materials in understanding depression, participants shared that the descriptions of real-life experiences helped them be in the "right frame of mind" to design for depression. The input materials and the workshop activities helped designers consider ethical concerns. Design for sensitive user groups requires rich discussions on ethical issues related to the user group in question [72]. Such discussions helped participants critique and revise their initial designs to address ethical concerns. The design process should include theory-informed materials and activities to uncover and draw attention to the complex ethical issues related to the specific user group. This further supports the necessity for designers to be in a particular state of mind to be able to address the needs of individuals living with mental health difficulties.

6.3 Benefit of theory-based materials as integral part of UCD design process for mental health

Understanding the target end users' personal experiences and needs is an essential component of UCD (User-Centered Design) in mental health [12]. Common practices include engaging service users or experts such as psychotherapists in in-depth interviews [68, 73], participatory design workshops [54, 70], or the co-creation of input materials [27]. However, involving real patients in early design stage or exploratory design work is often a challenge in the mental healthcare domain [20, 54]. Reasons include the complexity of involving patients with complex conditions [5], the emotionally taxing practice for designers and researchers to work with such a vulnerable group [56, 72], the potential

risk of affecting both designers' and users' mental well-being [56], and the complex procedures for safeguarding both parties during fieldwork [24]. Prior work indicates that a considerable number of mobile apps for depression on the marketplace do not involve clinicians in the design process, and that the effectiveness of these apps cannot be guaranteed [67]. Some might even present a risk of eliciting potential harm [63, 76]. Therefore, to ensure the safety, effectiveness and engagement of mental health technologies, it is important to explore methodologies to translate service users' values, requirements and design guidelines into actionable materials to assist design practice.

We believe that the theory-based materials introduced in this work could complement the UCD process in several manners. Firstly, the personas and scenarios could be used as an introduction to depression before meeting real patients, or as a means to understand the users' needs when accessing real patients is impossible. Secondly, the theory cards could be employed as a tool to help designers 1) understand the roots of the users' needs and 2) refine design ideas. Finally, applying the materials to generate theory-informed solutions at later UCD design stage could facilitate the communication between designers and clinical psychologists or users living with depression.

6.4 Safeguarding strategies to prevent designers' discomfort should be included in the design process when using materials that make end-users' conditions more relatable

Although some participants said that they would have liked to have more details about the persona's experience with depression, either in a textual form (e.g., virtual chat) or in a visual form (e.g., video personas), other participants expressed concerns about this. Comments suggested that additional visual cues might create a feeling of discomfort in designers. In addition, a persona being a succinct description of a user group, it is affected by the What You See Is All There Is (WYSIATI) cognitive bias [51]. Due to the WYSIATI phenomenon, designers rely on present information to make judgements. Such judgements are often informed by stereotypes [39]; therefore it is essential to control for biases when designing personas to avoid reproducing stereotypes. Thus, the right balance needs to be found to provide enough content for designers to understand user needs, 1) without causing any distress in designers who might themselves have a history of mental health difficulties, and 2) controlling for the reproduction of stereotypes. Another option to increase designers' engagement with the personas and scenarios might be to use role play [54]. Having a participant or facilitator play the persona might allow for the fictional user to appear more interactive, and for the designers to take part in this design activity with less risk to experience discomfort than if they were interacting with a real user. Indeed, previous work has highlighted that exposure to end users' experiences may generate distress in researchers [56]. A "self-recovery" intervention should be provided to HCI designers post-exposure, however, more research is needed to create and implement such interventions [47, 74]. While the workshop succeeded in fostering empathy without being too emotionally charged for participants, designers' engagement with the personas and scenarios could be further increased, for example by using role play [54].

6.5 Striking the balance between limiting and opening the design space is key when introducing theory-informed materials in the design process

Presenting design guidelines, such as input materials or user requirements, can be beneficial for its potential of communicating complex user requirements, relevant theories, and guiding designers through design process. However, it is important to keep in mind that design materials should not and cannot exhaustively cover psychology theories without overwhelming designers [9]. Allowing for flexibility in the design process - such as encouraging ideation beyond the input materials - is important to avoid limiting designers' creativity and discussion [34], and reduce the risk of forcing designers towards specific design directions [9, 23].

Our findings reveal that even when the design space is somewhat bounded by the input materials and design activities, the openness of the design space is maintained. For instance, all groups generated several mobile app features that were not covered or represented in the theory cards they were provided. Indeed, although each group was assigned to one particular use context and given a subset of the theory cards, several of the app features designed covered several contexts (e.g. goal setting and progress review). One reason could be that designers were asked to first generate design ideas based on the personas and scenarios, and only then were presented with the subset of theory cards specific to a use context. In sum, introducing the theory cards only after having a first ideation with the personas and scenarios may have helped in maintaining the design space open. Thus, we argue that the theory cards work best as an idea refinement tool rather than initial guidelines for idea generation, which addresses issues identified in previous works [9, 34].

Besides, it was mentioned that the technological examples on each theory card might be too concrete, might narrow down the design space, or be perceived as an enforcement of digital solutions. To address this, future work could include replacing the technological examples with design guidelines, non-technological "real world" examples, or the input of domain experts (such as psychologists) to help designers visualize possible interventions.

7 LIMITATIONS AND FUTURE PERSPECTIVE

In the field of mental health in HCI, one common approach for effectively communicating complex user requirements and conditions is to engage users or experts directly to the design process [27, 28, 68, 73], The authors acknowledge the importance of engaging end-users and domain experts in the design process [12]. However engaging patients or clinicians, is often a challenge in early stage of UCD design works in the mental healthcare domain, due to potential ethical risks and complex procedures to safeguard service users [5], clinicians, researchers [24, 56]. Our work aims to bridge the gap by exploring and proposing a new design method to facilitate designers generating theory-informed design solutions before engaging with domain experts in later design stages. Our findings demonstrated the effectiveness of the theory-based materials for communicating complex domain knowledge (i.e., clinical psychology theories) rapidly to HCI design practice. One future improvements of this work could be engaging with clinical psychologists to elaborate the input-materials before directly participating in the design work, when engaging clinicians is less challenging.

Additionally, this paper focuses on how the theory-informed materials were designed by the authors and used by the participants. A future perspective could be to get clinicians or end users with lived experience of depression to provide feedback on the design artifacts (i.e., app features) generated from the workshop to further evaluate the clinical validity of the outcomes of this method.

Finally, a wider implication could be for future research to develop theory-based input materials to guide design for other mental health conditions such as anxiety. This approach could also be leveraged to support other sensitive settings beyond mental health, where accessing and engaging end users can be challenging. An example could be designing for women living in a culture impeding their self-expression [2], or for people living with severe mental illness [36] or suicidal ideation [33].

8 CONCLUSION

Depression is a mental health condition associated with a range of cognitive impairments (e.g., biased autobiographical memory processing and difficulties in goal setting and planning), which are widely explored in the field of psychology, but have generally been overlooked in HCI research and design practices, due to the longstanding gap between clinical research and design practice. To address the research-practice gap, our study explored an approach to communicating clinical psychology findings and theories through a suite of digestible theory-informed materials (i.e., personas, scenarios

and theory cards) that are relevant to designers of mobile apps for depression management. We have explored how theory-informed materials facilitate the design process for mental health technologies by deploying them in a series of design workshops. We found that the materials can facilitate designers' understanding of depression, elicit empathy towards the target users, and guide designers in integrating psychological theories into their design efforts. Our findings open up new design opportunities for incorporating complex domain knowledge in HCI design. This is particularly useful for supporting non-expert designers in early stages of the user-centered design cycle for mental health technologies by supporting the production of theory-grounded design solutions. Furthermore, the domain knowledge gained and design solutions generated throughout the process can provide a foundation to facilitate later communication with domain experts or end-users in a participatory design process.

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Appendix F

Ethics document of study 2

Lancaster University

Computing and communications

Participant information sheet

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about technology-based intervention for memory specificity training with personalized data.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?

Previous findings have shown that people with depressive symptoms tend to experience reduced autobiographical memory specificity. That is say, when they try to recall their personal memories, they would find it hard to recall specific events and their details. They also have a strong tendency to overgeneralize their life stories into a negative tone, which would further worsen their depressive mood. Memory Specificity Training (MEST) is an autobiographical episodic memory-based training, which is specifically designed to address this overgeneralization problem. The mechanism of MEST intervention is to motivate users to practise their ability to recall specific personal memories prompted by a list of cue words. To date, MEST has been proven effective in reducing over-general recall in both depressed samples and clinical groups.
Our study aims to digitalize this paper-based MEST intervention, with more personal and engaging cues. Running on wearable technologies (e.g. mobile phones, smart watches… etc), this intervention is more accessible for people with depressive concerns.

Before we designing this digitalized-intervention, we would like to conduct an interview to explore the challenges these memory impairments brings to depressed people's daily life, what are the current treatments used for addressing these impairments, the limitations and strengths of these treatments, and their potential to be digitized.

Why have I been invited?

You have been approached because you – are an expert therapist working with people living with depression. Your participation will help us explore the potential of this digitized intervention.

What will I be asked to do if I take part?

If you decided to take part, this would involve the following:
We would like to conduct an interview and ask about your experience while working with clients living with depression. We would like to know what problems they may

face while recalling autobiographical memories and how these may impact on people's lives. We will also ask the methods you use to help people suffering from depression address the issue of over overgeneralization; what works and how they can be improved.
This interview will take around one hour and data will be collected anonymously. We will perform this interview via phone, Skype or face to face.

What are the possible benefits from taking part?
Taking part in this study will allow you to share your experience from working with your clients with depression. It will allow you to share your insights about how memory-related difficulties may bring challenges in their daily life, which methods you used to address these difficulties and how we may use technology to support such methods.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary and you are free to withdraw at any time, without giving any reason

What if I change my mind?

As explained above, you are free to withdraw at any time and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study

What are the possible disadvantages and risks of taking part?

No
Will my data be identifiable?
I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

Participants in the focus group will be asked not to disclose information outside of the focus group and with anyone not involved in the focus group without the relevant person's express permission.

How will my data be stored?

Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.

I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?

I will use the data you have shared with only in the following ways:
I will use it for academic purposes only. This will include my PhD thesis and other publications, like conference papers and journal papers. I may also present the results of my study at academic conferences

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes, so that although I will use your exact words, you cannot be identified in our publications.

If anything you tell me in the episodic memory record, like pictures or diary suggests that you or somebody else might be at risk of harm, I will be obliged to share this information with my supervisor: Professor Corina Sas, as she is also involved in this study. If possible I will inform you of this breach of confidentiality.

This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network. AffecTech is funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?

This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?

If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: c.qu3@lancaster.ac.uk, or my supervisor: Prof. Corina Sas, email address: c.sas@lancaster.ac.uk.

- If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: **a.friday@lancaster.ac.uk**

Sources of support

If you feel any discomfort in this study, you could access to the mental health service provided by Lancaster University for help. The address: http://www.lancaster.ac.uk/student-based-services/wellbeing-counselling-and-mental-health/contact/.

Or you could contact your GP and ask for referral to external services, or self-referral to Mind Matters at https://www.lancashirecare.nhs.uk/Mindsmatter.

Thank you for considering your participation in this project.

Lancaster University

Faculty of Science and Technology Research Ethics Committee (FSTREC)
Lancaster University

Application for Ethical Approval for Research

This form should be used for all projects by staff and research students, whether funded or not, which have not been reviewed by any external research ethics committee. If your project is or has been reviewed by another committee (e.g. from another University), please contact the FST research ethics officer for further guidance.

In addition to the completed form, you need to submit **research materials** such as:

i. Participant information sheets
ii. Consent forms
iii. Debriefing sheets
iv. Advertising materials (posters, e-mails)
v. Letters/emails of invitation to participate
vi. Questionnaires, surveys, demographic sheets that are non-standard
vii. Interview schedules, interview question guides, focus group scripts

Please note that **you DO NOT need to submit pre-existing questionnaires or standardized tests** that support your work, but which cannot be amended following ethical review. These should simply be referred to in your application form.

Please submit this form and any relevant materials **by email as** a **SINGLE attachment** to *fst-ethics@lancaster.ac.uk*

Section One

Applicant and Project Information

Name of Researcher: Chengcheng Qu

Project Title: Digitalized MEST Trainer- intervention for memory specificity training with personalized data

Level: PhD

Supervisor (if applicable): Dr Corina Sas

Researcher's Email address: c.qu3@lancaster.ac.uk
Telephone: 7923189737
Address: School of Computing and Communications

Names and appointments/position of all further members of the research team:

Is this research externally funded? If yes,

ACP ID number: *AffecTech ITN*
Funding source: *EC*
Grant code:

Does your research project involve any of the following?

þHuman participants (including all types of interviews, questionnaires, focus groups, records relating to humans, use of internet or other secondary data, observation etc.)

☐ Animals - the term animals shall be taken to include any non-human vertebrates or cephalopods.

☐ Risk to members of the research team e.g. lone working, travel to areas where researchers may be at risk, risk of emotional distress

☐ Human cells or tissues other than those established in laboratory cultures

☐ Risk to the environment

☐ Conflict of interest

☐ Research or a funding source that could be considered controversial

þ Social media and/or data from internet sources that could be considered private

☐ any other ethical considerations

Yes – complete the rest of this form

No – your project does not require ethical review or submission of this form

Section Two

Type of study

þ Includes *direct* involvement by human subjects. ***Complete all sections apart from Section 3.***

☐ Involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants. ***Complete all sections apart from Section 4.***

If your research involves data from chat rooms and similar online spaces where privacy and anonymity are contentious, please complete all sections

Project Details

1. Anticipated project dates (month and year)
Start date: Nov 2017 **End date:** Dec 2020

2. Please briefly describe the background to the research (no more than 150 words, in lay-person's language):
Depression is predicted to be one of the leading cause of health disorders by year 2020 in developed countries. Depression can be associated with difficulties in recalling and managing autobiographical memories, such as overgeneralization, and negative-bias which could worsen depression symptoms.

Memory Specificity Training (MEST) aims to address this overgeneralization problem. With repeated recall of specific personal memory prompted by cue words, it has been shown effective in reducing over general recall in both depressed samples and clinical groups. We plan to digitalize this intervention, through wearable technologies assuming that the training would have better effect if it could related to participants' specific memory, as opposed to the current intervention which uses generic cueing material.

3. Please state the aims and objectives of the project (no more than 150 words, in lay-person's language):
The study is aiming at designing, developing and evaluating a novel digitalized intervention method, as a wearable technology, to help people decrease over general negative recall of their autobiographical memories.

4. Methodology and Analysis:
This study will involves two workshops and semi-structured interviews.

First, this study will involve semi-structured interviews and one workshop with psychotherapists, with the aim of discussing the feasibility of digitalizing this intervention and for exploring requirements for designing such technology.

We will also conduct another semi-structured interviews with people with depressive concerns. The aim of the interviews are to capture and understand real experiences about how memory related difficulties bring challenges to depressed people's daily life. The interviews also aimto capture the current treatments for addressing these impairments, their benefits and limitations.

Then, we will organize a second workshop with 10 people with depressive concerns with the to explore preferable ways of modifying people's personal pictures, if such photos are to be used as self-relevant cueing material. Modification of pictures should be in a way that pictures are recognizable, but not too easily readable. Additionally. the photo editing should not make it too hard to recognize the photo neither). During the workshop, we will show users their modified personal photos, and ask them to recall details of their specific memory cues by the pictures.

We will collect participant's feedback and preference for different types of photo filtering, and which filtering/modifying technique that they would find engaging and motivates them to explore their memories. We will also explore the impact of these cues on recall.

Section Three

Secondary Data Analysis

Complete this section if your project involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants

1. Please describe briefly the data or records to be studied, or the evaluation to be undertaken.

2. How will any data or records be obtained?

3. Confidentiality and Anonymity: If your study involves re-analysis and potential publication of existing data but which was gathered as part of a previous project involving direct contact with human beings, how will you ensure that your re-analysis of this data maintains confidentiality and anonymity as guaranteed in the original study?

4. What plan is in place for the storage of data (electronic, digital, paper, etc)? Please ensure that your plans comply with the Data Protection Act 1998.

5. What are the plans for dissemination of findings from the research?

6a. Is the secondary data you will be using in the public domain? YES/NO
6b. If NO, please indicate the original purpose for which the data was collected, and comment on whether consent was gathered for additional later use of the data.

7.What other ethical considerations (if any), not previously noted on this application, do you think there are in the proposed study? How will these issues be addressed?

8a. Will you be gathering data from discussion forums, on-line 'chat-rooms' and similar online spaces where privacy and anonymity are contentious? YES/NO

If yes, your project requires full ethics review. Please complete all sections.

Section Four

Participant Information

Complete this section if your project includes *direct* involvement by human subjects.

1. Please describe briefly the **intended human participants** (including number, age, gender, and any other relevant characteristics):

We plan to involve around 5-10 psychotherapists in the discussion and designing phrase, i.e. co-participatory design sessions and semi-structured interviews .
For the semi-structured interviews with people living with depression, we plan to involve around 15-20 people who posts as being, or have history of depression diagnosis on online forums.

In the second workshop, we plan to involve 10 students, from Lancaster University. Participants will be recruited if they have concerns about their depression tendency.

2. How will participants be **recruited** and from where?

The psychotherapists would be people who are involved in AffecTech project, and participants of the second workshop would be recruited from posters putted in Lancaster University counselling services (we will inquiry and ask permission before putting those posters).
For semi-structured interviews with experts, we will find psychotherapists through online platforms with list of psychotherapists working in England, and reach them by emails.

For semi-structured interview with people living with depression or have history of depression diagnosis, we will find them by online search: We will follow a Chinese forum, where people have experience of depression write posts and share about their stories while living with depression. We will identify the posts, which authors mentioned about their diagnosis of depression, and contact them via sending message through this Chinese forum.

3. Briefly describe your **data collection methods**, drawing particular attention to any potential ethical issues.
4.

Video record would be made during the design workshop. Those video records will be translated into notes and design guidelines, and will never be open to public access. These videos will be kept securely on the Lancaster University desktop hard disk, and will be destroyed once the project ends. The second workshop will involve people with concerns about their depressive symptoms. Also since it will access people's personalized memory, there might be privacy issue. The wearable technology such as commercial lifelogging will be developed in later phrase, and participants will be informed about the privacy risks of capturing personal information through such technologies. However, the study will make provision that participants could confirm whether they want to share those recorded data before they are shared with the Researcher.

4. Consent

4a. Will you take all necessary steps to **obtain the voluntary and informed consent** of the prospective participant(s) or, in the case of individual(s) not capable of giving informed consent, the permission of a legally authorised representative in accordance with applicable law? **YES**

If yes, please go to question 4b. If no, please go to question 4c.

4b. Please explain the procedure you will use for **obtaining consent**?. If applicable, please explain the procedures you intend to use to gain permission on behalf of participants who are unable to give informed consent.

All participants will receive and be asked to read participation information sheet. The sheet will contain information that briefs them about the study and its procedure. They can sign the consent form if they agree with those information; they can also quit this study at any stage as they wish.

4c. If it will be necessary for participants to take part in the study **without their knowledge and consent at the time**, please explain why (for example covert observations may be necessary in some settings; some experiments require use of deception or partial deception – not telling participants everything about the experiment).

5. Could participation cause **discomfort** (physical and psychological e.g. distressing, sensitive or embarrassing topics), **inconvenience or danger beyond the risks encountered in normal life**? Please indicate plans to address these potential risks. State the timescales within which participants may withdraw from the study, noting your reasons.
The semi-structured interview with psychotherapists should not bring discomfort since we will ask about their experience while working with clients.

Since the semi-structured interview with people who suffered from depression might include questions about their own experience while living when depression, there might be a chance that they will feel uncomfortable. However, giving the fact that these people have already started to write their experiences in public forums and willing to engage in conversations with their readers, we could see that they are already prepared and have th ability to talk about these experiences. The chance that this interview leads to emotional discomfort to them is rather little.
We will also take clear notice of participants' emotional arousal, and pause the interview immediately if they still feel discomfort during the interview. We will offer them comforting service (kind listening of their thoughts, guide them to perform mindful breathing, etc.). After the recovery, they can voluntarily choose either to continue this interview or quite at any time. We will inform them that they can quit at any time in the first place. If necessary, they can feel free to access the mental health service：

- Online platform for mental health support: reaching psychotherapists and psychological counselling helpline:
  - http://www.zx165.com/
  - http://www.jiandanxinli.com/
  - http://www.xinli001.com/
- Online platform for taking psychological and mindful courses:
  - http://www.iepsy.com/
  - https://static.xinli001.com/msite/index.html#/lesson-index

During the second workshop, we will access and modify participant's publically shared pictures on social media. We will first ask participants' permission of accessing and modifying their photos (from the mentioned resources) in the consent form of the workshop. We will also inform them that the pictures we may pick for the workshop may related to their emotional events, and ask their permission too. As the emotional events behind the photos may lead to emotional arousal, and we

will only proceed if they are comfortable to with this possible emotional arousal. Additionally, we will focus more on people's positive memories than negative ones, and there should be more positive emotions, compared to negative ones, triggered during this workshop.

However, when the pictures that we pick are from participant's unpleasant memories, there is still possibility that they may feel uncomfortable (e.g. angry, sad…etc). We will take clear notice of participants' emotion arousal during the workshop, if negative emotional arousal is raising significantly, we will pause this workshop immediately and provide comforting services to the participant (e.g. hot beverages, fresh air and kind listening) until she/ he feels better. After the recovery, they can voluntarily choose either to continue the workshop or quit at any time. We will inform them that they can quit this study at any time. If necessary, they can feel free to access the mental health service provided by Lancaster University for help. The address is: http://www.lancaster.ac.uk/student-based-services/wellbeing-counselling-and-mental-health/contact/ will be given to them in the informed sheet.

If they experience further mental discomfort from the workshop, we could also help them to contact their local GP and ask for referral to external services.

However, since the picture are selected from participants' shared information (either from public information from their social networking software, or shared with us before the workshop). Those pictures are already pre-selected by user themselves. From this, we could see that as they already have the experience and ability to face those pictures themselves. There should be little possibility of causing participant's emotional discomfort.

6. How will you protect participants' **confidentiality and/or anonymity** in data collection (e.g. interviews), data storage, data analysis, presentation of findings and publications?

The study outcomes will be published in conference and journal papers, while the information of all participants who attend the interviews and workshops will be anonymous.

The workshop will be designed to make sure that no data related to specific personal memories would be sent to anywhere but the users' and researchers' device. Also in the publication of these study outcomes, participant's information will remain being anonymous.

7. Do you anticipate any ethical constraints relating to **power imbalances or dependent relationships**, either with participants or with or within the research team? If yes, please explain how you intend to address these?

N/A.

8. What potential **risks may exist for the researcher** and/or research team? Please indicate plans to address such risks (for example, noting the support available to you/the researcher; counselling considerations arising from the sensitive or distressing nature of the research/topic; details of the lone worker plan you or any researchers will follow, in particular when working abroad.
N/A.

9. Whilst there may not be any significant direct **benefits to participants** as a result of this research, please state here any that may result from participation in the study.

We expect the benefit may be significant for both psychotherapists and depressed participants who attend the semi-interview and the workshop: As we will raise their awareness of memory impairments in depression and share our knowledge about addressing these memory impairments, which are evidence-proven to be effective in mitigating depression.

The workshop will be exploring a way to prompt users to engage with their memories.

10. Please explain the **rationale for any incentives/payments** (including out-of-pocket expenses) made to participants:
N/A.

11. What are your plans for the **storage of data** (electronic, digital, paper, etc.)? Please ensure that your plans comply with the Data Protection Act 1998.

The record of the interviews and workshops will be destroyed once the project is finished.
Textual data will be kept until 10 years. ii) Audio recordings will be destroyed once the project has ended.

The record of the second workshop, as modified personal photos (and posts in SNS or comments about their pictures), would be only be storage anonymously and never be shared to any third parties without the permission of the participant. Additionally, the records from individuals who are involved in this workshop would be destroyed once the project is finished.

We might also conduct one or a few questionnaire-based tests (For example, BDI(Beck, Steer, & Brown, 1996) for depression measurement and AMT(Williams & Broadbent, 1986)) for memory retrieve specificity) before and after the workshop. The aim of these tests is to measure participants' moods and memory recall specificity ability. The measures would only be used to compare users' emotional changes before and after the workshop. Those measures will only be storaged anonymously and never be shared to anyone. Additionally, the measures of individual who are involved in this workshop would be destroyed once the project is finished.

12. Please answer the following question *only* if you have not completed a Data Management Plan for an external funder.

12.a How will you make your data available under open access requirements?
The privacy of the data will be preserved and anonymised

12b. Are there any restrictions on sharing your data for open access purposes?
Textual transcription will be anonymised and open to public access.

Video of the workshop and measures from individual's emotional state in the workshop will not be made open to public access.

13. Will **audio or video recording** take place? ☐ no þ audio þ video

13a. Please confirm that portable devices (laptop, USB drive etc) will be **encrypted** where they are used for identifiable data. If it is not possible to encrypt your portable devices, please comment on the steps you will take to protect the data.

Portable devices will be encrypted.

i) Files and folders will be encrypted.
ii) ii) Security codes will be assigned to computerized records.

13b. What arrangements have been made for **audio/video data storage**? At what point in the research will tapes/digital recordings/files be destroyed?

Textual transcription will be kept for 10 years on the secure, password-protected server at Lancaster University.

Video of the workshops and interviews and measures from individual's emotional states in the will not be made open to public access, and they will be destroyed as soon as the project is finished.

13c. If your study includes video recordings, what are the implications for participants' anonymity? Can anonymity be guaranteed and if so, how? If participants are identifiable on the recordings, how will you explain to them what you will do with the recordings? How will you seek consent from them?

In the first design workshop, since the interest is the design ideas, we will record the voice and images from long distance and make sure their faces are not clearly recorded recognisable.
In the second workshop, since it's about recoding users reaction and memory processing procedure when they recall memory from an edited pictures, video records(including voices and their hands& the picture they are pointing) will be recorded. But the faces will not be recorded.

14. What are the plans for dissemination of findings from the research? If you are a student, mention here your thesis. Please also include any impact activities and potential ethical issues these may raise.
Study results would be published as conference papers and journals.

15. What particular ethical considerations, not previously noted on this application, do you think there are in the proposed study? Are there any matters about which you wish to seek guidance from the FSTREC?
N/A

Section Five

Additional information required by the university insurers

If the research involves either the nuclear industry or an aircraft or the aircraft industry (other than for transport), please provide details below:

Section Six

Declaration and Signatures

I understand that as Principal Investigator/researcher/PhD candidate I have overall responsibility for the ethical management of the project and confirm the following:

- I have read the Code of Practice, Research Ethics at Lancaster: a code of practice and I am willing to abide by it in relation to the current proposal.
- I will manage the project in an ethically appropriate manner according to: (a) the subject matter involved and (b) the Code of Practice and Procedures of the University.
- On behalf of the University I accept responsibility for the project in relation to promoting good research practice and the prevention of misconduct (including plagiarism and fabrication or misrepresentation of results).
- On behalf of the University I accept responsibility for the project in relation to the observance of the rules for the exploitation of intellectual property.
- If applicable, I will give all staff and students involved in the project guidance on the good practice and ethical standards expected in the project in accordance with the University Code of Practice. (Online Research Integrity training is available for staff and students here.)
- If applicable, I will take steps to ensure that no students or staff involved in the project will be exposed to inappropriate situations.
- I confirm that I have completed all risk assessments and other Health and Safety requirements as advised by my departmental Safety Officer.

þ Confirmed

Please note: If you are not able to confirm the statement above please contact the FST Research Ethics Committee and provide an explanation.

Student applicants:

Please tick to confirm that you have discussed this application with your supervisor, and that they agree to the application being submitted for ethical review ☒

Students must submit this application from your Lancaster University email address, and copy your supervisor in to the email in which you submit this application

All Staff and Research Students must complete this declaration:

I confirm that I have sent a copy of this application to my Head of Department (or their delegated representative) . **Tick here to confirm** ☒

Name of Head of Department *(or their delegated representative)*

Adrian Friday

Applicant electronic signature: Chengcheng Qu Date 07/11/2017

Interview guide:

Psychological studies have shown that people who suffer from depression also suffer from some autobiographical memory impairments, for example: overgeneralization, negative-bias to the past and future. The aim of the study is to capture and understand what challenges these memory impairments brings to depressed people's daily life, what are the current treatments are in addressing these impairments, the limitations and strengthens of these treatments, and their potential to be digitalized.

List of questions:

General questions:

- For how long have you been living with depression?
- What level of depression are you suffering from? (mild /moderate/ MDD)?

Questions for different memory deficit categories:

Overgeneralization:

- Does this overgeneralization problem affect your daily life? If yes, can you tell me three negative impact?
- Have you tried to address this overgeneralization problem?
    - If yes, what treatment did you use?
        - Did you use any materials in addressing this problem? What are the content and media of these materials? Are these materials personal? If yes, what value do you think they bring?
    - If no, what do you think will be working in addressing this problem?
    - Can you see the value of self-relevant digital material to address overgeneralization problem? Would it work? Why/why not?

Negative bias to the past:

- Do you think you have the tendency of keep thinking about bad memories, while ignoring the positive ones?
- Have you tried to look back at negative emotional events specifically? If yes, which cognitive problem you tried to address (list top three if there are more than one)?
    - Which treatment did you use? Have you used any personal or special material in addressing this/these problem?
    - Can you list top three problems that bothers you?
- Have you helped them recall positive memories as part of training? Do you have any problem while trying to recall positive events? If yes, can you identify this problem? (Or list top three problem if there are more than one)?
    - Did you try to address this/these problem(s)?
        - If yes, which treatment did you use? Have you used any type of materials in addressing this/these problem(s)? What are the content of these materials? Are these materials personal? If yes, what value do you think they bring?
        - Can you list top three problems of negative bias that bothers you?
    - Can you see the value of self-relevant digital material to address overgeneralization problem? Would it work? Why/why not?

Negative bias to the present/future:

- When you interpret your present and future, do you always have negative or positive interpretation? Why?
- Do you think this brings you any problem in daily life? Did you use any treatment in addressing these problems? Which treatment did you use?
    - Did you use any types of material? Did you used any personal material? If yes, did you find them helpful? If yes, what value do you think they bring?

Ending: engaging+ gap of current IT:

- Have you ever experienced problems engaging in treatment? If yes, can you list top three reasons of this? How do you managed to solve this problem?
- Have you ever tried any online platform of cognitive behaviour therapy? If yes, which ones did you use?
    - Are you satisfied with this technology? If no, why?
    - How do you think about this technology?

CONSENT FORM

Project Title: ***Digitalized wearable Mest Trainer- wearable technology for memory specificity training with personalized data***

Name of Researchers: Chengcheng Qu

Email: : c.qu3@lancaster.ac.uk

Please tick each box

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. If I withdraw within 3 weeks of commencement of the study my data will be removed. If I am involved in focus groups and then withdraw my data will remain part of the study. ☐
3. If I am participating in the focus group I understand that any information disclosed within the focus group remains confidential to the group, and I will not discuss the focus group with or in front of anyone who was not involved unless I have the relevant person's express permission. ☐
4. I understand that any information given by me may be used in future reports, academic articles, publications or presentations by the researcher/s, but my personal information will not be included and I will not be identifiable. ☐
5. I understand that my name/my organisation's name will not appear in any reports, articles or presentation without my consent. ☐
6. I understand that any interviews or focus groups will be audio-recorded and transcribed and that data will be protected on encrypted devices and kept secure. ☐
7. I understand that data will be kept according to University guidelines for a minimum of 10 years after the end of the study. ☐
8. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent_____ **Date** _____ Day/month/year

One copy of this form will be given to the participant and the original kept in the files of the researcher at Lancaster University

Appendix G

Ethics document of study 5

Lancaster University

Faculty of Science and Technology Research Ethics Committee (FSTREC)
Lancaster University

Application for Ethical Approval for Research

This form should be used for all projects by staff and research students, whether funded or not, which have not been reviewed by any external research ethics committee. If your project is or has been reviewed by another committee (e.g. from another University), please contact the FST research ethics officer for further guidance.

In addition to the completed form, you need to submit **research materials** such as:

i. Participant information sheets
ii. Consent forms
iii. Debriefing sheets
iv. Advertising materials (posters, e-mails)
v. Letters/emails of invitation to participate
vi. Questionnaires, surveys, demographic sheets that are non-standard
vii. Interview schedules, interview question guides, focus group scripts

Please note that **you DO NOT need to submit pre-existing questionnaires or standardized tests** that support your work, but which cannot be amended following ethical review. These should simply be referred to in your application form.

Please submit this form and any relevant materials **by email as** a **SINGLE attachment** to *fst-ethics@lancaster.ac.uk*

Section One

Applicant and Project Information

Name of Researcher: Chengcheng Qu

Project Title: Digitalized Memory Trainer for depression- intervention for addressing memory impairments in depression with personalised data

Level: PhD

Supervisor (if applicable): Dr Corina Sas

Researcher's Email address: c.qu3@lancaster.ac.uk
Telephone: 7923189737
Address: School of Computing and Communications

Names and appointments/position of all further members of the research team:

Is this research externally funded? If yes,

ACP ID number: *AffecTech ITN*
Funding source: *EC*
Grant code:

Does your research project involve any of the following?

Human participants (including all types of interviews, questionnaires, focus groups, records relating to humans, use of internet or other secondary data, observation etc.)

☐ Animals - the term animals shall be taken to include any non-human vertebrates or cephalopods.

☐ Risk to members of the research team e.g. lone working, travel to areas where researchers may be at risk, risk of emotional distress

☐ Human cells or tissues other than those established in laboratory cultures

☐ Risk to the environment

☐ Conflict of interest

☐ Research or a funding source that could be considered controversial

☐Social media and/or data from internet sources that could be considered private

☐ any other ethical considerations

Yes – complete the rest of this form

No – your project does not require ethical review or submission of this form

Section Two

Type of study

Includes *direct* involvement by human subjects. ***Complete all sections apart from Section 3.***

☐ Involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants. ***Complete all sections apart from Section 4.***

If your research involves data from chat rooms and similar online spaces where privacy and anonymity are contentious, please complete all sections

Lancaster University

Project Details

1. Anticipated project dates (month and year)
Start date: Nov 2017 **End date:** Dec 2020

2. Please briefly describe the background to the research (no more than 150 words, in lay-person's language):
Being predicted to be one of the leading cause of health disorders by year 2020 in developed countries, depression is currently raised more attention in research field. Depression can be associated with difficulties in properly recalling and managing autobiographical memories. One of them is to overgeneralize their previous experiences in a negative manner, which could worsen in depression symptoms, and even lead to social dysfunction.

One of our most recent works published at CHI (the flagship HCI conference) [4] developed a few guidelines for designing memory technologies to address the identified memory impairments in depression [1, 2, 4]. The design guidelines inspired by both clinician's practical experience in working with memory impairments in depression, and a few neuropsychological interventions for addressing memory impairments in depression, including Memory Specificity Training (MEST), which specifically aims to address the memory impairment in depression. With repeated recall of specific personal memory prompted by cue words, it has been proved effective in reducing over general recall in both depressed samples and clinical groups. We plan to design and develop a digital memory system, through wearable technologies, assuming that if the training would have better effect if it could related to participants' specific memory, as opposed to the current, intervention which uses generic cueing material.

3. Please state the aims and objectives of the project (no more than 150 words, in lay-person's language):
The study is aiming at designing and developing a novel wearable, memory-assisting memory technologies, inspired by neuropsychological interventions that designed to help users with depression to alleviate their memory impairments, especially to decrease over-general negative recall of their memories.

4. Methodology and Analysis:
This study will involve two focus group meetings and two workshops.

We plan first to conduct a **focus group study**, including two meetings for refining and validating the design scenarios of the memory system. In the focus group study, we will present participants our pre-generated hypothetical design scenarios of the designed mobile app, showing how this system could help them in the following scenarios: planning positive events, prompting to engage in planned positive events, capturing positive moments when it is happening, and reviewing the captured records.
The first focus group meeting with be running with patients receiving treatments from Jaume I University and IRCCS Istituto Auxologico Italiano (Italy). We will then run the second focus group meeting with psychotherapists from the clinical psychology department in both the Jaume I University and Universita Cattolica del Sacro Cuore (Italy) for collecting perspectives from both patients and clinicians.

We will ask participants to reflect on each of the scenarios based on their own experience of either living with depression, or working with depression, and help us to refine our design scenarios and make sure they are close to depressed users' real life.

After the scenario is validated from the focus group study, this study will involve co-participatory design **workshop study,** with the aim of discussing the feasibility and gather design ideas of this wearable, memory assistive system, which inspired by identified neuropsychological, memory-based interventions [1, 2]. The co-participatory workshop will involve multiple sections, conducted with psychotherapists and interaction designers. After the discussion, the ideas and inspirations will be collected as design implications, for guidelines in designing the digitalized memory technology, which would be developed in later stage. After the workshop, we also will conduct a semi-structure interview to collect designers' feedback of the workshop and materials used in the workshop.

After the first **workshop**, we plan to organize the second workshop, individually with 10 normal people with depressive concerns. The content of this workshop is about to explore preferable ways of modifying people's personal pictures. Modification of pictures should be in a way that the pictures are recognizable, but not too easily readable. Additionally, the photo editing should not make it too hard to recognize the photo neither. For instance, the processing techniques could include: 1) erase colors, 2) pixelating, 3) blurring or 4) extracting keywords from users' description of their memories behind the picture. During the workshop, we will first show users their modified personal memory cue and ask them to recall details of their specific memory behind this picture. We will also ask participants to interact with their processed memory cues (e.g., coloring their processed photos). We will compare participants' mood changes before and after the interaction, using well-being scales such as the Positive and Negative Affect Schedule (PANAS) [5] and the Subjective Happiness Scale (SHS) [3].
The idea of the workshop is to collect participant's feedback and ideas regarding to our modification to their digital possessions as cues of their emotional memories, including personal data, e.g., their pictures. We would like to hear their preference in filtering/modifying technique that they would find engaging and motivates them to explore their memories that associate with these memory cues. Students who attend this workshop is not necessary students with diagnosed depressive disorder, since we are just exploring preferable design inspiration from this workshop.

[1] Dalgleish, T. and Werner-Seidler, A. 2014. Disruptions in autobiographical memory processing in depression and the emergence of memory therapeutics. *Trends in Cognitive Sciences*. 18, 11 (2014), 596–604. DOI:https://doi.org/10.1016/j.tics.2014.06.010.

[2] Hitchcock, C., Werner-Seidler, A., Blackwell, S.E. and Dalgleish, T. 2017. Autobiographical episodic memory-based training for the treatment of mood, anxiety and stress-related disorders: A systematic review and meta-analysis. *Clinical Psychology Review*. 52, (2017), 92–107. DOI:https://doi.org/10.1016/j.cpr.2016.12.003.

[3] Lyubomirsky, S. and Lepper, H.S. 1999. A measure of subjective happiness: Preliminary reliability and construct validation. *Social Indicators Research*. (1999). DOI:https://doi.org/10.1023/A:1006824100041.

[4] Qu, C., Sas, C. and Doherty, G. 2019. Exploring and designing for memory impairments in depression. *Conference on Human Factors in Computing Systems - Proceedings* (New York, New York, USA, 2019), 1–15.

[5] Watson, D., Clark, L.A. and Carey, G. 1988. Positive and Negative Affectivity and Their Relation to Anxiety and Depressive Disorders. *Journal of Abnormal Psychology*. (1988). DOI:https://doi.org/10.1037/0021-843X.97.3.346.

Section Three

Secondary Data Analysis

Complete this section if your project involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants

1. Please describe briefly the data or records to be studied, or the evaluation to be undertaken.

2. How will any data or records be obtained?

3. Confidentiality and Anonymity: If your study involves re-analysis and potential publication of existing data but which was gathered as part of a previous project involving direct contact with human beings, how will you ensure that your re-analysis of this data maintains confidentiality and anonymity as guaranteed in the original study?

4. What plan is in place for the storage of data (electronic, digital, paper, etc)? Please ensure that your plans comply with the Data Protection Act 1998.

5. What are the plans for dissemination of findings from the research?

6a. Is the secondary data you will be using in the public domain? YES/NO
6b. If NO, please indicate the original purpose for which the data was collected, and comment on whether consent was gathered for additional later use of the data.

7.What other ethical considerations (if any), not previously noted on this application, do you think there are in the proposed study? How will these issues be addressed?

8a. Will you be gathering data from discussion forums, on-line 'chat-rooms' and similar online spaces where privacy and anonymity are contentious? YES/NO

If yes, your project requires full ethics review. Please complete all sections.

Section Four

Participant Information

Complete this section if your project includes *direct* involvement by human subjects.

1. Please describe briefly the **intended human participants** (including number, age, gender, and any other relevant characteristics):

For the first focus group meeting, we plan to involve 5-8 people from each institution (Spain and Italy) who are receiving clinical treatment from the psychology department, while not living with severe or clinical depression to join the first focus group meeting to participate the first focus group meeting. For the second focus group meeting, we plan to involve around 5-7 psychotherapists from each institution (Spain and Italy) in the discussion and designing phrase, i.e. co-participatory design sessions. The subclinical depressed participants or the clinical psychologists would be recruited from partner universities of the AffecTech project: We plan to visit the clinical psychology department of Universitat Jaume I De Castellon (Spain), Universita Cattolica del Sacro Cuore (Italy) for this workshop.

For the first workshop study, we plan to recruit psychologists that have knowledge and experience of encouraging behavioral changes to people with depression. We plan to involve psychologists from our partner universities (I.e., UJI in Spain, UCSC in Italy), or psychologists that are interested in our studies from Universities in the UK.
We also plan this workshop with interaction designers, HCI students, or HCI researchers recruited from research instituations (e.g., Lancaster University, Trinity College Dublin). Designers will be recruited if they are currently taking, or have taken Human-Computer Interaction courses or have experience of interaction design .

In the second workshop, we plan to involve 10 students, from Lancaster University. Participants will be recruited if they have concerns about their depression tendency.

2. How will participants be **recruited** and from where?

To recruit the service users, we will get help the psychologists in UJI (Spain) or Universita Cattolica del Sacro Cuore (Italy), who will refer their patients to sign up our focus group study through a doodle link. Patients will only be referred to the study if they are living with mild to moderate depression, and are willing to participate in our study.

To recruit the clinicians, we plan to reach them by sending email invitations, both individually or through maillist of the psychology department in our partner universities. Please see recruitment email on page 32, Appendix 1.

Interaction designers will be recruited by sending email invitations through snowball recruiting strategy, where participants can be recruited from sending email invitation through maillist of the their university and can recommend others to join our study. Please see recruitment email on page 32, Appendix 2.

Participants of the second workshop would be recruited from posters putted in Lancaster University counselling services (we will inquiry and ask permission before putting those posters), or via email invitation. A draft of the recruitment poster could be found in page 28.

3. Briefly describe your **data collection methods**, drawing particular attention to any potential ethical issues.

Audio record would be made during the focus group studies, and video record would be made during the design workshop. Those audio and video records will be translated into notes and design guidelines, and will never be open to public access. For the workshop audio record, we will hire an external transcriber to transcribe data into text (confidentiality agreement to be seen in page 26). The transcription will be finished by the researchers of this project. Since the participants of the first workshop are patients who might only speak Spanish, if needed, a researcher will be hired to translate the audio record from Spanish or Italian to English (confidentiality agreement to be seen in page 26). These videos will be kept securely on the Lancaster University desktop hard disk, and will be destroyed once AffecTech project ends.
The Second workshop will involve people with concerns about their depressive symptoms, and might involve privacy issue as it will access people's personalized memory. The wearable technology such as commercial lifelogging will be developed in later phrase, and participants will be informed about the privacy risks of capturing personal information through such technologies. However, the study will make provision that participants could confirm whether they want to share those recorded data before they are shared with the Researcher.

4. Consent

4a. Will you take all necessary steps to **obtain the voluntary and informed consent** of the prospective participant(s) or, in the case of individual(s) not capable of giving informed consent, the permission for a legally authorised representative in accordance with applicable law? **YES**
If yes, please go to question 4b. If no, please go to question 4c.

4b. Please explain the procedure you will use for **obtaining consent**?. If applicable, please explain the procedures you intend to use to gain permission on behalf of participants who are unable to give informed consent.

All participants will receive and be asked to read participation information sheet. The sheet will contain information that briefs them about the study and its procedure. They can sign the consent form if they agree with those information; they can also quit this study at any stage as they wish.

4c. If it will be necessary for participants to take part in the study **without their knowledge and consent at the time**, please explain why (for example covert observations may be necessary in some settings; some experiments require use of deception or partial deception – not telling participants everything about the experiment).

5. Could participation cause **discomfort** (physical and psychological e.g. distressing, sensitive or embarrassing topics), **inconvenience or danger beyond the risks encountered in normal life**? Please indicate plans to address these potential risks. State the timescales within which participants may withdraw from the study, noting your reasons.

For minimizing the risk of stress for participants with subclinical depression in the **focus group study,** We will run the focus group with clinical psychologist and avoid questions that may induce their negative memories. All of the hypothetical scenarios are about planning and engaging positive events, and capturing positive memories. In addition, we will follow a distress protocol [1] to further safeguard participants as follows:
If participants indicate as experiencing high levels of stress, or exhibit behaviours that suggest that the focus group discussion is stressful, the researcher (clinical psychologist) will stop the discussion, and ask the following questions to access participants' mental state. Questions include [1]:

1) Tell me what thought are you having?
2) Tell me what are you feeling right now?
3) Do you feel you are able to go on about your day?
4) Do you feel safe?

The discussion can be resumed only if the participants feel able to carry on. If participants prefer not to carry on, the researcher (clinical psychologist) will accompany them to a quiet area and encourage them to contact their mental health provider. If immediate risk is identified, the researcher will encourage participants to call local emergency service, or call local authorities on participant's behalf, with their consent.

Reference:

[1] Haigh, C. and Witham, G. 2015. Distress Protocol for qualitative data collection. *Manchester Metropolitan University*. 31, 1 (2015), 1–4. DOI:https://doi.org/10.4218/etrij.09.0208.0294.

The chance for the focus group meeting with clinicians and the first workshop study bringing discomfort is arguably small as content of the study is to discuss prototype design with participants as clinical psychologists.

During the second workshop, we will access and modify participant's public shared pictures. We will first ask participants' permission for accessing and modifying their photos (from the mentioned resources) in the consent form of the workshop. We will also inform them that the pictures we may pick for the workshop may related to their emotional events, and ask their permission too. As the emotional events behind the photos may lead to emotional arousal, and we will only proceed if they are comfortable to with this possible emotional arousal. Additionally, we will focus more on people's positive memories than negative ones, and there should be more positive emotions, compared to negative ones, triggered during this workshop.

However, when the pictures that we pick are from participant's unpleasant memories, there is still possibility that they may feel uncomfortable (e.g. angry, sad…etc.) We will take clear notice of participants' emotion arousal during the workshop, if negative emotional arousal is raising significantly, we will pause this workshop immediately and provide comforting services to the participant (e.g. hot beverages, fresh air and kind listening) until she/ he feels better. After the recovery, they can voluntarily choose either to continue the workshop or quit at any time. We will inform them that they can quit this study at any time. If necessary, they can feel free to access the mental health service provided by Lancaster University for help. The address is: http://www.lancaster.ac.uk/student-based-services/wellbeing-counselling-and-mental-health/contact/ will be given to them in the informed sheet.

If they experience further mental discomfort from the workshop, we could also help them to contact their local GP and ask for referral to external services.

However, since the picture are selected from participants' shared information (either from public information from their social networking software, or shared with us before the workshop). Those pictures are already pre-selected by user themselves. From this, we could see that as they already have the experience and ability to face those pictures themselves. There should be little possibility of causing participant's emotional discomfort.

6. How will you protect participants' **confidentiality and/or anonymity** in data collection (e.g. interviews), data storage, data analysis, presentation of findings and publications?

The workshop will be designed to make sure that no data related to specific personal memories would be sent to anywhere but the users' and researchers' device. Also in the publication of these study outcomes, participant's information will remain being anonymous.

7. Do you anticipate any ethical constraints relating to **power imbalances or dependent relationships**, either with participants or with or within the research team? If yes, please explain how you intend to address these?

N/A.

8. What potential **risks may exist for the researcher** and/or research team? Please indicate plans to address such risks (for example, noting the support available to you/the researcher; counselling considerations arising from the sensitive or distressing nature of the research/topic; details of the lone worker plan you or any researchers will follow, in particular when working abroad.
Since the researcher will conduct the focus group and the first workshop study outside the campus, there might be potential risk during the travel. However, since the researcher will only conduct daily research activity as he/she does in every working day. The risk for this overseas research work is very little.

However, for preventing any harm while researcher conducting their research while conducting this research overseas, the researcher will follow Lancaster University lone working policy. The researcher has already taken the course **Risk Assessment** on **Moodle** (as suggested from Safety Office of Lancaster University).
Before planning this research trip, the researcher will undertake a sufficient risk assessment.

9. Whilst there may not be any significant direct **benefits to participants** as a result of this research, please state here any that may result from participation in the study.
The workshop will be exploring a way to prompt users to engage with their memories.

10. Please explain the **rationale for any incentives/payments** (including out-of-pocket expenses) made to participants:
For attracting participants to join our study, and for thanking them contributing their time, we will reward each participants who join the focus group meeting for £20 per hour as amazon voucher for their participantion. Additionally, we will reward each participants of co-design workshop for £20 amazon voucher, as it takes 3 hours. The students who join the second workshop study will receive £10 amazon voucher.

11. What are your plans for the **storage of data** (electronic, digital, paper, etc.)? Please ensure that your plans comply with the Data Protection Act 1998.

The record of the focus group study and the first workshop will be destroyed once the project is finished.

The record of the second workshop, as modified personal photos (and posts in SNS or comments about their pictures), would be only be storage anonymously and never be shared to any third parties without the permission for the participant. Additionally, this records from individuals who are involved in this workshop would be destroyed once the project is finished. We might also conduct one or a few questionnaire-based tests (For example, BDI(Beck, Steer, & Brown, 1996) for depression measurement

and AMT(Williams & Broadbent, 1986)) for memory retrieve specificity) before and after the workshop. Aim of the tests are to measure participants' moods and memory recall specificity ability. The measures would only be used to compare users' emotional changes before and after the workshop. Those measures will only be storaged anonymously, never be shared to anyone, and will be destroyed once the project is finished.

12. Please answer the following question *only* if you have not completed a Data Management Plan for an external funder.

12.a How will you make your data available under open access requirements?

The privacy of the data will be preserved and anonymised

12b. Are there any restrictions on sharing your data for open access purposes?

Video of the workshop and measures from individual's emotional state in the workshop will not be made open to public access.

13. Will **audio or video recording** take place? ☐ no audio video

13a. Please confirm that portable devices (laptop, USB drive etc) will be **encrypted** where they are used for identifiable data. If it is not possible to encrypt your portable devices, please comment on the steps you will take to protect the data.

Portable devices will be encrypted.

i) Files and folders will be encrypted.
ii) ii) Security codes will be assigned to computerized records.

13b. What arrangements have been made for **audio/video data storage**? At what point in the research will tapes/digital recordings/files be destroyed?

Anonymous data, as audio record of the focus group meetings and the video of the workshops and questionnaire-based measures from individual's emotional states will be stored on university approved encrypted storage devices and on Lancaster University ,anaged services in Box (secure cloud storage). The box folder will be owned by Chengcheng Qu and will only be accessible to current memebers of supervisory team (i.e., Prof Corina Sas). No physical data or participant information will be collected or stored besides the consent forms, which will be stored in a locked cabinet, in a locked office. The researcher and her supervisor, Prof. Corina Sas, may review all anonymized records related to this study. All publications and presentations resulting from this research will present either anonymized examples of specific work, or aggregate quantitative data. The raw data will be stored until the end of the AffecTech project, i.e., December 2020.

13c. If your study includes video recordings, what are the implications for participants' anonymity? Can anonymity be guaranteed and if so, how? If participants are identifiable on the recordings, how will you explain to them what you will do with the recordings? How will you seek consent from them?

In the first design workshop, since the interest is the design ideas, we will record the voice and images from long distance and make sure their faces are not clearly recorded recognisable.

In the second workshop, since it's about recoding users reaction and memory processing procedure when they recall memory from an edited pictures, video records (including voices and their hands& the picture they are pointing) will be recorded. But their faces will not be recorded.

14. What are the plans for dissemination of findings from the research? If you are a student, mention here your thesis. Please also include any impact activities and potential ethical issues these may raise. Study results would be published as conference papers and journals.

15. What particular ethical considerations, not previously noted on this application, do you think there are in the proposed study? Are there any matters about which you wish to seek guidance from the FSTREC?
N/A

Section Five

Additional information required by the university insurers

If the research involves either the nuclear industry or an aircraft or the aircraft industry (other than for transport), please provide details below:

Section Six

Declaration and Signatures

I understand that as Principal Investigator/researcher/PhD candidate I have overall responsibility for the ethical management of the project and confirm the following:

- I have read the Code of Practice, Research Ethics at Lancaster: a code of practice and I am willing to abide by it in relation to the current proposal.
- I will manage the project in an ethically appropriate manner according to: (a) the subject matter involved and (b) the Code of Practice and Procedures of the University.
- On behalf of the University I accept responsibility for the project in relation to promoting good research practice and the prevention of misconduct (including plagiarism and fabrication or misrepresentation of results).
- On behalf of the University I accept responsibility for the project in relation to the observance of the rules for the exploitation of intellectual property.
- If applicable, I will give all staff and students involved in the project guidance on the good practice and ethical standards expected in the project in accordance with the University Code of Practice. (Online Research Integrity training is available for staff and students here.)
- If applicable, I will take steps to ensure that no students or staff involved in the project will be exposed to inappropriate situations.
- I confirm that I have completed all risk assessments and other Health and Safety requirements as advised by my departmental Safety Officer.

Confirmed

Please note: If you are not able to confirm the statement above please contact the FST Research Ethics Committee and provide an explanation.

Student applicants:

Please tick to confirm that you have discussed this application with your supervisor, and that they agree to the application being submitted for ethical review ☒

Students must submit this application from your Lancaster University email address, and copy your supervisor in to the email in which you submit this application

All Staff and Research Students must complete this declaration:

I confirm that I have sent a copy of this application to my Head of Department (or their delegated representative) . **Tick here to confirm** ☒

Name of Head of Department *(or their delegated representative)*

Adrian Friday

Applicant electronic signature: Chengcheng Qu Date 07/11/2017

Lancaster University

Lancaster University

Computing and communications

Participant information sheet—focus group study (service users)

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about – *Digitalized Memory Trainer for depression-intervention for addressing memory impairments in depression with personalized data.*

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?
Previously research has demonstrated that when a depressed individual tries to recall their memories, they would normally find it hard to recall specific events and the details of those events happened in their life. They also have a strong tendency to overgeneralize their life stories into a negative tone, which could further enhance their depressive mood. Both clinical psychotherapists and laboratory neuropsychologists develop their approach to address the above issues. Inspired by these approaches, we have developed a few guidelines for designing memory technologies, which aims to address the identified memory impairments in depression. We plan to design and develop a digital memory system, through wearable technologies, to help users living with depression to actively engage in planning and enjoying happy events in their life, and capture the moment as cues to enhance positive memory recalling to against depression.

Why have I been invited?
I am approaching you with the hope that you may like to collaborate in the design of this memory assistive system. Your participation will help us explore the potential of this digitised intervention, from the feedback we could collect from you, we could go further and address these challenges of depression faced by many other people. I would be very grateful if you would agree to take part in this study.

What will I be asked to do if I take part?
If you decided to take part, this would involve the following:

We would like to conduct focus group meeting with you, where we will show you the pre-generated hypothetical design scenarios of our to-be-designed mobile app, showing how could this system help them in the following scenarios: planning positive events, prompting to engage in planned positive events, capturing positive moments when it is happening, and reviewing the captured records.
We would ask you to reflect on each of the scenarios, base on your own experience of living with depression and help us to refine our design scenarios and make sure they are more close to depressed users' real life.

What are the possible benefits from taking part?
During the workshop, we provide another way that you could look back and explore your own experience of living with memory problems that associate with depression. We will also inspire you by exploring ways to address these memory problems, to help you alleviate depression better.
You will also have a chance to share your opinions and suggestions to help us understand the life of people living with depression, which could inspire a better design of our technology. By doing this, you are contributing to helping other people who are suffering from depressive disorder.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary, and you are free to withdraw at any time, without giving any reason

What if I change my mind?
As explained above, you are free to withdraw at any time, and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study

What are the possible disadvantages and risks of taking part?
The group discussion might be stressful for you, or with a chance to distress you by invoking unpleasant memory.
We will try our best to minimise the risk of your participation by avoiding questions that might invoke your negative memories. Additionally, we will run this study with a clinical psychologist who can provide immediate help if we identify any distress from you.

Will my data be identifiable?
After the observation, only I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

We will ask you, as participants in the focus group, not to disclose information outside of the focus group and with anyone not involved in the focus group without the relevant person's express permission.

How will my data be stored?
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.
I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the data you have shared with only in the following ways:
I will use it for academic purposes only. This will include *my PhD thesis and other publications, like conference papers and journal papers.* I may also present the results of my study at academic conferences
When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes, so that although I will use your exact words, you cannot be identified in our publications.
If anything you tell me in the episodic memory record, like pictures or diary suggests that you or somebody else might be at risk of harm, I will be obliged to share this information with *my supervisor: Professor Corina Sas, as she is also involved in this study.* If possible I will inform you of this breach of confidentiality.
This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?
This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: **c.qu3@lancaster.ac.uk,** or my supervisor: Prof. Corina Sas, email address: **c.sas@lancaster.ac.uk.**

- If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: a.friday@lancaster.ac.uk

Sources of support

If you feel any discomfort in this study, you could access contact the standby clinical psychologist for help.

[Stand-by psychologist's information to be added while decided with the clinical psychology department of Jaume I University or IRCCS Istituto Auxologico Italiano].

Thank you for considering your participation in this project.

Lancaster University

Lancaster University

Computing and communications

Participant information sheet --focus group study (Clinical psychologists)

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about --*Digitalized Memory Trainer for depression-intervention for addressing memory impairments in depression with personalized data.*

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?
Previously research has demonstrated that when a depressed individual tries to recall their memories, they would normally find it hard to recall specific events and the details of those events happened in their life. They also have a strong tendency to overgeneralize their life stories into a negative tone, which could further enhance their depressive mood. Both clinical psychotherapists and laboratory neuropsychologists develop their approach to address the above issues. Inspired by these approaches, we have developed a few guidelines for designing memory technologies, which aims to address the identified memory impairments in depression. We plan to design and develop a digital memory system, through wearable technologies, to help users living with depression to actively engage in planning and enjoying happy events in their life, and capture the moment as cues to enhance positive memory recalling to against depression.

Why have I been invited?
We are approaching you because you – are an expert therapist working with people living with depression. Your participation will help us explore the potential of this digitised intervention.

What will I be asked to do if I take part?
If you decided to take part, this would involve the following:
We would like to conduct focus group meeting, where we will show you the pre-generated hypothetical design scenarios of our to-be-designed mobile app, showing how could this system help them in the following scenarios: planning

positive events, prompting to engage in planned positive events, capturing positive moments when it is happening, and reviewing the captured records.
We would ask you to reflect on each of the scenarios, base on your own experience of working with patients with depression and help us to refine our design scenarios and make sure they are more close to depressed users' real life.

What are the possible benefits from taking part?
Taking part in this study will allow you to share your experience of working with your clients with depression. It will allow you to share your insights about how memory-related difficulties may bring challenges in their daily life, and how to design a mobile system to help them address these problems.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary, and you are free to withdraw at any time, without giving any reason

What if I change my mind?
As explained above, you are free to withdraw at any time, and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study

What are the possible disadvantages and risks of taking part?
No

Will my data be identifiable?
I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

We would kindly ask you, as participants in the focus group, to not disclose information outside of the focus group and with anyone not involved in the focus group without the relevant person's express permission.

How will my data be stored?
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.

I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the data you have shared with only in the following ways:
I will use it for academic purposes only. This will include my PhD thesis and other publications, like conference papers and journal papers. I may also present the results of my study at academic conferences

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes, so that although I will use your exact words, you cannot be identified in our publications.

This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network. AffecTech is funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?

This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: **c.qu3@lancaster.ac.uk**, or my supervisor: Prof. Corina Sas, email address: **c.sas@lancaster.ac.uk**.

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: a.friday@lancaster.ac.uk

Sources of support
If you feel any discomfort in this study, you could access to the mental health service provided by the psychology department of [Jaume I University or IRCCS Istituto Auxologico Italiano (Italy)] fo help.

Thank you for considering your participation in this project.

Lancaster University

Lancaster University

Computing and communications

Participant information sheet—workshop (clinical psychologists)

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about – Digitalized Memory Trainer for depression-intervention for addressing memory impairments in depression with personalized data.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?
Previously research has demonstrated that when a depressed individual tries to recall their memories, they would normally find it hard to recall specific events and the details of those events happened in their life. They also have a strong tendency to overgeneralize their life stories into a negative tone, which could further enhance their depressive mood. Both clinical psychotherapists and laboratory neuropsychologists develop their approach to address the above issues. Inspired by these approaches, we have developed a few guidelines for designing memory technologies, which aims to address the identified memory impairments in depression. We plan to design and develop a digital memory system, through wearable technologies, to help users living with depression to actively engage in planning and enjoying happy events in their life, and capture the moment as cues to enhance positive memory recalling to against depression.

Why have I been invited?
We are approaching you because you – are an expert therapist working with people living with depression. Your participation will help us explore the potential of this digitised intervention.

What will I be asked to do if I take part?
If you decided to take part, this would involve the following:
You will participate in a co-participatory design workshop, where we plan to present our refined design scenarios to you and encourage you to discuss each of the scenarios for 15 minutes, for exploring the possible technical solutions to mitigate

the problems in such scenarios. We will then ask you to join 20-minute sketching with the designer (me) to visualise the design idea.
After we run through all of the design scenarios, we will encourage you to act as service users and use their design prototype in each of the design scenarios. This step is to identify potential problems brings by the technology, and thus advance their design for addressing these problems.

What are the possible benefits from taking part?
Taking part in this study will allow you to share your experience of working with your clients with depression. It will allow you to share your insights about how to design a mobile system to help them address these problems.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary, and you are free to withdraw at any time, without giving any reason

What if I change my mind?
As explained above, you are free to withdraw at any time, and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study.

What are the possible disadvantages and risks of taking part?
No

Will my data be identifiable?
I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

We would kindly ask you, as participants in the workshop, to not disclose information outside of the focus group and with anyone not involved in the workshop without the relevant person's express permission.

How will my data be stored?
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.

I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the data you have shared with only in the following ways:
I will use it for academic purposes only. This will include *my PhD thesis and other publications, like conference papers and journal papers.* I may also present the results of my study at academic conferences

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes, so that although I will use your exact words, you cannot be identified in our publications.

If anything you tell me in the episodic memory record, like pictures or diary suggests that you or somebody else might be at risk of harm, I will be obliged to share this information with *my supervisor: Professor Corina Sas, as she is also involved in this study.* If possible I will inform you of this breach of confidentiality.

This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?
This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: **c.qu3@lancaster.ac.uk, or my supervisor**: Prof. Corina Sas, email address: **c.sas@lancaster.ac.uk.**

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: a.friday@lancaster.ac.uk

Sources of support
If you feel any discomfort in this study, you could access to the mental health service provided by the psychology department of of [Jaume I University, IRCCS Istituto Auxologico Italiano (Italy), or Mindsmatter] fo help.

Lancaster University

Thank you for considering your participation in this project.

Participant information sheet—workshop (Interaction designers)

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about – Digitalized Memory Trainer for depression-intervention for addressing memory impairments in depression with personalized data.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?
Previously research has demonstrated that when a depressed individual tries to recall their memories, they would normally find it hard to recall specific events and the details of those events happened in their life. They also have a strong tendency to overgeneralize their life stories into a negative tone, which could further enhance their depressive mood. Both clinical psychotherapists and laboratory neuropsychologists develop their approach to address the above issues. Inspired by these approaches, we have developed a few guidelines for designing memory technologies, which aims to address the identified memory impairments in depression. We plan to design and develop a digital memory system, through wearable technologies, to help users living with depression to actively engage in planning and enjoying happy events in their life, and capture the moment as cues to enhance positive memory recalling to against depression.

Why have I been invited?
We are approaching you because as a interaction designer, you have experience of designing digital products for helping users. Your participation will help us explore the potential of this digitised intervention.

What will I be asked to do if I take part?
If you decided to take part, this would involve the following:
You will participate in a co-participatory design workshop, where we plan to present our refined design scenarios to you and encourage you to discuss each of the scenarios for 15 minutes, for exploring the possible technical solutions to mitigate the problems in such scenarios. We will then ask you to join 20-minute sketching with the me and other designers to visualise the design idea.
After we run through all of the design scenarios, we will encourage you to act as service users and use their design prototype in each of the design scenarios. This step is to identify potential problems brings by the technology, and thus advance their design for addressing these problems.

What are the possible benefits from taking part?

Taking part in this study will allow you to share your experience of working with your clients with depression. It will allow you to share your insights about how to design a mobile system to help them address these problems.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary, and you are free to withdraw at any time, without giving any reason

What if I change my mind?
As explained above, you are free to withdraw at any time, and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study.

What are the possible disadvantages and risks of taking part?
No

Will my data be identifiable?
I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

We would kindly ask you, as participants in the workshop, to not disclose information outside of the focus group and with anyone not involved in the workshop without the relevant person's express permission.

How will my data be stored?
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.

I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the data you have shared with only in the following ways:

I will use it for academic purposes only. This will include *my PhD thesis and other publications, like conference papers and journal papers.* I may also present the results of my study at academic conferences

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes, so that although I will use your exact words, you cannot be identified in our publications.

If anything you tell me in the episodic memory record, like pictures or diary suggests that you or somebody else might be at risk of harm, I will be obliged to share this information with *my supervisor: Professor Corina Sas, as she is also involved in this study.* If possible I will inform you of this breach of confidentiality.

This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?

This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?

If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: **c.qu3@lancaster.ac.uk, or my supervisor**: Prof. Corina Sas, email address: **c.sas@lancaster.ac.uk.**

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: a.friday@lancaster.ac.uk

Sources of support

If you feel any discomfort in this study, you could access to the mental health service provided by your university for help.
[Insert information of each University here. E.g.,
The student counselling information for participants from Lancaster University: http://www.lancaster.ac.uk/student-based-services/wellbeing-counselling-and-mental-health/contact/.
The student counselling information for participants from Trinity College Dublin: https://www.tcd.ie/Student_Counselling/.]
Or you could contact your GP and ask for referral to external services, or self-referral to Mind Matters at [insert local healthcare information here. For instance, the information for participants from Lancaster is: https://www.lancashirecare.nhs.uk/Mindsmatter.]

Thank you for considering your participation in this project.

13/12/2016

Lancaster University

Lancaster University

Computing and communications

Participant information sheet –workshop (LU students)

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about – *Digitalized Memory Trainer for depression-intervention for addressing memory impairments in depression with personalized data.*

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?

Previously research has demonstrated that when a depressed individual tries to recall their memories, they would normally find it hard to recall specific events and the details of those events happened in their life. They also have a strong tendency to overgeneralize their life stories into a negative tone, which could further enhance their depressive mood. Both clinical psychotherapists and laboratory neuropsychologists develop their approach to address the above issues. Inspired by these approaches, we have developed a few guidelines for designing memory technologies, which aims to address the identified memory impairments in depression. We plan to design and develop a digital memory system, through wearable technologies, to help users living with depression to actively engage in planning and enjoying happy events in their life, and capture the moment as cues to enhance positive memory recalling to against depression.

Why have I been invited?

I am approaching you with the hope that you may like to collaborate in the design of this novel digitalized MEST intervention. Your participation will help us explore the potential of this digitized intervention, from the feedback we could collect from you, we could go further and address these challenges of depression faced by many other people. I would be very grateful if you would agree to take part in this study.

What will I be asked to do if I take part?

If you decided to take part, this would involve the following:

1. You will give us permission for viewing your personal photos: including photos provided by you (before the workshop, you can choose to select and provide photos you would like to share with us. You do not have to provide any pictures if you do not want to). We will also view public photos you shared on your Social Networking Software, i.e. Facebook, and pick pictures we think represents your special life event. No pictures without your permission will be used in this study.
2. You will give us permission for editing some of your personal photos (including covering recognizable faces showing on the pictures, adding filters…etc.)
3. You will agree to write down a 1-2 sentence long description for some of the photos we pick to present in the workshop.
4. You agree to attend our workshop, in which we will provide you with a series of your personal photos with certain modification, or keywords extracted from the descriptions you have written. And you will be asked to recall details being covered in the picture. You will also be asked to recall the detail of this event.
5. The photos we picked (from the channels mentioned above) may be related to your emotional personal event and may trigger some emotional arousal (e.g. sad, angry, happy, excited…etc.), you agree that we are allowed to trigger these potential emotions from you.
6. You agree to finish a post-questionnaire with questions regarding to this workshop and the way we edit photos for memory retrieval purposes.

What are the possible benefits from taking part?

During the workshop, we provide another way that you could look back and explore your personal emotional memories. While you are looking back at your personal event from the modified photos, you will also have a chance to practise your skill of specific memories recalling. As demonstrated in previous researches, improving specific memory recalling ability would lead to significant improvement of depressive symptoms.

We would expect to collect your opinions and suggestions in photo modification and use them as the design guideline in later prototype designing and developing. You will have a chance to contribute to our study and help people who are suffering from depressive disorder.

Do I have to take part?

No. It's completely up to you to decide whether or not you take part. Your participation is voluntary and you are free to withdraw at any time, without giving any reason

What if I change my mind?

As explained above, you are free to withdraw at any time and if you want to withdraw, I will extract any data you contributed to the study and destroy it. Data means the information, views, ideas, etc. that you and other participants will have shared with me. However, it is difficult and often impossible to take out data from one specific participant when this has already been anonymised or pooled together

with other people's data. Therefore, you can only withdraw up to 6 weeks after taking part in the study

What are the possible disadvantages and risks of taking part?
This workshop will have access to your personal data, mainly photos that you either shared with us or on public social networking sites (e.g. Facebook). We would also probably use some other personal data that your shared with either us, for example, comments about your photos, while designing your personal material in the workshop. The data could also be the posts you shared with the general public, such as your SNS timeline. However, we promise to never spread your information to any other parties. Your personal photos and records will be neither sent to any other device or be viewed by anybody without permission from you.

Will my data be identifiable?
After the observation, only I, the researcher conducting this study will have access to the data you share with me, and my supervisor, Prof Corina Sas.
I will keep all personal information about you confidential, that is I will not share it with others. I will anonymise any audio recordings and hard copies of any data. This means that I remove any personal information.

How will my data be stored?
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers.

I will store hard copies of any data securely in locked cabinets in my office.

I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic).

In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the data you have shared with only in the following ways:
I will use it for academic purposes only. This will include *my PhD thesis and other publications, like conference papers and journal papers.* I may also present the results of my study at academic conferences

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. When doing so, I will only use anonymised quotes , so that although I will use your exact words, you cannot be identified in our publications.

If anything you tell me in the episodic memory record, like pictures or diary suggests that you or somebody else might be at risk of harm, I will be obliged to

share this information with *my supervisor: Professor Corina Sas, as she is also involved in this study.* If possible I will inform you of this breach of confidentiality.

This study is funded by AffecTech, a Marie Sklodowska-Curie Innovative Training Network funded by European Commission H2020. The funder expects me to make my data available for future research and use by other researchers. We will only share anonymised data in this way and will exclude all personal data from archiving.

Who has reviewed the project?
This study has been reviewed and approved by the Faculty of Science and Technology Research Ethics Committee.

What if I have a question or concern?
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Chengcheng Qu, email address: c.qu3@lancaster.ac.uk, or my supervisor: Prof. Corina Sas, email address: c.sas@lancaster.ac.uk.
If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the head of Department, Professor Adrian Friday, with email address: a.friday@lancaster.ac.uk

Sources of support
If you feel any discomfort in this study, you could access to the mental health service provided by Lancaster University for help. The address: http://www.lancaster.ac.uk/student-based-services/wellbeing-counselling-and-mental-health/contact/.
Or you could contact your GP and ask for referral to external services, or self-referral to Mind Matters at https://www.lancashirecare.nhs.uk/Mindsmatter.

Thank you for considering your participation in this project.

Confidentiality Agreement for the Transcription of Qualitative Data

Name of Study:	Digitalized Memory Trainer for depression- intervention for addressing memory impairments in depression with personalised data
Study PI:	Professor Corina Sas

In accordance with the Research Ethics Committee at Lancaster University (UREC), all participants in the above-named study are anonymised. Therefore any personal information or any of the data generated or secured through transcription will not be disclosed to any third party.

By signing this document, you are agreeing:

- not to pass on, divulge or discuss the contents of the audio material provided to you for transcription to any third parties
- to ensure that material provided for transcription is held securely and can only be accessed via password on your local PC
- to return transcribed material to the research team when completed by the agreed deadline and do so in password protected files
- to destroy any audio and electronic files held by you and relevant to the above study immediately after transcripts have been provided to the research team, or to return said audio files.
- to assist the University where a research participant has invoked one of their rights under data protection legislation
- to report any loss, unscheduled deletion, or unauthorised disclosure of the audio material to any third parties, to the University immediately
- only act on the written instructions of the University/researcher
- to, upon reasonable request, allow the researcher, or other University representative, to inspect the location and devices where the audio material is stored to ensure compliance with this agreement
- to inform the University's Data Protection Officer if you believe you believe you have been asked to do something with the audio material which contravenes applicable data protection legislation
- to not employ any other person to carry out the work on your behalf.

Your name (block capitals) _____

Address at which transcription will take place

_____

_____

Your signature _____

13/12/2016

Lancaster University

Date _____

Lancaster University

Recruitment poster:

13/12/2016

Appendix 1
Recruitment email therapists:
Hi all,

We are researchers at Lancaster University, running a co-design study with psychologists for generating design ideas of mobile systems to encourage users living with depression to plan and engage in potentially pleasant activities.

We are writing to invite you to join our study, which includes a focus group meeting and a co-design workshop. The proposed date is [insert date here].
If you are interested in attending, please email me directly so we can have an idea of numbers.
We are looking forward to talking to you.

Best,
Chengcheng

Appendix 2
Recruitment email (HCI designers in Lancaster University):

Hi all,

We are researchers at Lancaster University, running a workshop study for generating design ideas of mobile systems to encourage users living with depression to plan and engage in potentially pleasant activities.

We are writing to invite you to join the co-design workshop. You do not need to be an expert in depression to take apart, as your skillset in HCI design is sufficient. We will prepare a £20 amazon voucher for appreciating your time and participation.

If you are interested in attending, or know others who might be interested, please sign up by clicking the following link and enter your name and preferred date, so we can have an idea of numbers.

We are looking forward to talking to you.

Best,
Chengcheng

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