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Article

ReWIND: A CBT-Based Serious Game to Improve Cognitive Emotion Regulation and Anxiety Disorder

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Abstract

Games have shown successful intervention outcomes and can be used to complement the treatment of anxiety disorders. However, current serious game solutions are designed to be task-based rather than story-based. We present ReWIND, a serious role-playing game (RPG) applying cognitive behavioral therapy (CBT) to design anxiety-relevant storylines and game mechanics. ReWIND advances state-of-the-art mental health games by seamlessly integrating CBT elements and strategies into the game's storytelling so players can learn how CBT is applied in anxiety scenarios as they play through the game. Our goal is to examine the effectiveness of ReWIND in improving cognitive emotion regulation and anxiety disorders. Through a randomized controlled trial, 40 participants were recruited, of whom half were randomly assigned to play ReWIND while the others worked on a non-game task. Anxiety and cognitive emotion regulation levels were measured before and after the interventions. Our findings show ReWIND significantly reduces the severity level of anxiety symptoms and trait anxiety levels and increases perceived control of anxiety better than the non-game task. ReWIND also obtained positive ratings for its usability and practicality in real life, helping participants to cope better with anxiety disorders.

1. Introduction

Serious games have great potential for expansion in various fields, including mental health [1]. With current technological advancement in video game development, the integration between game and healthcare treatment has shown to yield positive results [2], [3]. Serious games for mental health interventions are promising, thus bolstering the feasibility of developing a serious game for therapeutic purposes [4]. However, it is essential to devise non-invasive strategies to support the treatment of people suffering from mental illnesses. Otherwise, the

strategies may be perceived as coercive and cause an opposite effect during the therapy sessions. Hence, a better understanding of the efficacy of game intervention leveraging cognitive behavioral therapy (CBT) is important in introducing a better way to tackle issues in the mental health domain.

Specifically, we have chosen to focus on anxiety disorders as they are a common type of mental disorder, are highly prevalent among mental diseases, and inflict a significant burden on patients [5], [6]. Anxiety disorders can be caused by a number of psychosocial factors, including early adversity, stress, trauma, and genetic vulnerability, all of which can be present as neurobiological and cognitive dysfunctions [7]. With the widespread use and acceptance of digital technologies, it is worthwhile to investigate how game interventions may facilitate therapeutic processes for addressing anxiety-related issues affecting decision-making, behaviors, and quality of life. Existing studies have explored game solutions for specific anxiety disorders such as agoraphobia [8], social anxiety disorder (SAD) [9], post-traumatic stress disorder (PTSD) [10], and certain specific phobias [11], but the absence of a dedicated serious game intervention that seeks to improve the overall cognitive emotional regulation processes and anxiety level is the motivation of our study.

Existing gamification solutions [12] and serious games [2] for improving mental health and well-being lack a seamless infusion of cognitive-behavioral therapeutic theories into the gameplay due to the task-driven design. However, task-driven game solutions usually focus on extrinsic motivation such as collecting points, which is not enough to change negative thoughts and drive health behavioral changes [3], [13]. In this paper, we present the design of a serious game, ReWIND, focusing on game mechanics that make it an enjoyable and engaging game while infusing CBT elements into the gameplay and stories to improve cognitive emotion regulation and anxiety level. Role-playing game (RPG) is a game genre that naturally incorporates decision-making elements for the purpose of developing behavioral, social, and even language skills [14]. These elements are leveraged in ReWIND to guide individuals with anxiety disorders to change the way they perceive their surroundings using functional and rational means. Through the game's structural flow and storyline, we attempt to simulate real-life situations and lead players to think more clearly and thoroughly whenever they encounter similar occurrences in real life. By practicing ways of developing positive thought patterns towards the issues faced under negative stimuli through play, players' cognitive emotion regulation and anxiety disorders could be improved in real life.

Our main goal is to evaluate the overall performance of ReWIND particularly in the implementation of our CBT-game framework used to guide the design of RPG-style game mechanics and storylines in concert with therapeutic content. We tested several hypotheses with respect to ReWIND's capacity to reduce participants' anxiety symptoms and improve their cognitive emotion regulation. This study contributes to the development of a complementary and non-intrusive therapeutic solution that assumes the form of a game with more meaningful and anxiety-relevant content and gameplay. Specifically, we show how CBT elements can be incorporated into gaming dynamics to improve cognitive emotion regulation and anxiety disorders in participants showing moderate to high anxiety.

2. Related Work

Prior studies on gamification and serious games for mental health treatment predominantly target children and adolescents with an age group ranging from 7 to 19 years old. For example, Treasure Hunt [15], [16] is designed for the age group 8 to 13, SmartCAT2.0 [17] for 9 to 14, and SPARX [18] for 12 to 19. Existing research studies focus on game designs that are geared towards younger populations. As a result, existing therapeutic games targeting anxiety may not appeal to or be as effective for adults.

Furthermore, most existing game-based solutions narrowly target only one specific type of anxiety disorder such as SAD [9], [19], and specific phobia [11] including agoraphobia [8], which can limit the game's relevance to a broader population with anxiety disorders. Some games also do not focus solely on anxiety (e.g., Dojo [20] targets externalizing and anxiety problems while Pesky gNATs [21], [22] targets depression and anxiety). Meanwhile, ReWIND focuses on anxiety alone but increases the breadth of coverage within the anxiety space to cater for anxiety disorders at a more general level or can be extended to cover more than one specific type of anxiety disorder.

CBT, a mixture of cognitive and behavioral intervention strategies, has been proven to be effective in the treatment of anxiety disorders [23], but has only been introduced into games as a series of tasks in previous studies [8], [9], [17], [24]. In other words, CBT elements are not connected seamlessly with each other within the game flow or storyline. Instead, the CBT elements are delivered separately and one at a time to players. For example, the first task in the game introduces players to cognitive distortion before moving on to the second task, which introduces effective coping strategies. Both tasks are carried out in separate sessions, thus CBT is not delivered in its entirety when players go through the game during each session. As such, players may struggle to understand the more holistic view of CBT and how each element is related to each other. This is due to the nature of gamification being partially game-based [25] or the serious game is designed to be task-driven in the first place.

There has not been any research on using CBT in games with story-driven settings to help people with anxiety disorders. One probable reason is the difficulty of integrating session-based CBT content into a story-based design. The challenge lies in creating standardized, anxiety-relevant scenarios while incorporating CBT elements, especially when the scenarios must reflect a wide range of symptoms experienced by individuals with anxiety disorders. This is the challenge we have undertaken in our study with the design of ReWIND.

In terms of CBT game evaluation, the most common measures include pre- and post-tests on anxiety symptoms and game usability, particularly satisfaction in playing the game. Only SmartCAT 2.0 [17] included more specific learning measures to assess the acquisition of four CBT skills. Dojo [20] and Pesky gNATS [21], [22] also included behavioral measures focusing on externalizing and internalizing behaviors. In our study, we adopted the common pre- and post-test design on the assessment of anxiety scales but also included cognitive emotion regulation measures to gauge the efficacy of ReWIND.

3. ReWIND: A story-based CBT serious game

ReWIND is a CBT-based serious game in the role-playing game (RPG) genre designed specifically to improve cognitive emotion regulations and anxiety disorders in patients through psychoeducation. The use of RPGs for both healthcare and educational purposes has been supported by various studies [26], [27]. As ReWIND is designed for young adults, we created a three-dimensional (3D) virtual world enriched with anxiety-relevant stories in which the players explore through a third-person perspective (i.e., role-play). The 3D virtual world affords a greater level of immersion and a sense of "actually being there", thus providing a more vivid experience in challenging players to change distorted beliefs through the character's actions and consequences in role-play scenarios [27], [28]. ReWIND is a PC game developed with Unity Game Engine 2019 LTS. We have chosen PC as the platform for ReWIND as PC games remain the most accessible and widely used in anxiety reduction interventions [29], particularly among young adults our game targets.

The overarching story revolves around the virtual character named Lucas, a pathfinder who travels around the game world and encounters six quest givers (Alisa, Ben, Lars, Elizabeth, Louisa and Roman) in need of help to overcome anxiety-inducing hardships. Players play the role of Lucas and assist quest givers in resolving their problems to complete each quest in the

game. In the first encounter, a quest giver explains to Lucas the problem he or she faces, including the distorted beliefs and the consequences (Figure 1a). By completing a series of interactions with other non-playing characters (NPCs) as well as tasks such as item gathering (collect items requested by an NPC) and maze-solving (reach the end of the maze), players learn a set of CBT strategies in the process of disputing the distorted beliefs of the quest givers through Lucas' perspective (Figure 1b and Figure 1c). Upon the completion of a quest, players observe the new effect of successful disputation along with a summary (Figure 1d).

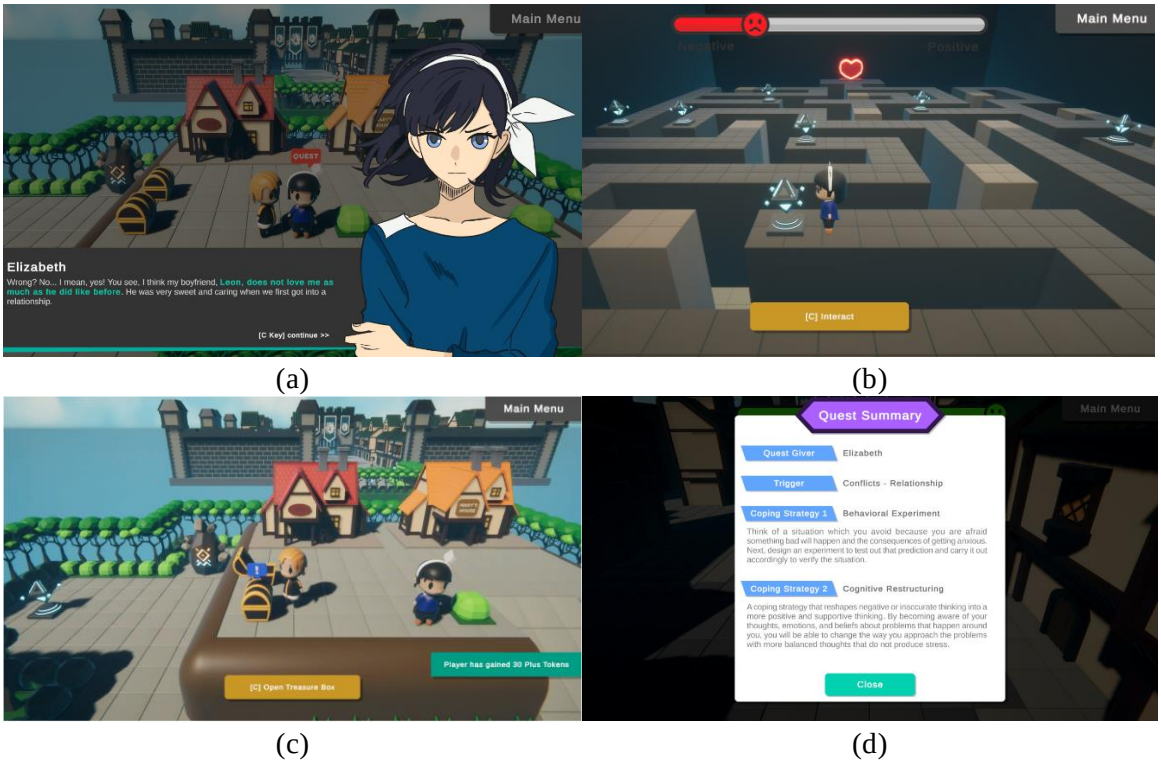


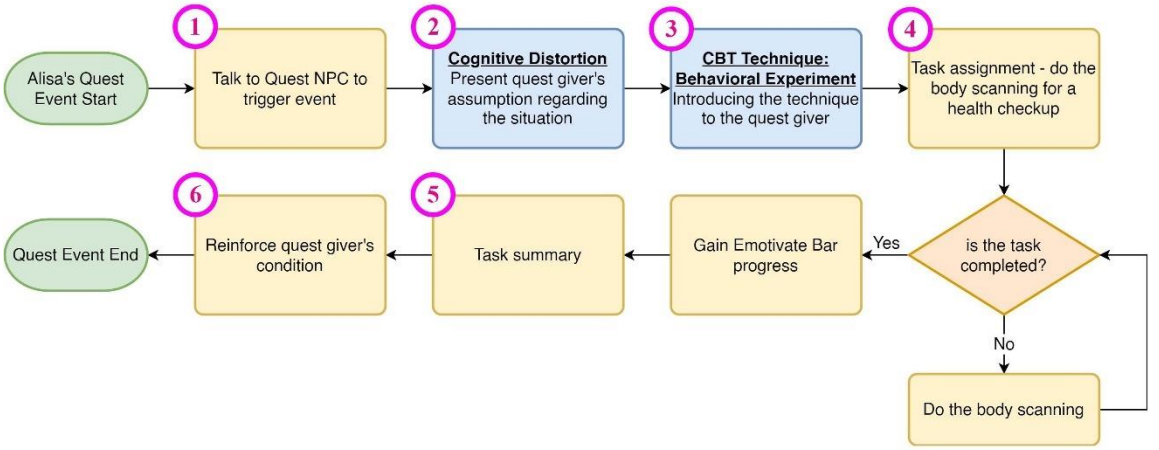
Figure 1. Players learn various CBT strategies by playing through each quest in ReWIND through Lucas' perspective

ReWIND attempts to stimulate the player's cognition in different situations through anxiety-relevant sub-stories embedded within a quest in the game and to think more critically through Lucas' perspective. Each sub-story is designed as a game scenario or quest anchored on Ellis' ABCDE model [30] of activating event (A), belief (B), consequence (C), disputation (D), and effect (E), a CBT model based on the Rational-Emotive Behavior Therapy (REBT) framework, to simulate situations where individuals with anxiety disorders might find hard to overcome. The game scenarios were remodeled after actual experiences and symptoms described in anxiety posts on mental health forums. We selected anxiety posts in which the writers either catastrophized, kept ruminating, or exhibited a lack of refocus on planning about an activating event (A), leading to irrational beliefs (B) that trigger anxiety. Catastrophizing [31], [32], rumination [33]–[35] and a lack of refocus on planning [36], [37] are three cognitive emotion regulation (CER) deficits common in anxiety disorders. As a result of the irrational beliefs, the negative impact on daily functioning serves as a reference for the corresponding consequences (C). The A, B, and C are materialized as a series of dialogs between Lucas and the quest givers. We consistently used dialogs to showcase the interactions between game characters to avoid introducing too much variability in the storytelling. ReWIND then teaches the player how to identify and dispute (D) the irrational beliefs through the incorporation of two CBT coping strategies, a decision-making question within the storyline and game mechanics in each quest. The following five CBT coping strategies, including two mindfulness trainings consistent with general CBT principles [38], are introduced in ReWIND.

a. **Behavioral experiment**: A CBT technique that involves patients planning out experiments and testing out their anxious thoughts and fears [39]. In Alisa's quest revolving around health fear shown in Figure 2, Dr. Gwen introduces behavioral experiment to Alisa by asking her to test the validity of her health fear through a series of information gathering activities designed to collect evidence to invalidate her irrational beliefs, including examining the outcome of a body scan reflecting her actual healthy condition.
b. **Cognitive restructuring**: A CBT technique aimed at reshaping negative or faulty thoughts, evaluations, and beliefs that cause psychological disturbance into more positive and supportive ones [40], [41]. The cognitive restructuring process is reflected in Elizabeth's quest shown in Figure 3, in which Elizabeth goes through a maze and reshapes her cognitive distortion caused by fear arising from relationship conflicts. She is exposed to different questioning and problem-examining processes that eventually generate alternatives that bring about cognitive changes.
c. **Problem-solving**: Problem-solving is an approach used in CBT focusing on internal thought processes as one mechanism of change, starting with identifying the general orientation, followed by problem definition, alternative generation, decision-making, and lastly outcome verification [42]–[44]. Roman's quest centering around work stress incorporates problem-solving into the storyline shown in Figure 4. Roman is told to ask his colleagues for suggestions to improve his work performance, whereby he is exposed to different problems he struggles with and alternatives to those problems. The quest event ends with him making his decision after verifying the outcome.
d. **Relaxation**: Breathing exercises are another CBT technique that can help patients relax the body while at the same time developing the good habit of prioritizing a short time for daily relaxation [39]. Figure 5 shows how breathing exercise is introduced in the form of meditation under the waterfall (takigyo) in the storyline after Master Yamato has heard about Lars' fear of being at death's door. Players are encouraged to follow the instructions and perform the breathing exercise together with the character.
e. **Mindfulness practice**: Mindfulness, being part of the third wave of CBT approaches, is defined as recognizing what is happening in the present moment and focusing our attention on the task at hand [45]–[47]. In Louisa's quest on handling study stress, the player is introduced to mindfulness practice by engaging in the task of collecting specific rocks while observing the process as illustrated in Figure 6.

Finally, each quest ends with a positive effect (E) that reinforces the intended CBT impact. As the game progresses, players can observe the disputation (D) process and the effect of each quest, a process that consequently facilitates effective cognitive emotion regulation skills that may help improve anxiety disorders. The A, B, C and E are weaved into the storyline of a quest to provide contextual information vital to drive gameplay focused on D.

All six quests were designed with and verified by two psychology experts who are part of the research team and went through multiple rounds of playtesting. One key feature that makes ReWIND stand out from existing anxiety serious games is the built-in flexibility for players to explore the quests in any desired order in the 3D virtual world without following a strict sequential order or level. ReWIND was designed from scratch, including the virtual world, 3D models, game characters, animations, visual artwork, narratives and dialogs.



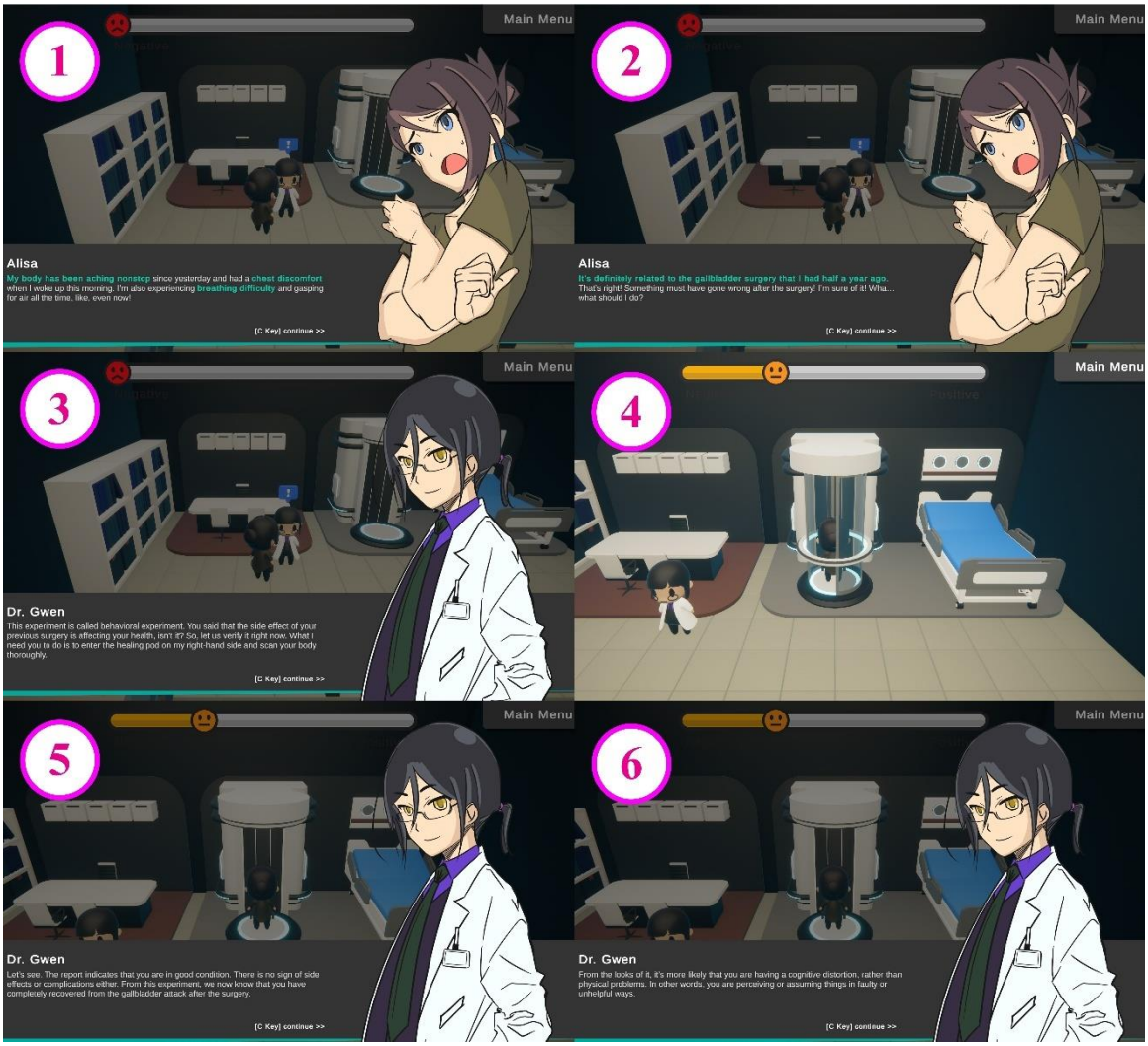


Figure 2. Alisa's quest with the behavioral experiment strategy

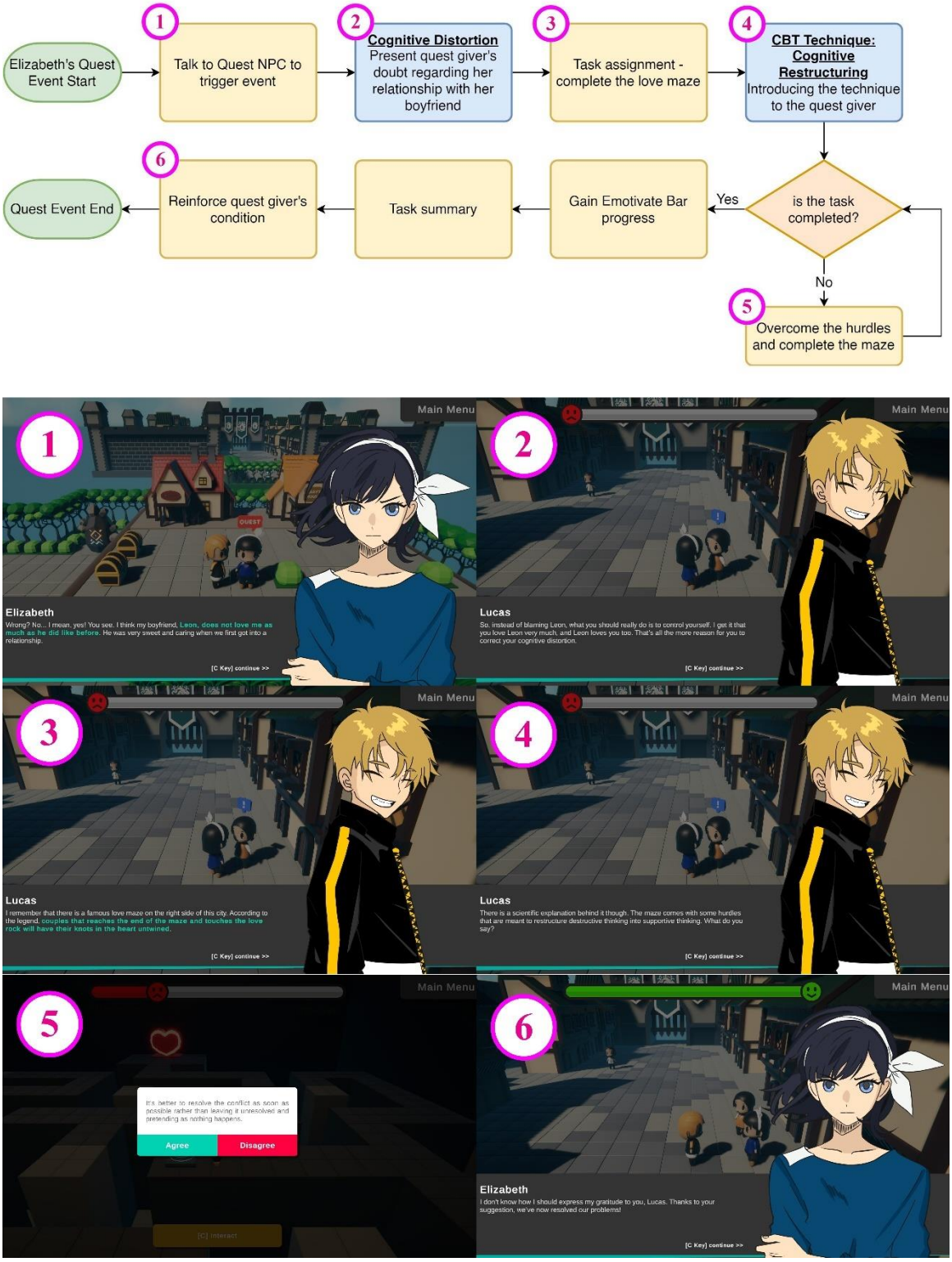
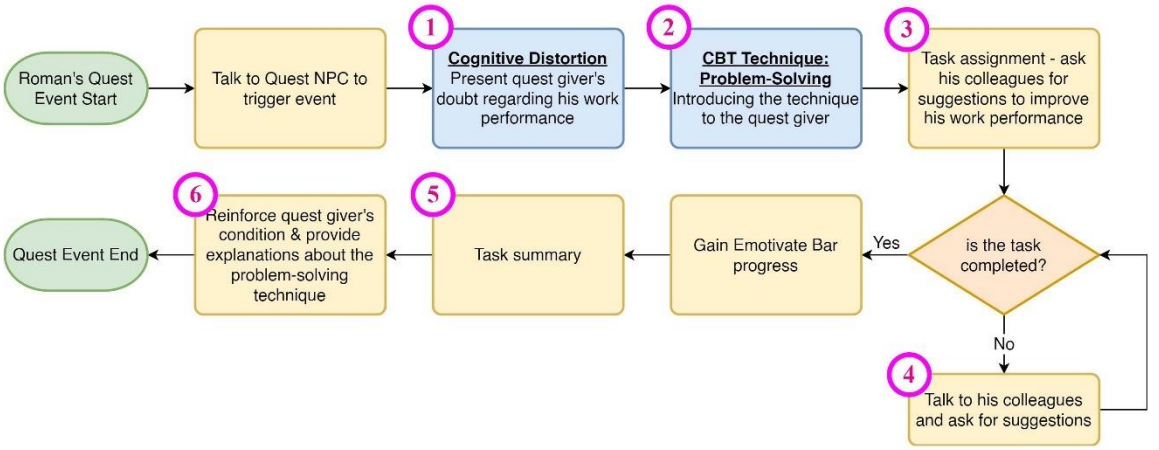


Figure 3. Elizabeth's quest with the cognitive restructuring strategy



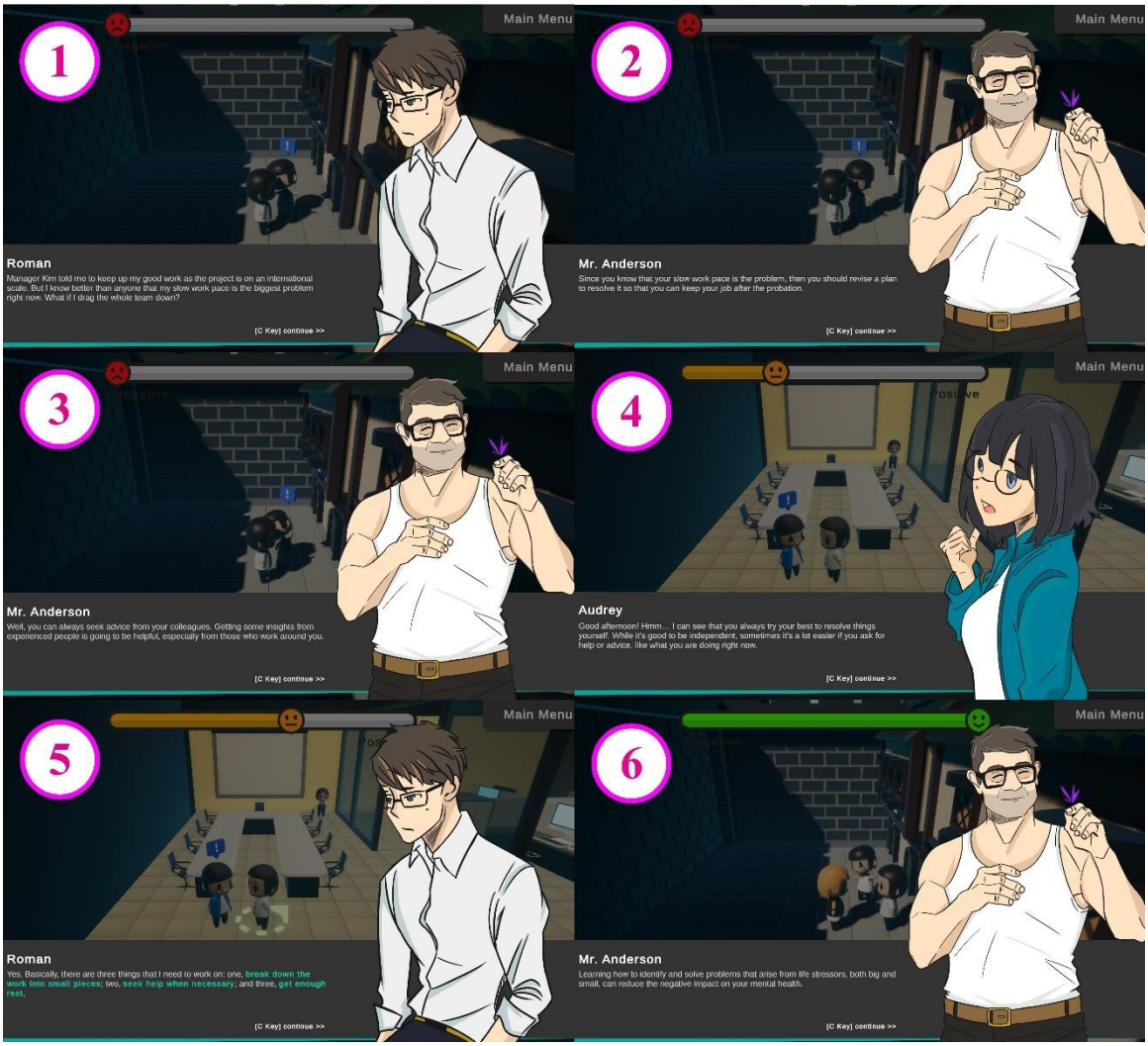


Figure 4. Roman's quest with the problem-solving strategy

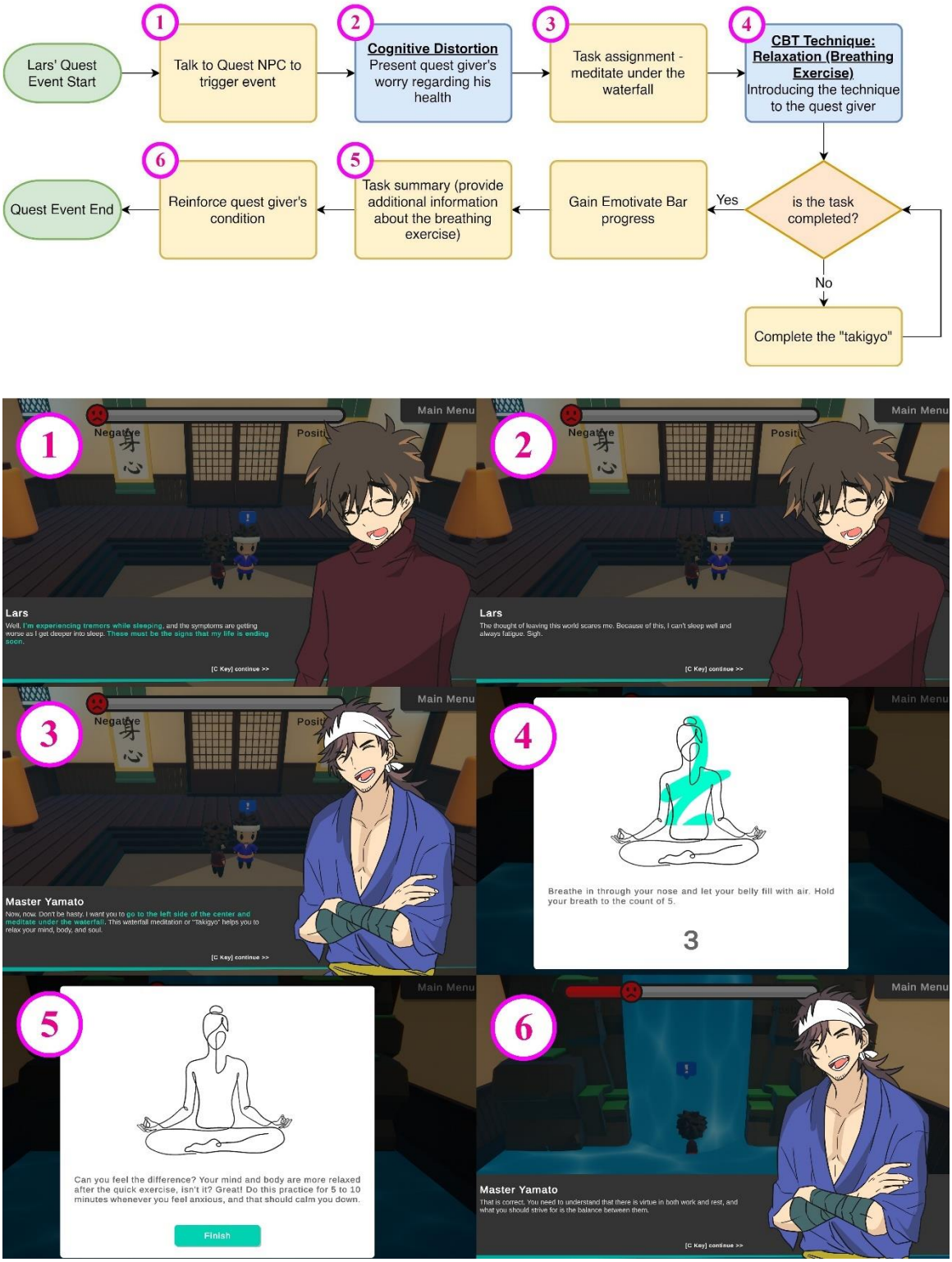


Figure 5. Lars' quest with the relaxation strategy

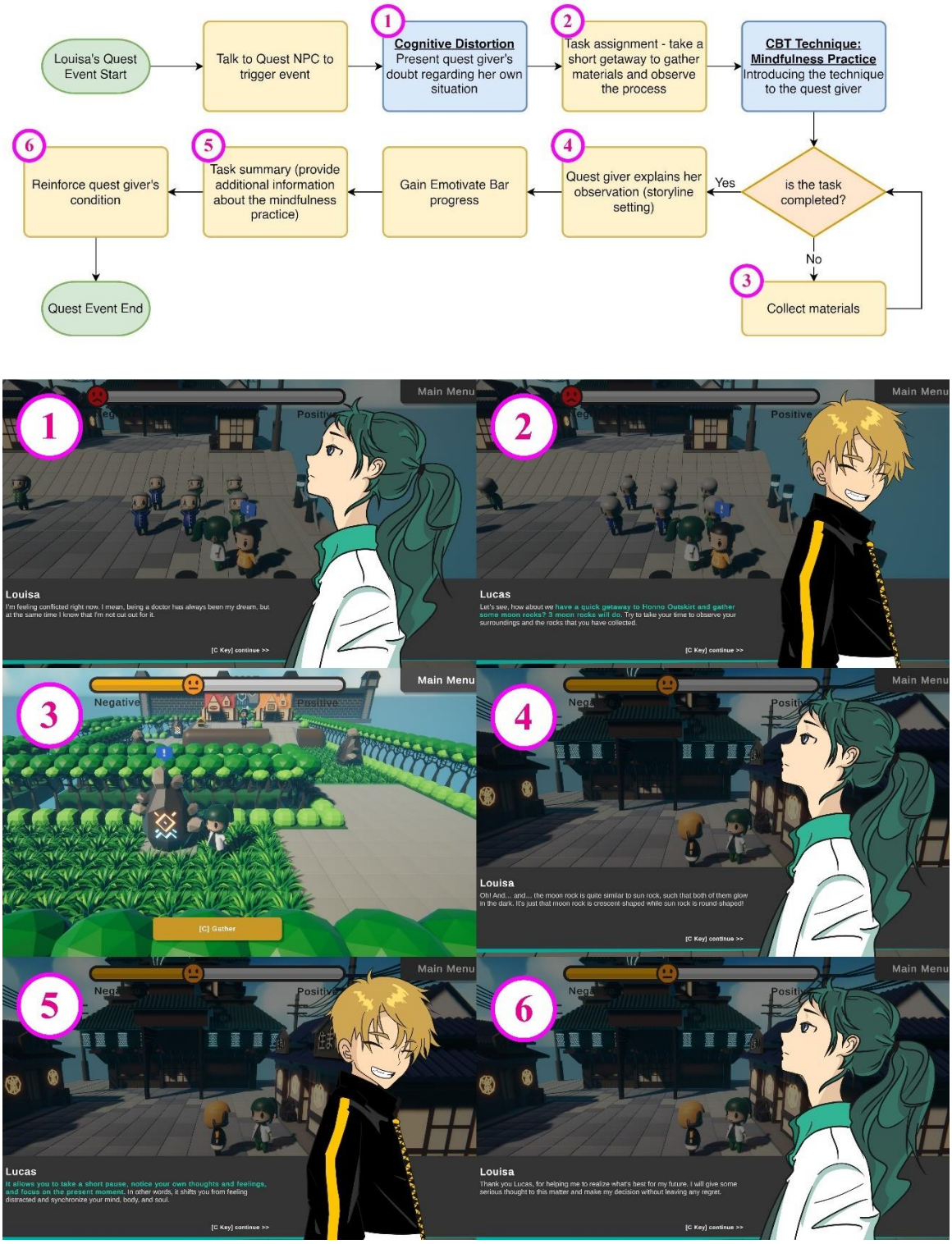


Figure 6. Louisa's quest with the mindfulness practice strategy

In addition, other game mechanics shown in Figure 7 have been designed to increase the playability of ReWIND. For example, the quest system serves as a bridge between the therapeutic content and the player, the decision-making dialog provides opportunities for the players to practice spontaneous decision-making skills, the Emotivate Bar visualizes emotional changes of the quest givers, the navigation system provides clues for orientation, and the in-game incentive system motivates players to explore the game world and keep playing.

Figure 7. The Emotivate Bar is visibly shown at the top of the game and the fluorescent circular arrow around the character controlled by the player provides navigation clues

4. Methodology

The aim of this study is to evaluate the effectiveness of ReWIND in improving cognitive emotion regulation and anxiety measures. In this study, a randomized controlled trial (RCT) as shown in Figure 8 was conducted. Participants who met the screening criteria were recruited and divided into two groups. The first group played the game, ReWIND (treatment group) while the second group worked on a non-game task (control group). Four instruments related to anxiety disorders and cognitive emotion regulation strategies (CERS) were used to measure the participant's condition before and after the intervention. Meanwhile, the game usability questionnaire was given only after the intervention.

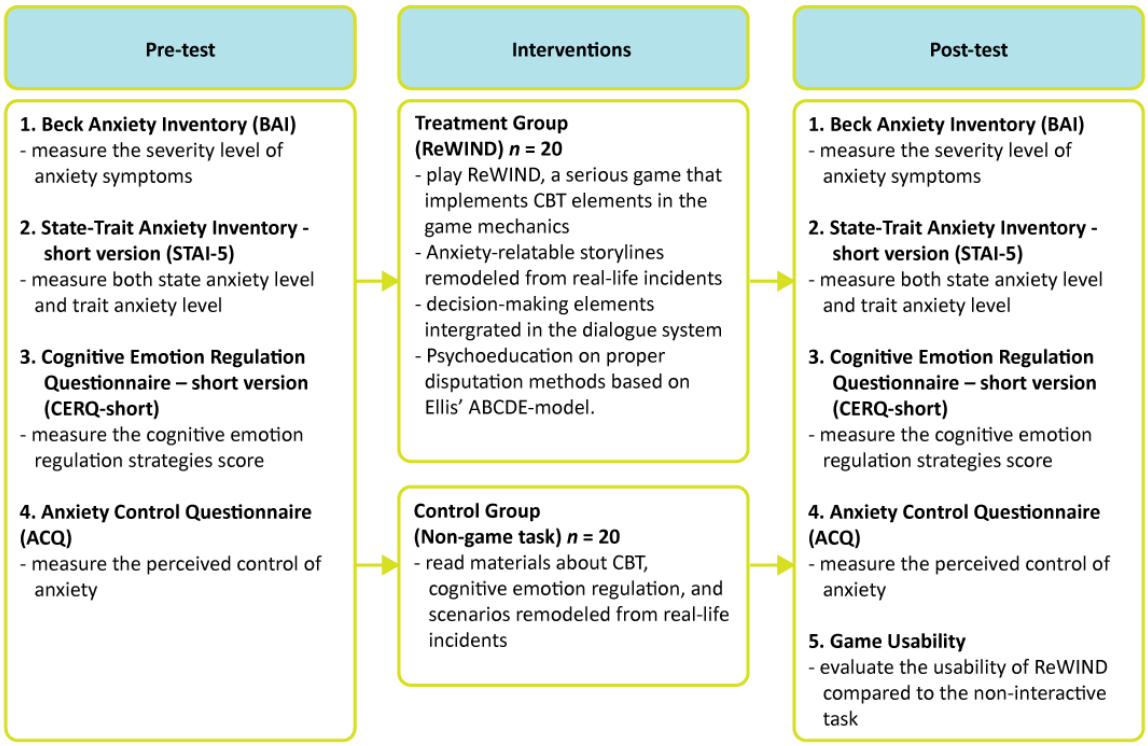


Figure 8. Experimental design for ReWIND

4.1 Hypotheses

Seven hypotheses shown in Table 1 were posited to investigate the effect of ReWIND on different constructs related to anxiety and cognitive emotion regulation. As for game usability, we compared ReWIND's aesthetics, relevance to real life and anxiety, fun, challenge, and satisfaction against the non-game task.

Table 1. Seven hypotheses posited in the study

Constructs	Hypotheses
Anxiety constructs	H1: ReWIND would lead to a greater decrease in the severity level of anxiety symptoms than the non-game task. H2: ReWIND would lead to a greater decrease in state anxiety than the non-game task. H3: ReWIND would lead to a greater decrease in trait anxiety than the non-game task. H4: ReWIND would lead to a greater increase in perceived control of anxiety than the non-game task.
Cognitive emotion regulation constructs	H5: ReWIND would lead to a greater decrease in rumination level than the non-game task. H6: ReWIND would lead to a greater decrease in catastrophizing level than the non-game task. H7: ReWIND would lead to a greater increase in the level of refocus on planning than the non-game task.

4.2 Measures

We measured anxiety through the severity of anxiety symptoms, state and trait anxiety levels, and perceived control of anxiety. Cognitive emotion regulation was measured through the frequency of participants engaging in three specific CERS (i.e., rumination, catastrophizing, and lack of refocus on planning) when they encountered negative events. For game usability, we focused on measuring aspects related to the game content and playability.

4.2.1 Severity level of anxiety symptoms

The Beck Anxiety Inventory (BAI) [48] is a self-report scale for anxiety with a focus on physical symptomatology. It consists of 21 items, including 13 items describing physiological symptoms, 5 items for cognitive aspects of anxiety, and 3 items for physical and cognitive connotation [49]. Each item is rated on a 4-point scale: 0 = "Not at all", 1 = "Mildly, but it didn't bother me much", 2 = "Moderately - it wasn't pleasant at times", and 3 = "Severely - it bothered me a lot". BAI yields one overall score indicating anxiety severity based on the symptoms experienced.

4.2.2 State and trait anxiety level

The short version of Spielberger State-Trait Anxiety Inventory (STAI-5) [50] was administered to assess both the state anxiety level and trait anxiety level of participants during the pre-test and post-test. State anxiety refers to the transitory emotional reaction to adverse events, whereas trait anxiety refers to the personality trait that predisposes people to manifest anxiety in threatening situations [51]–[53]. STAI-5 consists of two subscales: S-Anxiety subscale (STAIS-5) and T-Anxiety subscale (STAIT-5), whereby both sections contain 5 items each for different measurements. Participants are asked to rate how they feel at the current moment for STAIS-5 and how they generally feel about STAIT-5. Each item is rated on a 4-point scale: 1 = "Not at all", 2 = "Somewhat", 3 = "Moderately so", and 4 = "Very much so". It is sensitive to treatment effects and can test different aspects of anxiety, which is suitable for treatment outcome studies.

4.2.3 Cognitive emotion regulation strategies (CERS)

The Cognitive Emotion Regulation Questionnaire – short version (CERQ-short) [54] was administered to evaluate the cognitive emotion regulation strategies participants used in response to the experience of negative events. CERQ-short has 18-items in total and consists

of nine conceptually distinct subscales: (1) self-blame, (2) other-blame, (3) rumination, (4) catastrophizing, (5) putting into perspective, (6) positive refocusing, (7) positive reappraisal, (8) acceptance, and (9) refocus on planning. Based on our findings, individuals with anxiety disorders are more likely to have cognitive emotion regulation deficits in three cognitive aspects: rumination, catastrophizing, and lack of refocus on planning. Hence, we only considered subscales 3, 4, and 9 for the analysis. Each item is measured on a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always), and the individual subscale scores are obtained by summing the scores belonging to that subscale.

4.2.4 Perceived control of anxiety

The Anxiety Control Questionnaire (ACQ) [55] was administered to evaluate participants' perceived control of anxiety. The game scenarios in ReWIND were designed to help players rethink or rewire their thoughts about negative events and what they can do when they encounter negative events that would lead to more positive outcomes. As such, ACQ can be used to measure the perceived ability to control anxiety-inducing situations in participants. ACQ is a 30-item measurement consisting of 16 items for the event subscale and 14 items for the reaction subscale. Each item is measured on a 6-point Likert scale ranging from 0 (strongly disagree) to 5 (strongly agree), and the final score is obtained by summing the scores for both subscales. Following the state-of-the-art [56], the scale was used as a single measure regardless the existence of two possible factors in the scale: perceived control over internal emotional reactions and perceived control over external events.

4.2.5 Game usability

The six measures in our game usability questionnaire were adapted from MEEGA+ [57]. We selected only six usability measures similar to a prior study in evaluating the appeal of an anxiety game [58] but put a greater emphasis on story content relevance. The questions in our game usability questionnaire were reframed to fit both our story-based game and non-game contexts and reviewed by a game expert in the research team. We also ran through the usability questions in our initial game pilot tests with university student volunteers (i.e., playtesters) to ensure the questions were clearly comprehensible and understood. All participants were asked to evaluate the task performed in the intervention (applies to both treatment and control group) only in the post-test. The usability evaluation consists of 6 questions with different aspects rated on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree):

a. **Aesthetics**: The task is nice and appealing.
b. **Relevance (real life)**: The content in the task is applicable in real life.
c. **Fun**: The task is interesting enough to make me feel enjoyable during the therapeutic process.
d. **Relevance (anxiety)**: The content in the task is anxiety relatable.
e. **Challenge**: It is hard to go through all contents in the task.
f. **Satisfaction**: The task helps me cope better with my condition.

4.3 Participants

We targeted participants 18 years old or older from institutes of higher learning. Advertisements for the experimental study were posted on Facebook to recruit potential participants after obtaining ethical clearance from the USM Human Research Ethnics

Committee (JEPeM)[1] (Code: USM/JEPeM/21060492). Emails were also sent to university student mailing lists to reach out to a larger pool of potential participants. Those who expressed interest to participate in the experimental study were instructed to complete a screening questionnaire containing all items from BAI and STAI-5. Participants in both groups were told the study aimed to examine how CBT elements could be used in to educate players with anxiety to better handle negative emotions and were not informed of any specific expectations about anxiety to reduce the risk of priming. Participants were initially asked to provide informed consent to participate in the study and demographic information.

Participants who fulfilled the following criteria were accepted for the experimental study: (1) age of 18 or above, (2) able to understand and communicate in English, (3) willing and able to provide informed consent to participate in the experimental study, (4) have a total score of 22 or higher (moderate to severe anxiety) for BAI and (5) have a total score of 9.5 above for the S-Anxiety subscale or 13.5 above for the T-Anxiety subscale in STAI-5. Then, all qualified participants (i.e., participants showing moderate to high anxiety) were assigned to the treatment group and control group (n = 20 per group) using stratified random sampling. We used gender as the strata to ensure that the treatment and control groups have balanced numbers of male and female participants. In addition, pre-test screening results were also taken into consideration when dividing the groups to ensure that the experimental study commenced with both groups having a similar initial condition.

We estimated our target sample size based on previous studies related to CBT treatment for individuals with anxiety disorders [7], [59] using the statistical power analysis program G*Power 3 [60]. Studies have shown that CBT intervention has a medium to large effect size in anxiety disorders, hence we perform the computation with the following criteria: ANOVA repeated measures and within-between interaction with the effect size f = 0.25, alpha = 0.05, power = 0.85, number of groups = 2, and number of measurements = 2. The result indicated that a sample size of 19 participants for each group is required for the experimental study, leading to a total sample size of 38 participants. An adjustment has been made to round the number of participants per group to the nearest tenth, which resulted in the final sample size of 40 participants (2 extra participants to prepare for non-response and missing data).

The 40 participants who took part in the experimental study included 17 males (47.5%) and 23 females (57.5%). All participants were university students in Malaysia who were at least 18 years old. Participants were from various ethnic groups, including Malay (n = 13; 32.5%), Chinese (n = 21; 52.5%), Indian (n = 5; 12.5%), and Dusun (n = 1; 2.5%). A total of 11 female and 9 male participants were assigned to the treatment group, who played ReWIND during the intervention sessions. On the other hand, the control group, consisting of 12 female and 8 male participants, was assigned the non-game task. All participants from both groups completed all sessions without any dropout.

4.4 Experimental procedure

The intervention sessions were held throughout December 2021, and each session lasted from 30 minutes to 1 hour. For the treatment group, participants were required to attend three sessions in total. To avoid causing mental fatigue, we limited participants to play through only

[1] USM Human Research Ethics Committee: https://jepem.kk.usm.my

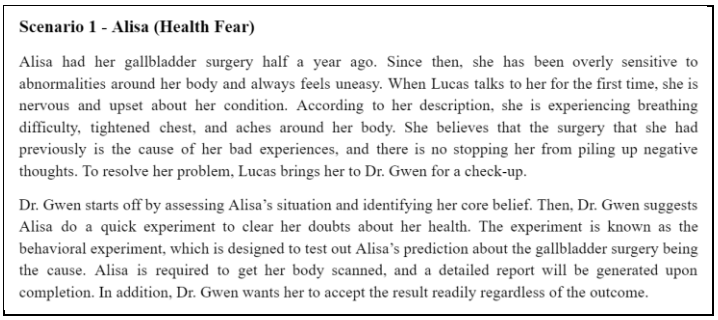
two game scenarios in each session under the observation of a researcher. To complete all six game scenarios, we scheduled three sessions with each participant in the treatment group. Meanwhile, there were only two sessions for participants in the control group due to the nature of the intervention. In the first session of the control group, we collected pre-test measures and assigned the non-game task in which participants could complete without any observation by the researcher. The second session was scheduled with the control participants to verify the completion of the non-game task and collect post-test measurements. Both groups completed all sessions within two weeks. Due to the COVID-19 pandemic, we tried to avoid face-to-face sessions with participants. As an alternative, all intervention sessions for both treatment and control groups were conducted online.

4.4.1 ReWIND (experimental group)

ReWIND is a CBT-based serious game assigned to participants in the experimental group during the intervention. The game controls consist of keyboard and mouse inputs to make it possible for participants to easily access the game remotely during the experiment. During the intervention sessions, participants were granted temporary remote-control access via Zoom Meeting to play the game. In other words, participants did not have to install the game on their own devices and were able to access the game as long as they were equipped with Internet connectivity. We went with such an arrangement to ensure the game ran smoothly without being affected by the differing hardware specifications of the participants' devices. Participants were given a short briefing about the gameplay and took the pre-test at the beginning of the first session, while the post-test questionnaire was administered in the third session (i.e., the last session for the treatment group). All sessions were supervised by a researcher to prepare for any unexpected adverse reaction. Participants were given clear instructions about the task at the beginning of every session. We attempted to control external factors by checking with participants to ensure the Internet connection was stable, asking participants to play ReWIND in a quiet environment, and observing participant readiness to work on the session task. Each session was recorded with the participant's consent. We also encouraged all participants to voice their thoughts (i.e., think aloud) while playing ReWIND and offered assistance as we observed their progress through the screen sharing feature.

4.4.2 Non-game task (control group)

The control group was assigned the non-game task instead of playing the game, whereby participants were asked to read the written materials without any interactive element. The reading material consisted of two parts. Part 1 introduced readers to cognitive behavioral therapy and emotion regulation deficits in the cognitive aspect. Part 2 described six different scenarios people with anxiety disorders are likely to encounter. An excerpt of a scenario is shown in Figure 9. All scenarios in writing shared similar content with game scenarios in ReWIND, including the storyline, portrayed characters, and coping strategies introduced. Participants took the pre-test at the beginning of the first session and the post-test at the end of the second session, which was also the last session for the control group. Given the nature of the task, participants were able to complete the reading task within the allocated duration of two weeks.



Scenario 1 - Alisa (Health Fear)

Alisa had her gallbladder surgery half a year ago. Since then, she has been overly sensitive to abnormalities around her body and always feels uneasy. When Lucas talks to her for the first time, she is nervous and upset about her condition. According to her description, she is experiencing breathing difficulty, tightened chest, and aches around her body. She believes that the surgery that she had previously is the cause of her bad experiences, and there is no stopping her from piling up negative thoughts. To resolve her problem, Lucas brings her to Dr. Gwen for a check-up.

Dr. Gwen starts off by assessing Alisa's situation and identifying her core belief. Then, Dr. Gwen suggests Alisa do a quick experiment to clear her doubts about her health. The experiment is known as the behavioral experiment, which is designed to test out Alisa's prediction about the gallbladder surgery being the cause. Alisa is required to get her body scanned, and a detailed report will be generated upon completion. In addition, Dr. Gwen wants her to accept the result readily regardless of the outcome.

Figure 9. Excerpt of the reading material used in the non-game task

4.5 Strategy of analyses

During the screening process, all participants were required to fill out both BAI and STAI-5. Both BAI and STAI-5 from the screening questionnaire were also included as part of the pre-test measurements along with CERQ-short and ACQ from the pre-test questionnaire. At the end of the last session for both interventions, all measurements (i.e., BAI, STAI-5, CERQ-short, ACQ, and Game Usability) were collected as post-test results. The mixed-design analysis of variance (ANOVA) model was used to compare the mean differences between ReWIND and the non-game task to observe any statistical difference in terms of interaction between the two interventions at different time points (pre-test and post-test). The analysis was performed using SPSS and the results were used to identify whether our hypotheses were sufficiently supported.

5. Results

5.1 Anxiety

Table 2 presents the means, standard deviations and F-values of the interaction between intervention types and time periods for all anxiety measurements taken during the pre-test and post-test in both treatment and control groups. Given that gender was used as the strata when dividing the groups, we did not control gender as a covariate in the analysis. In terms of anxiety related constructs, there is a statistically significant interaction between intervention types and time periods for BAI ($F(1,38) = 6.746$, $p < 0.05$), STAIT-5 ($F(1,38) = 4.562$, $p < 0.05$), and ACQ ($F(1,38) = 8.031$, $p < 0.05$), which indicates a greater decrease in severity level of anxiety symptoms and trait anxiety level, and a greater increase in perceived control of anxiety compared to the non-game task. However, there is no statistically significant interaction between intervention types and time periods for STAIS-5, with $F(1,38) = 2.512$ and $p = 0.121$. Even though the STAIS-5 scores started at a similar point, the drop in state anxiety level is similar for both intervention types, implying that the score difference between both interventions is negligible.

Table 2. Means, standard deviations, and p-values of all anxiety-related measurements

	Pre-test		Post-test		F-value (df_1, df_2)
	Mean (SD)				
	ReWIND	Non-game task	ReWIND	Non-game task	
Anxiety					
BAI	24.05 (11.067)	21.70 (9.494)	13.20 (8.883)	18.80 (9.556)	6.746 (1,38)*
STAIS-5	11.50 (3.517)	11.35 (3.924)	8.15 (3.588)	9.70 (3.757)	2.512 (1,38)
STAIT-5	14.80 (3.412)	13.75 (2.954)	10.70 (3.130)	12.15 (3.558)	4.562 (1,38)*
ACQ	70.15 (17.282)	70.55 (12.322)	84.90 (20.290)	74.15 (15.742)	8.031 (1,38)*

*Note: * = $p < 0.05$*

5.2 CERS

Table 3 presents the means, standard deviations and F-values of the interaction between intervention types and time periods for the CERS-related measurements taken during the pre-test and post-test in both treatment and control groups. In terms of CERS, improvement in mean scores is observed for all three CERS between pre- and post-test conditions for ReWIND but there is no statistically significant interaction between intervention types and time periods for rumination ($F(1,38) = 1.079$, $p = 0.306$), refocus on planning ($F(1,38) = 3.138$, $p = 0.085$), and catastrophizing ($F(1,38) = 0.503$, $p = 0.482$) scores. This shows that playing ReWIND does not lead to a significant difference in rumination or catastrophizing compared to the non-game task. The refocus on planning score after playing ReWIND is also not significantly higher compared to completing the non-game task. However, participants show improvement in refocus on planning after playing ReWIND while the contrary is observed with the non-game task.

Table 3. Means, standard deviations, and p-values of all CERS-related measurements

	Pre-test		Post-test		F-value (df_1, df_2)
	Mean (SD)				
	ReWIND	Non-game task	ReWIND	Non-game task	
CERS					
Rumination	7.85 (1.755)	8.05 (1.276)	5.85 (2.159)	6.65 (1.981)	1.079 (1,38)
Refocus on planning	7.70 (2.342)	7.90 (1.252)	8.35 (2.134)	7.55 (1.538)	3.138 (1,38)
Catastrophizing	6.60 (1.930)	6.35 (1.981)	5.10 (2.553)	5.25 (2.023)	0.503 (1,38)

5.3 Game usability

Table 4 presents the means and standard deviations of six different evaluation items with different aspects related to game design to examine the usability and applicability of ReWIND compared to the non-game task.

Table 4. Means and standard deviations of game usability evaluation items

Question	ReWIND		Non-game task	
	Mean	SD	Mean	SD
[Aesthetics] The task is nice and appealing.	4.75	0.55	4.20	0.70
[Relevance (real life)] The contents in the task are applicable in real life.	4.85	0.37	4.90	0.31
[Fun] The task is interesting enough to make me feel enjoyable during the therapeutic process.	4.65	0.59	4.20	0.83
[Relevance (anxiety)] The contents in the task are anxiety relatable.	4.75	0.55	4.65	0.59
[Challenge] It is hard to go through all contents in the task.	1.50	0.61	1.65	0.99
[Satisfaction] The task helps me cope better with my condition.	4.40	0.68	4.30	0.66

The first aspect considered is the aesthetics of ReWIND compared to the non-game task. ReWIND ($M = 4.75$, $SD = 0.55$) is rated more appealing than the non-game task ($M = 4.20$, $SD = 0.70$), which is aligned with our expectations and design goals. However, ReWIND has a slightly lower score than the non-game task in terms of relevance to real life, with $M = 4.85$, $SD = 0.37$ against $M = 4.90$, $SD = 0.31$. As for fun, ReWIND, with $M = 4.65$, $SD = 0.59$, is a more interesting and enjoyable therapeutic solution compared to the non-game task ($M = 4.20$, $SD = 0.83$). While both interventions deliver contents that are relatable to anxiety, ReWIND ($M = 4.75$, $SD = 0.55$) is rated higher than the non-game task ($M = 4.65$, $SD = 0.59$). In addition,

both interventions have similar challenge ratings, with ReWIND (M = 1.50, SD = 0.61) being slightly easier to go through than the non-game task (M = 1.65, SD = 0.99). Finally, ReWIND (M = 4.40, SD = 0.68) achieved slightly higher satisfaction in helping participants cope better with their conditions than the non-game task (M = 4.30, SD = 0.66).

6. Discussion

The impact of game interventions on the participant's well-being has always been a matter of concern [61]. In this study, we are not attempting to establish a preventive measure for anxiety disorders. Rather, we are focusing on pre- to post-test changes and short-term effects in anxiety and cognitive emotion regulation. Consistent with the results from prior RCTs on CBT games for anxiety [18], [58] and other studies with no control group [15], [17], [20], our results indicate that ReWIND can effectively reduce the severity level of anxiety symptoms. Prior studies [18] have demonstrated that CBT delivered through a game yielded significant improvement in anxiety symptoms compared to the normal treatment control, but the between-group difference was not observed when one group played an anxiety game while another group played a commercial game [58]. Our study further adds empirical evidence that delivering CBT through a story-based game can achieve better results than a non-game task (control), suggesting that using a game purposefully to deliver therapeutic content can lead to positive psychological changes. On the other hand, the non-game task had little to no effect on reducing the severity level of anxiety symptoms, possibly owing to the lack of engaging and playful elements to help internalize the CBT strategies.

All participants experienced significant improvement in the state anxiety level regardless of the intervention type during the study, but there was only a negligible difference in the performance between ReWIND and the non-game task. State anxiety refers to the transitory emotional reaction to adverse events, such as apprehension, dread, and tension [52], [53]. As the reactions are more transient in nature, individuals usually do not engage in thorough thinking about how to react to these events. This could be the reason why neither intervention showed any significant difference as the CBT elements in the game focused on changing irrational beliefs or cognitive distortions. ReWIND yielded a significant difference in reducing the trait anxiety level than the non-game task. Trait anxiety is a personality trait that predisposes people to manifest anxiety in threatening situations [51], [52]. The fact that games are visual mediums allows ReWIND to simulate real-life situations that are commonly encountered by those with anxiety disorders. Furthermore, ReWIND provides practical solutions to allow participants to think more clearly and thoroughly through similar occurrences in real life. Meanwhile, the non-game task requires participants to imagine the scenarios without any visual support, which may be the primary reason for the lower efficacy than ReWIND.

In terms of CERS, ReWIND is more effective in improving rumination, catastrophizing and refocus on planning than the non-game task but the difference is not statistically significant. As such, we can conclude that the results show no difference in the improvement of cognitive emotion regulation deficits between participants who played ReWIND and those who did the non-game task. Despite the lack of group differences, it is important to note that participants from both intervention conditions experienced a significant reduction in rumination and catastrophizing scores pre- and post-test (within-subject effect). Similar within-subject effect is not observed for refocus on planning as both interventions show no significant difference in the pre- and post-test scores. One possible reason is that the expected cognitive changes require a longer duration and more therapeutic sessions for any real effect to manifest in the participants. A CBT treatment program usually consists of 10 to 15 sessions with each session lasting about 45 minutes to an hour [62]. Sessions are normally held once a week or at most every two weeks. Other studies on anxiety games have also persisted for up to three months

with higher participant attrition [18], [22]. Our study lasted only for one month, which is equivalent to only four sessions of a full-course CBT with no attrition. Therefore, it is reasonable to deduce that the duration of exposure to the game may influence its efficacy and that extending the duration or increasing the number of game sessions would be beneficial in producing more satisfactory results. ReWIND is not intended to replace CBT treatment programs but rather to serve as a complementary and non-intrusive therapeutic solution in the form of a game. Another possible reason for observing no significant difference in the performance between both interventions could be attributed to the stories being narrated in the form of text regardless of the intervention type. The scenarios in ReWIND are presented through dialog, whereas written narration is used in the non-game task. More creative strategies (e.g., adding visual cutscenes, voice lines, and sound effects) could potentially increase the dramatic effect of the story in ReWIND and improve its performance over the non-game task.

ReWIND is designed with a psychoeducational purpose veiled in interesting game mechanics, animated 3D characters and environments, anxiety-relevant stories and in-game incentives. Based on our usability results, ReWIND manages to captivate participants with its artful design. The interactivity afforded by games allows ReWIND to deliver a more fun experience than the non-game task, and the immersive experience makes it easy for participants to follow the anxiety relatable stories. Games are primarily visual media, thus allowing participants to immerse themselves in the storyline more easily by letting them experience the game world directly. Finally, the playful elements of ReWIND help participants simulate better coping with their situations as the CBT strategies can be delivered in a more engaging manner. ReWIND scores almost at par with the non-game task scores in terms of content relevance. The stories used in both interventions are similar. Only the mode of how the stories were delivered is different (i.e., game versus text). Evidently, participants find the stories designed using the ABCDE model to be applicable in real life regardless of the intervention condition.

Our study, which was conducted fully online during the COVID-19 pandemic, also shows that online delivery with minimal supervision to complement CBT treatment and psychoeducation is effective and offers low threshold to access. As ReWIND is designed for young adults, it is feasible for patients to play the game without the physical presence of a therapist unlike CBT games targeting young children [22], [58]. Our findings further reinforce that games have practical implications in making anxiety psychoeducation and long-term care delivery more cost-effective and accessible to a larger population.

7. Conclusion

In this paper, we introduced and showed the effectiveness of our psychoeducational serious game, ReWIND, to address the lack of a therapeutic serious game solution dedicated to improving cognitive emotion regulation and anxiety disorders. ReWIND advances state-of-the-art mental health games by seamlessly integrating CBT elements and strategies into the game's storytelling so players can learn how CBT can be applied in anxiety scenarios as they play through the game. ReWIND presents an alternative design, that is, a complete story-driven setting to weave CBT elements into the narrative and gameplay as opposed to existing games delivering CBT in the form of a series of tasks to complete. Various game mechanics have been designed to simulate how CBT strategies can be applied to help reduce anxiety and negative emotional states in players. More importantly, ReWIND is a proof-of-concept balancing the science of CBT in a fun and relaxing way to improve cognitive emotion regulation and anxiety disorders. Although results from the study are promising, the game scenarios so far only cover three common anxiety disorders (generalized anxiety disorder, panic disorder and hypochondriasis). It would be premature to assume that ReWIND, which has been shown to be effective for a few general types of anxiety disorders, would have the same effect on all types of anxiety disorders or other mental disorders with anxiety as part of the symptoms. Further

investigation is required to validate whether ReWIND works for a wider variety of anxiety disorders. In addition, the duration of the intervention sessions may not be extensive enough as the study only lasted for one month, which could subsequently limit the performance of ReWIND. It would be interesting to observe if different results are observed given a longer duration of the experimental study and on a larger sample. Another limitation can be attributed to participants' self-report measures. Some of the most common symptoms among those who potentially have anxiety disorders include overthinking and overemphasizing their conditions, and that might have caused inaccurate measurements during the pre-test and post-test. Having psychology experts provide the ratings on a participant's condition or verify the participant ratings during the pre-test and post-test assessments could be viable solutions in future work. Other future directions could also include adding artificial intelligence (AI) to the game such as enabling players to engage in more natural conversations with non-playing characters (NPCs) in the game to find out more about the CBT strategies and other relevant psychological concepts. This can expand the game's ability to provide more dynamic psychoeducational content.

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Conflicts of interest

The authors report there are no competing interests to declare.

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