RadiantLife: Exploring Usability Aspects of a Cognitive Bias Modification App Promoting Mental Health

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Abstract

Technological interventions such as Cognitive Bias Modification (CBM) apps can help to promote a positive mindset to prevent the (re)occurrence of mental health issues. For these apps to be successful, users should regularly answer questionnaires within the interface. Therefore, CBM apps should meet certain usability aspects that improve user-friendliness and adherence.

This qualitative study explored 'How to improve the usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction of a Cognitive Bias Modification app to increase its potential for adherence?'. For this, usability tests and following interviews were conducted. This process was iteratively repeated with two prototypes. Five female participants were recruited by convenience sampling. Via the Think-Aloud Method, transcripts were created that were analysed by thematic coding to find commonalities between the participants' views.

Most usability issues with the first prototype were addressed by creating the second prototype, leading to user satisfaction and perceived usefulness. This study identified some factors for improving the usability of a CBM app and reducing frustrations that could deter individuals from using the app. It was found, that designers should create an interface that is easy to understand, closely connected to the user's expectations, explains used methods, and provides freedom in navigation. Furthermore, a minimalistic, cohesive yet diverse system tailored to the user's context is important to enhance satisfaction. In addition, high-quality software and an iterative design process should be used to prevent errors and adapt to users' needs.

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Introduction

One-quarter of the European population suffers from at least one mental health issue (Statista Research Department, 2024). This includes the Dutch population which has a high prevalence of depression, anxiety, and eating disorders (Statista Research Department, 2024). The most affected persons are alone standing young adults between 18 and 39 with a prevalence of around 25 per cent of mental issues (Centraal Bureau voor de Statistiek, 2021). The symptoms of these diseases are manifold such as feeling sad or angry, having low self-esteem, and withdrawal from social life (Li et al., 2023; Statista Research Department, 2024). Due to the high prevalence of mental health issues, there is a heightened demand for mental health care in the Netherlands (Wijnen et al., 2023). This affects society because it accompanies a high national financial burden due to treatment costs and affected persons being less likely to contribute to economic growth. In addition, the mental health care system is significantly under-resourced (Van Dijk et al., 2023). The imbalance of people who need care and free spots in treatment results in long waiting times for the affected population which negatively affects the success rate of the treatment (Van Dijk et al., 2023). This highlights the need to reduce the pressure on the mental health care system through innovative approaches such as self-care mental health apps aimed at preventing stress to reduce the likelihood of mental health issues (Visser et al., 2019).

Impact of Chronic Stress on Cognitive Bias and Mental Health

According to the cognitive theory of depression, many psychopathological problems are associated with cognitive biases that change how people, perceive, process, evaluate, and respond to stimuli (Li et al., 2023). For example, chronic, recurrent, or extremely intense stress can alter perception because the human information processing system is influenced by emotions, knowledge, and thinking patterns (Bovy et al., 2022). Neurologically, activating a negative node in the neural system triggers related nodes that create an active negative neural

network which biases the stimuli to be interpreted as negative, known as *Negative Processing Bias* (Bovy et al., 2022). Additionally, stressed individuals have less specificity in their autobiographical (i.e. personal history) memory specificity, known as *Negative Memory Bias* (Bovy et al., 2022). Furthermore, research suggests that a negative mood leads to evaluations on a more generic level, causing over-generalisation, rumination, and impaired emotional regulation (Li et al., 2023).

Cognitive Bias Modification to Prevent Mental Illnesses

Even though Negative Memory and Processing Bias are known as a prominent factor in causing mental illnesses, there is a lack of research on how to prevent and modify this biased cognition (Bovy et al., 2022). However, *Cognitive Bias Modification* (CBM) aims to alleviate mental health symptoms by fighting these biases (Bovy et al., 2022). Traditionally, the main idea of CBM was to intentionally change cognitive and behavioural responses by associating negative information with neutral stimuli using basic learning principles and repeated rehearsal (Bovy et al., 2022; Li et al., 2023). However, research suggests that replacing negative information with positive stimuli is more promising in the long term. By asking the patient to recall positive events and memories, positive nodes can be activated which may lead to a widespread activation of related nodes (Bovy et al., 2022). This can reduce stress and alleviate the user's mood which may lead to a positive interpretation of a patient's view on their life, thus reducing their risk of a (re)emergence of mental health issues (Li et al., 2023). Still, there is a lack of evidence in the prevention and treatment of this matter since there is a gap between the potential of CBM theoretically and actual benefits in practice to reduce stress-related complaints. This gap is exacerbated by the predominantly laboratory-based research on CBM, limiting patients' access to CBM training (Bovy et al., 2022).

Advantages of User-Friendly Mental Health Apps

To address the limitations of previous research to apply theoretical promising results into practice, the study by Visser et al. (2019) created a CBM app. Within the app, participants were prompted several times for multiple days to recall positive situations, describe these events, and rate how positively they experienced them. Integrating CBM into a user-friendly mental health app allows people to regularly train their positive thinking (Bovy et al., 2022). Training in their natural environment facilitates the patient's ability to apply the techniques in the future as people can retrieve things better in the same context as it was stored (Wang, 2023). Additionally, apps are everywhere and every time accessible, and encourage independent training which increases patients' confidence in self-treatment (Bovy et al., 2022). Furthermore, using an app enables more people to be treated since it does not require immediate professional help to complete the exercises. Therefore, it reduces treatment costs and the lengths of waiting lists resulting in a less overstrained healthcare system (Li et al., 2023).

Usability Factors in Cognitive Bias Modifications Apps

However, while the app of Visser et. al (2019) showed improvement in positive autobiographical memories, there was a lack of adherence due to unsatisfactory usability experiences. Usability is defined as 'A measure of how well a specific user in a specific context can use a product/design to achieve a defined goal effectively, efficiently and satisfactorily' (What Is Usability - the Ultimate Guide, 2023). In detail, the usability of an app can be defined by five quality criteria. Firstly, *Learnability* refers to how fast users can learn, adapt, and accomplish basic activities when using the app for the first time (Tuama, 2022). Considering Norman's theory of mental models, this can be reached if a system works in a way that the user would have predicted (Nielsen & Chan, 2024). Such a prediction is called a *mental model.* A mental model allows users to use the app in a way that they interacted with other systems before. This helps them to learn the new system faster because

they can rely on their previous knowledge (Nielsen & Chan, 2024). Secondly, the *Efficiency* of an app design is measured by how quickly users can fulfil a task after understanding the basic functions. Thirdly, *Error Prevention* can define the quality of the app design in the way that one can test how many errors users encounter when using the app, how severe they are, and how quickly they recover from making them. Fourthly, the *Satisfaction* while using an app is another quality factor. It gives inside into how users feel while interacting with the app by testing whether they enjoy using it. Fifthly, the *Memorability* of an interface is related to how quickly users can recall the basic functions of an app after they have not been using it for a longer time (Tuama, 2022). Usability aspects are usually tested during iterative design processes including usability tests with prototypes in different development stages following interviews. Hereby, the user's opinion in combination with the researchers' observations of the interaction gives insight into usability shortcomings.

Investigating Usability Enhancements for Cognitive Bias Modification Apps

Building upon the study by Visser et al. (2019), this study aims to address shortcomings identified in previous research by assessing and refining the usability of the app interface. Thereby, the quality criteria for the usability of app prototypes will be considered. The last quality point of Memorability will not be examined as testing it would require a longer period than is feasible within the scope of this study. Since young people with high education are especially at risk, the participants will be students living in the Netherlands (Centraal Bureau voor de Statistiek, 2021; Nelson et al., 2021). Thus, the research question is: 'How to improve the usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction of a Cognitive Bias Modification app to increase its potential for adherence?' Furthermore, several sub-questions will guide this study: 'What challenges do users face in learning the basic functions of the prototypes in their first interaction and how can they be reduced? Which tasks do users find time-consuming or difficult to complete in the prototypes

and how can this be changed? What are common errors users make while using the prototypes and how can they be eliminated? What aspects of the prototypes do users find most satisfying or frustrating and how can user satisfaction be improved?'.

Method

Design

An explorative qualitative study design was chosen since the app is in its initial development stage. At this stage, working with a small sample is advantageous as it quickly generates valuable insights into the usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction (Harrison & Rentzelas, 2020). Furthermore, focusing on a smaller sample size helps to efficiently and iteratively refine these usability aspects to increase the app's design and therefore user adherence (Harrison & Rentzelas, 2020). For this iterative process, usability tests following semi-structured interviews with two app prototypes in different development stages were conducted. A semi-structured interview design was chosen since it gives the researchers order to address the intended topics but allows for the possibility to stay flexible for directing the interview towards a natural flow of conversation (Harrison & Rentzelas, 2020). For the usability tests, the Think-Aloud Method was used to gain real-time insight into the conscious processes of participants while using the app.

Participants

This study targeted students living in the Netherlands who experience stress regularly. Therefore, participants were included when categorised as young adults between 18 and 30 and residing in the Netherlands. Furthermore, they needed to experience stress related to their academic studies or other life circumstances at least once a month, which was measured by having a moderate stress level (i.e. at least a score of 8) on the Perceived Stress Test Scale (PSS-4) (Cohen et al., 1983). In addition, they needed to use their smartphones daily, because the final app aims to let users fill in questionnaires several times a day. Furthermore,

familiarity with smartphone apps is important for this study since participants need knowledge about technology to give valuable insight.

Participants were excluded when they were minors because they could not provide consent. Individuals below 18 or above 30 years old were excluded due to the research focusing on young adults. Furthermore, participants who did not have proficiency in either German or English were excluded since these are the languages the researchers used for the interviews. Finally, participants with severe mental health diagnoses were excluded to protect them from possible harm, as the app might unintentionally worsen symptoms without professional guidance, thereby endangering their overall well-being.

Five female participants were interviewed in this study. They were between 20 and 25 years old (M=22.4; SD=1.85). Four participants were German and one was Dutch. They were all enrolled in the Bachelor of Science Psychology study programme of the University of Twente in the Netherlands. The participants were recruited by convenience sampling via the researcher's contacts.

This research has been approved by the BMS Ethics Committee (Ethical Approval Number: 240330). All participants were informed about the procedure and the use of their data. In addition, they participated voluntarily and gave informed consent before they conducted the usability tests and were interviewed (Appendix A).

Materials

Interview Schedules and Usability Test

The interview schedules were developed by creating several subtopics: the overall user experience, user preferences, and usability and content aspects that were important to address the research questions (Appendix B; Appendix C). Based on the subtopics, initial questions from the researchers were individually developed to grasp the whole scope of the addressed topics. The interview schedules were iteratively revised by exchanging feedback

between the researchers and the supervisors. The usability test tasks were implemented into the interview schedule. The tasks consisted of fulfilling all modules within the app prototypes.

Pre-Measure

To assess participants' stress levels, the PSS-4 was used (Appendix D). The test consists of four questions designed to evaluate the extent to which individuals perceive their lives as unpredictable, uncontrollable, and overwhelming. Responses are measured by using a Likert scale ranging from 0 (never) to 4 (very often) (Cohen et al., 1983). The scores were summed up by looking at the scoring criteria by Cohen et al. (1983). A low stress level is indicated by a score between 0 and 7, a moderate stress level by a score of 8 to 11, and a high stress level by a score of 12 to 16.

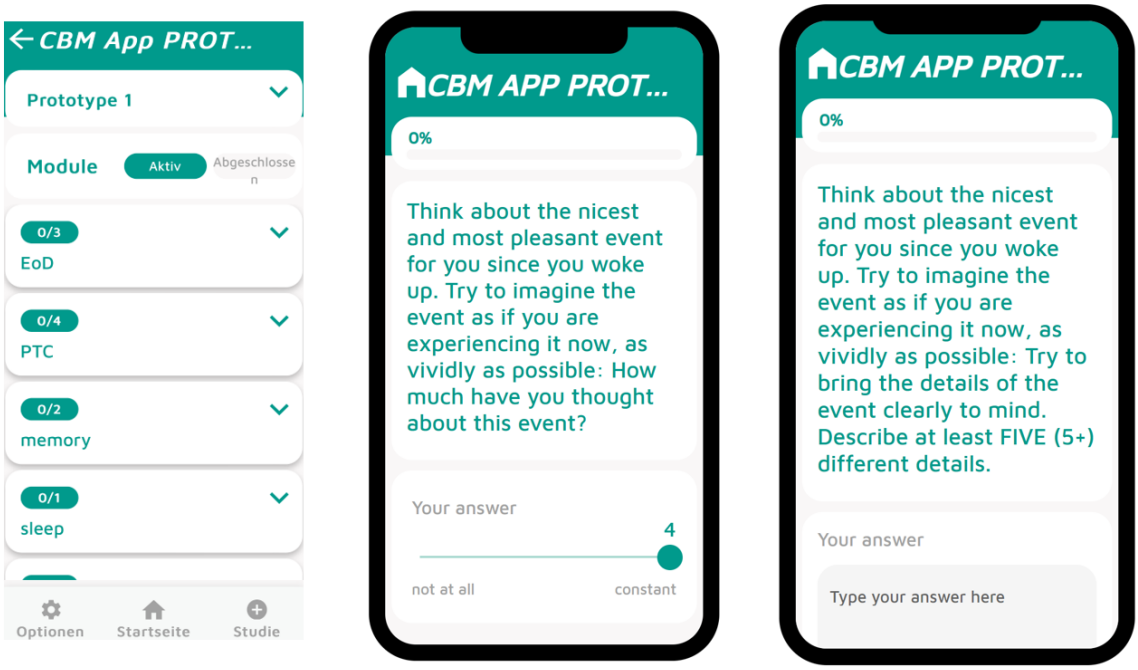
Prototype Development

The *Twente Intervention and Interaction Machine (TIIM)* was used to develop the prototypes. It is an iOS and Android-compatible mobile application that enables researchers to create interventions and collect research data from participants on their smartphones (Universiteit Twente, n.d.). The creation of the first prototype was based on the prototype questions of the study by Visser et al. (2019). The prototype consisted of five modules based on the questionnaires that were used in the study of Visser et al. (2019) that asked about *Sleep, Mood, Memory Bias, Positive Train*ing, and the *End of Day* of the participants. Additionally, the researchers decided to include two other cognitive bias modification techniques to test user's preferences and compare their perceived usefulness in a different study. Therefore, four additional modules were added to test each bias and their modification to get insights into their applicability: *Attention Bias, Attention Bias Redirection, Interpretation Bias,* and a *Reappraisal Technique*. Thus, the first app prototype consisted of nine modules which contained several subquestions (Figure 1). The creation of the second

prototype was based on the findings of the first interview transcript analyses and will thus be explained in the *Results* section of this report.

Figure 1

Example Screenshots of the First Prototype



Note. From left to right: Menu, an example of a Likert scale question, and an example of an open question.

Procedure

The research procedure consisted of two main parts. In the first phase, participants tested the initial prototype. Based on their feedback, refinements were made. In the second phase, participants tested the updated version of the prototype and compared their experiences.

First Research Phase

In the first research phase, participants were invited for an interview including a usability test. Before the procedure started, they were provided detailed information about the

study, its purpose, and the activities involved. Informed consent was obtained from each participant individually. Following, the participants were asked about their demographical data and conducted the PSS-4. They were then prompted to envision a stressful scenario to establish appropriate experimental conditions before engaging in the tasks to explore the app's functionalities. This step was crucial as it heightened participants' stress levels to comprehensively assess the efficacy because they could empathise with the anticipated end users. Following, while interacting with the first prototype during the usability test, participants were instructed to verbalise their thoughts, feelings, and reactions out loud (i.e. Think-Aloud Method) to gain insight into their cognitive processes. After completing the usability tasks, participants were interviewed to gather qualitative insights. Interview questions included inquiries about their overall experience, preferences, suggestions for improving the app interface, and questions that grasped the four usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction. Additionally, participants were asked about content aspects that were investigated in another research paper.

After all participants conducted the first part of the research, the prototype was refined within the TIIM environment of the University of Twente. While doing so, the researchers assessed common patterns among the preferences, identified usability and content issues of the participants, and addressed these in the new prototype design.

Second Research Phase

After finishing the second prototype design, the second research phase of the study was conducted. The same participants as in the first research phase conducted a usability test and answered interview questions. Before the usability test started, they confirmed that they still gave their consent and conducted the PSS-4. Within the usability test, participants filled out three questionnaires based on the cognitive bias modification techniques provided within the app. Following, interview questions were asked to explore participants' overall

experiences, preferences, and suggestions. The same questions about usability as in the first interview were addressed, in addition to some questions to compare the two experiences the users had with the two different prototypes. After the second interview, participants were debriefed, providing additional information about the study's goals and addressing any questions or concerns they might have.

Data Analysis

To effectively use the usability test results via the Think-Aloud Method and the interview questions, the collected data was transcribed using the software TurboScribe (*TurboScribe: Transcribe Audio and Video to Text*, 2023). The researchers used orthographic transcription (i.e. word by word) because they were interested in the participants' concerns. A data-driven approach was chosen to discover new insights instead of having any pre-determined theoretical concepts, ideas or predictions of the data (Harrison & Rentzelas, 2020).

A thematic analysis approach was chosen to analyse the transcripts of the usability tasks and interview questions because the researchers were interested in extracting themes to identify commonalities among the participant’s answers. The analysis was conducted by following the six steps of thematic analysis and by using the software ATLAS.ti (ATLAS.ti Scientific Software Development GmbH, 2024). Firstly, the researchers familiarised themselves with the data. Secondly, initial codes were generated by highlighting interesting points while reading the transcripts. Thirdly, the researchers refocused on searching for broader themes among the initial codes. Fourthly, the themes were reviewed again to refine the list by removing or recombining themes. Fifthly, the individual themes were named and defined. Sixthly, transcripts were recoded using the final thematic list (Harrison & Rentzelas, 2020). There was created one coding scheme for each of the two development stages.

Results

The research question ‘How to improve the usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction of a Cognitive Bias Modification app to increase its potential for adherence?’ guided the analysis process. The observations of the researchers aligned with the interview transcripts.

PSS-4 Test Results

Within each interview, participants were asked to fill out the PSS-4. The scores of each participant per test can be found in Table 1. In the first research phase, all participants had a moderate stress level. In the second research phase, three participants were moderately stressed and two had a low stress level. On average, participants had a moderate stress level in both tests.

Table 1

Results of the PSS-4

Participant	Score	
	Test 1	Test 2
P1	8	6
P2	9	8
P3	8	6
P4	10	10
P5	8	11
Mean (SD)	8.6 (0.8)	8.2 (2.04)

Codes After the First Research Phase

After the first research phase, 11 codes were found that were sorted into four code groups that were in line with the usability aspects addressed in the research question (i.e.

Learnability, Efficiency, Error Prevention, and Satisfaction). An overview of the coding scheme including each code's frequency of positive and negative comments can be found in Table 2.

Table 2

Quantity of Codes of the First *Research Phase*

Code	Frequency of Comments	
	Positive (%)	Negative (%)
Learnability		
Navigation		5 (100%)
Question Layout	8 (25%)	24 (75%)
Module Layout		12 (100%)
General Layout	13 (56.5%)	10 (43.5%)
Efficiency		
Retrieving Personal Events		4 (100%)
Word Limit		4 (100%)
Error Prevention		
Loading Time		4 (100%)
Terminology		6 (100%)
Satisfaction		

General Critique	7 (53.8%)	6 (46.2%)
Consistency		6 (100%)
Diversity		8 (100%)
Total	28 (24%)	89 (76%)

Code Group: Learnability

Within the group of Learnability, four codes were established. The first code ‘Navigation’ refers to participants’ comments about the navigational flow of the app. Participants expressed frustration with the app stemming from limited freedom to navigate the interface like the inability to return to the menu easily. For example, one participant said ‘I think it's annoying that you can't click on return.’

The second code ‘Question Layout’ refers to quotes about the presentation of questions. On the one hand, participants criticised that the formulation of some questions was too long which made it difficult to understand when first reading them. Especially, the attention bias modification question was difficult for the participants to understand: ‘It is 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’. Additionally, it was criticised that there was no neutral answer category on the Likert scale. Furthermore, it was noted that the words ‘very unpleasant’ and ‘very pleasant’ were difficult to read. They appeared as one word because they were too long for the mobile screen. On the other hand, participants described that they preferred the Likert Scales over the open questions. They were ‘easy because it was straightforward questions compared to the other ones’.

The third code ‘Module Layout’ refers to participants’ quotes about the presentation of the modules. They faced difficulties assessing what the modules were about because their

names were abbreviated in the menu. Furthermore, the module order was different to what they expected. Participants criticised this discrepancy, stating it was difficult for them to anticipate what module would come next or where to find the right questionnaire: ‘So I think this would be nice if it's in a fixed order where I have to search less’.

The fourth code ‘General Layout’ encompasses participants' comments about the presentation of the general interface. On the one hand, they liked the app’s straightforwardness because there is just one question at a time, they could see when questions and modules were already answered and how many were left, that there were ‘finish’ and ‘previous’ buttons, that the colours in the app were calming and that there was an overview of the given answers when finishing the module. One participant stated that the app was ‘incredibly easy to understand’. On the other hand, they criticised that it was sometimes difficult to understand what had to be done. They wished for more direct information on how to answer the questions: ‘I think having a definition or an explanation about what is meant by the most significant event compared to the most important event would be helpful’.

Code Group: Efficiency

Within the group of Efficiency, two codes were established. The first code ‘Retrieving Personal Events’ refers to participants' experiences with recalling events when engaging in the app’s tasks. They found it difficult to recall positive memories within the memory bias modification modules because they did not experience so much on that day: ‘I don't know maybe if I would be stressed in the morning then thinking about the nicest and most pleasant event since I woke up would be difficult because I did not yet experience so much’.

The second code ‘Word Limit’ refers to participants' feedback on the number of words they could enter. For example, participants had difficulties restricting themselves to describing certain events in a maximum of five words: ‘You could write a whole essay about that’.

Code Group: Error Prevention

Within the group of Error prevention, two codes were established. The first code ‘Loading Time’ refers to participants' comments about the duration it takes for the app to load or respond. They stated troubles using the app due to delays in accessing different pages or being able to type in their answers: ‘It is loading a bit long’.

The second code ‘Terminology’ refers to comments about the understandability of words. There were difficulties among all participants because they did not know one term which was the word *gloomy*.

Code Group: Satisfaction

Within the group of satisfaction, three codes were established. The first code ‘General Critique’ refers to quotes of participants commenting on their overall experience using the app. On the one hand, common themes within this code included participants expressing frustration over the time-consuming nature of the app, annoyance with design choices, or a general perception of the app's lack of usefulness: ‘I do not feel better after completing the questionnaires’. On the other hand, participants described that they liked the simplicity of the app, the rewarding feeling of completing the questionnaires, that it helped them to gain positivity, and that there was a variety of CBM techniques.

The second code ‘Consistency’ refers to comments regarding the coherence of elements within the app interface. They mentioned inconsistencies in capitalisation or abbreviations of words, and unnecessary bullet points in some of the questions.

The third code ‘Diversity’ refers to quotes regarding the variety of content. They criticised a lack of diversity in the question formulation. The questions were very similar, and participants were unsure about the distinctions between them: ‘Now I'm a bit confused, […] how is this question different to the other?’.

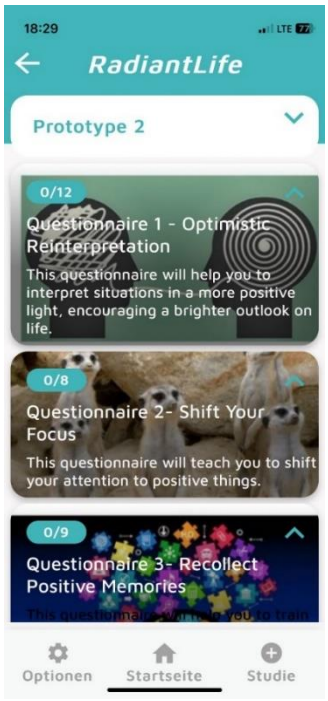
Creation of the Second Prototype

Based on the codes established after the first research phase, the researchers assessed the most significant and feasible points for improvement within the TIIM environment. They examined that the 'Navigation' and 'Loading Time' codes are errors within the TIIM environment that can not be changed when using this software. Due to some positive impressions of the 'General Layout', the researchers kept the simplicity and colours of the app design. To address the critique of the 'Question Layout', the Likert Scale format was changed from horizontal to vertical to improve readability. Additionally, a neutral answer option was added. Moreover, the researchers critically evaluated all questions, changed formulations of open questions, and made the overall layout more coherent to address issues due to 'Consistency'. The researchers gave the app a name (i.e. 'RadiantLife') to make it more realistic and interesting to approach participants 'General Critique'. Additionally, three design changes were made to make the app more user-friendly.

Firstly, because participants criticised the 'Module Layout', the researchers reduced the number of modules from nine to three. Some questions were deleted (i.e. questions about sleep and the end of the day) since they were used as control questions in the study by Visser et al. (2019) which did not make sense within this study because participants did not use the prototype daily. The only control question in the second prototype was how participants evaluated their mood on a Likert Scale from one to ten before and after filling in a questionnaire to gather relevant data on satisfaction associated with the prototype usage. The modules themselves were categorised and named by their cognitive bias modification techniques. To avoid confusion, the researchers gave the modules more comprehensible names. Additionally, they included small pictures and short descriptions for each module to make it more appealing (Figure 2).

Figure 2

Homescreen of the RadiantLife App Prototype



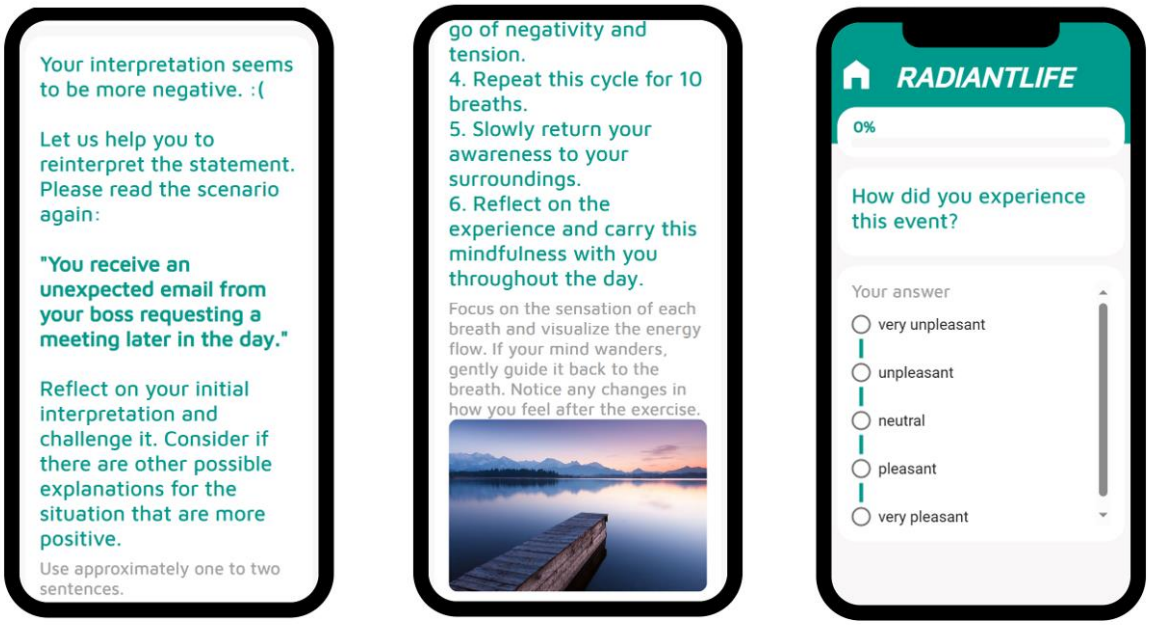
Secondly, when entering the modules, participants were provided with a short description of the purpose of each questionnaire. This was a response to the request for additional information to understand what has to be done. For questions that posed challenges, such as difficulty in 'Retrieving Personal Events', complex 'Question Layout', 'Word Limit' restriction and unfamiliar 'Terminology', the researcher changed the wording and layout and provided additional hints to guide participants in formulating their answers.

Thirdly, to address the lack of 'Diversity' all three modules were designed differently in their content (Figure 3). In the Interpretation Bias Module, participants were asked to evaluate ambiguous situations on a Likert Scale that ranged from *very negative* to *very positive*. If their interpretation was neutral or positive, they were prompted with a rewarding congratulation and were then directed to the next scenario. However, if their interpretation was more negative, they were encouraged to reinterpret the situation before proceeding with the next scenario. In the Attention Bias Modification Questionnaire, participants were invited

to do a mindfulness meditation exercise to redirect their focus on the positive things in life. The Memory Bias Modification Questionnaire included the same questions as the first prototype. However, layout changes were made to improve consistency. After completing each module, participants were congratulated for working on their mental health.

Figure 3

Example Screenshots for each Module of the RadiantLife App Prototype



Note. From Left to Right: Interpretation Bias-, Attention Bias-, and Memory Bias Module.

Codes After the Second Research Phase

After the second research phase, 7 codes were determined that were again sorted into the four code groups in line with the four usability aspects addressed in the research question (i.e. Learnability, Efficiency, Error Prevention, and Satisfaction). Of the seven codes of the first coding scheme, six were maintained in the second coding scheme (i.e. Navigation, Module Layout, General Layout, Retrieving Personal Events, General Critique, and Diversity). Their definitions stayed the same as stated in the section *Codes After the First Research Phase* and will not be discussed again. However, the content of the quotes changed and will be summarised. Besides that, one code was added based on participants' comments

(i.e. Progress Bar). Five codes from the first coding scheme did not occur in the second research phase due to a lack of quotes addressing these topics (i.e. Question Layout, Word Limit, Loading Time, Terminology, and Consistency).

An overview of the coding scheme including each code's frequency of positive and negative comments can be found in Table 3.

Table 3

Coding Scheme of the Second Research Phase

Code	Frequency of Comments	
	Positive (%)	Negative (%)
Learnability		
Navigation	39 (90.7%)	4 (9.3%)
Module Layout	11 (100%)	
General Layout	22 (100%)	
Efficiency		
Retrieving Personal Events		3 (100%)
Error Prevention		
Progress Bar		8 (100%)
Satisfaction		
General Critique	52 (100%)	

Diversity		13 (100%)
Total	124 (81.6%)	28 (18.4%)

Code Group: Learnability

Within the group of Learnability, three codes were established. Similar to the first research phase, quotes within the code ‘Navigation’ indicated that participants’ navigation flow was disrupted by a lack of possibility to move freely through the app. For example, one participant said ‘At one point I couldn't see the *Go back to the menu* button’. However, there were also positive comments from participants who appreciated how straightforward it was to understand what actions they needed to take because they felt guided in how to proceed.

The second code ‘Module Layout’ shows exclusively positive comments contrary to the first research phase. Participants preferred the new module arrangement into three main modules in the right order, the clear definitions and names of modules, and the explanation of the questionnaire techniques: ‘I think helpful was that it was explained how these methods work. […] I can get the sense’.

The third code ‘General Layout’ now also exclusively includes positive quotes, opposing the comments in the first research phase. Participants appreciated the new Likert Scale Design, the pictures, the cohesiveness, and the readability: ‘Last time I was so triggered because the fonts didn't fit each other and sometimes there were bullet points, sometimes there weren't. It was ugly, there were no pictures, there was no explanation. And there were like 20 questionnaires. Now it is 100% better’.

Code Group: Efficiency

Within the group of Efficiency, one code was established. The code ‘Retrieving Personal Events’ is similar to the issues encountered in the first prototype of participants

facing difficulties retrieving positive memories within the memory bias modification modules because they did not experience so much that day.

Code Group: Error Prevention

Within the group of Error Prevention, one new code was established called ‘Progress Bar’. Here, one participant noticed that the progress bar percentage did not end at 100% when finishing the questionnaires: ‘If I end the questionnaire there, it says only 88 per cent’.

Code Group: Satisfaction

Within the group of Satisfaction, two codes were established. The first code ‘General Critique’ summarises all user satisfaction comments as in the first research phase. However, in the second research phase, quotes were exclusively positive. This can be demonstrated by the following quote: ‘I think it's plus 100 per cent. I saw the design and I was like wow, that's improvement’. Furthermore, participants stated that they enjoyed the task within the attention bias modification module and appreciated the positive feedback they got after finishing some tasks because it motivated them to continue. Additionally, participants believed in the app’s potential to support a positive mindset and reduce stress: ‘I could use the app to get a clear mind and to take a step back.’

The second code ‘Diversity’ refers to participants’ comments about task diversity. Similarly to the quotes in the first research phase, they expressed concern that the questionnaires could be perceived as monotonous and repetitive when filling them out daily. Specific suggestions to increase diversity were incorporating features such as a graph indicating completion frequency for each module, integrating positive affirmations, introducing various media types like audio or video descriptions, and allowing users to customise the interface, such as choosing preferred colours. Furthermore, one participant proposed giving the app a distinct brand identity: ‘Maybe the app could benefit from a certain

style with a logo, a little avatar, or home design, because now it had visuals, but they were not connected'.

Discussion

This paper aimed to explore: 'How to improve the usability aspects of Learnability, Efficiency, Error prevention, and Satisfaction of a Cognitive Bias Modification app to increase its potential for adherence?' The comparison of the codes and their quotes showed that the second prototype was more user-friendly supported by the mainly positive quotes and the evaluation of the researchers.

Altogether, this study identified four key points for improving the usability of a CBM app to avoid frustration and increase user adherence. Firstly, to improve Learnability and reduce frustrations, designers should create an interface that is easy to understand and provides freedom in navigation like integrating an emergency exit that directly leads the user back to the home menu. Secondly, to improve Efficiency, a minimalistic design should be used. In addition, designers should consider the timing of sending out questionnaires to adapt their formulation based on the moment of the day. Thirdly, for Error Prevention, high-quality software to create the prototypes and an iterative design process should be used to prevent issues like loading times and progress bar inaccuracies that could lead to frustrations. Fourthly, for user Satisfaction, a cohesive yet diverse and engaging design can help to prevent monotony. Additionally, designers should incorporate participants' suggestions to adapt to their needs. The following will discuss each of the four findings in depth.

Learnability

The discussion of Learnability was guided by the question: 'What challenges do users face in learning the basic functions of the prototypes in their first interaction and how can they be reduced?'. In the first prototype, users were disrupted in their navigational flow, were confused by the module and question layout and found it difficult to understand what they

had to do. The researchers decided to face these issues by changing the overall layout according to participants' comments, which resulted in participants stating overall ease of use and comprehensibility. The improved perception of the app interface can be explained by Norman's theory of mental models which states that users create internal representations based on their experiences (Nielsen & Chan, 2024). A mental model allows users to understand the app based on interactions with other systems. This helps them to learn the new system faster because they can rely on their previous knowledge (Nielsen & Chan, 2024). The confusion caused by the initial prototype's layout suggests that the app design did not align with users' expectations of an app interface. Even though participants still faced navigation problems in the second prototype, these issues were mainly due to errors within the TIIM software. As participants stated they were annoyed by not having the possibility for free navigation, designers should include features like a home button. This is in line with the findings of Nielsen (n.d.) that a system should provide an 'emergency exit' that allows one to escape from an unwanted path if clicking on a wrong item. Thus, an intuitive app design that provides freedom in navigation improves Learnability because users can effectively understand how the interface works (Nielsen & Chan, 2024). This might be particularly important for CBM apps because their intended users deal with extensive stress, which decreases their ability to cope with frustrations (Folkman, 2013). Therefore, these users could benefit from avoiding extensive instructions or trial and error because it might increase their likelihood of adherence.

Efficiency

The discussion of the usability aspect of Efficiency was guided by the question: 'Which tasks do users find time-consuming or difficult to complete in the prototypes and how can this be changed?'. In both research phases, users faced difficulties recalling personal events in the memory modification questionnaire. This was mainly because participants did

not experience so much on that day. Schwarz (2007) found that the timing of sending questionnaires should be considered since context and time can influence cognitive processing and recall accuracy. Therefore, future designers should address this issue by adapting questionnaire formulation based on the moment of the day and giving additional hints to guide the user on what exactly to recall. Besides that, users stated that the open questions were more time-consuming and sometimes difficult to understand due to lengthy descriptions and too little information on how to answer the questions. Therefore, a straightforward design that leaves little room for interpretation of the questions was preferred. This aligns with Nielsen (n.d.) who found that unnecessary information distracts the user from the relevant content, highlighting the need for a minimalistic design.

Error Prevention

The discussion of the usability aspect of Error Prevention was guided by the question: 'What are common errors users make while using the prototypes and how can they be eliminated?' Besides minor errors, users faced difficulties with long loading times and with the percentage in the progress bar, probably caused by the software TIIM. As stated in the guide of Sommerville (2011), high-quality software is needed to create reliable, efficient, and user-friendly app interfaces. Additionally, literature about usability testing suggests that iterative testing is key in determining errors in a system to find the fundamental cause and eliminate it (Norman, 1988; The Interaction Design Foundation, 2024).

Satisfaction

The discussion of Satisfaction was guided by the question: 'What aspects of the prototypes do users find most satisfying or frustrating and how can user satisfaction be improved?'. During both usability tests, users perceived the app design as repetitive. Using an app regularly is more likely if people find the features in an app varied and interesting to prevent monotony (Norman, 1988). Therefore, future designers should increase the task

diversity of CBM apps. While interacting with the first prototype, users were frustrated by the lack of consistency and efficiency, repetitive question design and formulation, and a lack of perceived usefulness. Changes during the creation of the second prototype improved the feedback during the usability test which can be supported by the fact that the general critique was not just 53.8 but 100 per cent positive. This can be attributed to the iterative process: by considering the participant's requirements during the first usability test, the researchers understood the users' needs, which assisted them in designing the second prototype (The Interaction Design Foundation, 2024). Thus, to provide continuous improvements, Satisfaction can be further increased by incorporating participants' suggestions to adapt to their needs.

Limitations

This study faced four limitations. Firstly, the recruitment of participants via the researcher's contacts limited the diversity of the sample and might have introduced bias. All participants were female psychology students which might have influenced the results of the usability tests. Their perspective could differ from others in the target group due to their deeper understanding of psychological concepts. Furthermore, the sample consisted, on average, of moderately stressed participants, which differs from the final app targeting highly stressed individuals. Thus, the sample might not represent the app's intended users fully. Secondly, the study could not test the app daily due to time constraints. Using the app for a few days might have given further insights into how users' views of the app evolve over a longer duration. Thirdly, the study examined only two prototypes, which might not capture all potential usability issues. More iterative testing with additional prototypes could help to refine the app.

Practical Applications and Future Research

This study was the first to explore the usability aspects of a CBM app prototype. The iterative study design provided an idea of how each usability aspect can be improved to increase user adherence. Therefore, the results of this study can be used as a base to refine CBM apps to make mental health care more accessible for the broad population and alleviate the pressure off the mental health care system by potentially reducing cognitive bias.

Future research should look more into usability by using iterative evaluation to make the app more user-friendly. Researchers could, for example, explore options for more diversity in the content by including different media types or increasing the variation in questionnaire formulation. Additionally, when testing a new prototype, researchers could try to simulate real-life conditions more closely by letting participants use the prototype for several days.

Conclusion

To conclude, this study provided valuable insights into how to improve the usability aspects of Learnability, Efficiency, Error Prevention, and Satisfaction of CBM apps. This might be particularly important for a CBM app because its intended users deal with extensive stress, which decreases their ability to cope with frustrations that could deter individuals from using the app. It was found, that designers should create an interface that is easy to understand, closely connected to the user's expectations, explains used methods, and provides freedom in navigation. Furthermore, a minimalistic, cohesive yet diverse system should be used. Designers should consider the timing of sending questionnaires to adapt their formulation based on the moment of the day. In addition, a high-quality software and an iterative design process should be used to prevent errors and adapt to users' needs. This study showed that user-centred iterative refinement is important to increase user friendliness and

adherence. Implementing these insights can help to refine future CBM apps to support the mental health care system by making mental health care more accessible.

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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:

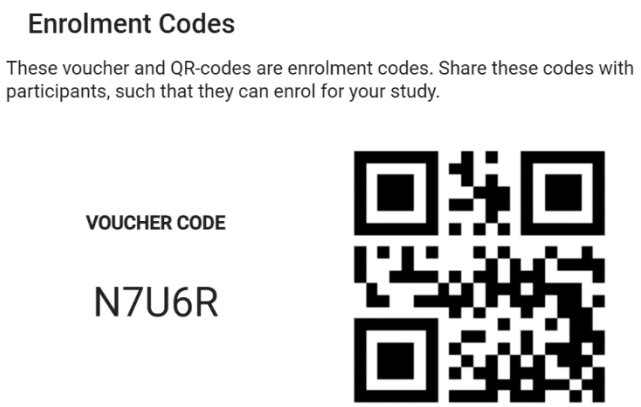
Sophie- Charlotte Degner, s.degner@student.utwente.nl

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

Appendix B: First Interview Schedule

Instructions before:

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



- 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

- 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 fill in 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

<u>Learnability:</u>

- 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?)

<u>Efficiency:</u>

- 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?"

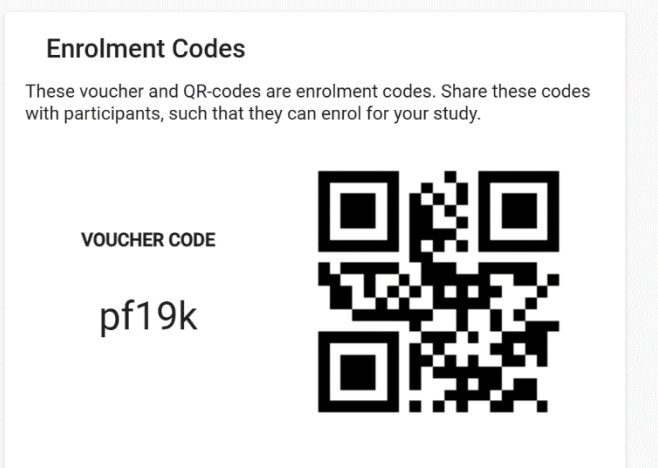
8. Conclusion

"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

Instructions before:

Apply for Study



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

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

<u>Efficiency</u> (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 contents app 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 Test Scale (PSS-4)

Figure D1

Screenshot of PSS-4 Instructions

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.