Enhancing App Content and Cognitive Bias Modification Techniques to Support Students Dealing with Stress for an Experience Sampling App

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Abstract

Objective: Effective digital mental health applications are becoming more and more necessary as stress and mental health problems among students become more common. Such devices can provide easily available solutions and support to aid with dealing with stress. This study aims to identify suitable Cognitive Bias Modification (CBM) techniques for use in an Experience Sampling (ES) app specifically designed for students dealing with stress. Additionally, it seeks to evaluate how these techniques should be designed to maximize user engagement.

Methods: Participants were recruited for the study through personal contacts using a convenience sample strategy. A usability test and semi-structured interviews were techniques used to collect the data. interpretation bias-, attention bias, and memory bias modification were the three main CBM approaches that were highlighted.

Results: Overall, the second prototype improved significantly from the first one. Upon incorporating user feedback, the majority of participants felt the app to be user-friendly, with concise and appealing content. The Optimistic Reinterpretation and Shift Your Focus techniques were preferred by most of the participants, with three out of five favouring these methods. The Recollecting Positive Memories technique was less favoured due to its brevity. Moreover, participants enjoyed the interactive features like the praise notification, making the users experience encouraging and highly motivating. Lastly, participants suggested that the app could be improved with adding more techniques for variety, customizable features, and regular content updates to maintain engagement.

Conclusion: This study shows that integrating CBM techniques into an app helps reducing students stress levels. The improved second prototype emphasizes clear instructions and interactive features to enhance user engagement. However, limitations include a homogeneous sample and capturing feedback at a single point in time. Further refinements are needed to effectively introduce the app and advance mental health support.

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Introduction

There has been a noticeable rise in the prevalence of mental health concerns among undergraduate students, as demonstrated by studies that document elevated rates of depression, anxiety, and excessive stress (Meeks et al., 2021; Storrie et al., 2010; Galderisi et al., 2015; Dopmeijer et al., 2021). A substantial majority of university students express increased levels of psychological distress (Stallman & Hurst, 2016). Research has established significant correlations between stress and negative mental and physical health consequences, highlighting the importance of tackling stress-related issues among university students (Peer et al., 2015; Jensen et al., 2023). Regardless of the presence of campus resources designed to promote the mental health of students, a considerable number of individuals fail to seek assistance for psychological issues. Barriers to accessing mental health care encompass time constraints, a long waiting list, scepticism regarding the necessity or immediacy of therapy, and apprehension regarding personal stigma, which is further intensified by challenges such as symptom identification and the acceptance of stress as normal in university settings (Choudhury et al., 2023; Meeks et al., 2021).

These barriers that hinder accessing mental health services for students highlight the necessity for proactive and personalized interventions, including easily accessible and innovative solutions that students can use independently without needing to visit a healthcare professional. To address these challenges, mental health apps present an innovative strategy for reaching and assisting with mental health issues (Visser et al., 2019). Mobile apps offer enhanced accessibility, convenience, cost-effectiveness, reduced social stigma, and personalization options compared to traditional services (Wong et al., 2021; Bakker et al., 2016). By creating a mental health app that is focused on addressing specific stressors, the overall well-being of individuals can be significantly improved (Visser et al., 2019).

Higher stress levels experienced by students throughout their college years might have adverse consequences on their well-being and academic performance (Stallman & Hurst, 2016). These raised stress levels can increase negative cognitive biases, that are strongly linked with maladaptive cognitive processes (Woud & Becker, 2014). In turn, these processes trigger maladaptive emotional and behavioural reactions which create an interplay between thoughts, feelings, and actions leading

vulnerable individuals into a 'psychopathological downward spiral' and potentially resulting in symptoms associated with anxiety or depression (Woud & Becker, 2014). Cognitive bias modification (CBM) has been identified as a promising strategy for targeting implicit cognitive processes that play a role in both the development and persistence of psychopathology (Jones & Sharpe, 2017). This technique relates to procedures that seek to directly modify automatic cognitive processes, including attention, interpretation, and memory, which are hypothesised to play a role in the development and persistence of mental health issues (Jones & Sharpe, 2017; MacLeod & Mathews, 2012). By addressing these biases, CBM could be an effective approach to reducing the negative cognitive patterns associated with stress.

According to the results of cognitive-experimental studies, mental health conditions can be addressed through modifications targeting three distinct biases: attention bias modification (ABM), cognitive bias modification for interpretation (CBM-I), and memory bias modification (Woud & Becker, 2014; Koster & Hoorelbeke, 2015). In the context of ABM, individuals undergo training to selectively focus on neutral or positive stimuli while actively avoiding negative or threatening stimuli (Jones & Sharpe, 2017). The dot-probe paradigm is routinely used to alter biases which modifies the contingencies between the target and the probe by replacing threatening stimuli with the probe more frequently during the training (Koster & Hoorelbeke, 2015).

In contrast, CBM-I enables participants to engage in a task that aims to resolve ambiguity by determining whether a sentence, paragraph, or picture is biased positively or negatively (Jones & Sharpe, 2017). The Ambiguous Scenarios (AS) paradigm is the most employed training approach for CBM-I and is used to educate individuals in interpreting emotionally ambiguous information coherently and redirect naturally negative interpretations toward more neutral or positive alternatives (Jones & Sharpe, 2017; Lee et al., 2015). CBM-I research suggests that addressing interpretive bias can improve emotional resilience in stressful situations and reduce anticipatory anxiety about the future (White et al., 2016).

Moreover, memory bias modification techniques offer a promising approach for enhancing memory specificity and reducing over-general autobiographical memory styles, which are commonly linked to disorders such as depression. According to Bovy et al. (2022), individuals with depression

tend to recollect general autobiographical experiences more frequently than specific ones and perceive past and future autobiographical occurrences as predominantly negative rather than positive. Hence, to promote persistent positive memory recall and counteract the negative memory bias, participants are asked to retrieve, assess, and describe recent positive events (Bovy et al. 2022).

While these CBM techniques show promise in combating negative thought patterns, they are rarely used outside laboratory settings. This traditional approach might be inconvenient for students because it requires several sessions, time, and financial resources (Visser et al., 2019). Even though CBM has the potential to be used as a flexible self-administered e-health treatment and tool for preventing recurrence, the main challenge lies in translating it into everyday life (Visser et al., 2019). To address these difficulties, experience sampling methodology (ESM), a structured diary technique known for its effectiveness in the mental health domain, can aid in overcoming this hurdle (Bovy et al., 2022).

Before discussing the benefits of ESM, it should be noted that this method will not be used in the current phase of the study. The focus is on establishing the app's functionality and user-friendliness in a controlled environment first. This foundational step is crucial for refining CBM techniques based on initial feedback. Implementing ESM in future research will build upon this groundwork and enhance the app's effectiveness and practical application in real-world scenarios.

Despite the limited research on integrating the Experience Sampling Method (ESM) with cognitive bias modification (CBM) in an app, studies have shown promising results. The pilot study by Visser et al. (2019) and the follow-up study by Bovy et al. (2022) demonstrated that using a smartphone app for CBM training in natural environments increases the likelihood of real-world application which resulted in a general rise of positivity in memory bias. This approach offers benefits like enhanced ecological validity, continuous monitoring, and seamless integration into daily activities, making it suitable for students to identify cognitive biases and monitor stress (Bovy et al., 2022). Even with these positive outcomes, both studies highlighted the need for better adherence and app design for improved integration into daily life (Visser et al., 2019; Bovy et al., 2022). To bridge this gap, implementing multiple CBM techniques simultaneously, rather than focusing on one technique (MBM), could enhance adherence and overall impact (Bovy et al., 2022). The variety of

techniques can make interventions more engaging and adaptable to individual needs. Additionally, by improving the app's content design to maximize user engagement, this research seeks to build upon the findings of Visser et al. (2019) and Bovy et al. (2022).

Accordingly, the quality of the content is an essential factor in users' adoption and usage of mobile health apps (Wang & Qi, 2021). Assessing the quality of app content entails evaluating multiple facets. Firstly, it involves evaluating if it is well-written and directly significant to the app's objective or subject matter (Stoyanov et al., 2015). Secondly, the quality can be assessed by accuracy which refers to the correctness and reliability of the information provided by the app (Wang & Qi, 2021). Moreover, relevance is another important aspect that refers to how well the app's content aligns with and addresses the specific health needs or concerns of its users (Wang & Qi, 2021). Furthermore, apps that provide rich information and explanations about mental health problems and methods of addressing them are vital for the user to understand the information clearly and interact with the app (Alqahtani et al., 2019). In addition, the health-related information presented in the app corresponds to contemporary guidelines and is grounded in empirical evidence which ensures that the strategies follow accepted principles of behaviour modification (Bardus et al., 2016). Therefore, users are more invested in well-designed apps that let them engage with them and lead to regular app usage (Bardus et al., 2016). The thorough evaluation of these components helps determine the overall quality and effectiveness of the application's content in achieving its intended objectives.

While cognitive bias modification (CBM) techniques hold promise for supporting students' well-being, particularly when integrated with mobile mental health apps, research remains lacking on suitable CBM techniques for students dealing with stress and how the content design of these apps can maximize user engagement. To bridge this gap, this study seeks to explore the following research question: **"***Which cognitive bias modification (CBM) techniques are suitable to use in an experience sampling (ES) app for students dealing with stress and how should these techniques be designed to maximize user engagement?"*

Methods

Design

A qualitative design was used to thoroughly investigate users' experiences, views, and preferences in the development of the Cognitive Bias Modification (CBM) app. Using a smaller sample size in the early stages of developing the CBM app allows for rapid iterative improvements which ensures that design choices align effectively with the important criteria of the final CBM application. Thus, an iterative approach was used to improve the content aspects of the app. Lastly, the study was approved by the BMS ethical committee / Domain Humanities & Social Sciences and received approval number 240330.

Participants

The study included a sample of five students from the University of Twente who were residents of the Netherlands. These participants were recruited through convenience sampling via the researcher's personal contacts and reported that they are experiencing stress related to their academic studies or other life circumstances at least once a month. Participants were included when they were between the age range of 18 and 30 years of age. Participants needed to have an adequate level of technological proficiency and familiarity with smartphone apps and use their smartphones daily.

The study excluded persons who were below the age of 18 or above the age of 30, as well as individuals who lacked competency in either German or English. Participants were excluded when they did not give consent. Furthermore, those who have been diagnosed with serious mental health conditions were unable to participate in the research. This exclusion is necessary because individuals with severe mental health conditions may be more vulnerable to distress or exacerbation of symptoms when participating in certain research activities.

The study had a sample of five female participants, ranging in age from 20 to 25 years, with a mean age of 22.4 (SD=1.85). A significant proportion of the participants possessed German nationality (N = 80%) and thereafter the Dutch nationality (N = 20%). All participants were currently enrolled in the Psychology Bachelor's program at the University of Twente in the Netherlands. Every participant was provided with information regarding the process and the utilisation of their data. Furthermore, they freely volunteered and provided informed consent before being interviewed and doing the usability testing.

Materials

Consent Form PSS-4 Scale

The study incorporated several tools, such as the perceived stress test scale (PSS-4), the interview schedule, the CBM app prototype, and recording equipment for conducting interviews.

Prior to participation, participants were given a written consent form that outlined the study's objectives, methodologies, and rights. They were obligated to sign this document (Appendix A). Furthermore, participants were administered the Perceived Stress Scale 4 (PSS-4) to evaluate their stress levels (Appendix D). The PSS-4 is a validated scale developed by Cohen et al. (1983) that consists of four items designed to measure the perception of stress. The items in the PSS-4 ask participants about their feelings of control, confidence, positivity, and overwhelm in the last month. Participants respond to each item using a 5-point Likert scale, where the responses range from: Never, Almost Never, Sometimes, Fairly Often, and Very Often. Hence, PSS-4 scores, which range from 0 to 16 (with higher scores indicating higher perceived stress), are interpreted as follows: 0-7 indicates low stress, 8-11 indicates moderate stress, and 12-16 indicates high stress.

Interviews and Usability Tests

Moreover, the interview covered topics on relevance, clarity, coverage, effectiveness, integration, user engagement, comprehensiveness, and suggestions for improvement of the app's cognitive bias modification techniques for promoting positive thinking (Appendix B; Appendix C). To adequately address the necessary topics of the content, detailed questions were developed to ensure comprehensive data collection.

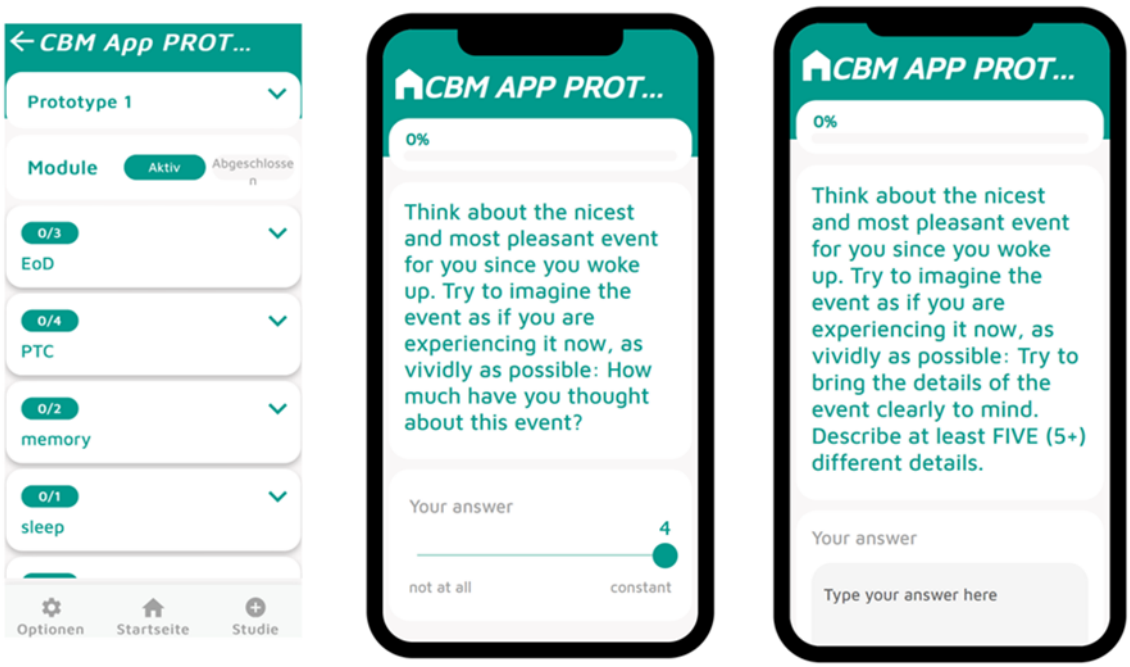
To carry out the usability test, participants needed to have access to a smartphone to engage with the Twente Intervention and Interaction Machine (TIIM) application, allowing researchers to visually observe any pauses or interactions with specific questions during the study. It is a software platform developed by the BMS Lab at the University of Twente that enables researchers to create and manage interventions through a mobile application (Infohub | Twente Intervention and Interaction Machine (TIIM) | BMS Lab, n.d). In addition, a laptop was utilized to take notes and provide assistance during the interview process. During interviews recordings were made using Apple devices, specifically an iPhone and an iPad to accurately capture participant responses.

Process of Creating First Prototype

The first prototype was originally based on the questions of Bovy et al. (2022) and entailed five modules: Mood, Sleep, Memory Bias, Positive Training, and End of Day. To fully address the researchers' research questions for the current study, two additional CBM techniques were implemented which were named Attention Bias Redirection (ABM) and Interpretation Bias Reappraisal (CBM-I). Before adding these two modification techniques, we included two assessment modules of Attention Bias and Interpretation Bias that were designed to serve as prompts equivalent to the Memory Bias measure (Bovy et al., 2022) and ensured consistency in the study's methodology. In total four new modules were added: Attention Bias, Attention Bias Redirection, Interpretation Bias, and Interpretation Bias Reappraisal. Therefore, the first app prototype entailed nine modules with several questions (Figure 1). The second prototype was created based on the feedback and suggestions on the first prototype which will be described in more detail in the results section.

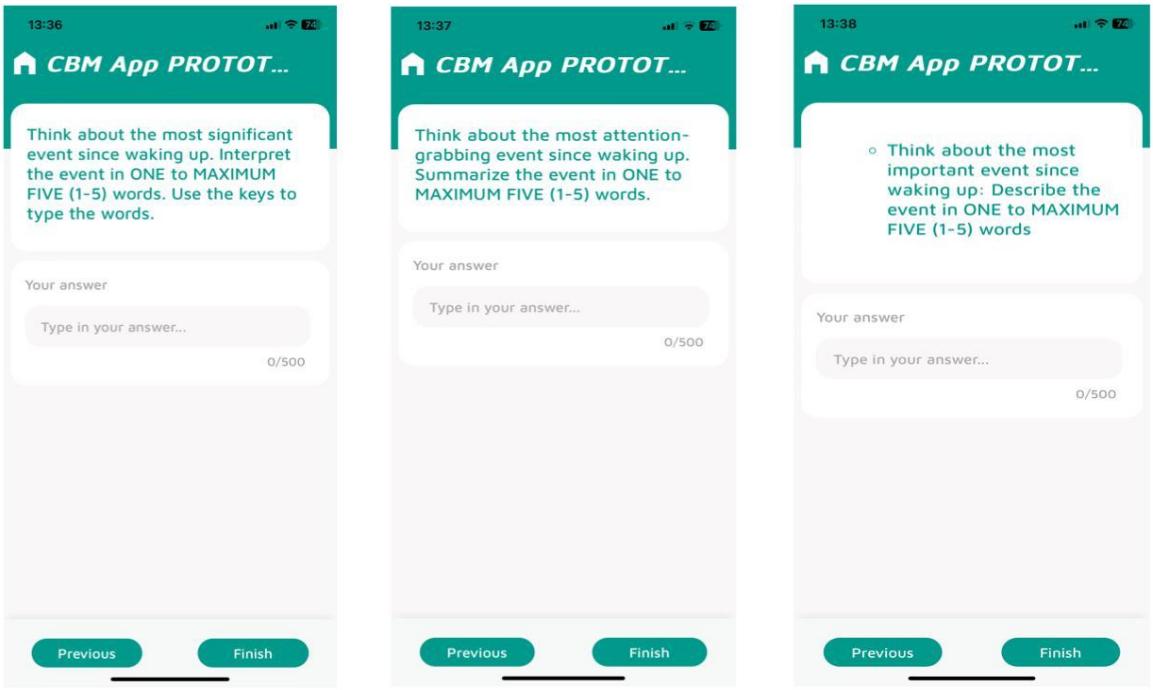
Figure 1

Homescreen, Likert Scale Task, and Open Question Task of the First Prototype



Note. This figure illustrates the various modules used in the first Prototype including Mood, Sleep, Memory Bias, Positive Training (PTC), End of Day (EoD), Attention Bias (AB), Attention Bias Redirection, Interpretation Bias (CBI), and Interpretation Bias Reappraisal. Also, participants were asked to respond to both the Likert scale- and open-question tasks.

Figure 2



Note. This figure illustrates the three assessments that served as prompts for CBM-I, ABM, and MBM.

Procedure

Participants were invited to partake in two interview rounds. Before beginning the first phase, participants were given detailed information about the study and its objectives and then asked to provide informed consent. Afterward, participants provided demographic information and completed the PSS-4 questionnaire. Following this, participants conducted a usability test with the current version of the CBM app based on the prototype of Bovy et al. (2022). During this usability test, participants were required to complete modification techniques related to the interpretation bias modification questionnaire, the attention bias modification questionnaire, and the memory bias modification questionnaire. While participants interacted with the app researchers observed their behaviour and recorded relevant data. Hence, participants were encouraged to articulate and express their thoughts, challenges, and reactions verbally while interacting with the app prototype using the Think-Aloud Method. This approach was used to gather insights into participants' reactions to the app's content, which is essential for refining the usability and content and to better meet user needs and preferences. Subsequently, participants took part in a semi-structured interview session aimed at

gathering qualitative as they provided flexibility, guiding discussions without strict rules, and allowing for focus and exploration (Kallio et al., 2016).

Based on the first usability test and interview feedback, the app's interface and functionality were refined to address usability and content issues and enhance user experience. Data from tests and interviews were analysed separately and then integrated to develop a comprehensive understanding of user experiences. A new CBM app prototype was then created, incorporating the suggested improvements. The same participants as for the first usability test were invited to engage in a second usability test, this time with the revised prototype of the app. Like the first test, participants interacted with the app while researchers observed their behaviour and recorded the data. Following the usability test, participants participated in a second interview to gather additional qualitative insights into user perceptions, preferences, and suggestions for further improvement. Notably, the second interview schedule asked similar questions as the first one but delved deeper into user experiences, preferences, and perceptions of the app's effectiveness and sustainability. Throughout the usability and content testing sessions, researchers closely observed participants' interactions with the app, noting any difficulties, successes, or patterns in their usage behaviour. Upon completion of the study activities, participants were provided with a debriefing session. Additionally, participants were thanked for their participation and provided with information on how their input would contribute to the development of the CBM app.

Data Analysis

The results from the usability test and interviews were transcribed by the software Turbo Scribe. This software was chosen to gather conventional transcriptions, ensuring that every word spoken during the interview was accurately captured. The qualitative data acquired from both usability tests and interviews were analysed according to thematic analysis. Researchers were interested in uncovering reoccurring ideas, concepts, and experiences about the usability, content, and user engagement of the application. The thorough examination of transcripts was done by the software Atlas.ti. Qualitative data from interviews were analysed to identify common themes, preferences, and areas for improvement, while data from usability tests were analysed to assess user performance metrics. A data-driven inductive approach was used to uncover new insights.

Subsequently, initial codes were assigned to certain portions of the data, and themes were derived by a repetitive process of immersing the data and consistently comparing it. Moreover, the researchers redirected their focus toward identifying overarching patterns within the initial codes. Following the initial coding process, the researchers reviewed the themes to refine the list, merging or removing redundant ones. Next, each theme was carefully named and defined. Finally, the data was recorded to align with the finalized thematic framework.

Results

After finishing the two research phases, the interview responses and observations by the researchers from the usability test were analysed in detail. Also, the researchers found that the interview transcripts aligned closely with the observation findings. Following the presentation of the PSS-4 test results (Table 1), the codes from both phases will be defined, explained, and illustrated with specific examples from participants' quotes.

PSS-4 Test Results

The scores of the five participants can be found in Table 1. Overall, participants exhibited moderate stress levels measured and were taken during two separate usability tests, each corresponding to a different prototype of the app.

Table 1

Results of the PSS-4

Participant	Test 1	Test 2
P1	8	6
P2	9	8
P3	8	6
P4	10	10
P5	8	11
Average	8.6	8.2
SD	0.9	2.3

Note. SD= Standard Deviation.

Coding Scheme After First Research Phase

The following part will present the results obtained from the first prototype of the app. These findings played a crucial role in identifying important areas that needed improvement, which were then implemented in the second prototype. Following the first research phase, a total of eleven codes were identified and further categorized into six code groups. Overall, 149 comments were found and divided into positive, neutral, and negative comments. During the coding process, one code 'Expectations of Techniques' was identified where participants frequently gave neutral responses. This led to the creation of a neutral comment category to accurately reflect these responses. A detailed breakdown of these comments can be found in Table 2 below.

Table 2

Quantity of Codes of the First Prototype

Codes	Positive Comments	Neutral Comments	Negative Comments
Content Clarity and Comprehensiveness			
Clarity and Sufficiency of Explanations	4	0	56
Content Relevance and Applicability			
Ease in Implementing Techniques	0	0	16
Relevance to Positive Thinking	2	0	4
Effectiveness of Positive Thinking Techniques			
Awareness and Potential of CBM Techniques	1	0	6
Impact on Mindset and Thought Patterns	2	0	3
Preferences for Positive Thinking Techniques			
Expectations of Techniques	0	5	0
Range of Techniques Offered	0	0	4
Preferred Techniques	6	0	5
User Engagement and Interaction			
Engagement with Interactive Features	2	0	10
Willingness to Use Regularly	2	0	3
Suggestions for Improvement			
Desired Additions to the App	18	0	0
Total	37	5	107

Content Clarity and Comprehensiveness

Under the code 'Clarity and Sufficiency of Explanations', participants expressed difficulties understanding the shortenings of every module used within the app's content. One participant remarked, "Okay, now I'm just like, what is PTC?". They highlighted that especially the module names must be refined. Moreover, participants felt the app lacked depth and detail in its instructions as one stated, "I think it's confusing to me if I just have to describe my positive or neutral image or if I have to describe how I come from my negative to my positive one." Consequently, unclear instructions interrupted participants from focusing on the techniques as they needed to reread them many times. Also, participants expressed a desire for more comprehensive explanations to facilitate their understanding of the techniques with one stating, "No, like I wish for more depth and detail, just like explaining the aim, how it works, what it is, how it's supposed to work, what effects can I have or consequences, benefits can I get from these techniques." Lastly, they expressed confusion regarding the distinctions between certain types of questions, particularly the differentiation between a "most significant event," an "attention-grabbing event" and an "important event (Figure 2). However, some participants found the mood, sleep, and Likert scale tasks straightforward to answer. In conclusion, participants highlighted the need for clearer module names, more detailed instructions, and better explanations within the app to enhance understanding and ease of use.

Content Relevance and Applicability

The first code, 'Ease in Implementing Techniques' highlights experiences regarding how manageable and straightforward it was to apply the techniques provided by the app during the usability test. Hence, participants struggled to reflect on events that had not occurred yet or were not recent. For instance, one participant mentioned, "Yeah, I was a bit confused sometimes. But also, because I had not done many things today, it was hard for me to describe the actual impactful events in comparison to a fuller day." Moreover, participants voiced frustration with the task format, which often required them to articulate detailed ideas in just a few words.

The second code, 'Relevance to Positive Thinking,' shows differing views on whether the methods are compatible with promoting positivity. Therefore, one participant felt the content was overly negative and suggested a more positive focus: "I think the content that was there, yes, but it

could be more on the positive side because now it felt like more negatively oriented." Another participant noted that although the app's techniques could be relevant and helpful for encouraging positive thinking, they primarily focused on evaluating recent events rather than teaching new concepts or strategies. In conclusion, participants struggled with the techniques task format and expressed a desire for more focus on positivity in the content.

Effectiveness of Positive Thinking Techniques

In the first code of 'Awareness and Potential of CBM Techniques', participants evaluated the extent to which they noticed the integration of cognitive bias modification approaches within the app. Participants expressed uncertainty about noticing the integration due to a lack of explanation regarding CBM and its potential benefits. One participant remarked, "I'm not sure, since it wasn't really explained in the app what cognitive bias modification is or how far it can help me." One participant recognized the integration of CBM due to prior knowledge.

The third code of this code group is 'Impact on Mindset and Thought Patterns'. Participants provided varied feedback regarding the impact of the positive thinking techniques on their mindset. Some expressed that the techniques encouraged them to engage in deeper reflection and consideration or that it helped them focus on positive aspects of their day which led to a perceived benefit. However, others indicated minimal impact stating, "It did not help that much, like maybe a little bit. But no, not that much. Because I already thought about it before," indicating limited effectiveness due to prior introspection. Overall, participants varied in their awareness of cognitive bias modification (CBM) integration and reported mixed impacts on their mindset indicating a need for better explanations regarding CBM and enhancements in the techniques.

Preferences for Positive Thinking Techniques

The first code, 'Expectations of Techniques,' concerns what participants anticipated finding in the app. All participants had no expectations of the techniques. For instance, one participant stated, "I didn't really think about these positive thinking approaches or exercises before, so I also wasn't quite sure what to expect, so therefore I would say I didn't expect something that I didn't find."

The second code, 'Range of Techniques Offered,' addresses the variety and diversity of techniques in the app. Overall, participants found the multitude of questionnaires overwhelming,

making the app feel chaotic and confusing. They also noted that the techniques lacked diversity as one stated, "No, I would not say so, because like there was like only one technique in that sense, which is about like the positive rethinking." Moreover, another mentioned, "I wouldn't describe it as broad because in the end most of them are questions that are just answered with either describing something or the Likert scale." Lastly, one participant specifically mentioned missing techniques, such as meditation.

The third code, 'Preferred Techniques,' highlights the participants' preferences for specific techniques. Notably, some participants preferred two techniques, resulting in the distribution of preferences. Three participants favoured the Interpretation Bias Reappraisal Technique, appreciating its focus on reinterpreting negative events positively with one stating, "Yeah, I think the two things that definitely for sure stand out were first of all reflecting what did I achieve and trying to make something bad into something good. Those were for me the two most efficient ones." Two participants found the Positive Training Condition Task effective, particularly for reflecting on personal achievements and thus getting a more positive feeling. One participant preferred the Redirected Technique, while another did not favour any technique. To conclude, participants' lack of expectations regarding the app's techniques and the need for a broader range of diverse techniques underscores the importance of clearer communication about the content to enhance user engagement and satisfaction. Besides, most participants preferred the Interpretation Bias Reappraisal Technique.

User Engagement and Interaction

The first code in this group is 'Engagement with Interactive Features' refers to how engaging and motivating users found the interactive elements or components within the app. One participant noted, "For me it was not optimal because I had to also put myself in a lot of negativity and first I associated with a lot of negative words, and I think that had more impact on me than the positive reframing afterwards." Also, participants suggested enhancing the design by reducing the number of open questions to improve engagement and motivation. Lastly, some participants point out instances of unnecessary repetition of the content stating, "Yeah, now it's a bit repetitive because it says the same thing as before. It's a bit annoying because I have to read the same thing again." In contrast, another

participant stated that the features were engaging as they allowed them to reflect on their experiences and activities.

The second code within this code group is 'Willingness to Use Regularly'. Overall, participants had mixed feelings about the potential benefits of regular use of the app. While one participant suggested that regular use could make certain techniques more familiar and effective over time, another expressed scepticism about the app's ability to reduce stress: "I don't know if it would help me like reappraising my stress because I do not feel better afterward." To sum up, participants had varied experiences in their engagement with interactive features and expressed mixed feelings about the app's potential benefits with regular use.

Suggestions for Improvement

The code 'Desired Additions to the App,' encompasses participant suggestions for enhancing the app's functionality and content by adding new features to the app. One participant emphasized the importance of incorporating social support features within the app, while another recommended adding links to meditation resources. Also, participants proposed features to enhance user control and personalization, such as changing and switching modules based on preference. Finally, participants suggested that reflection guides would encourage thoughtful responses, with one mentioning, "But then with some tasks, you had to think a little bit more... maybe that could be also noted in the app, that you can take a minute and think about how you would describe something." Overall, participants provided valuable insights into enhancing the app through social support features, meditation links, and improved user control, like personalization.

Process of Creating Second Prototype

Following the initial usability test and subsequent interviews, valuable feedback was collected and analysed. In response, the second prototype was carefully crafted within the TIIM App and several improvements were implemented regarding the content aspects.

Clear and Sufficient Explanations

Firstly, the app was given a more fitting name for a Positive Thinking Technique App, namely ‘RadiantLife’ (Figure 3). Participants desired more clarity, comprehensiveness, and detailed explanations which can be seen under the code ‘Clarity and Sufficiency of Explanations’. Hence,

detailed explanations and descriptions of the techniques were provided before each task to enhance participants' understanding and to clarify the purpose behind each activity. (Figure 3). Also, the use of abbreviations in the app's content created confusion, which necessitated improvement of the module names. Thus, modules were refined and reduced to three, now named "Optimistic Reinterpretation (CBM-I)," "Shift Your Focus (ABM)," and "Recollect Positive Memories (MBM)" (Figure 3).

Improvement of Clear Instructions

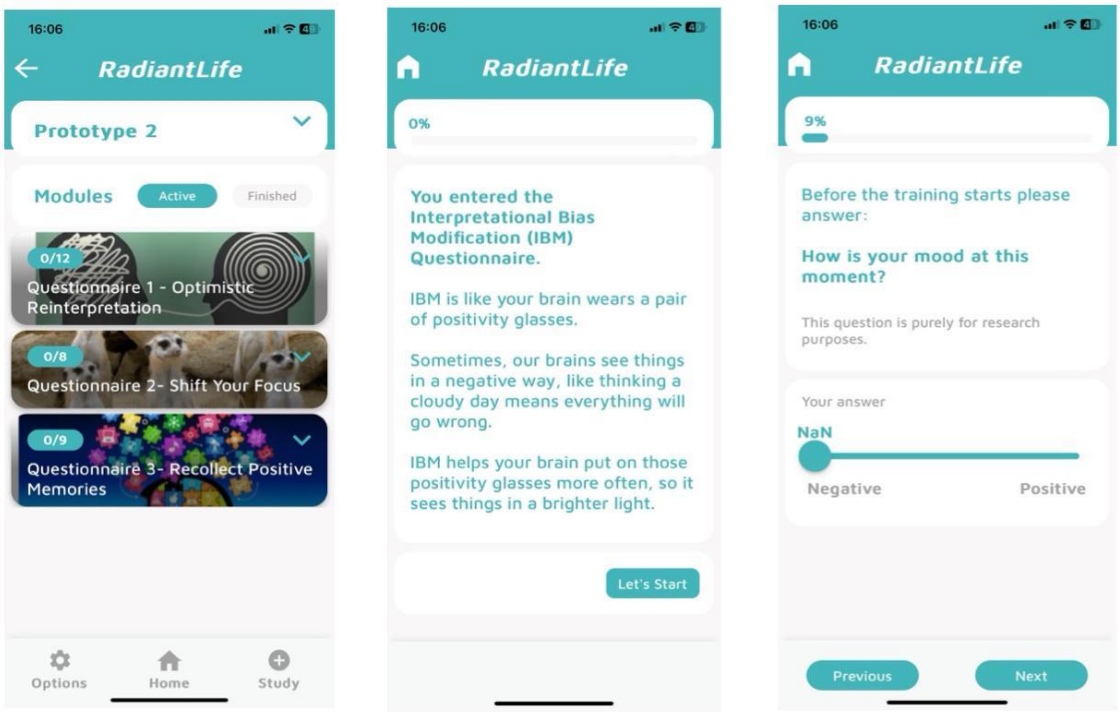
Furthermore, participants highlighted the absence of sufficient instructions and guidance within the app. To address this, clear instructions were provided to offer participants a better understanding of how to implement each technique (Figure 4). Also, participants complained that explaining their ideas in just a few words was challenging and not easy to implement. Therefore, the instructions for the open questions were revised to allow responses in one to two sentences (code: Ease in Implementing technique). Also, participants struggled to reflect on events that had not occurred yet or were not recent. Hence, examples close to reality should make the tasks more relatable and applicable to users (Figure 4).

Enhancing User Engagement and Mood Assessment

Under the code Engagement and Interaction with App, participants complained about the perceived negative content in the app. Hence, praises like ‘Congratulations’ after each accomplished task were integrated to counteract this and promote a more positive experience. Moreover, under the code Desired Additions to the App, one participant's feedback was regarding the absence of meditation techniques in the app. This idea was implemented into the Shift Your Focus Questionnaire (ABM), which aimed to broaden the range of techniques to users and enhance user engagement. Lastly, under the code ‘Impact on Mindset and Thought Patterns’ participants' mood was assessed before and after each task to capture mood changes more accurately.

Figure 3

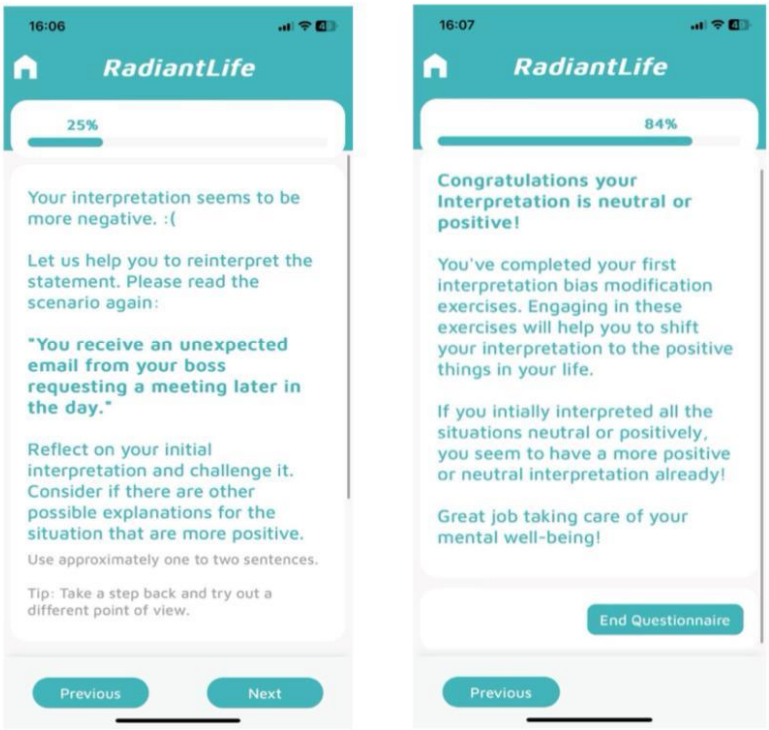
Homescreen of the RadiantLife App, Explanation of Optimistic Reinterpretation Task, Mood Tracker



Note. This figure illustrates the Homescreen featuring the refined module names, including the new name of Prototype 2, 'RadiantLife', alongside improved explanations for the Optimistic Reinterpretation task and the addition of a mood tracker.

Figure 4

Example of Daily Life Situation and Engaging Interaction Features



Note. This figure illustrates a participant's initial negative interpretation along with instructions aimed at modifying negative cognitive biases. Participants subsequently received positive feedback, which served to motivate them and reinforce a positive mindset.

Coding Scheme After Second Research Phase

Following the second research phase, 13 codes were determined and categorized into seven code groups. Overall, 189 quotes were found and divided into positive, and negative comments. A detailed breakdown of these comments can be found in Table 3 below.

Table 3

Quantity of Codes of the Second Prototype

Codes	Positive Comments	Negative Comments
Content Clarity and Comprehensiveness		
Clarity and Sufficiency of Explanations	28	4
Content Relevance and Applicability		
Ease in Implementing Techniques	9	2
Relevance to Positive Thinking	4	0
Effectiveness of Positive Thinking Techniques		
Awareness and Potential of CBM Techniques	5	0
Impact on Mindset and Thought Patterns	23	2
Preferences for Positive Thinking Techniques		
Expectations of Techniques	2	3
Range of Techniques Offered	6	2
Preferred Techniques	16	8
User Engagement and Interaction		
Engagement with Interactive Features	21	9
Willingness to Use Regularly	19	0
Suggestions for Improvement		
Desired Additions to the App	17	0
Recommendation of the App		
Factors Influencing Regular Usage	0	4
Likelihood of Recommendation to Others	4	1

Total	154	35

Content Clarity and Comprehensiveness

In the subcode 'Clarity and Sufficiency of Explanations' participants reported varied experiences with understanding the app's content. Some encountered difficulties, such as one participant who was confused by a particular sentence: "The first technique had a sentence, which I did not understand. It was, 'IBM is like your brain wears a pair of positivity glasses." Another participant expressed confusion about task completion status, stating it's finished at 98% and not at 100%.

However, participants expressed predominantly satisfaction with the improved clarity and sufficiency of the content in the second prototype stating, "I think it was really clear in this prototype and it was explained really well and also in like easy and straightforward terms, but also with enough information given and examples." Additionally, participants appreciated the balance between detail and brevity. Moreover, participants highlighted a clearer understanding of the purpose of each component of the app. One participant stated, "I understood better the purpose of each different part of the app. That I also felt like I actually accomplished something or I could see the purpose of the app." Overall, participants found the second prototype's content much clearer and more sufficient to use, leading to a better understanding of the app's purpose and a more satisfying user experience.

Content Relevance and Applicability

The first, sub-code 'Ease in Implementing Techniques,' reflects that participants generally found the techniques easy to apply. One noted that it was simple to figure out the app’s tasks, while another appreciated the ease of answering. The techniques' adaptability and convenience were highlighted, with a participant stating, "You can do it in the train. You can do it in the library. You can do it everywhere. And therefore, it's very applicable." However, challenges arose in social contexts. One participant mentioned "I had to breathe and stuff like that I could not really do it because I felt ashamed because I cannot do it often. I'm struggling doing things like that when someone is watching."

The second sub-code, 'Relevance to Positive Thinking Techniques,' shows that participants found the app's techniques relevant and clarifying with one stating, "Yeah, I think they were relevant

because it was clarifying, and it used many positive elements and encouraging." Another participant appreciated specific examples, like comparing a cloudy day to a negative mindset, finding it a helpful illustration. To sum up, participants found the techniques both easy to implement and relevant, however, some challenges were noted in applying them in a social context.

Effectiveness of Positive Thinking Techniques

The first sub-code, ‘Awareness and Potential of CBM Techniques,’ shows that participants recognized the potential of these techniques to address negative biases. One participant suggested, "Yes, especially if you use it like on a daily basis and like, maybe like twice a day if you wake up and before you go to sleep, for example."

The second sub-code, ‘Impact on Mindset and Thought Patterns,’ highlights the positive effects on participants' mental states and cognitive processes. Participants reported feeling both mental and physical calmness as well as noticeable reductions in stress levels. One person stated, "I think I felt more of a mental calmness with the positive memories and optimistic reinterpretation. But especially a physical calmness with the shift your focus exercise. But overall, I felt more like less weight on my shoulders and more calm. I think more focus on the positive thoughts." Just one participant mentioned that they felt no difference before and after the tasks and did not recognize any changes in thought patterns. Overall, participants acknowledged the significant potential of CBM techniques to improve mindset and thought patterns, with most experiencing significant mental and physical benefits.

Preferences for Positive Thinking Techniques

The first sub-code, 'Expectations of Techniques' addresses participants' sense of fulfilled or unfulfilled expectations regarding the tasks. Overall, participants were satisfied with the techniques. However, the last task which aimed at recollecting positive memories seemed insufficient. One participant remarked, "I have to say the last thing, I think it's too short. I think there's one question missing or something," or "I just expected something more and nothing came. I was a bit disappointed."

The second sub-code, 'Range of Techniques Offered,' refers to the variety and diversity of techniques within the app. Participants appreciated the simplified prototype design, noting "There

were way fewer questionnaires, so it was more clear what and which belong to which topic and also therefore easier to use." They also valued the brevity of exercises, finding them concise and manageable compared to the previous prototype. However, there were also calls for more variety in techniques, with some participants expressing a desire for additional options as one participant noted, "I think for now it was good, but if I would struggle, then it would be also nice to have more options, not like, that I have to do them, but if I want that there are more options for me to engage."

The third sub-code, 'Preferred Techniques,' highlights participants' varied feedback on their preferred techniques across the three questionnaires. Overall, participants appreciated all three techniques but —Optimistic Reinterpretation and Shifting Focus—obtained the most preference. Notably, some participants chose two techniques, consistently selecting the first two options, resulting in a balanced distribution of preferences.

Out of the five participants, three favoured the Optimistic Reinterpretation exercise, while an equal number preferred the Shift Your Focus technique with one participant stating: "The second one I really liked because I was in my own mind and I was thinking about stuff. And telling myself positive affirmations of you can do it. It will be fine. It will be fun." Interestingly, only one participant expressed a preference for the Recollecting Positive Memories exercise stating, "I preferred most the memory exercise because I thought, again, about a nice event that happened within the last day. And I remembered details that I wasn't that aware of before." Moreover, participants cited several reasons for not preferring the last technique. Some found it less effective, lacking significant change in thought patterns. Others mentioned practical challenges, like difficulty using it on the go. Also, others found this technique too short: "I just expected something a bit more and nothing came. It was a bit disappointing in a way." Overall, participants expressed satisfaction with the range of techniques, and favoured the Optimistic Reinterpretation and Shifting Focus exercises, while suggesting enhancements for the Recollecting Positive Memories technique to better meet their expectations.

User Engagement and Interaction

The first sub-code, 'Engagement and Interactive Features,' reflects participants' positive engagement with the app's interactive features and their concerns about potential fatigue or disengagement. One participant noted, "It gave me sort of feedback so like congratulations, you're now

having a positive view, which was I think motivating to keep on improving and to keep on using the app." Another participant remarked an overall positive vibe stating, "Yes, there was an overall positive vibe from the text. So, I felt motivated to participate."

However, participants also expressed concerns about getting bored or losing interest over time. Participants noted the significance of regularly updating the content to prevent monotony stating: "But if the examples change, if I could change the layout, if I could decide which questionnaire, maybe put two questionnaires more in there, and then I can choose three a day to mix things up because I don't like to be bored."

The second sub-code, 'Willingness to Use Regularly,' reflects participants' willingness to use the app regularly, especially during times of stress. One participant highlighted the immediate and long-term benefits of regular use, stating, "Yes, I would do so because I feel like then I would actively do something about it and in the moment it makes me feel better and maybe then long term as well." Participants anticipated that they would use the app regularly as it could lead to changes in their mindset, and overall well-being and enhance the attention towards biases. In conclusion, participants found the app engaging and beneficial and expressed a willingness to use it regularly, especially if the content is updated to maintain their interest and motivation.

Suggestions for Improvement

In the code 'Desired Addition to the App' participants provided insightful suggestions for improving the app's functionality and user experience. One participant suggested incorporating self-appreciation tasks to focus on personal strengths and qualities, stating, "Maybe something, what could be nice is some self-appreciation tasks, that you are focusing on you, like on yourself, on your strength and like which kind of person you are." Another desired addition was to include a feature for tracking usage frequency, exercises, and their impact on the user's feelings. Additionally, participants suggested enhancing the depth of the 'Recollect Positive Memories Task' and adding an extra question to ensure a more comprehensive experience.

Another user suggested personalized themes and content for instance envisioning the app as a diary with customizable colours and layouts to enhance the user experience. They said that tailoring the experience could make it feel more engaging and motivating. Other suggestions included starting

the app with a session on reinterpreting negative experiences and allowing users to input and rephrase their own negative experiences, thus personalizing the app's content to better meet individual needs. Lastly, some noted that potential app reminders daily could help in becoming more aware of negative thoughts and encouraging regular self-reflection. In summary, these suggestions highlight the importance of personalization, self-appreciation tasks, tracking features, and regular reminders in enhancing user engagement.

Recommendation of App

The first code, 'Factors Influencing Regular Usage,' highlights factors like participants' type of stress or experiences that could influence regular usage with one participant stating, "But of course, it's like some people that have different types of stress and some things are out of their power. It might be not the best to recommend. But if there's a stressful situation, for example, where somebody is sick, and then you're saying, like, okay, let's reinterpret this event might not be suitable." Another emphasized that some CBM techniques require users to draw from their own experiences (such as the Recollect Positive Memories Task), which can become monotonous if they do not encounter many relevant situations over time which can lead to disengagement and decreased motivation.

The second code, 'Likelihood of Recommendation to Others,' shows varying degrees of willingness to approve the app based on perceived benefits and personal experiences. One participant highlighted the potential benefits for individuals experiencing stress, particularly appreciating the mindful exercises: "I would recommend it to others because it could help them to deal with their stress and to change their way of thinking and their mindset about negative stuff." Another participant emphasized its role in mindset shifting and promoting positivity. However, some participants felt the need for additional features or consistent personal use before confidently recommending it as one participant expressed, "I think if it's a bit more options then I would maybe recommend it. But also I feel like I would first need to use it myself regularly to then be able to recommend it." Overall, the app's regular usage can be influenced by factors such as the type of stress and the need for varied content, while recommendations to others depend on perceived benefits, additional features, and personal usage experience.

Comparison of Positive and Negative Comments Across Prototypes

After evaluating the positive, neutral, and negative comments for both prototypes, a table was created to illustrate the percentage change between Prototype 1 and Prototype 2. Table 4 below, shows the counts of positive and negative comments for each prototype, along with the percentage change calculated relative to Prototype 1. Positive comments increased substantially from 37 in Prototype 1 to 154 in Prototype 2, representing a 316.22% increase. Moreover, negative comments decreased notably from 107 in Prototype 1 to 35 in Prototype 2, indicating a -67.29% change.

Table 4

Percentage Change of Prototypes

Comments	Prototype 1	Prototype 2	Percentage Change
Positive	37	154	316.33%
Negative	107	35	-67.29%

Discussion

This study aimed to determine which CBM techniques are suitable for an experience-sampling app for students dealing with stress and how the app's content should be designed to maximize user engagement. By evaluating different CBM techniques and their implementation within the app, this study provides insights into the content aspects and user preferences essential for developing effective mental health interventions.

Preferences of CBM Techniques

Based on the results, all CBM techniques examined were found suitable for inclusion in an experience sampling (ES) app for students dealing with stress. However, interpretation bias modification, and attention bias modification, stood out as the most preferred. These techniques were emphasized for their capacity to promote mental and physical calm, a shift in thought patterns, and a positive mindset which make them particularly helpful for students who are dealing with stress.

In contrast, the Recollect Positive Memories Technique was less favoured. Participants mentioned that this technique seem less effective, stating minimal changes in thought patterns and practical challenges, such as difficulty completing the task while on the go. Additionally, they found the technique too brief.

One reason CBM-I has been chosen as one of the preferred techniques may be because of its use of real-life scenarios in tasks, which helped people picture and connect with them. According to Steinmann et al. (2020), CBM-I works best when people vividly imagine these scenarios. This is done by creating images in your mind in great detail and realism which makes the cognitive exercises more engaging and may eventually lead to more noticeable changes in interpretation biases (Steinman et al., 2020). Thus, due to the real-life scenarios, participants in the current study could probably imagine them more vividly, leading to an effective cognitive bias modification.

Another key factor contributing to the preference for CBM-I and ABM techniques in this study could be the differences in time and cognitive effort required. CBM-I involves modifying negative interpretation biases through brief cognitive exercises, such as reinterpreting ambiguous real-world scenarios more positively or neutrally (Jones & Sharpe, 2017). Similarly, ABM redirects attention away from negative stimuli towards neutral or positive stimuli (Koster & Hoorelbeke, 2015), using e.g. meditation or other focused attention tasks that can be implemented in various settings.

In contrast, MBM techniques focus on recalling positive memories, which might demand more cognitive engagement and time commitment from users. According to Visser et al. (2019), systematic practice in recalling positive events in CBM-Memory can counter ruminative thinking by actively fighting negative thought patterns and reinforcing positive memory schemata. This repeated retrieval of positive information not only facilitates long-term retention but also strengthens associations with positive memories (Visser et al., 2019). This indicates that users must continually recall and reinforce positive memories, which is a repetitive and effortful cognitive process.

Hence, these findings indicate that CBM-I and ABM might be more practical for short-term interventions and can more readily modify attention and interpretation biases. These techniques appear to be effective as they may quickly influence participants through engagement with current events or shifts in focus. On the other hand, while MBM might have significant long-term benefits, it requires systematic practice and cognitive effort, to counter rumination and achieve positive results.

Furthermore, another reason the Recollect Positive Memories Technique was not chosen as one of the preferred ones might be that, according to Koster and Hoorelbeke (2015), this CBM technique showed significant results for participants who particularly deal with depression.

Consequently, it may be less suitable for individuals experiencing stress. There is little evidence to support the claim that modifying memory bias has a beneficial impact on approaching stress levels.

Lastly, participants in the current study expressed a sense of incompleteness and missing elements in the MBM technique. Specifically, participants wished for longer tasks and more comprehensive questions to better facilitate the recall of positive memories. This feedback suggests that the MBM technique might have been less preferred due to these perceived shortcomings, indicating that participants found it less engaging and effective compared to other CBM techniques.

Content Design for CBM Techniques

The second prototype's results demonstrate a significant improvement in the user experience. The designed techniques were appreciated by the participants due to their engagement, ease of implementation, and clarity in explaining the content. Higher satisfaction and a better overall app experience resulted from the second prototype's improved instructions and explanations which successfully addressed the initial complaints. According to Alqahtani et al. (2019), individuals with mental health problems frequently complain about the absence of guidance when using mental health applications, which can cause frustration and decrease focus. Consistent with this, the current study found that providing in-depth explanations and comprehensive information significantly enhanced user satisfaction and engagement. This finding aligns with Alqahtani and Orji's (2020) study, where users of mental health apps also indicated a preference for apps that offer in-depth explanations and comprehensive information about mental health disorders and treatments.

Maximizing User Engagement

Additionally, participants found the interactive features to be encouraging, such as the praise “Congratulations” users got after completing tasks. This is consistent with studies (Alqahtani et al., 2019) that show positive reinforcement is beneficial for users dealing with mental health concerns. These features not only increase user engagement but also help in concentration and frustration reduction.

Moreover, based on participant's feedback the app could still be improved by offering personalization in the content. Personalization provides customized content, features, and services to match users' needs and preferences. According to the findings, users expressed a want for

customization choices since they would personalize and motivate their use of the application. Accordingly, personalizing elements such as assessment questions within an application can enhance its overall effectiveness and usability (Alqahtani et al., 2019).

Similarly, participants emphasized the significance of regular change in the content over time to avoid boredom and fatigue; for example, switching and incorporating fresh techniques. Similar findings were found in research by Alqahtani & Orji (2020), which found that providing unlimited usage of the app and regularly introducing new content to the mental health app are approaches to decrease low engagement with the app and retain users. When applications neglect to update their material, users become easily bored.

Moreover, participants felt an overall positive vibe from the content while interacting with the techniques which made their experience with the app more engaging and motivating. The study by Stawarz et al. (2018) highlighted the importance of incorporating positivity within mental health apps to enhance user engagement and experience.

Strengths and Limitations

This study has three notable strengths that are important to address. One of the strongest points of this study is the iterative design method that was used. By improving the second prototype based on feedback from the participants, the study presents a user-centered design method. The iterative process not only enhances the usability of the app but also makes sure that the end product better fits the preferences and needs of the target users.

Also, the detailed feedback that participants gave about the initial and improved prototypes can be used to enhance mental health apps in the future. Albeit a small number of people within this study, the different points of view give us a lot of information about how individuals use the app, and what struggles they encounter. This can help developers create more effective mental health interventions by addressing common issues and incorporating preferred features.

Lastly, the comprehensive evaluation of multiple CBM techniques (CBM-I, ABM, MBM) provided a comparison of their effectiveness and user preferences. This approach allows for a thorough understanding of which techniques are suitable for inclusion in a mental health app for students dealing with stress.

However, the study has four limitations that should be acknowledged. First, the sample might not have been representative of the whole population in terms of age, gender, academic field, or amount of stress. Most of the people in the group were German girls in their early twenties who were studying psychology at the University of Twente. Besides, psychology students may have prior knowledge about cognitive biases, which could influence their perception of the app. Hence, it is possible that this lack of variety could make it harder to use the results with a wider group of students and make the results less general.

Second, the usability testing and interviews reflect only one moment in time which does not provide a comprehensive understanding of how the intervention affects participants over an extended period. Initial reactions or feedback may not reliably indicate ongoing engagement, content interaction, or the long-term effectiveness of the techniques.

Also, the controlled setting of the study might be different from how it is used in real life, which could change the results. The way the subjects used the app in the study may not have been the same as how they would use it in real life. For example, one person had trouble using the Shift Your Focus Technique (ABM) because she felt uncomfortable being watched while she did it. It might have been enjoyable for her if she had been doing it by herself and in a more private place.

Lastly, while using the Perceived Stress Scale (PSS-4) to evaluate participants' stress levels, our results show that participants' stress levels were moderate. This may indicate a limitation in our selection of participants, as the app is intended to aid people with high-stress levels. Future research should focus on selecting a target group that aligns more closely with the intended use of the app, ensuring that participants experiencing high levels of stress are included to more accurately assess the app's effectiveness.

Implications for Future

One implication for the future includes testing the second prototype for several days and offering a different CBM technique every day. Moreover, going beyond just usability testing and doing longer-term studies in real-life situations can give us more information about how well and how often CBM methods work. By using this kind of app for a longer period, new information can be learned about how well and how long CBM techniques work to help students deal with stress.

To make such CBM apps more tailored and personalized to individuals' preferences, future researchers and app developers can focus on making CBM methods more adaptable to different types of stress and personal preferences. Moreover, the CBM future app should have regular updates, different kinds of content, and interactive features to keep users interested over time and stop them from getting bored.

Also, future research might examine how app features can be modified to accommodate a broader variety of participants, which would help to ensure that our findings apply to other contexts and demographics. This entails taking into account user differences in stress levels, age, gender, and academic backgrounds. For example, knowing which particular app features are interpreted differently by different demographic groups could help with changes that improve the app content and user engagement for a range of users.

Conclusion

This study's most important message is that Cognitive Bias Modification (CBM) techniques, especially interpretation bias modification- and attention bias modification techniques, would be suitable to implement in an experience sampling app to help students deal with stress. Moreover, the second prototype of the app represents a significant improvement over the first in its content aspects. The results show the importance of clear instructions and explanations, personalized content, and interactive features for getting users to be more engaged and successful. However, the study shows some limitations, like a homogeneous sample, capturing feedback at a single point in time, or a controlled setting. To effectively introduce the app to the target group and make a meaningful contribution to the mental health sector, further refinements are vital, such as recruiting a more diverse participant sample, enhancing personalization through customizable content, and incorporating varied CBM techniques to address different types of stress.

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Appendices

Appendix A

Informed Consent

Information Sheet for Participants

Purpose of the Research: The purpose of this research study is to explore the usability and content aspects of a Cognitive Bias Modification (CBM) app designed for mental health. The study aims to understand how users interact with the app, gather feedback on user experiences, and identify areas for improvement. By participating in this study, you will contribute valuable insights that can inform the development of future interventions aimed at supporting mental well-being.

Benefits and Risks of Participating: Participating in this research provides an opportunity to contribute to the development of a CBM app that may benefit individuals dealing with stress and mental health challenges. However, there may be risks associated with discussing personal experiences related to stress during interviews. Imagining stressful situations in the study could cause potential psychological distress or discomfort for participants

Please note that this research project has been reviewed and approved by the BMS Ethics Committee/domain Humanities & Social Sciences to ensure the protection of participants' rights and well-being.

Procedures for Withdrawal: Your participation in this study is voluntary, and you have the right to withdraw at any time without facing any consequences. If you decide to withdraw, you may do so by informing the researcher directly.

Data Handling and Confidentiality: Any personal information collected during this study will be kept confidential and handled in accordance with data protection regulations. Your data will be de-identified (anonymized) to safeguard your privacy. Research data will be stored securely and accessible only to authorized personnel. The information collected will be used for research purposes only and will be used for analysis and development of interventions and applications. Your participation and responses will remain confidential.

Retention Period for Research Data: Research data will be retained for a period determined by the University of Twente's data retention policies. After this period, data will be securely archived or disposed of in accordance with ethical guidelines.

Contact Details: If you have any questions or concerns about the research study, please contact the lead researcher:

Lead Researcher: Victoria Pohl

Email: V.pohl@student.utwente.nl

Phone: +491735160059

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl

Consent Form for Exploring Usability and Content Aspects of a Cognitive Bias Modification (CBM) App for Mental Health

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated [09/04/2024], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that participating in the study involves an audio-recorded interview. These recordings will be transcribed into text, and afterward, the recordings will be destroyed.	□	□
Risks associated with participating in the study		
I understand that taking part in the study involves the following risks: imagining stressful situations in the study could cause potential psychological distress or discomfort for participants	□	□
Use of the information in the study		
I understand that information I provide will be used for analysis and development of interventions and applications.	□	□
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs	□	□
Consent to be Audio/video Recorded		
I agree to be audio/video recorded. Yes/no	□	□
Future use and reuse of the information by others		
I give permission for the *audio recording* that I provide to be archived in the University of Twente so it can be used for future research and learning.	□	□

I agree that my information may be shared with other researchers for future research studies that may be similar to this study. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information. (Note: This separate consent is not necessary if you will only store and share deidentified data.)	□	□
I give the researchers permission to keep my contact information and to contact me for future research projects.	□	□

Signatures

_____ _____ _____

Name of participant [printed] Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____ _____ _____

Researcher name [printed] Signature Date

Study contact details for further information:

Sophie- Charlotte Degner, s.degner@student.utwente.nl

Victoria Pohl, v.pohl@student.utwente.nl

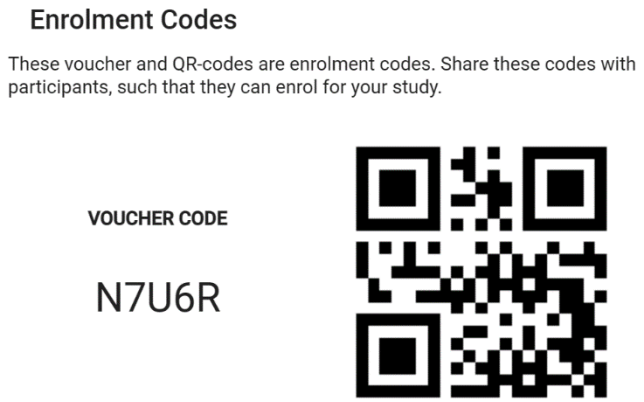
Appendix B

First Interview Schedule

Interview Schedule: Usability Test and Qualitative Interviews

Instructions before:

1. Download Tiim App
2. Register with your student account
3. Apply for Study:



(for us)

- Accept participant in TIIM environment

1. Introduction of Topic: Welcome participants and introduce the study:

- Thank you for participating in our research. Today, we'll be exploring the usability and content aspects of a stress management app prototype to gather insights into its effectiveness and user experience.

2. Informed Consent

- Before we begin, In the information sheet the purpose of the study and the procedures involved is explained . Please review the consent form and let me know if you have any questions. If you're comfortable with the information provided, please sign the form to indicate your consent to participate." (written)

- Okay so now I am gonna start the audio recording

3. Demographical Questions

- To better understand our participants, I'll ask a few demographic questions:
- What is your
    - age
    - Gender
    - Nationality
    - Occupation
    - Where do you live
- Do you use your smartphone on a daily basis?

    → how many hours do you use your phone per day on average

4. Perceived Stress Test Scale (PSS-4)

- Next, we'll assess your perceived stress levels using a short questionnaire. Please answer each question honestly based on your experiences in the past month (written)

Please rate from 0 to 4, with 0 being "Never" and 4 being "Very Often.

1. Over the past month, how often have you felt that you were unable to control the important things in your life?
2. Over the past month, how often have you felt confident about your ability to handle your personal problems?
3. Over the past month, how often have you felt that things were going your way?
4. Over the past month, how often have you felt difficulties were piling up so high that you could not overcome them?

5. Usability Test Tasks (Tasks not provided, tailored to research needs)

- I'll now provide you with a series of tasks to complete using the app prototype. These tasks will help us assess its usability and content aspects
- As you interact with the app prototype, please verbalize your thoughts, feelings, and reactions out loud. This will help us understand your cognitive processes and user experience in real-time.
- "Now, I'd like you to imagine yourself in a stressful situation. Close your eyes and visualize a scenario where you're facing a challenging deadline or dealing with a difficult situation in your personal life."

Open the tabs in this order and fuflill the tasks within, please elaborate on your thoughts while fulfilling the task:

Sleep

Mood

Memory

PTC,

AB

Redirecting Technique

CBI

Reappraisal Technique

EoD

7. Semi-Structured Interview

- "Now, I'd like to ask you some open-ended questions about your experience with the app prototype."

- "We're interested in hearing your thoughts, preferences, and any suggestions you have for improving the app's usability and effectiveness."

Overall Experience

- "Can you please describe your overall experience using the app prototype?"

    - "What aspects of the app did you find most helpful or enjoyable?"

    - Were there any challenges or frustrations you encountered while using the app?"

Preferences

"Do you have any preferences regarding the design, layout, or features of the app?"

Probes:

- "Were there any particular features of the app that stood out to you as particularly useful or ineffective?"

- "Do you think the app adequately caters to individual needs and preferences?"

Usability Aspects

Learnability:

- How easy was it for you to figure out how to use the app when you first started?
- Did you notice differences between the modules/ questions?
- (open/closed ; Multiple choice etc..)

- What questions did you find easy to answer?
- What questions were confusing or difficult to answer?

- Do you have any suggestions on how we can make it easier for first-time users to understand the questions/module/interface in the app?
    - (E.g. graphic, description, more overview?)

Efficiency:

- How quickly were you able to complete tasks within the app?

- Were there any features that helped you work faster?

- Were there any features that slowed you down?
- Do you have any thoughts on how we can improve the interactions to make them more efficient?

Error Prevention:

- Did you encounter any issues or errors while using the app?

- (How did you handle any mistakes you made while using the app?)

- (Do you have any ideas on how we can prevent or minimize errors in the future?)

Satisfaction:

- Overall, how satisfied were you with your experience using the app?
- What did you enjoy most about using the app?
- What could be improved?
- Would you consider using this app regularly? Why or why not?

→ do you think the app can be useful for you (purpose)

Content Aspects:

Content Relevance and Applicability:

- Did you find the information provided within the app relevant to promoting positive thinking and managing your mindset?

- Were you able to apply the strategies and techniques suggested in the app to get a more positive mindset ?

Information Clarity and Understanding:

- How clear and understandable did you find the techniques for promoting positive thinking explained in the app?

- Were there any concepts or instructions that you found confusing or difficult to follow?

Coverage of Positive Thinking Techniques:

- Did you feel that the app covered a broad range of techniques for promoting positive thinking?

- Were there any specific positive thinking approaches or exercises that you were hoping to find in the app but did not?

Effectiveness of Positive Thinking Techniques:

- Have you found the positive thinking techniques suggested in the app to be helpful in getting a more positive mindset?

- Can you provide examples of specific techniques or exercises from the app that you found particularly effective in promoting positive thinking?

Integration of Cognitive Bias Modification Approaches:

- Did you notice the integration of cognitive bias modification approaches within the app's strategies for promoting positive thinking?

- How effective do you think these bias modification techniques are in helping you adopt a more positive mindset?

User Engagement and Interaction:

- Did you find the interactive features or tools within the app engaging and helpful in promoting positive thinking?

- How did these features contribute to your overall experience in cultivating a positive mindset?

Comprehensiveness and Depth of Information:

- Did you feel that the app provided enough depth and detail in its explanations of techniques and concepts for fostering positive thinking?

- Were there any areas where you wished the app provided more information or guidance on specific aspects of promoting positivity?

Suggestions for Improvement:

- What improvements would you suggest to enhance the overall quality and effectiveness of the contents app approach to promoting positive thinking?

- Are there any additional resources or tools related to positive thinking that you would like to see added to the apps content to better support your needs?

Closing Remarks

- "Thank you for sharing your insights and feedback. Your input will be invaluable for improving the app prototype."
- "Is there anything else you would like to add before we conclude the interview?"

8. Conclusion

"Thank you for your participation and valuable feedback. If you have any further questions or comments, please don't hesitate to reach out. Your input will contribute to the improvement of stress management apps in the future."

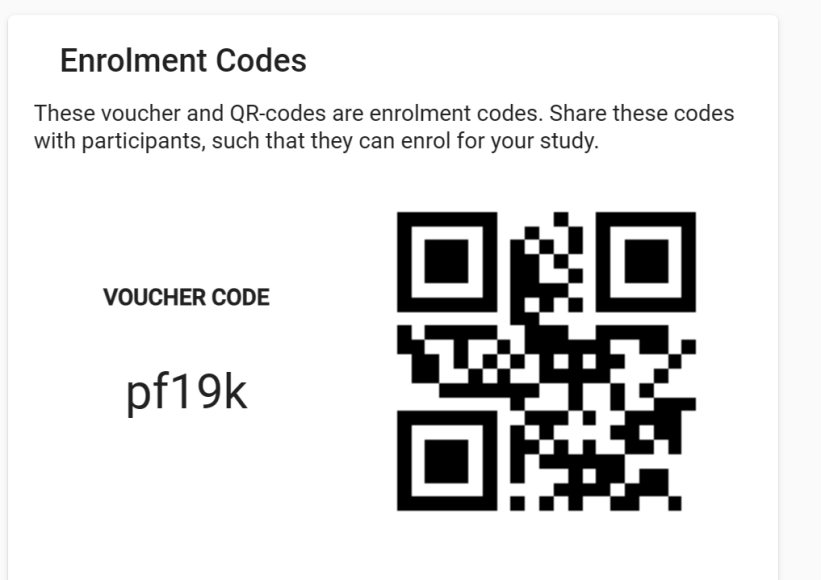
Appendix C

Second Interview Schedule

Interview Schedule: Usability Test and Qualitative Interviews

Instructions before:

Apply for Study



(for us)

- Accept participant

1.Introduction of Topic: Welcome participants and introduce the study:

- Thank you for participating in our research. Today, we'll be exploring the usability and content aspects of a positive thinking app prototype that we refined after the last session. To gather insights into its effectiveness and user experience we will conduct a usability test and ask similar questions as in the last interview.

It is important for you to know the purpose of the app to better evaluate your experience:

Imagine you will use this app on a daily basis, you will be prompted with the questionnaires several times a day. In the final version of the app, you could individually choose from the kinds of questionnaires that fit your needs the most. However, in this study, we want to test out three different techniques to compare their usefulness.

> Therefore, the app is designed to fit mental health practice into your daily life seamlessly. Through simple, guided activities based on Cognitive Bias Modification (CBM), you'll learn to focus on the positive aspects of your life, right from your smartphone. Practice anytime, anywhere, and start noticing a shift in your mood and outlook.

2. Informed Consent

- Do you still agree on the conditions of participating in this research? If not, or you want to review the information sheet with informed consent, you can say it now or withdraw from this interview at any time.

- before I start the audio I want to ask you to fill- out the **Perceived-Stress-Test Scale** again so we can compare your stress level from the first interview with the one now

Okay, then I will start the audio recording now.

3. Usability Test Tasks

- I'll now provide you with three tasks to explore the new app prototype. These tasks will help us assess its usability and content aspects.

- As you interact with the app prototype, please verbalize your thoughts, feelings, and reactions out loud. This will help us understand your cognitive processes and user experience in real-time.

1. Task fill in the first questionnaire called Questionnaire 1 - Optimistic Reinterpretation
2. Task fill in the second questionnaire called Questionnaire 2- Shift Your Focus
3. Task fill in the third questionnaire called Questionnaire 3- Recollect Positive Memories

4. Semi-Structured Interview

"Now, I'd like to ask you some open-ended questions about your experience with the app prototype."

"We're interested in hearing your thoughts, preferences, and any suggestions you have for improving the app's usability and effectiveness."

Overall Experience

- "Can you please describe your overall experience using the app prototype?"
  - "What aspects of the app did you find most helpful or enjoyable?"
  - Were there any challenges or frustrations you encountered while using the app?"

  → Can you please compare your overall experience to the first prototype?

Preferences

"Do you have any preferences regarding the design, layout, or features of the app?"

Probes:

- "Were there any particular features of the app that stood out to you as particularly useful?"
- "Do you think the app adequately caters to individual needs and preferences?"

→ Can you please compare your preferences to the first prototype?

Usability Aspects

Learnability (refers to how fast users can learn, adapt, and accomplish basic activities when using the app for the first time)

- - How easy was it for you to figure out how to use the app when you first started?
- - Did you notice differences in how fast you mastered things between the modules/ questions?
- (open/closed ; Multiple choice etc..)
-
- - What questions did you find easy to answer?

- - What questions were confusing or difficult to answer?
-
- → Can you please compare the learnability of the app to the first prototype?

IF CAN'T REMEMBER → tell them things that were said in last prototype:

- Complex Question Layout in Open Questions
- Challenges with Navigation (e.g. arrow)
- Confusion due to Abbreviations
- Illogical Module Arrangement
- Positive Impression of General Layout
- Request for more information/ Explanation

-
- - Do you have any suggestions on how we can make it easier for first-time users to understand the questions/module/interface in the app?
-

Efficiency (how quickly users can fulfill a task after understanding the basic functions)

- - How quickly were you able to complete tasks within the app?
-
- - Were there any features that helped you work faster?
- - Were there any features that slowed you down?
-
- → Can you please compare the efficiency of the app to the first prototype?
-
- - Do you think that making the app more efficient is beneficial to the overall experience of the app?
    - → if yes: Do you have any thoughts on how we can improve the interactions to make them more efficient?

Errors (how many errors users engage in when using the app, how severe they are, and how quickly they recover from making them)

- - Did you encounter any issues or errors while using the app?
-
- (How did you handle any mistakes you made while using the app?)

- → Can you please compare the errors of the app to the first prototype?
- IF CAN'T REMEMBER → tell them things that were said in last prototype:
- - Loading Time
- - Readability
- - Unfamiliar Terminology (Gloomy)
-
- (Do you have any ideas on how we can prevent or minimize errors in the future?)

Satisfaction:

- - Overall, how satisfied were you with your experience using the app?
-
- - What did you enjoy most about using the app?
-
- - What could be improved?

-
- → Can you please compare your satisfaction of using this app to the first prototype?
-
- - Would you consider using this app regularly? Why or why not?

→ do you think the app can be useful for you?

- Please describe what the purpose of this app is for you
- For whom do you think this app can be useful?

Content Aspects:

Content Relevance and Applicability:

- Did you find the information or content provided within the app relevant to promoting positive thinking and managing your mindset? Why or why not?

- Were you able to apply the exercises and techniques suggested in the app?

Information Clarity and Understanding:

- How clear and understandable did you find the techniques for promoting positive thinking explained in the app? Was it easy to understand?

- Were there any concepts or instructions that you found confusing or difficult to follow?

Preferences for Positive Thinking Techniques:

- Which cognitive bias techniques or exercises did you prefer the most? Why?
- Which cognitive bias techniques or exercises did you find less engaging or effective? Can you explain?
- Was the range of positive thinking techniques offered in this app sufficient for you?
- Were there any positive thinking approaches or exercises that you were hoping to find in the app but did not?

Effectiveness of Positive Thinking Techniques:

- Do you think the bias modification techniques and exercises can be helpful to you in adopting a more positive mindset if you use such an app on a daily basis?

- Did you notice any changes in your thought patterns or stress levels after using the app? If so, please describe

- Do you think you would notice changes in your thought patterns or stress levels when using the app daily?

- Which techniques helped you shift or have the potential to shift your thoughts into a more positive mindset? Why?

Integration of Cognitive Bias Modification Approaches:

Do you feel the app has potential to address cognitive biases or negative thought patterns?

User Engagement and Interaction:

- Did you find the interactive features or tools within the app engaging in promoting positive thinking?

- Would you prefer the content and features of the app to be tailored to your individual preferences and needs when using it on a daily basis?

- Do you feel that the app's content and features are already personalised to your individual preferences and needs when using the app on a daily basis?
- Do you believe that the app's content is sustainable for long-term use, or do you anticipate experiencing fatigue or disengagement over time? Why?

Comprehensiveness and Depth of Information:

- Did you feel that the app provided enough depth and detail in its explanations of techniques and concepts for fostering positive thinking? Or were there areas where you desired more in-depth explanations?

- Were there any areas where you wished the app provided more information or guidance on specific aspects of promoting positivity?

Suggestions for Improvement:

- What improvements would you suggest to enhance the overall quality and effectiveness of the content approach to promoting positive thinking?

- Were there any additional features or content you would like to see added to the app?

Recommendation of App:

- Would you consider using the app regularly in a period where you experience high levels of stress ?

- Do you believe the app could be beneficial in the long term?

- Would you recommend this app to others who are dealing with stress? Why and why not?

Closing Remarks

- "Thank you for sharing your insights and feedback. Your input will be invaluable for improving the app prototype."

- "Is there anything else you would like to add before we conclude the interview?"

8. Conclusion

"Thank you for your participation and valuable feedback. If you have any further questions or comments, please don't hesitate to reach out. Your input will contribute to the improvement of cognitive bias modification apps in the future."

Appendix D

Perceived Stress Scale 4 (PSS-4)

Perceived Stress Scale 4 (PSS-4)

(Cohen et al. 1983)

Instructions: The questions in this scale ask you about your feelings and thoughts during THE LAST MONTH. In each case, please indicate your response by selecting the option representing HOW OFTEN you felt or thought a certain way.

Never; Almost never; Sometimes; Fairly often; Very often

1. In the last month, how often have you felt that you were unable to control the important things in your life?
2. In the last month, how often have you felt confident about your ability to handle your personal problems?
3. In the last month, how often have you felt that things were going your way?
4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Scoring Instructions:
Total score is determined by adding together the scores of each of the four items. Questions 2 and 3 are reverse coded.

Questions 1 and 4: 0 = Never; 1 = Almost never; 2 = Sometimes; 3 = Fairly often; 4 = Very often
Questions 2 and 3: 4 = Never; 3 = Almost never; 2 = Sometimes; 1 = Fairly often; 0 = Very often

Citation:
Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 385-396.

Appendix E

Code Book Prototype 1

Code Group	Code	Definition	Example from Transcript
Content Clarity and Comprehensiveness	Clarity and Sufficiency of Explanations	Instances where participants commented on the clarity, detail, and comprehensibility of the app's explanations. This includes any confusion or difficulties in understanding specific aspects, the adequacy of technique descriptions, and the effectiveness of	"I think it's confusing to me if I just have to describe my positive or neutral image or if I have to describe how I come from my negative to my positive one." No, like I wish for more depth and detail, just like explaining the aim, how it works, what it is, how it's supposed to work, what effects can I have or consequences, benefits can I get from these techniques."

		explanations.	"I would say I did understand it, but it was not really explained, they just said yeah, just think about something positive and I expected more explanation or like in how far it can work, how my positive mind can be changed or like how I get a positive mind."
Content Relevance and Applicability	Ease in Implementing Techniques	Participants' feedback on how easy or difficult it was to carry out or implement the techniques provided by the app	"Yeah, I was a bit confused sometimes. But also, because I had not done many things today, it was hard for me to describe the actual impactful events in comparison to a fuller day." "Because when I have the Likert scale it's not that much of an effort. And when I'm stressed and I also additionally have to write something it's more I have to do and that kind of stresses me a bit, I would say."
	Relevance to Positive Thinking	The perceived relevance of the techniques to fostering positive thinking.	"I think the content that was there, yes, but it could be more on the positive side because now it felt like more negatively oriented."
Effectiveness of Positive Thinking Techniques	Awareness and Potential of CBM Techniques	Participants' views on whether the techniques could help them address cognitive biases and whether they recognize the integration of CBM	"I'm not sure, since it wasn't really explained in the app what cognitive bias modification is or in how far it can help me, because in my opinion it was a bit more unconscious, and therefore I'm not sure in how far it can be effective. Maybe if I knew what it is, I would have paid more attention to it."
	Impact on Mindset and Thought Patterns	Feedback on how the app affected participants' overall mindset and thought patterns and stress levels	"It did not help that much, like maybe a little bit. But no, not that much. Because I already thought about it before,"
Preferences for Positive Thinking Techniques	Expectations of Techniques	Instances where participants felt that the app and techniques did not meet their expectations	"I didn't really think about these positive thinking approaches or exercises before, so I also wasn't quite sure what to expect, so therefore I would say I didn't expect something what I didn't find"
	Range of Techniques Offered	Participants' feedback	"No, I would not say so, because

		on the variety and diversity of techniques provided by the app	like there was like only one technique in that sense, which is about like the positive rethinking"
	Preferred Techniques	Techniques that participants favoured or found most effective.	"Yeah, maybe the one question where you should think about a negative event in a more positive way, maybe that could be helpful"
User Engagement and Interaction	Engagement with Interactive Features	How engaging and motivating participants found the interactive elements of the app	"For me it was not optimal because I had to also put myself in a lot of negativity and first I associated with a lot of negative words, and I think that had more impact on me than the positive reframing afterwards."
	Willingness to Use Regularly	Participants' willingness to use the app regularly.	"I think it also is probably more helpful after more regular usage because I think for the first time doing something like redirecting your focus seems a bit strange but maybe if you do it more regularly then it's more like an exercise that you will get familiar with." "I don't know if it would help me like reappraising my stress because I do not feel better afterward"
Suggestions for Improvement	Desired Additions to the App	Participants' suggestions for additional features or content they would like to see in the app.	"for me, it's nice to have social support somehow. Or something like that, because that helps me the most. That is somehow possible to have it included in an app."

Appendix F

Code Book Prototype 2

Code Group	Code	Definition	Example from Transcript
Content Clarity and Comprehensiveness	Clarity and Sufficiency of Explanations	Instances where participants commented on the clarity, detail, and comprehensibility of the app's explanations. This includes any confusion or difficulties in understanding specific aspects, the adequacy of technique	"The first technique had a sentence, which I did not understand. It was, 'IBM is like your brain wears a pair of positivity glasses.' So I was a bit confused in the beginning." "I think it was really clear in this prototype and it was explained really well and also in like easy and straightforward terms, but also with enough information

		descriptions, and the effectiveness of explanations.	given and examples." All the difficult words were explained in the text." "Explanation was way longer. So I also understood it better what I was supposed to do and what it was meant for."
Content Relevance and Applicability	Ease in Implementing Techniques	Participants' feedback on how easy or difficult it was to implement or carry out the techniques provided by the app	"But it was easy for me to figure out." "It felt very easy for me to answer, and it felt good to do these exercises because it was thinking about positive things, and I also got positive feedback when finishing the exercise."
	Relevance to Positive Thinking Techniques	The perceived relevance of the techniques to fostering positive thinking.	"Yeah, I think they were relevant because it was clarifying and it used many positive elements and encouraging."
Effectiveness of Positive Thinking Techniques	Awareness and Potential of CBM Techniques	Participants' views on whether the techniques could help them address cognitive biases and whether they recognize the integration of CBM	"Yes, especially if you use it like on a daily basis and like, maybe like twice a day if you wake up and before you go to sleep, for example."
	Impact on Mindset and Thought Patterns	Feedback on how the app affected participants' overall mindset and thought patterns and stress levels	"I think I felt more of a mental calmness with the positive memories and optimistic reinterpretation. But especially a physical calmness with the shift your focus exercise. But overall, I felt more like less weight on my shoulders and more calm. I think more focus on the positive thoughts."
Preferences for Positive Thinking Techniques	Expectations of Techniques	Instances where participants felt that the app and techniques did not meet their expectations	"I have to say the last thing, what I just did, I think it's too short. I think there's one question missing or something. Because I was thinking about it, about the positive effect."
	Range of Techniques Offered Were there enough techniques? Or did they wished for more?	Participants' feedback on the variety and diversity of techniques provided by the app	"There were way fewer questionnaires, so it was more clear what and which belong to which topic and also therefore easier to use."

	Preferred Techniques	Techniques that participants favoured or found most effective.	"I think I liked the first one where I had to think about a situation and how I would interpret it, like, negative or positively, and then when I thought it's negative, then to reinterpret it in a positive way."
User Engagement and Interaction	Engagement with Interactive Features	How engaging and motivating participants found the interactive elements of the app	"It gave me sort of feedback so like congratulations, you're now having a positive view, which was I think motivating to keep on improving and to keep on using the app."
	Willingness to Use Regularly	Participants' willingness to use the app regularly.	"Yes but I think I would need daily reminders from my phone that I like use it now or do your daily modification now."
Suggestions for Improvement	Desired Additions to the App	Participants' suggestions for additional features or content they would like to see in the app.	"Maybe something, what could be nice is some self-appreciation tasks, stuff like that, that you are focusing on you, like on yourself and not only on situations, like on your strength and like which kind of person you are, stuff like that would be good."
Recommendation of App	Factors Influencing Regular Usage	Factors that could interfere with participants' use of the app regularly.	"But of course, it's like some people that have different types of stress and some things are out of their power. It might be not the best to recommend. But if there's a stressful situation, for example, where somebody is sick, and then you're saying, like, okay, let's reinterpret this event might not be suitable."
	Likelihood to Recommend to Others	Participants' likelihood of recommending the app to others	"I think I would recommend it to friends, especially mindful exercises, just to think about in life. Many people in my life who experience a lot of stress in their lives, I think it would be very beneficial."