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Serious games for serious pain: Development and initial testing of a cognitive behavioral therapy game for patients with advanced cancer pain

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Abstract

Purpose: Cancer-related pain is prevalent among people with advanced cancer. To improve accessibility and engagement with pain-cognitive behavioral therapy (pain-CBT), we developed and tested a serious game hosted within an mHealth intervention that delivers pain-CBT and pharmacologic support. The game focuses on teaching and practicing cognitive restructuring (CR), a central pain-CBT intervention component.

Methods: The pain-CBT game was developed through partnerships with commercial and academic game developers, graphic designers, clinical experts, and patients. Patients with metastatic cancer and pain participated in iterative, semi-structured interviews. They described their experience playing each level and reflected on relevance, clarity, usability, and potential changes. Content codes captured patients' suggestions and informed game refinements.

Results: The final game includes five levels that prompt players to distinguish between adaptive and maladaptive thoughts that are pain- and cancer-specific. The levels vary in objective (e.g., hiking, sledding), interaction type (e.g., dragging, tapping), and mode of feedback (e.g., audio, animation). Fourteen participants reviewed the game. Patients appreciated the pain- and cancer-specific thought examples, with a few noting that they made them feel less alone. Many stated that the game was fun, relatable, and an engaging distraction. Others noted that the game provided

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helpful CR practice and prompted reflection. For example, one 40 y/o woman said the game "brings [a thought] to the forefront so you can acknowledge it, and then maybe you could let it go or …do something about it."

Conclusion: Patients coping with cancer pain found the CR game helpful, enjoyable, and satisfactory. Serious games have the potential to increase engagement while facilitating learning and rehearsal of psychological skills for pain. Future testing will evaluate the efficacy of this serious game.

Context Summary:

Key objective: Pain psychologists and palliative care clinician scientists collaborated with software engineers and graphic designers to develop a mobile phone-based serious game to teach patients with cancer to distinguish adaptive and maladaptive pain specific thoughts.

Knowledge generated: Patients with cancer pain reviewed the game, reported high acceptability, and qualitatively described feeling validated and less alone in their pain experience and appreciating the game as a useful distraction from pain. A few noted that the game reduced the stigma associated with pain psychology interventions.

Relevance: Serious games have the potential to engage people with cancer in novel ways. This preliminary report found encouraging user acceptance and paves the way for expanded research in this area.

Introduction

Games developed toward "serious" purposes (e.g., health education, behavior change) use the entertainment inherent in gameplay to enhance engagement in educational tasks and foster a transfer of skills learned from the game to real life.[1–4] Many of these "serious games"[1,2] have shown promise in supporting behavioral change and knowledge acquisition in a variety of chronic health conditions in both children and adults, including depression,[5] negativity bias,[6] cancer[7–9] and HIV.[10] However, evidence in the field of serious games for cancer symptoms is limited by small sample sizes and restricted evaluation methodologies.

Cancer-related pain is both common[11] and undertreated among people with advanced cancer.[12,13] Psycho-behavioral treatments, including cognitive behavioral therapy for pain (pain-CBT), are effective for chronic non-cancer and cancer-related pain.[14–22] Unfortunately, typical in-person psycho-behavioral pain management treatments are not often feasible for people with cancer. Insufficient staffing of trained therapists and high symptom burden often prevent completion of traditional pen-and-paper or computerized pain-CBT treatment (i.e., 60-minute, module-based sessions).[23,24] Serious games are a promising medium which may make psycho-behavioral pain treatments more accessible and engaging to patients with advanced cancer and pain.[25] While games focused on cancer-related knowledge and self-management have been developed, there are few serious games intended to support patients in managing cancer pain by employing evidence-based treatments.

Cognitive behavioral therapy (CBT) treatment skills are a focus of many serious games,[26–38] yet development and implementation of serious games for pain-CBT have not been

previously reported. For example, cognitive restructuring (CR) is a technique focused on reducing and modifying negative thoughts and has been identified as a core treatment factor for CBT.[14–22,39] Researcher-developed serious games with CR exercises have been found to be usable,[27] enjoyable,[30,37] and effective[5,26,29] by their target populations. However, existing commercial CR games/apps are variable in quality and are not tailored or tested in specific populations.[40] Moreover, these CR games have not specifically targeted maladaptive thoughts related to pain, or engaged pain coping.

To enable accessible pain-CBT treatment, we developed a multi-level game to be delivered within an existing mobile health (mHealth) application.[25] The mHealth application supports patients with advanced cancer in managing their pain by combining pain-CBT treatments and pharmacologic support.[41] The purpose of this serious game is to help patients learn and rehearse pain-CBT skills with a focus on CR for cancer pain self-management. In line with Phase Ia (Design—define) in the ORBIT model of behavioral intervention development[42] and building off of our previous work,[25] we present a blueprint for developing a serious game using cross-disciplinary collaboration for future researchers and clinicians. The aim of this project is to summarize patient feedback and suggestions for future directions of the game and to test preliminary acceptability and feasibility with target users.

Methods

Game Development Overview

We established cross-disciplinary partnerships that enabled us to focus on user-centered design while retaining the scientific question regarding the therapeutic utility of the game. The multi-institutional partnerships included a pain psychologist/behavioral scientist, graphic designers, a commercial game development firm, and researchers specializing in games for education, oncology, and palliative care. Patients with cancer pain were engaged throughout each stage of development to ensure the resulting serious game was appropriate for players with advanced cancer and pain.[43,44] During early stages of game development, a patient panel (n=4) including individuals who had a history of cancer pain and were familiar with pain-CBT, helped derive game topics, content (e.g., real-life maladaptive thoughts related to cancer pain), and visual designs. Then throughout development, we presented the content and visual animatics to patients individually. Game developers iteratively made changes in response to patient feedback.

Game and Content Development Procedures

The game was developed using the highly flexible and customizable Game Maker Language (GML), which was well suited for a development team comprised of students and professionals.[45,46] The game used a single-player, 2-dimensional, 3rd-person perspective, which was strategically chosen to reduce cognitive load and the emotional threat of the maladaptive thoughts for this seriously-ill population.[47,48] Exercises in the game encouraged players to reflect on maladaptive thoughts about pain and use pain-CBT content learned within its parent mHealth intervention.[25] In this context, the experience of pain and its treatment are defined throughout this game using the biopsychosocial model of pain,

including biological, psychological, and social influences on the initiation and maintenance of the pain experience.[49]

We employed a user-centered, iterative development process[50] to ensure that the final product remained focused on the needs of the target audience while staying within the practical limitations of time and budget.[51] First, the development team held brainstorming sessions to identify scenarios to depict pain-CBT concepts in a game format. Second, content was drafted by the study team and reviewed/modified by patient stakeholders to ensure end-user acceptability. Third, the team reviewed several prefabricated game structures (e.g., rewards, sounds, player control, theme) and mechanics (e.g., quiz questions, aim-and-shoot, matching, drag-and-drop) that the developers could easily customize. The PI of the study (DA) selected adaptive and maladaptive thoughts from examples patients previously provided for the games and clarified necessary visual designs for the "look and feel" of the game. Fourth, the game development and design team originated level settings and game elements, which were iteratively reviewed by the research team and patients. Together, we identified accessible game objectives (e.g., walking, popping balloons, and fishing) that could be easily modified for this purpose.

The patient panel provided feedback on game mockups intended to simplify abstract concepts using visual metaphors. They recommended implementing a progress bar, increasing accessibility by programming audio feedback, using visual animation to convey abstract concepts, and adding non-judgmental language.

Participants and Study Procedures

Participants were recruited from two NCI-designated cancer centers (Stephenson Cancer Center [SCC] in Oklahoma and Dana-Farber Cancer Institute [DFCI] in Massachusetts). Patients were eligible to participate if they were diagnosed with a metastatic or locally advanced malignancy, if they currently or recently (≤6 months) used opioids for chronic cancer pain in an outpatient setting, and if they owned a smartphone. Patients who had significant cognitive impairment and who did not speak English were not eligible to participate. Patients provided informed consent to participate under procedures approved by DFCI and SCC Institutional Review Boards.

Once a clickable prototype was developed, patients (n=14) participated in lab and field testing and completed individual interviews to provide their feedback. Lab testing included a 30–45-minute in-person or Zoom interview where participants played the clickable prototype of the game on their personal phone, study phone, or desktop computer (as preferred by the patient) and were immediately queried about their experience of the game. Field testing included playing the game on a personal phone or study phone in patients' home environments; they received a single "push" notification to initiate playing the game and had access to the parent mHealth app for 28 days. Patients then engaged in individual, semi-structured interviews conducted over Zoom within one to two weeks of field testing.

Interviews were conducted by DRA (PI and pain psychologist) and by K-AA and SMD (research technicians with education in social sciences) and were audio-recorded. DRA and K-AA developed the interview guide, which was informed by existing user-acceptability

measures,[52] and DRA trained study staff in interviewing. At the beginning of each interview, the interviewer (DRA, K-AA, SMD) provided participants with an introduction to the study and its purpose. Participants were instructed to play the game while sharing any extemporaneous feedback and were then asked a series of semi-structured user-acceptability questions[52] to explore their experience of the game and perception of the game's acceptability, ease of use, understandability, clarity, and relevance.[53,54]

Analysis of feedback and game modifications

During and after interviews, research technicians took field notes covering behavioral observations. After each interview, SMD listened to interview audio recordings and transcribed responses, recommendations, quotes, and reactions. The study team determined that data saturation had been reached when subsequent interviews did not reveal novel feedback and patient recommendations had been substantiated by other participants.

During initial game development, we created content codes to capture patient suggestions. We discussed significant recommendations (e.g., recurrent, strongly endorsed) and determined which were feasible to implement as modifications to the game. Following interview completion, SMD and DRA conducted framework analysis,[55,56] coding interviews, developing a framework, creating a matrix, and later generating themes to organize patients' feedback and inform further game iterations.

Results

Pain-CBT cognitive restructuring game

We created one game with five levels. To support learning, practice, and application of the CR skill, an interactive thought bubble was integrated into each game level. The bubble delivered a therapeutic message drawing on cognitive-behavioral skills and encouraged differentiation between maladaptive and adaptive thoughts related to cancer pain. Each level gradually built the player's skills in CR. Level objectives modelled pain-CBT skills (e.g., meditating and blowing maladaptive thought clouds away, popping balloons containing maladaptive thoughts, analogizing a steep hike to building resilience in the face of maladaptive thinking, selecting adaptive thoughts to catch fish, and choosing adaptive behaviors to sled down a mountain; see Figure 1).

Game mechanics were straightforward and intuitive, prioritizing therapeutic goals over complex gameplay.[57,58] The characters were large and moved slowly, example thoughts were written to a 7th-8th grade reading level, and the graphics and engagement cues were simplified compared to standard commercial game features. Players' choices were immediately registered as an input that caused the game to pause or progress. To reinforce learning, patients received explicit, corrective visual and audio feedback when they made selections (e.g., a smiling character vs. a red corrective message and an error sound; Figure 1).[59]

Patient feedback

A total of 14 patients tested clickable game prototypes. See Table 1 for participant demographics. Feedback from patients following game testing grouped around two primary themes: 1) playing the game shifted in-the-moment experiences of pain and negative emotions and 2) playing the game facilitated learning about pain-specific CR. The two themes were interdependent and simultaneously occurring processes.

Playing the game shifted in-the-moment experiences of pain and negative emotions: While the games were designed to promote learning and skill acquisition, patients described that playing the game shifted their in-the-moment experience of pain and other negative emotions by validating their experience and offering a fun or relaxing distraction.

Patients identified different aspects of the serious game that were validating. These elements included highly relevant content specific to cancer pain, supportive tone, characters that responded to patients' selections, and gentle yet informative selection feedback. One participant described feeling validated by the game:

> "It's nice to know you're not alone when you're miserable. And so the fact that I can identify with so many of the thoughts that I should let go means that other people are feeling the same way [chuckles]…" (Female, 46, Desmoid fibromatosis)

Patients noted that the content normalized their negative experiences coping with cancer pain and thus promoted hopefulness, made them feel less alone in their experience, and increased their desire to engage with and learn from the game.

Several participants said that they could see themselves playing or did play the game when they were feeling overwhelmed or needed a peaceful distraction: "You can pull it out when you're in the doctor's office or going through chemo or whatever. You can have it with you at all times to help." (Female, 46, Desmoid fibromatosis). Overall, the peaceful aesthetic of the game provided a useful distraction from acute pain or stress, with one patient emphasizing:

> "And sometimes in your mind you, you know, when you're in cancer pain, you're looking for a distraction, but you don't want it to distract you from what your – your goal is, which would be, like, your goal in playing this game…mentally I feel like it would help me to get out of my head, you know, a little bit, and I mean maybe because then you wouldn't be so focused on the pain." (Female, 40, Ovarian cancer)

Some patients also played the game to have fun and appreciated the gamified elements and objectives.

Learning about pain-specific cognitive restructuring: Many noted that the game prompted reflection on their current thinking patterns and fostered their ability to practice differentiating between adaptive and maladaptive thoughts, as intended. "It [the game] kind of makes you think about it a little bit. Think about your pain and what you're doing" (Male, 75, Kidney cancer). Another stated,

> "Like I think that [maladaptive thought] all the time and I like that it brings it to the forefront so you can acknowledge it, and then maybe you could let it go or maybe you could do something about it." (Female, 40, Ovarian cancer.)

Two others described that the game encouraged reflection on alternative ways of thinking:

> "I like being able to read the negative thought at go, 'Yeah, I've thought that before.' But then the positive, it's like 'okay, that's a good way to look at that.'" (Female, 60, Pancreatic cancer)

> "I mean, it makes you think of how—it makes me think of how negative I'm thinking and I should let that go. Because I am keeping it." (Female, 42, Lung cancer).

Patients appreciated learning pain-CBT skills while playing the game and sought perceivable progress, such as scoring or immediate positive feedback. They felt that the game would best support learning shortly after diagnosis when informational needs are high, but resources are overwhelming. They felt that the game complimented what they learned from providers.

Relevant game content promoted patients' engagement in CR to improve their coping with cancer pain. Because of the bidirectional relationship between their positive experiences and their learning from the game, they perceived the game to be a viable resource to learn from and to support healthy coping in everyday life.

Feedback on game features: As patients began playing demos of the game, they provided feedback to improve comprehension, relevance, player experience, and ease of use. Where possible, feedback was implemented by the game development and design team. See Table 2 for participant feedback and relevant changes.

To improve comprehension, patients suggested reducing repetition in thought pairs, clarifying instructions and score bar functionalities, and adding pop-up messages that would provide validating feedback when a player incorrectly labels a maladaptive thought as adaptive. They wanted more complexity in the game, including greater obstacles, mini-games, rewards, and customization (e.g., personalized avatars). For a few levels, participants requested a quicker pace, fewer clicks to proceed, mood-congruent music, consistent colors, and more detailed character animation. A few patients wanted to remove the score bar because it was perceived as punitive, whereas others felt that it was a needed game element. The score bar was retained as it was a central aspect for learning; however, it was modified to be more visually discreet.

A few participants were disappointed by the lack of challenge and complexity in the serious game, comparing its features to games they played at home for entertainment. Participants often disagreed on what the primary purpose of the game *should* be (e.g., learning, emotional validation, fun, intellectual challenge), which impacted their recommendations for game modification. In some cases, participants stated that they would play the game to learn from the CR exercise but would either not continue playing after completing their learning or would continue playing for distraction.

Discussion

In collaboration with patients and game developers, we developed a serious game for patients with cancer pain to learn pain-CBT skills, primarily cognitive restructuring. In preliminary testing, patients indicated that the game prompted reflection and helped them learn how to modify maladaptive thinking styles related to their cancer pain. Unexpectedly, the game also reportedly served as a useful distraction from acute pain or distress and promoted relaxation. While future iterations and efficacy testing of the game are still necessary, this study can inform the development of serious games that better support the management of complex symptoms in oncology and palliative care populations, such as pain.

Many patients described the game as a notable distraction from their cancer pain and negative emotional experience, resulting in reduced suffering. Above and beyond distraction, many also felt that the game validated their pain experience and reduced feelings of isolation. This led to an openness to engaging with and learning from the game. Acknowledging the role of psychological factors in the pain experience can elicit significant stigma for patients who may feel that such acknowledgements reinforce the idea that the "pain is all in my head." This stigma often deters individuals from exploring psychological coping techniques and promotes reliance on biomedical treatments.[41,60–62] Serious game play may be an avenue to circumvent perception of interpersonal judgement or stigma (e.g. discussion about one's own thoughts driving pain with a clinician) by using a 3rd person perspective in the game, creating psychological distance to promote a more judgement-free internal reflection. Serious games present an exciting opportunity to deliver accessible psychological treatment in a creative and approachable manner, especially for those who are less engaged by other delivery mechanisms.

Our experience emphasizes that serious games require cross-disciplinary partnerships that include clinicians, patients, and game developers. These partnerships are especially important when designing games for people experiencing severe illness, which impacts intervention content, game mechanics, and game design. For example, processing speed, working memory and other cognitive functions can be limited in the advanced cancer population[44,63–66] and serious games should account for these limitations. Interestingly, some patients noted that game characters sometimes felt juvenile or that the animations were slower than necessary. While slowed game mechanics were fundamental, collaboration with patients helped us identify the right balance between accessible game mechanics and speed. Patients wanted the game to be fun but not too realistic, which could feel threatening. In clinical contexts this requires careful consideration to avoid the extremes of either being too "fun" and juvenile versus too "serious." To create a successful serious game, patients should be involved in each stage of development, participate in actual testing, and provide feedback to inform iterations.

Serious games can provide appropriate and wanted distractions during the cancer experience and previous studies indicate they can effectively promote symptom management and cancer-based education.[7–9,67,68] In this study, the content development and acceptability testing procedures completed with the serious game were evidence-informed and developed

through a structured user-centered design methodology. Findings present promise for the application of serious games in the context of cancer pain management and provide direction for others interested in developing serious games for symptom management. See Table 3 for a list of recommendations for game development. Further testing is needed to evaluate the game's efficacy against traditional in person or telehealth pain-CBT. Of note, a few patients who were screened for the study declined participation due to discomfort with using smartphones. Findings may be mostly generalizable to individuals who regularly use smartphones; current data suggests at least 85% of adults in the U.S. own a smartphone.[69] Future iterations of this serious game will include additional psychoeducational components of complete biopsychosocial domains of pain and integration with pharmacotherapy support for cancer pain. Serious games may provide a unique solution to making abstract psychological content more accessible and approachable to patients coping with cancer symptoms.

Funding:

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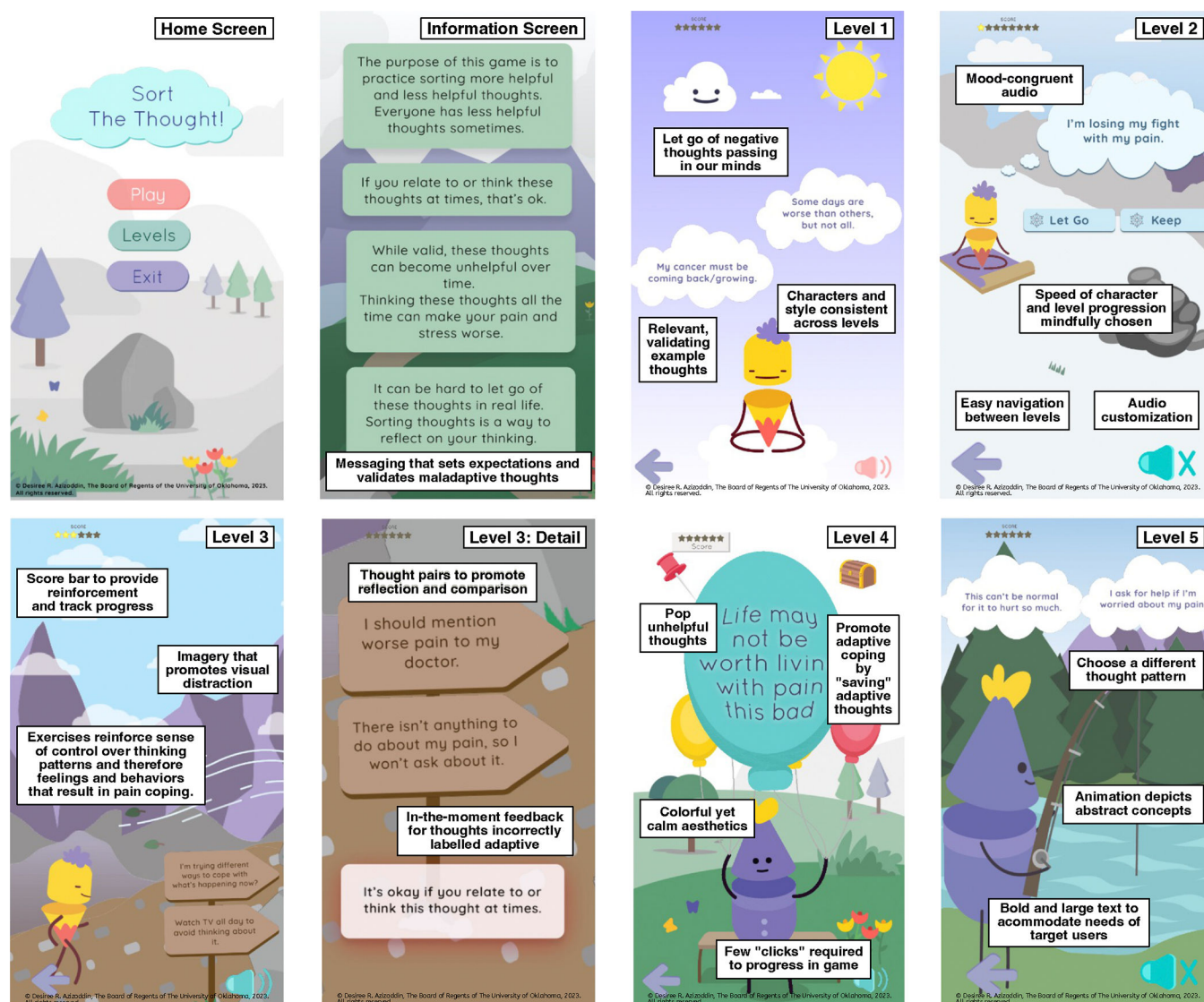
Figure 1. Screen shots of behavioral pain-CBT game (five levels included) that focus on learning and practicing CR specific to the cancer pain experience

NOTE: Level 1: Meditation Under an Open Sky: The first level is designed to introduce players to the game's mechanics and therapeutic context. Set against a calming backdrop of an open sky, players encounter thought clouds representing their inner thoughts. The objective is to recognize and select positive thoughts, fostering a practice of mindfulness and CR. **Level 2: Sledding Down a Mountain**: Players navigate a character sledding down a snowy mountain. They encounter clouds with thoughts and need to select to keep or let go of each respective thought. **Level 3: Climbing a Mountain**: Players climb a mountain, a metaphor for overcoming challenges through a positive mindset. As they ascend, they encounter and sort through a mix of thoughts, continuing to practice CR in a more challenging environment. **Level 4: In the Park with Balloons**: This level introduces a new character in a park, surrounded by balloons (thoughts). The patient selects a balloon with a thought and must choose to 'pop' the negative ones, reinforcing the practice of discarding maladaptive thoughts, or select to 'keep' the positive thoughts. **Level 5: Fishing**

for Relaxation: Set by a peaceful lake, players 'fish' for thoughts, deciding which to keep and which to release. This activity, often associated with relaxation and mindfulness, offers a reflective space for players to consolidate the CR skills they've developed.

Table 1.

Individual Interview Demographics, N=14

	N (n%) or M (SD)
Female	11 (79%)
Age	50.1 (9.75) years Range: 38–75 years
Race	
White	14 (100%)
American Indian/ Alaska Native	
Black/ African American	
Current opioid use	
Short-acting	14 (100%)
Long-acting	9 (64%)
Cancer type	
Head and Neck	4 (29%)
Gynecological	3 (21%)
Breast	2 (14%)
Lung	1 (7%)
Pancreatic	1 (7%)
Hematologic	1 (7%)
Kidney	1 (7%)
Other	1 (7%)
Interview length (minutes)	
m(sd)	0:40:57 (0:10:11)
Range	0:21:45–1:03:08
Zoom interviews	13 (93%)
In-person interviews	1 (7%)
Rural residence	2 (14%)

Note: Panel participants were excluded from demographic data collection.

Table 2.

Participant Feedback on Sort the Thought: STAMP+CBT

Playing approach: Shifting in-the-moment experiences of pain and negative emotions	
Distraction/fun	• Gameplay contributed to sense of fun.
	• Length of levels was appropriate.
	• Animations/action were too slow: *sped up character response time.*
	• More obstacles needed. *
	• New game elements needed. *
	• Mini-games would enhance engagement. *
Relaxation	• Appearance and music were calming.
	• Language and tone were relaxing.
	• Scoring and receiving feedback on answers compromised relaxing tone.
	• Passively reading thoughts instead of categorizing them would be more relaxing.
	• Avoid negativity to preserve relaxing tone.
Validation	• Identification with character through level objectives enhanced feeling of validation.
	• Language was supportive.
	• Scoring and yes-or-no answer feedback did not feel validating.
	• Increasing the challenge of the CR exercise would make the game feel less validating.
	• Harsh/patronizing feedback would feel invalidating.
	• Implying excessive control or focusing on the "bright side" would feel invalidating.
	• Detailed animated facial expressions and additional interactions with characters (e.g., eye contact) would feel validating.
	• Narrative-based aesthetic feedback (e.g., character looks increasingly disheveled after multiple incorrect answers) would be a validating way to communicate correctness/incorrectness. **
	• The ability to create an avatar would enhance feelings of validation. **
	• Add validating messages in response to player selections: *Added to levels in game.*
Playing approach: Learning about pain-specific cognitive restructuring	
	• Setting and level goals support learning.
	• Score bar enhances learning.
	• Being able to track score over time would support learning.
	• Realistic, relatable thoughts are important when practicing the CR exercise.
	• Reduce repetition and avoid harsh or patronizing feedback.
	• Make it more difficult to distinguish maladaptive and adaptive thoughts as levels progress. *
	• Include additional answer feedback: *Added to levels in game.*
	• Add informational pop-up messages related to thoughts: *Added to levels in game.*
	• Build clinician support into gameplay. *

Note:

*
Feedback that will result in changes to be applied in future iterations of the game.

**
Feedback not applied as this was out of scope due to cost.

Table 3.

Development Recommendations

Meet with game developers, software developers, and patients early on.
Clarify the primary goals of the game.
Ascertain desired complexity of initial and future versions of the game.
Consider requirements for producing a workable version of the game that can be built upon in the future with further iterations and funding.
Determine whether the game will be available on mobile platforms, the web, or both.
Understand limitations imposed by the server you will host the game on, especially privacy-related barriers, and how that may impact the data you collect using the game.