CBT-Darts: Identifying Cognitive Distortions in an Immersive VR Game

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ABSTRACT

Cognitive Behavioral Therapy is a empirically validated treatment for anxiety and depression. By identifying negative thinking patterns (cognitive distortions), individuals are able to reevaluate and reframe thinking patterns for better mental health. Building on previous research in digital health interventions, we explore the use of games and VR for increasing awareness of cognitive distortions. *CBT-Darts* is an immersive VR game where players match statements to cognitive distortions by throwing darts at balloons. By mixing a physical and cognitive task, we hope to create an engaging and fun way to teach how to identify cognitive distortions.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; • **Applied computing** → *Health informatics.*

KEYWORDS

Cognitive Behavioral Therapy, Virtual Reality, Social Anxiety, Mental Health

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1 INTRODUCTION

Mental disorders are highly prevalent among the general population, but specially in college students, with approximately 35% of college students claiming to have at least one mental disorder [4]. Initial onset of most psychiatric disorders is during college years (between 18 and 24) [20]. Social anxiety disorder (SAD) is one of the most predominant mental disorders with symptom onset in childhood or early adolescence [6]; early interventions programs are key to enabling college students to deal with "emerging adulthood" [2]. This is a period characterised by stressors (e.g., academic, social, financial, etc.) resulting from new experiences (e.g., moving away, meeting new people, more responsibility, etc.) [13].

Several barriers (such as stigma, privacy concerns, financial limitations, lack of available services, etc.) prevent college students from accessing help [5, 10]. Research on digital mental health interventions emphasises the importance of these tools not only for accessing medical care on college campuses, but also for increasing their mental health literacy [19, 21] Lehtimaki et al.'s [21] systematic review for instance found that computerized CBT (Cognitive Behavioral Therapy) was especially effective in the treatment of anxiety and depression on college students. Moreover, gamified interventions that integrate CBT concepts have also demonstrated a significant positive impact on anxiety levels [1]. CBT can also be associated with virtual reality where the immersive nature of Virtual Reality (VR) and its capabilities of control and customization of scenarios allows the patient to explore and experience stressfull situations in a safer environment [11].

In line with previous research exploring the potential of CBT applied to games [3, 7, 9, 13, 14] and VR [11, 23], we designed and developed *CBT-Darts*, an immersive VR game for teaching college students about CBT concepts. The game mixes a physical task (throwing darts at balloons) with a cognitive task (identifying negative thinking in statements) in a fun fast and short game (± five minutes), compatible with Meta Quest 2/3 devices.

2 RELATED WORK

Cognitive Behavioral Therapy is an empirically validated reinforcement treatment that has proven effective for mental health issues such as depression and anxiety [22]. CBT adopts a goal-oriented approach of recognising and addressing distorted or irrational negative thoughts. For any event there is a trigger, an interpretation (how the event is perceived based on automatic thoughts, beliefs, predictions, and assumptions) and a reaction (emotions and behaviour)[3, 13]. Cognitive distortions (also known as distorted thinking) results in misinterpreted or disproportionate reactions (e.g., negative emotions or behaviours leading to poor mental health) [24]. CBT supports that by recognising these cognitive distortions, individuals can reevaluate and re-frame them to develop coping skills [15]. While, CBT is usually delivered in a clinical setting through face-to-face sessions with a psychotherapist [8], digital interventions, either therapist-guided [17] or self-guided [16] have shown positive results. Ongoing research is focused on improving the effectiveness of entirely self-guided interventions in order to make psychotherapy more accessible, as well as, exploring new ways to deliver CBT such as games or VR.

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Serious games with CBT elements have proved to be statistically effective in alleviating anxiety [1]. Heng et al.[14], through a serious role-playing game (using CBT concepts to design the storylines and the gameplay mechanics), showed positive psychological changes while using engagement and playfulness to internalize the CBT strategies. Báldy et al. [7] studied how to design and evaluate a serious game aiming at awareness of therapy skills (CBT) associated with social anxiety disorder; in this game immersion and sense of presence were two fundamental aspects in creating believable scenarios. Another work that also incorporated CBT concepts in their gameplay, had the aim to assess the efficacy and acceptability of their game directed to professional clinicians and adolescents that suffer from clinical anxiety disorders [9]. By reshaping the more complex CBT concepts into fun concrete representations, it made the CBT process more suited to the developing needs of adolescents. This also supports the same finding in Heng et al.'s [14] work where the gamification of CBT appears to be an effective way of ensuring more attractiveness and adaptability to younger adults.

Wu et al. [23] conducted a systematic review and meta-analysis about Virtual Reality-Assisted Cognitive Behavioral therapy (VR-CBT) for Anxiety Disorders and found that it has a potential advantage over the normal CBT by offering an alternative for patients who might be reluctant to engage in real life situations, serving as an intermediary step. Another aspect highlighted in this review is the privacy aspect exclusive to a VR environment. In a more pratical and direct way, Geraets et al. [11] performed a study to assess the feasibility and effectiveness of VR-CBT for patients with generalized SAD. Each participant would engage in 16 one-hour individual sessions once or twice a week where they would test their approach behaviors and beliefs (CBT concepts) in customised VR environments with the support and feedback of a therapist. The results confirmed that VR-CBT enabled patients to experience social encounters more positively, decreased level on anxiety in social interaction, less depressive symptoms and in general an improved quality of life. The results also show that exposure in VR allowed for a gradual increase in difficulty level by controlling the environment properties whereas *in vivo* exposure such control is not possible.

3 DESIGN & IMPLEMENTATION OF *CBT-DARTS*

Drawing on research on CBT and VR for Mental Health, we designed and implemented *CBT-Darts*, an immersive VR game aligning a physical task (throwing darts) with a cognitive tasks (identifying the cognitive distortion behind a statement). The rationale of having both physical and cognitive tasks is supported by previous work where exergames are conduits for learning [12, 18]. The game was made in the Unity game engine[1], using the XR Interaction toolkit[2]. The game is compatible with Meta Quest 2/3[3], and uses both hand controllers. The game takes place at a college party, an environment which many college students are exposed to and that often creates social anxiety. The 3D environment is populated with animated avatars from the Microsoft RocketBox Avatar Library[4].

Fig. 1 shows multiple games elements that the player can interact with. The darts games starts when the player enters the area in front of a table (F in fig. 1). On the right side, an avatar character (Dave, see H in fig. 1)) explains how to play the game (D in fig. 1) Once the player chooses to start the game, several helium balloons appear representing cognitive distortions (B in fig. 1). On the right side of the table, a list of statements is present with one statement selected (A in fig. 1); these statements are negative thoughts that a individual might have. The goal of the task is to match the statement to the cognitive distortion it represents; this is done by the physical task of picking up a dart on the table (G in fig. 1) and throwing it at the correct balloon – the difficulty of task is increased by moving and overlapping balloons and the need to create a projectile trajectory with the dart. Correctly popping the matching balloon, increases your score (C in fig. 1) and moves to another statement. Incorrectly popping a balloon, decreases your score. A helper is available for players in the form of an interactable sheet with definitions of cognitive distortions (E in fig. 1).

Table 1 shows cognitive distortions used in the game (Mind Reading, Catastrophizing, Black-and-White Thinking, Filtering, Overgeneralization and Should Statements), with the definition used in the game (E in fig. 1), and example statements (A in fig. 1). These examples are shown in three levels, moving from negative to positive: initial (L1), progressing (L2) and overcome (L3). The statements were created by a large language model (LLM) given the definitions of the cognitive distortions; in the future, we plan to incorporate a LLM (e.g., Unity LLM[5] using Mistral-7B model) to allow for more replayability of the game. While other cognitive distortions exist (e.g., emotional reasoning, minimising, etc.) [15, 24], in order to not increase the cognitive complexity of the tasks, we chose to focus on a limited set.

4 CONCLUSION & FUTURE WORK

This demo work presents *CBT-Darts*, an immersive VR game for learning about cognitive distortions, a key element of CBT. By treating it as game mechanic, as previously used in [3, 13], we believe that having players identify the cognitive distortion can lead to better understanding of their actions and emotions. For future work, we plan to expand the game (maintaining the party scenario) to include other small games to represent and teach about CBT concepts, as well as creating opportunities for more replayability and engagement. Finally, we hope to conduct user evaluations with college students to better understand the effect and potential of games as channels for mental health.

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[3] https://www.oculus.com/quest/
[4] https://github.com/microsoft/Microsoft-Rocketbox
[5] https://github.com/undreamai/LLMUnity

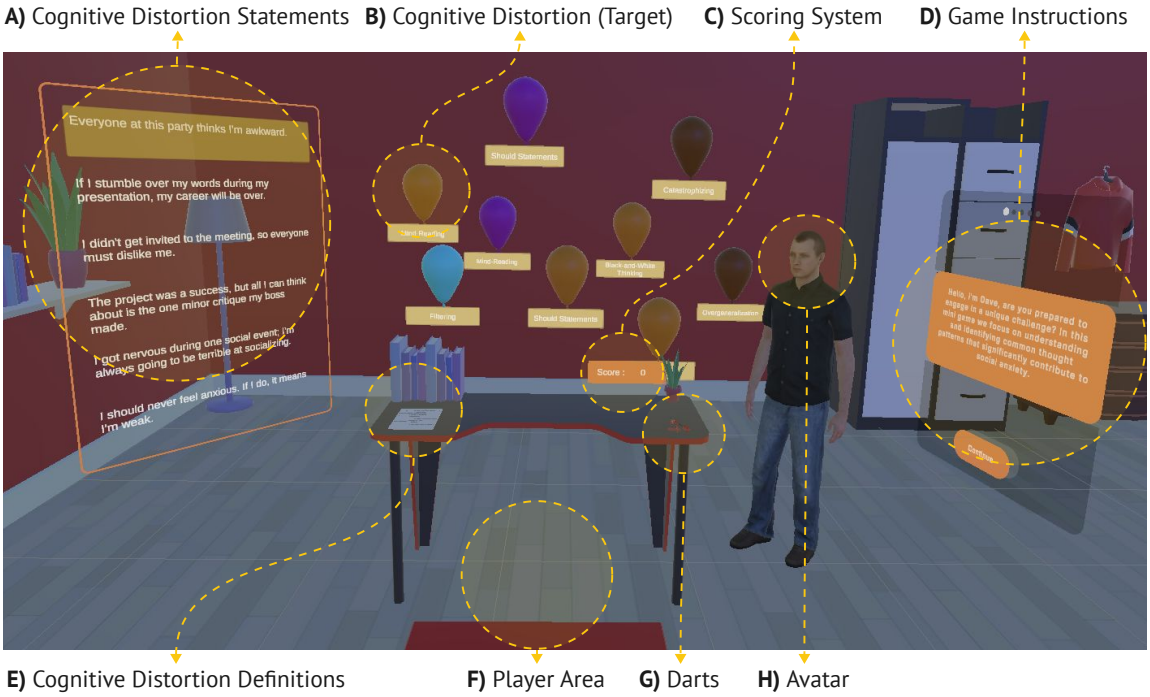

Figure 1: Game Elements in the *CBT-darts* game.

Cognitive Distortion	Level	Statement
Mind Reading	Def.	Thinking you know what others are thinking about you, usually something negative, without any real evidence.
	L1	"*Everyone at this party thinks I'm awkward and out of place.*"
	L2	"*Instead of guessing or projecting what others might be thinking, I should consider that many might not even be noticing me as they're engaged in their own discussions.*"
	L3	"*I can't actually know what anyone else is thinking. Instead of trying to read minds, I'll concentrate on enjoying the event.*"
Catastrophizing	Def.	Expecting the absolute worst to happen from a situation, blowing things out of proportion.
	L1	"*If I fumble a sentence in my presentation, it will ruin my career completely.*"
	L2	"*I might be exaggerating the consequences of a simple mistake. Realistically, everyone makes mistakes and they're rarely as disastrous as feared.*"
	L3	"*One misstep during a presentation isn't a career-ender; it's an opportunity to learn and improve. My career is built over many experiences, not just one.*"
Black-and-White Thinking	Def.	Seeing everything as one extreme or another, with no middle ground or shades of gray.
	L1	"*Because I wasn't invited to the meeting, it clearly means everyone dislikes me.*"
	L2	"*I may be seeing this situation in absolutes—either liked or disliked—without considering other neutral possibilities for not being invited.*"
	L3	"*I recognize that social situations are complex and not being invited is not a definitive judgment of my character.*"
Filtering	Def.	Only paying attention to the bad parts of a situation and ignoring any of the good aspects.
	L1	"*My project succeeded, but all I can fixate on is that single negative comment from my boss.*"
	L2	"*I might be magnifying the negative and minimizing the positive feedback, which skews my perception of the whole project.*"
	L3	"*Constructive criticism is part of professional growth. It's essential to balance it with recognition of my successes and not let it overshadow them.*"
Overgeneralization	Def.	Taking one negative event and assuming it will always repeat in the future.
	L1	"*I felt awkward at one party; now I'm convinced I'm always awkward in social settings.*"
	L2	"*I could be drawing too broad a conclusion from a single uncomfortable experience. Each social event offers a new opportunity.*"
	L3	"*Being nervous occasionally is normal and doesn't mean I'm inherently bad at socializing. Each event is a chance to improve and adapt.*"
Should Statement	Def.	Setting rigid rules for how you and others should act, leading to disappointment when these expectations aren't met.
	L1	"*I shouldn't ever feel anxious. Feeling anxiety means I'm not coping well.*"
	L2	"*I'm setting unrealistic standards for myself by saying 'should' and 'shouldn't' about my feelings. It's healthier to acknowledge that anxiety is a common emotional response.*"
	L3	"*Experiencing anxiety is normal. Learning to manage it effectively is a sign of emotional resilience and strength.*"

Table 1: Cognitive Distortions in *CBT-Darts*

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