CatHill: Emotion-Based Interactive Storytelling Game as a Digital Mental Health Intervention

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ABSTRACT

In this paper, we introduce CatHill, an emotion-based interactive storytelling game leveraging Cognitive Behavioral Therapy (CBT) to help college students with chronic mental health conditions. The game utilizes evidence-based stories to integrate three CBT techniques: exposure therapy, cognitive restructuring, and relaxation training. We propose a novel interface only controlled by players' mouths to engage players better. The game allows players to chat with non-player characters (NPCs) and their speech emotions will deeply influence NPCs' actions and story progression. Besides, players can also conduct mindful breathing exercises by breath control. Such fun and impressive interaction modes teach young people to understand the correlation among thoughts, emotions, and behaviors and change irrational automatic thoughts, and overcome anxiety or distress. Through our practice, we show that popular game elements and new interaction technologies have the potential to expand the impact of digital mental health interventions.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**; HCI **design and evaluation methods**.

KEYWORDS

mental health; emotion-based game; CBT

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1 INTRODUCTION

Mental health problems (e.g. anxiety disorders and depression) are prevalent among college students [3, 11] and have been steadily increasing [21, 41]. Studies have shown that minor mental problems in young adulthood may develop into lifetime mental health disorders without intervention [28]. Cognitive-behavioral therapy (CBT) is a practical approach to treating depression and anxiety [23, 40], and it thus becomes one of the most popular models of psychotherapy in face-to-face therapy for university students. But on-campus counseling services are often unable to deal with a continued increasing demand [30, 45]. Additionally, the majority of students who may be most at risk are reluctant to seek counseling [21, 29, 38] due to various reasons, such as privacy concerns, mental illness stigma, a shortage of mental health literacy, etc. [2, 16, 50, 59].

In such cases, numerous digital mental health interventions (DMHIs) emerge to reach people unable or unwilling to access traditionally delivered mental health help [15, 34, 39]. Research has shown that DMHIs based on CBT can effectively bridge the gap between face-to-face CBT therapy and self-guided CBT methods, but the alarmingly high attrition rates among existing DMHIs [12, 15, 46, 53] reveal that "engagement", remains a continued challenge for DMHIs [17, 42, 60]. Consequently, it is necessary to be innovative and strategic in providing psychological assistance in a manner that is both accessible and non-threatening to young people [24, 47, 48].

Serious games and gamification are such innovative and engaging methods that are increasingly used in applied health interventions, with a growing body of research identifying their value [7, 14, 35, 52, 57]. With higher customizable and more interactive elements, serious games offer "appealing potential", "engaging potential" and "effectiveness potential" to reach more users, reduce high attrition rates, and improve intervention effectiveness [10, 13]. However, due to the lack of uniform design guidelines, the difference in game genres and features that appeal to and motivate

players is significant among existing serious games [49]. It is valuable to collect design experience from popular games and explore novel elements appropriate for future mental health games [13].

This work presents our research-in-progress on expanding design possibilities of new interaction technologies and popular game elements for serious games. Towards this goal, we present an emotion-based interactive storytelling game, CatHill, leveraging CBT to enhance college students' mental health. This game possesses a brand-new user interface only controlled by the user's mouth, including breath and voice input, to enhance the player's immersive experience and to further improve the intervention effectiveness of serious games. The preliminary evaluation showed that our game could effectively help users learn CBT knowledge in a more fun and interactive way and provide a safe and controllable place to challenge negative thought patterns. We hope that our research process brings new insights to other DMHIs.

2 GAME GOALS

The goals of our game are as follows: **1)** Regard the game as an appealing type of DMHI and reduce college students' preconceived resistance to mental health interventions. **2)** Create a safe and controllable place to support self-help CBT training that allows college students with chronic mental health conditions (depression and anxiety) to rethink and challenge cognitive disorders usually appearing in their campus life and to learn positive strategies to adjust. **3)** Exploring more interesting and well-suited interaction modes to deliver the CBT principle, enhancing players' understanding of specific mental health knowledge.

3 GAME DESIGN

We refer to the Therapeutic game design model [63], dividing the design process into two aspects: therapeutic perspective and game perspective. We first identify therapeutic elements that we plan to embed in the game, and then we consider how to emulate those therapeutic elements from the game perspective.

3.1 Game Genre

We choose "interactive storytelling game" as our game genre because storytelling can provide impressive guidance, transforming therapeutic information into a memorizable form to apply in relevant moments in a patient's life [18]. Therapists have accepted to use of stories in CBT practices [4]. Meanwhile, the development of digital tools is expanding the impact of interactive storytelling. Popular narrative games often use highly personalized elements and interesting interaction modes to increase people's intrinsic motivation and engagement [5, 44, 54, 55], which is also important to build therapeutic alliances between DMHIs and users.

3.2 Therapeutic Perspective

CBT is a structured, goal-oriented type of psychotherapy for challenging and changing negative thought patterns [33]. It is rooted in the fundamental conception that individuals' cognition influences their emotional and behavioral responses to life situations. Traditional CBT is generally delivered in a clinical environment by a professional therapist over several face-to-face talking sessions [9]

and self-help practices after consulting [27, 58]. Therapists help patients identify negative thoughts and how to respond to situations effectively. Besides, therapists help patients master several CBT techniques, and patients need to keep self-help training in daily life to ensure the effectiveness of the treatment. Key techniques employed by CBT to address anxiety and depression: systemic gradual exposure (i.e. exposure therapy), homework, emotional heuristics, cognitive restructuring, etc. [32, 33]. In our work, we emulate three basic CBT techniques:

1) Exposure Therapy: Exposure therapy involves the target patient to the anxiety source or related context without the intention to cause any danger, and fear is minimized at each of a series of steadily escalating steps or challenges, and the patient can terminate the procedure at any time [26]. In our design, we use game reality to offer a unique opportunity for exposure therapy - College students can regard the game as a non-threatening and low-risk practice to rethink the anxiety source or related context.

2) Cognitive Restructuring: The technique designed to identify cognitive distortion, and develop alternative thoughts that more realistically reflect experience is named "cognitive restructuring" [31]. Cognitive restructuring emphasizes the CBT principle that the relationship between emotions, thoughts, and behaviors [8, 43]. In our design, players will gain a deep understanding of the CBT principle through more fun and immersive interaction modes, for example, using their own voice to propose suggestions to non-player characters (NPC). Their speech emotion will influence the game unfolding and NPCs' actions, and they, therefore, learn that changing their negative thought patterns and behaviors can lead to positive results. Besides, our game also offers rational alternative explanations to educate the player after each story chapter.

3) Relaxation Training: Relaxation training assists patients to "control the degree of physiologic arousal experienced during or in anticipation of feared events" [20]. As the assistive technology of CBT, relaxation training, comprising both progressive muscular relaxation and breathing control, visualization, and meditation, further improve the effectiveness of CBT [56]. In our games, deep breathing is smoothly integrated into the story as an indispensable part of the game. Players can practice different mindfulness breathing techniques in a fun experience.

3.3 Game Perspective

Various efforts are integrated to achieve our game goal: narrative design, interaction design, and audiovisual design.

3.3.1 Narrative Design. To maximize the effectiveness of the narrative intervention, evidence-based storytelling becomes our narrative design goal. We invite a cartoonist, a postgraduate student majoring in Chinese language and literature, and a registered psychological counselor to assist with our narrative design.

1) Story Theme: Our first-hand data for adapting the CBT stories comes from PKU BBS, a well-known college-student forum in China. In the forum, the on-campus Health & Counseling Center has built an online counseling platform. The professional therapist will answer each anonymous request timely. We thus collect a diverse and inclusive range of samples of psychological problem descriptions. These descriptions laid the foundation for identifying

our narrative themes. We screened a sample of 2,135 valid psychological problem descriptions, and the consultation time between 2020 and 2022 to ensure the timeliness of the sample. Psychological problem descriptions that are not related to campus life and cannot be addressed through self-help CBT are not included in our discussion. Thematic analysis was employed for the analysis of our data and the finalization of our story themes: academic, socializing, identity, and future plan. Each theme comprises more detailed sub-themes, for example, "socializing" includes public speaking anxiety, social anxiety, etc.

2) Character Design: Due to the word limit, we only "social anxiety" as an example to introduce our character design process. We analyze the psychological descriptions under the subtheme of "social anxiety" to extract some common characteristics of this group. For example, the descriptions "I feel like everyone is looking at me" and "I am afraid to meet anyone I know" were labeled as "sensitive" and "susceptible to environmental influences". These codes formed the basis of our character design. We used non-realistic elements to distance the story from real life to create a richer narrative space. Finally, we defined the character with social anxiety as humans living in the cat world.

3) Story Generation: We first organize story raw materials under each subtheme, and then we adapt and generate a metastory based on these raw materials, avoiding pointing to any specific story we collect. Under the cat world view for redesign, each plot will be deconstructed into several stages of the hero's journey. We combine the ABC model and Hero's Journey (an archetypal story pattern) to generate our game story.

3.3.2 Interactive Design. **1) Dialogue Design:** CBT encourages each person to become their own therapist, and they should carefully examine how their thoughts and emotions influence their behavior in their lives. In our game, chatting with NPCs is the way players influence the game story. Players play the "therapists" and persuade their patients to accept positive thoughts through dialogue interaction. The players can also agree with the NPC's negative thoughts, and they will see a different outcome. Our dialogue design is based on the defence attorney technique, which is a CBT tool by using the metaphor of a court trial to encourage patients to play the role of "defense lawyers", and makes patients' challenge to negative thoughts clear and concrete by defending positive thoughts [32]. According to the theory, we divide the dialogue into four parts: the present statement of negative beliefs (thought), the facts supporting negative beliefs (defence), the facts denying negative beliefs (prosecution), and the conclusion confronting the problem of cognitive distortion (judge's verdict). Fig.1 shows the dialogue design for Chapter 1 and the two storylines that lead to it.

2) Breath Control: Self-regulation of deep breathing as one of the relaxation training is the first-line and supplemental treatment for stress, anxiety, depression, and some emotional disorders [25]. In our design, diverse forms of breathing exercises (e.g., slow and fast breathing, 4-7-8 breathing, etc.) are categorized into different levels of difficulty, which become part of the game story. Players can repeatedly practice and master these relaxation skills in the game. Besides, breathing is also a directly controlled physiological signal that can enhance unique and engaging play experiences through natural interaction in our game [6]. The players bond themselves
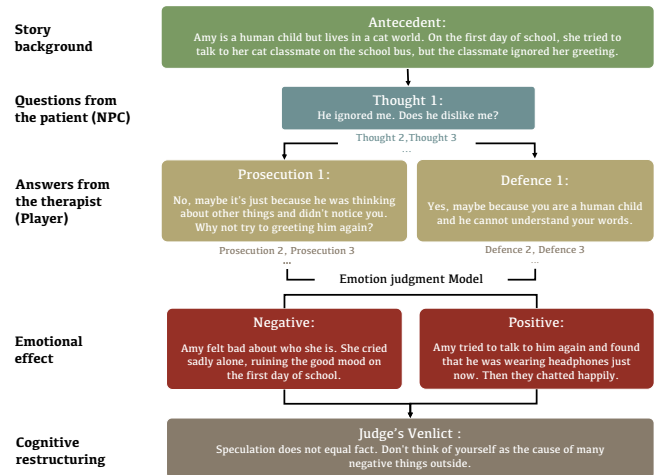
Figure 1: Mapping defence attorney technique to dialogues

together to their characters in the game by breath control - they can see their breathing mapped to the game character's movement in real-time, accompanied by corresponding sound effects.

3) Emotion Adaptive Storytelling: Adaptive storytelling is an emerging area of narrative games that increases player engagement by adding more personalized elements. Game developers design unique adaptive elements to reach the purpose of design. In the context of our research, we emphasize the CBT principle that thoughts, emotions, and behaviors are interconnected. We reinforce this principle through emotional adaptation.
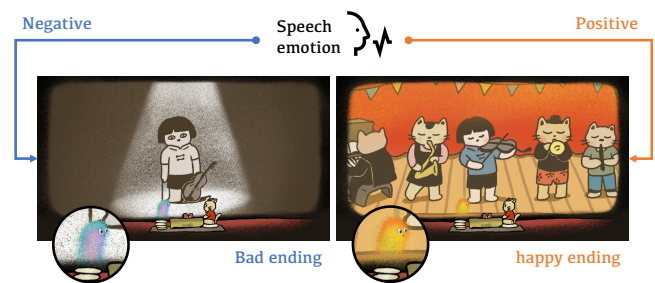
Figure 2: Players' speech emotions will influence the game in two aspects: aesthetics and story unfolding

In our design, voice control allows players to use their own words and voices to control the game and communicate with the characters. We extract players' facial expressions, text, and acoustic features during gameplay as the basis for emotional judgment. Voice control is a novel interaction mode to increase the intimacy with the characters and the enjoyment and immersion of the game [1], and has been used in popular games, for example, The Broken Seal encourages players to spell uttered with their voice to battle enemies. Radio General lets players manage and contact their men through merely a radio. Besides, voice input also unifies our game controls to full mouth control. Players' speech emotions will affect the game's progression. So, they can understand how their words and emotions, and thoughts influence behavior.

The game emphasizes this influence in two aspects (see fig 2) : 1) Aesthetics: the appearance of NPCs and the color of the memory will change in response to the player's emotions. 2) Story: the NPCs' actions and story development will also change in response to the player's emotions. Hence, our game both engages users during the interaction with the technology and encourages users to reflect upon their emotional state and emotional regulatory skills.

3.3.3 Audiovisual Design. Considering that evidence-based storytelling will bring players a certain sense of tension, we adopted the "cozy game" [51] design approach in our audiovisual design to alleviate this bad mood. We use the 2D hand-drawn style to represent our game world, bringing a more natural and familiar touch. Warm, soft color palettes (yellow, orange) without strong contrast constitute our game visuals. We invited a professional soundtrack artist to match our game with background music that is as soft, non-intrusive, and fitting as possible. As an aesthetic incentive, these designs attract players to keep engaging with the game.

4 GAME CONCEPT

Our interactive storytelling game, which we dub CatHill, progresses as a role-playing game that incorporates breath control and speech emotion recognition. In this game, the player plays as a psychotherapist in the cat world. This role can enter the patient's inner world through special kung fu (breath control), experience the negative life events of the patient from a first-person perspective, examine and judge these events from a third-person perspective and give rational alternative explanations and suggestions by voice input. Players' responses (speech emotion) will determine how the patient's actions and the story unfold. This game is a PC game, and the player can play it on a personal computer.

4.1 Game World

Once upon a time, people and cats lived together in CatHill where the special flu of "emotional transparency" prevails. If people with this flu are in a bad mood for a long time, their bodies will gradually become transparent and even disappear. Cat therapists can use special kung fu to access their patients' memories, helping them adjust to cognitive distortions by walking through the past with their patients, and leading them to reverse their memories to a happy ending, helping them to recover their bodies.

4.2 Game Play

Our games are turn-based, with each chapter being a separate ministory. The cat therapist advances game progression by changing game scenes (see Fig.3). Three CBT techniques are embedded in these scenes.

(a) Practice Room: Relaxation Training. After choosing their cat-therapist role, The player enters the practice room. He/she must successfully learn a special kung fu (breathing skills) before he/she moves to the next scene because it allows the player to enter the patient's inner world. Our game visuals and audio offer fun guidance for players to help them finish such relaxation training.

(b) Office: The player receives the task list through the snail phone in the office, which contains basic information about the patient. The player needs to use the kung fu learned in the practice room to enter the patient's inner world.
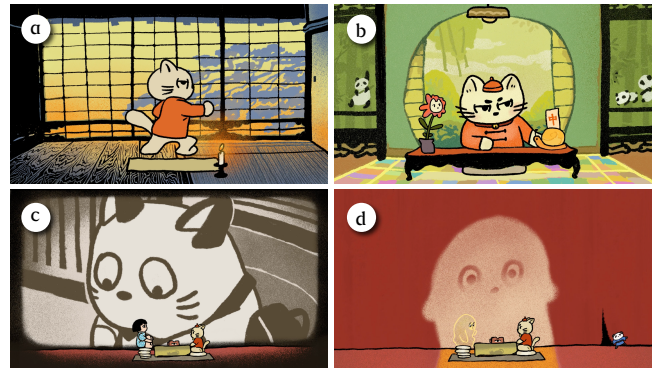

Figure 3: Four main scenes of CatHill

(c) Patient's Inner World: Exposure Therapy & Cognitive Restructuring. In this scenario, the therapist and the patient experience the patient's story together through the patient's point of view. During the viewing process, the patient chats with the player before making a choice. The player uses intuition to propose suggestions to the patient. The patient will then make choices to move the story forward. The player will view the impact of his/her suggestions on the patient's actions and the result of the story.

(d) Treatment Room: Cognitive Restructuring. At the end of the treatment, the assistant will tell the player the result of the treatment and offer another positive treatment plan (introduce the definition of the negative thinking appearing in the patient and provide a rational alternative explanation).

5 TECHNICAL SUPPORT

5.1 Sentiment Analysis

In this game, the player's sentiment should be captured in real-time to help the game engine chooses a reasonable reply, which could make the player feels pleasant. To achieve this goal, we perform sentiment analysis based on multimodal information of the player. The game device would record a video when the player speaks. From a recorded video, we extract the audio, its corresponding text, and the consecutive frames of the player's face. With the collected visual, textual, and acoustic information, we pick out an effective method to analyze the player's sentiment.

5.1.1 Methodology. The architecture of our sentiment analyzer is shown in Figure 4. The original input can be regarded as a short video, and the expected output is a kind of sentiment (i.e., positive, neutral, or negative). Firstly, the analyzer would split the video into two parts, the audio track and a series of frames. We utilize the Automatic Speech Recognition (ASR) API of Tencent Cloud for the audio track to obtain the text the player says. To analyze these data, we apply a state-of-the-art model for Multimodal Sentiment Analysis (MSA) - MultiModal InfoMax (MMIM) [19]. This model extracts the features from visual and acoustic information via LSTM and encodes the textual information with BERT Encoder. A Fusion Network would combine the extracted features to estimate the possibility of the player being positive or negative.
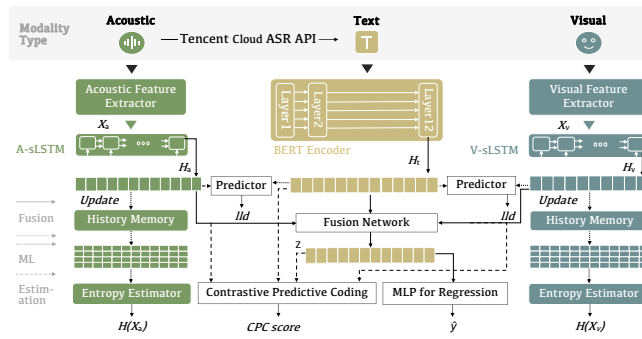
Figure 4: The architecture of our sentiment analyzer

5.1.2 Implementation. We implement the method described above in Python. Thanks to MMSA [61, 62] and MMSA-FET [37], the workflow of MSA is unified and simplified. We can choose any valid dataset to train and evaluate a supported MSA model. For the training part, we use CH-SIMS v2.0 dataset [36], the largest semi-supervised Chinese MSA dataset containing 2121 refined video segments with annotations. For the evaluation part, we collected 73 videos recorded during the game's testing process and their emotion labels to measure the effectiveness of our method.

5.1.3 Evaluation. After training the model for two epochs on CH-SIMS v2.0 dataset, we fed the 73 videos used for evaluation to the model and got the prediction scores. We take zero as the threshold, i.e., a sample is positive if it receives a score greater than 0, negative otherwise. The accuracy achieved in our game scene was 75.53%, which is a reasonable level of performance for sentiment detection. While the accuracy may not be optimal, it is still within a usable range for our needs. More importantly, we found some reasons that affect the accuracy of speech emotion recognition in-game scenarios, which may shed some light for other game developers who wish to use speech emotion recognition in their games. We can continue to optimize the sentiment analysis model based on these findings: 1) Players' speech emotions while playing the game are not as pronounced as in the samples from the standard multimodal dataset, and their facial expressions change subtly. 2) Most failed cases got a wrong prediction because of semantic shift. The player may talk about something negative at first and turn to positive later. We infer that our current method hardly captures this kind of shift.

5.2 Breath-control Animation Speed

Players achieve relaxation training by breath-control their characters in CatHill. We propose a novel method to tune animation speed. Specifically, we use the microphone of the game device to record the players' breathing sound instantly. Every time the player inhales and exhales, the volume of the sound rises and falls. Hence, we can roughly detect the player's real-time respiratory rate and control the animation to speed up and slow down at the same frequency.

6 PLAYER EVALUATION

We conducted a preliminary evaluation to test our game prototype by recruiting 10 college students (5 males and 5 females, mean age 23). The questionnaires include System Usability Scale (SUS), Game

Experience Questionnaire (GEQ) [22], and CBT knowledge tests. We create two versions of the CBT knowledge test for the pre-game test and post-game test. Each knowledge test consisted of 10 questions that required the user to judge and give a rational explanation for a specific psychological problem description. Players were asked to fill out the pre-game CBT knowledge test before the game and the SUS, GEQ, and post-game CBT learning tests after experiencing three chapters of the game. A short interview was conducted with each player after finishing all questionnaires.

Ultimately, the average SUS score of SUS is 84.8% (SD=1.81), the GEQ average score of 85% (SD=0.36), the mean CBT knowledge score before the game was 50% (SD=1.35), and the mean score after the game was 88% (SD=1.26). In the interview, 100% of the participants agree the game stories are full of highly familiar plots to their daily life. The results show that CatHill brings a relatively high level of immersion for players, effectively helping players learn about CBT knowledge. A player said, "This game is appealing and changes my view of serious games." Another player expressed, "The voice interaction is highly similar to face-to-face counseling. I especially liked the breath control session, and I even want to experience more!" While players also report that the first view of the story is too immersive and makes them nervous, we could later use fun animation to remove this tension.

7 FUTURE WORK

Our future work focuses on two aspects.

Technical improvement: 1) Micro-expression detection. Micro-expressions are facial expression changes that are short-lived and difficult to perceive, which can reflect a person's true emotions and psychological state. This technique can help the model better understand the emotion of players, which is significant to the game. 2) Fine-tuning of the sentiment analysis model on the game scene. We intend to analyze the emotional changes, which may better identify some complex emotional transitions in a sentence.

Evaluation Plan: We will conduct a 3-arm randomized controlled trial, and use (Self-Rating Anxiety Scale) ASA and (Self-rating Depression Scale) SDS to screen 45 target users. They are randomly assigned to one of the three groups (test, control, and waitlist) for 15 days. The test group is asked to use CatHil; the control group needs to use Moodgym - a non-gamification computerized CBT; and the waitlist group doesn't receive any intervention. All participants are required to complete ASA, SDS, cognitive emotion regulation (CERQ), learning effects tests, and interviews before and after the trial. We expect to observe significant differences among the three groups in terms of cognitive emotion regulation, anxiety, and depression symptom severity from our study results.

Based on this game, we hope to take the CBT game as one of the samples of digital mental health interventions and further explore the opportunities and design space for gamification to support mental health for different groups. We will reflect on our findings and design experience in a full paper in the form of theory.

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