

# Playful User-Generated Treatment: A Novel Game Design Approach for VR Exposure Therapy

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## ABSTRACT

Overcoming a range of challenges that traditional therapy faces, virtual reality exposure therapy (VRET) yields great potential for the treatment of phobias such as acrophobia, the fear of heights. We investigate this potential and present playful user-generated treatment (PUT), a novel game-based approach for VRET. Based on a requirement analysis consisting of a literature review and semi-structured interviews with professional therapists, we designed and implemented the PUT concept as a two-step VR game design. To validate our approach, we conducted two studies. (1) In a study with 31 non-acrophobic subjects, we investigated the effect of content creation on player experience, motivation and height perception, and (2) in an online survey, we collected feedback from professional therapists. Both studies reveal that the PUT approach is well applicable. In particular, the analysis of the user study shows that the design phase leads to increased interest and enjoyment without notably influencing affective measures during the exposure session. Our work can help guiding researchers and practitioners at the intersection of game design and exposure therapy.

## CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Virtual reality**.

## KEYWORDS

virtual reality, exposure therapy, user-generated content, game design

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## 1 INTRODUCTION

Simple phobias such as acrophobia (the fear of heights) or claustrophobia (the fear of closed spaces) cause problems that affect many people. In western countries, 7–9% of the population suffer from simple phobias [7], which can evoke panic [114] and can reduce the quality of life. Commonly, individuals tend to avoid spaces or situations where their phobia could be triggered. Therefore, a therapy is desirable in many cases. The most common therapy for acrophobia (and many other phobias) is exposure therapy [84]. Exposure therapy can follow a paradigm of immediate extreme or gradual exposure, with the latter being more common. The gradual exposure therapy aims to teach the patients coping strategies when facing situations that may trigger anxiety or panic and also to gradually lower the experienced intensity of the stimulus and the physiological response to it.

Due to relying on physical stimuli, exposure therapy can be difficult to implement and manage. For example, it is often not possible to travel to places with certain heights. However, a considerable and growing body of work is evidencing that exposure therapy can successfully take place in virtual reality (VR). It has been shown that virtual exposure can be as effective as real exposure [32, 42, 43, 85] and that VRET can successively be applied in treatment [43, 86]. In some cases, virtual therapy can even be more effective [28, 66, 68] and enjoyable [28, 50, 51]. In this way, VRET overcomes a range of challenges that traditional therapy faces, e.g. logistics and safety. Moreover, VRET allows for the efficient and scalable design of individually adapted therapy plans [73, 86] and can relieve therapists [28, 54]. Although 7–9% of the population suffers from simple phobias [7], only very few people undergo a therapy [74] and even if they do, many abandon it, often due to a lack of motivation [5, 16, 20, 50].

Games user research (GUR) established serious games [1] and gamification [39] as effective approaches to foster motivation for learning [22, 31, 38], physical activities [10, 105], work [36, 58] and therapy [50, 77, 103, 104]. While existing literature provides a good understanding of motivational game design (e.g. MDA [62]), it can be argued that common game design strategies for fostering motivation require careful consideration for the context of exposure therapies, as their implementation may interfere with requirements for a successful therapy. Therefore, in this work we investigate the potential of motivational game design elements, including patient-generated content for motivational games, in VRET. Our work was guided by the following research questions:

RQ1: *What are the specific requirements for a game-based virtual reality exposure therapy application?*

RQ2: *How can motivational game design be applied to virtual reality exposure therapy?*

With the more specific follow-up questions for conceptual validation:

RQ3: *For the selected motivational game design strategy: can measurable differences in motivation be achieved?*

RQ4: *For the selected motivational game design strategy: can the resulting exposure experience be expected to be comparable to a non-modified VRET approach?*

To address these research questions, our research is composed of the following parts: (1) To inform the requirements (RQ1) we conducted a literature review that is summarized in Section 2 and two interviews with professional therapists who had a background in traditional exposure therapy that are discussed in Section 3. (2) Based on these results, we developed a two-step concept for motivational games for exposure therapy called PUT which lets users create the anxiety-inducing experience themselves followed by an exposure phase. We built a VR game for exposure therapy (RQ2) that implements the concept in a prototypical fashion (Section 4). (3) To begin answering RQ3 and RQ4, we subsequently conducted a lab-based user study with 31 non-acrophobic subjects to investigate the effect of content creation on player experience, motivation and height perception compared to a baseline condition without the PUT element (Section 5). (4) To provide early-stage ecological validation of our outcomes, we conducted an online survey with 6 professional therapists (Section 6).

Our studies reveal that the PUT approach is well applicable. In particular, the analysis of the user study shows that the design phase leads to increased interest and enjoyment without notably influencing affective measures during the exposure session. Our work provides guidance for game design of computer-mediated exposure therapy.

## 2 BACKGROUND

Our work is informed by conventional and VR-based *exposure therapy*, *motivational game design* and *games for mental health*.

### 2.1 Exposure Therapy

Cognitive behavioral therapy (CBT) is based on a cognitive model of mental illness, which links thoughts, behavior and emotion [45].

The model assumes that one's "emotions, behavior and psychology are influenced by their perception of events. It is not a situation in and of itself that determines what people feel, but rather how they construe a situation" [12]. CBT is problem-oriented focusing on improving the patient's current state with mutually agreed SMART-goals: specific, measurable, achievable, realistic and time-limited [45]. CBT-based mental treatment methods such as exposure therapy (ET) are recognized as the most effective therapy methods [43, 84]. "Exposure therapy is a psychological treatment that was developed to help people confront their fears. [...] In this form of therapy, psychologists create a safe environment in which to 'expose' individuals to the things they fear and avoid. The exposure to the feared objects, activities or situations in a safe environment helps reduce fear and decrease avoidance" [4]. ET is based on two main mechanisms: (1) *Natural habituation* describes a natural decay in physiological response after frequent exposure to the anxiety stimulus. (2) *Cognitive revaluation* is a mechanism that comprises the patients' reflection on the exposure and their fear reaction [84]. The therapy procedure consists of three main phases: preparation, exposure, and reflection. Over time, ET typically varies between gradual and concentrated increase in the stimulus strength (e.g. increases in height). Scharfenberger discriminates three types of exposure therapy: *in-sensu* where the participants only image the exposition to the stimulus, *in-vivo* – an exposure to real stimuli and *in-virtuo* [110] an exposure to virtual stimuli (i.e. VR) [95]. *In-virtuo* exposure, as realized by VRET, offers several advantages over the exposure *in-vivo*, since the treatment can be conducted in the therapist's office or in remote settings and on patients who are too anxious to undergo an *in-vivo* exposure [43]. Furthermore, VRET allows for flexible adjustments to individual needs [86]. VRET uses immersive displays – most commonly head-mounted displays (HMDs) –, spatial audio and frequently reality-based user interfaces [63] for interaction to create strong immersion [19, 100, 102] and a sense of presence [41, 98, 99, 115]. A substantial body of research has applied psycho-physiological measures in the process of VRET and reported on studies that showed effectiveness of exposure in VR and VRET as viable options for treatment of claustrophobia [18, 75], fear of heights [40, 48, 61, 69], fear of flying [71], anxiety disorder [54, 70], and public speaking [67] among others. Emmelkamp et al. showed that exposure to heights in VR can achieve the same effect as *in-vivo* therapy [42]; a result that has been reproduced multiple times [28, 66, 83, 86]. Further meta-analyses on VRET studies provide strong arguments for applying VRET in clinical contexts [17, 28, 50, 56, 86].

We add to this body of research by developing a new approach for VRET that applies a two-step game design. Insights from previous work on motivational game design and game design for mental health further informed the design of these 2 phases.

### 2.2 Motivational Game Design

Literature on game experience often aims to understand features of games that shape player engagement (c.f., [96, 116]) and to transfer this knowledge into recommendations, guidelines, or principles for the design of more appealing games and engaging interactive systems with a purpose [21, 39]. An array of theoretical frameworks has been developed that helps to structure engaging characteristics

of games [21, 111]. These theories are adjacent to flow theory [35] as well as self-determination theory (SDT) [92] which remain the most commonly applied theories to inform and validate game design and metrics of player experience [21, 111].

In his early work in the field, Malone identified challenge, fantasy, and curiosity as 3 key elements of engaging design [76]. For individual game mechanics, a broad array of frameworks exists [2, 52, 82, 89] that identified common structures in game design and linked them with experimentally-focused empirical research. While a large portion of the literature builds on *functional challenges*, which address physical or cognitive skills of the players [30], games with *emotional challenges* received much attention recently. These games confront players with emotionally salient material through narratives, frightening scenarios, strong characters or difficult choices players have to make [30, 37]. In such settings, the players' gratifications can result from resolutions of tensions within the narratives and overcoming negative emotions [15, 30, 44, 55]. However, emotional challenges require a careful design as they can also lead to frustration and disengagement with the game [55]. In relation to ETs, facing and overcoming negative emotions have been recognized as capable elements for shaping engagement and motivation in game design. Accordingly, Ilinx [11, 25] or vertigo games [23, 24] are built around core experiences of vertigo that can become enjoyable in the context of play. As fear tends to be avoided by individuals, games that provide enjoyment from an inherently negative experience could positively contribute to engagement in exposure therapy. In our work, we found that emotional challenges rather than functional challenges in the game should play an important role during an exposure phase in VRET. We also present suggestions how these emotional challenges could be designed.

### 2.3 Game Design For Mental Health

Games for health offer considerable potential for a broad range of application areas and enable not only fostering engagement and motivation, but also guidance (e.g. on treatment protocols in the absence of health professionals) and analysis (through tracing behaviour and/or engagement) [103]. According to Fleming et al. [46], game design offers 3 potentials for health interventions: (1) *appealing potential* by reaching out to target groups without access to treatment otherwise [13, 46, 77], (2) *engaging potential* [17, 93] due to games' enjoyable nature, and (3) *effectiveness potential* since they allow for sensory rich interactive learning experiences. Coyle et al. [33] identified mental health as a key challenge that faces society and argue towards technology-facilitated intervention methods. The authors provide development guidelines for mental-health interventions (MHIs) and suggest that HCI experts and therapists should work in conjunction in a two-phase development cycle [33].

Most literature agrees upon the fact that serious game design for health is a multidisciplinary field where different stakeholders from game design and behavioral change should team up [26, 47, 109]. There is a shared consent that the role of the therapists is essential for a successful and effective intervention [26, 47]. *Clear goals, feedback, engagement, enjoyment and challenge* are recurrently reported as game elements that support motivation in serious games [45, 46, 57, 109]. However, there has been little research that systematically analyzed effects of game elements on mental

health [13]. Johnson et al. reviewed literature that reports empirical evidence on the effect of gamification on health. The authors identified 10 gamification elements and pointed out that "not a single study captured game design elements on intrinsic motivation (e.g. motivation to exercise)" [65] but rather gamification around rewards which address Cole et al.'s *functional challenges* [30]. In this paper, we analyze effects of game elements for mental health games, e.g., on motivation, and thus add a novel contribution to game design for mental health.

## 3 REQUIREMENT ANALYSIS

Designing VRET games is challenging since concepts of traditional exposure therapy and game design elements need to be combined to achieve the desired therapeutic objectives [13, 77]. Additionally, therapists should be involved in the design process as these applications are to be used in a collaborative therapy setting [47]. However, as of now there are few tested game design patterns and no generalizable guidelines for the design of therapeutic games in the domain of VRET that were derived based on the expertise of therapy practitioners. To fill this gap, we conducted and analyzed semi-structured interviews with professional therapists who have a background in treating patients using traditional exposure therapy.

### 3.1 Interview Design & Structure

In preparation of the interviews, a semi-structured document was composed, consisting of bullet points from various themes that were of interest to us to address RQ1. As we aimed for unexpected input by the therapists to arise, the structure of each interview was kept rather flexible, allowing the examiner to adapt to the situation by adding or rephrasing certain questions. The preparation process of the interview followed Helfferich's method of qualitative analysis from the social sciences domain [59] and included the following 4 steps: (1) Collection, (2) Inspection, (3) Sorting and (4) Subsuming.

Following this approach, the interview document was divided into 4 categories: Techniques and Procedures (C1), Setting and Scenarios (C2), Tasks and Motivation (C3) and Supplemental (C4). C4 carried all items that could not be categorized into one of the identified clusters but still remained relevant to address RQ1.

### 3.2 Interview Participants

In total, 2 experts, both self-identifying as female, agreed to participate in the inquiry. Both could draw on substantial expertise in traditional ET. One expert held a master's degree in clinical psychology, had finished clinical training in CBT and was currently working as psychotherapist specialized in posttraumatic stress disorder (PTSD), depression and the influence of childhood maltreatment. The other interviewee held a diploma in psychology and was also working as a psychological therapist offering a variety of therapeutic methods in individual or group sessions. Both had experience in using ET to treat specific phobias on a regular basis.

### 3.3 Conduct of Interview

The interviews were conducted as 30 to 40 minutes long face-to-face conversations in a location of the respective therapist's choosing. Following an introductory conversation, the experts signed a consent form. This detailed the usage of audio recordings and

anonymized further processing of data gathered throughout the interview. As a next step, the examiner began to work through the semi-structured interview.

### 3.4 Interview Analysis

We fully transcribed the audio recordings and conducted a deductive qualitative content analysis [78] using the categorization approach described above. The content analysis was conducted deductively since a basic categorisation had been carried out already in preparation of the interviews. We refrained from deploying an inductive approach as our overall objective was to derive requirements that a technical VRET implementation should account for. As C1 - C4 were created with the aim for a technical solution to ET, they served as a meaningful foundation for the analysis process. In the first step of the analysis, each statement given by the therapists was coded into these four basic categories (C1-C4). A single coding item could be one or multiple sentences belonging to one response. After the material was processed for a first screening, the basic categorization was revised. To ensure validity of the re-categorization and overall coding process, we conducted an inter-coder agreement check [78]. For that purpose, two examiners processed the material independently, created their own categories and coded the data accordingly. As a result of discussion between both coders, 9 final sub-categories emerged. Techniques and Procedures (C1) was divided into: Therapy Procedure (C1.1), Role of Therapist (C1.2), Motivation of Patients (C1.3) and Possible Symptoms (C1.4). Setting and Scenarios (C2) was split into: Impact of Environment (C2.1) and Environment Characteristics (C2.2). Tasks and Motivation (C3) was divided into: Rewards (C3.1) and Possible Tasks (C3.2). Lastly, the additional category Supplemental (C4) was replaced by: Practical Applicability (C4). The categories along with the coding scheme are provided as supplementary materials: <https://osf.io/4cq3k>.

### 3.5 Interview Results

We provide an overview of summarized insights derived from the interviews and link them to game design considerations.

Regarding therapy procedure, the first step in ET is referred to as *probatory*, which serves to discuss and collaboratively decide the steps of ET between patients and therapists. This is necessary in preventing therapy from being experienced to be “other-directed” or imposed upon oneself from the patient’s perspective. In the following course of therapy, patients are confronted with their phobia multiple times until a state of habituation is achieved. In game design, this can be linked to gradual, possibly customized or adaptive increases in challenge relative to one’s own skills. Such patterns are closely linked to flow and the *competence* dimension of SDT.

During therapy, therapists educate patients regarding the effectiveness of the therapeutic approach as well as potential challenges and difficulties. On top of that, therapists have the role of motivators and companions, especially in the first sessions while they gradually recede from directly intervening with the process. In game design, this can be linked to the *relatedness* dimension in SDT, but should be considered in interplay with *autonomy*. It also relates to a range of social and multiplayer game design patterns.

A vital factor determining the outcome of therapy is the patient’s motivation. In line with CBT’s SMART goals [45], motivation is achieved by introducing moments of partial success that are linked to the patient’s small objectives. Motivation is greatly increased by making the patients feel autonomous, e.g. when they finally take the step to seek out phobia-triggering situations on their own. Rewards are a common component of ET and should be used to facilitate motivation. They should be defined by the patients themselves and come in a variety of forms. Both interviewees emphasized the importance of social support and its role as a reward system. In game design terms, this outcome provides clear motivation to explore the potential of games to foster motivation and engagement. More specifically, it invites the consideration of traditional game design elements, such as points, badges or leaderboards, and more complex patterns around personal development (e.g. from RPGs).

During exposure, certain physiological symptoms (e.g. extensive sweating, accelerated heart rate and shaking legs) are expected to appear. Therapists can make use of heart rate measurements and anxiety meters to observe these symptoms. In relation to games, this outcome is important, as traditional game design patterns would overlook this element. It can however, as detailed below, be considered through patterns that emphasize the role of an involved therapist. This can also be linked to promising potential around using modern interaction devices that can record physiological signals, such as wearables, camera-based analysis, etc.

Based on the probatory phase, therapists determine a variety of scenarios for their patients to be exposed to. These scenarios address visual and tactile senses and have some relation to the patient’s daily life. The scenarios usually come in rich variety while not switching between settings too rapidly before reaching habituation. The patients autonomously define which environments they prefer and what level of intensity they choose to confront in a session. In general game design terms, this links to generative / customizable / personalized content and – as further detailed below – this also offers an opportunity to consider user-generated content.

The interviews indicate that one of the simplest and yet most useful tasks in ET is doing nothing at all while focusing on the environment (e.g. the edge of a cliff) and the symptoms it evokes. In relation to games, this constitutes another “unusual” element. When relating to game design patterns, “atmospheric” games and the associated patterns are relevant. This also marks the crucial consideration that the exposure phase may not be easily compatible with the majority of established game design patterns, which typically focus on functional challenges [30] (skill-based tasks) and narrative [9], which are both designed to be captivating.

In summary, the experts agreed that a VRET system could generally be used effectively in ET. They pointed out that the application’s content should not be random but scientifically sound and thus, incorporate traditional therapy concepts. The interviewees stated that VRET can become a vital part of therapy but should not replace real exposure. This calls for the consideration of possible game design patterns that can serve a dual-flow purpose in the sense of seeking alignment between (serious) therapy aims with game-oriented motivation mechanics [103].

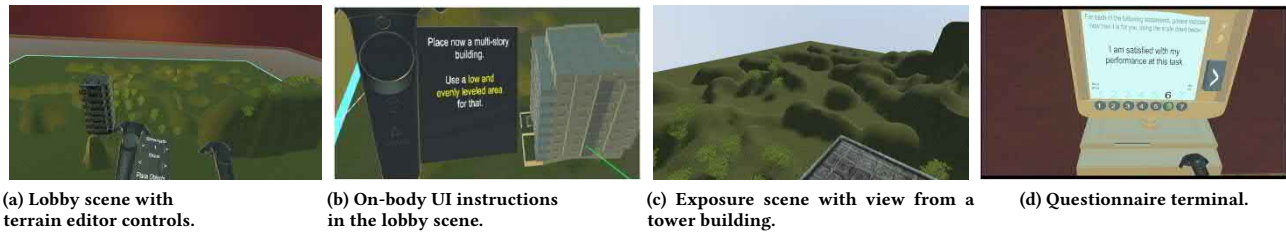


Figure 1: Screenshots of the VRET application.

### 3.6 Requirements & Design Implications

Based on the insights from the expert interviews, we discuss how game design patterns can be combined to build a VRET system that is tailored to support therapists who conduct traditional ET in treatment of acrophobia. We derive a variety of requirements (*R1-R5*) that should be taken into account when designing a VRET system:

*R1: Motivation.* From the interviews, we gathered that one key aspect of motivation in the context of ET is autonomy. Patients are motivated by pro-actively determining the course of therapy. More precisely, by defining sub-goals and deciding which situations to expose themselves to, they are more engaged in the process which helps them to eventually reach habituation. In summary, a VRET application should emphasize the sense of autonomy. This can, for example, be achieved by giving users the opportunity to choose or shape a scenario and the respective tasks.

*R2: Communication.* In line with requirements frequently stated in the literature [26, 47], the communication between therapists and patients was identified to be another crucial element of ET. Since therapists function as motivators, educators and companions during therapy, a VRET system should enable direct communication between them and their patients. This can be achieved by either placing both in the virtual scene (e.g. as avatars [48, 67]) or at least allowing audio feedback to guide patients through the experience.

*R3: Scenario habituation.* Scenarios should give patients a chance to reach habituation. Therefore, users should have enough time to become familiar with their surroundings. Scenes should come in a variety of different aesthetics in dependence of the respective phobia but are not allowed to be switched too quickly.

*R4: Non-distracting tasks.* Regarding tasks that provide a meaningful occupation in the virtual scene, the experts proposed some additional requirements. The typical activity during traditional ET involves exposing oneself to the situation in absence of any other specific activities. As a result, tasks in a virtual environment (VE) should not be distracting, to avoid shifting the focus from the situation to completing some arbitrary task. Notably, this excludes the majority of common game design patterns, which are often built around particular functional challenges and narratives. To enhance motivation, the activities in the VE have to be designed with care and should be linked to real-life rewards.

*R5: Physiological symptoms.* Physiological symptoms are direct results of phobia exposure and help the therapists to monitor the

situation and react accordingly. A VRET system should be designed in a way that prevents additional symptoms due to technical flaws. Visual stuttering, an unstable frame rate or other visual glitches have to be eliminated. Otherwise, physiological symptoms might be wrongly attributed to the virtual exposure although they emerged on account of technical defects.

## 4 GAME DESIGN FOR PLAYFUL USER-GENERATED TREATMENT

Our approach splits the VRET experience into 2 distinct phases (Fig. 1): (1) The design phase, where participants use a terrain editor in VR to create their exposure (Fig. 1a and 1b); (2) The actual exposure phase, in which the participants enter their (self-designed) terrain at full scale (Fig. 1c).

The key of the concept is to allow users to design their exposure in a simulation (top-down view of a miniature map) before they experience it in the exposure at full-scale from a first-person perspective. This approach is in line with recommendations by Mine who found that user-generated content motivates creativity and self-expression as well as that world-in-miniature models can help conceptualizing the VE [80]. This “sandbox” approach is designed to foster intrinsic motivation by creating an engagement with – and a degree of personal relevance of – the exposure through playful creative action (*R1 Motivation*). Further, the approach empowers patients to adjust the degree of exposure to their specific needs, assess their limits and reflect on the progress, all in collaboration with the therapists. The terrain editor can also be included in the preparatory talks between the therapists and the patients in VR (*R2 Communication*) and help visualize the anxiety-producing stimuli. Since a self-paced *scenario habituation* (*R3*) was regarded as an important aspect, both phases needed to be designed in a way that gives users enough time and the right interaction options to either shape and customize (design phase) or explore and experience (exposure phase) the virtual scenario. Moreover, for the exposure phase, the interaction needs to be kept simple and focus on allowing the attentive perception of the exposure, explicitly avoiding any potentially *distracting tasks* (*R4*). Finally, we opted for a proven consumer-grade VR setup (HTC Vive), as the technical setup itself should not cause any additional *physiological symptoms* (*R5*).

### 4.1 Design Phase

For the design phase, we created a terrain editor that employed game elements from sandbox games [49, 90, 108] (e.g. Minecraft [81])

and interaction techniques from applications for 3D content creation (e.g. Tilt Brush [53], Blender [14]), which allow designing own worlds and offer great platforms for customization [112]. In the terrain editor, users interact with the VE in tabletop mode using the VR controllers and a commonly used laser pointer metaphor [64, 72]. The terrain is displayed in miniature form situated in a lobby room. To shape the terrain, users press the up and down buttons on the touch pad to raise or lower the terrain respectively. We attached a body-anchored [3, 94] UI at the controller of the non-dominant hand. From there, users get help or instructions and can select assets (e.g. buildings, nature or characters) to place in the terrain for decoration and personal customization. The asset library consists of 6 exemplary decoration objects: trees, rocks, grass, bushes, stumps, and wooden cottages. The spawn points can be placed as viewing platforms at different points of height (e.g. on buildings or mountains), which then become entry points in the exposure phase. Therapists can pre-select specific assets for the patients that are convenient for the individual cases. They also have control over the minimum and maximum heights and slopes for the VRET as these parameters are most significant for shaping the intensity of the stimulus.

## 4.2 Exposure Phase

The exposure phase resembles examples from existing literature (cf. [43, 86]). To further support a clear focus on the experience, context menus, teleportation and terrain editing tools are disabled. As a general safety precaution, we implemented a panic button: when pressing all four grip-buttons simultaneously, the screen fades out and users immediately teleport back to the lobby.

We implemented our concept using Unity3D and a HTC Vive with the bundled hand-held controllers as the VR platform. This described approach presents an exemplary instance of an implementation that adheres to the requirements and illustrates a specific response to RQ2 in addition to the general requirements discussed above.

## 5 LAB-BASED USER STUDY

To validate the viability of the requirements and the specific approach described in response to RQ2 above and to provide empirical evidence with respect to RQ3 and RQ4, we designed and conducted a user study with non-acrophobic subjects, which investigates the effect of content creation on player experience and height perception. The study employed the acrophobia VRET setup with a playful terrain editor and an exposure to heights in VR as described above. The study took place in a lab, in which users wore an HTC Vive head-mounted display and could move around in a tracking space of approx. 2×3 m. The overall size of the virtual landscape at full scale simulates a world of approximately 40×60 m with heights up to 70 m. However, the surrounding skybox indicates a much larger space and allows for the perception of real-world scale exposure.

Our study included 2 conditions in a mixed between-subjects setup with repeated-measures. In the first condition ( $C_{PUT}$ ), the participants were asked to shape and decorate the terrain with the built-in VR terrain editor. In the control condition ( $C_{ctrl}$ ), the subjects could only view a pre-defined terrain they were about to enter. Both groups were informed that they would enter the terrain

they were viewing or shaping in the second scene. We employed subjective self-reports as measures of intrinsic motivation, affect and anxiety. The assignment to the groups was randomized after balancing for gender. The study received an ethical approval.

To examine how the playful sandbox-style shaping of the exposure environment affects motivation (RQ3) and the perception of height (RQ4), we derived the following hypotheses:

**Hypothesis H1:** The activity of shaping terrains provides a measurably higher motivation than viewing a predefined terrain.

**Hypothesis H2:** There is a measurable difference on subjective ratings of anxiety induced by exposure to height between a self-created terrain and a predefined terrain.

## 5.1 Participants

We advertised the study on campus, via university mailing lists and through word-of-mouth. During acquisition, all subjects were pre-screened using the acrophobia questionnaire (AQ) [29] to exclude participants showing tendencies for acrophobia. An Anxiety Score of >45.45 and an Avoidance Score of >8.67 were determined as thresholds to exclude subjects from the experiment as it is one standard deviation below the score averages of clinical acrophobics [6, 29]. 31 participants (25% self-identifying as female) volunteered for our study. The mean age was 24.32 years ( $SD=4.32$ ). None of the participants showed clinical tendencies for acrophobia (anxiety:  $M=18.87$ ,  $SD=11.67$ , avoidance:  $M=3.55$ ,  $SD=2.36$ ). 20 participants experienced VR once; the others had no prior experience with VR. The groups were balanced for gender ( $U=133.5$ ,  $p=0.49$ ), age ( $t_{29}=1.159$ ,  $p=0.25$ ), avoidance ( $t_{29}=-1.03$ ,  $p=0.31$ ) and anxiety ( $t_{29}=-0.73$ ,  $p=0.47$ ).

## 5.2 Apparatus

In our study, we used the prototype as described in Section 4 with the following adjustments. To only allow valid viewpoints in the scene, we restricted the placement of the spawn points to specific plausible regions (e.g. viewing platform or rooftops of a building). Additionally, after completion of the design phase, the following adjustments were applied to the terrain: a) a straight abyss down to the ground level was cut at the view point and b) the surface of each mountaintop was flattened (without notably changing the total height). For the final spawn points, we calculated the position on the spawn platform that was furthest away from the abyss. The rotation was set to look away from the ledge. To avoid users watching down the “end of the world”, we restricted the rotation of the buildings so that the viewing platform would always face towards the center of the terrain. For consistency between the trials in the design phase, we provided only one single circular shaped terraforming brush with a medium strength.

As we aimed to assess repeated self-reports in VR, to avoid breaks in presence [101] we added questionnaire terminals (see Fig. 1d) as world-anchored in-VR questionnaires (inVRQs) [3, 87]. In the terrain scene, we positioned the questionnaires on the opposite side of the ledge to minimize interference with the exposure when responding.

### 5.3 Measurements

We assessed intrinsic motivation using the *Intrinsic Motivation Inventory* (IMI) [91] on the 4 sub-scales *Interest-Enjoyment*, *Competence*, *Effort-Importance*, and *Tension-Pressure* with 7-point Likert scales. To get an impression of the participants' emotional state, we applied the *Positive and Negative Affect Scale* (PANAS) [34]. PANAS consists of 2 sub-scales (10-items each) that assess positive and negative affect respectively on 5-item Likert-scales.

Cleworth et al. [27] showed that non-phobic subjects rate the exposure to different heights with different ratings. Therefore, we included subjective measures of anxiety as to validate the effectiveness of the VE. To measure levels of anxiety induced by the exposure to heights, we used the 20-item *State-Trait-Anxiety-Inventory* (STAI) [106]. STAI contains 2 sub-scales (10 items each) that access the propensity to be anxious (*trait anxiety*) and a temporary anxiety with fluctuating intensity (*state anxiety*). As an additional measure of affliction, we used the *Subjective Units of Distress-Scale* (SUDS) [6, 8] – a single-item visual analog scale ranging from 0 (no anxiety) to 100 (highest anxiety).

### 5.4 Procedure and Tasks

We first informed the participants about the study procedure and gained their consent for participation. Next, the subjects stated basic demographics and were randomly assigned to one of the conditions ( $C_{PUT}$  or  $C_{ctrl}$ ). Subsequently, the participants entered the lobby scene. Depending on the conditions, we instructed the subjects differently. In both conditions, they initially entered an empty lobby where we explained the panic switch, navigation and interaction with the inVRQs. After the tutorial, the participants rated their anxiety on the SUDS and we activated the terrain. For  $C_{PUT}$ , we explained the controls of the terrain editor and asked the participants to shape and decorate the landscape to their liking, but with the constraint that the terrain should contain 3 viewing platforms with different heights each (mid high hill 30 m, high hill 50 m and a tower building 70 m). We chose these heights because all exposures should evoke a sense of notable height at different intensities for convenient subjects (explicitly not suffering from acrophobia). For  $C_{ctrl}$ , we pre-designed a terrain that contained the same types of elements available for placement and modification in the other condition. To create a meaningful duration for the pre-exposure phase, the subjects were instructed to inspect and memorize the scene. In both conditions, the participants thereby engaged with the terrain for 3–5 min. After 2 min in, the participants gave a second SUDS rating. After finishing the editing or memorizing task respectively, the participants completed the IMI as well as a third SUDS and were further instructed to proceed to the next scene (teleport to the next location).

In random order, the participants teleported to all 3 spawn points and underwent an exposure to heights from each platform. To ensure that the participants were exposed to the heights and did not have their eyes shut, we implemented a secondary task. The participants should throw down a ball and read a series of numbers displayed on the ground when they looked down the pit. Although the secondary tasks can potentially facilitate an unintended playful experience or a distraction, this or similar tasks have been applied in the experimental setups to encourage participants engaging with

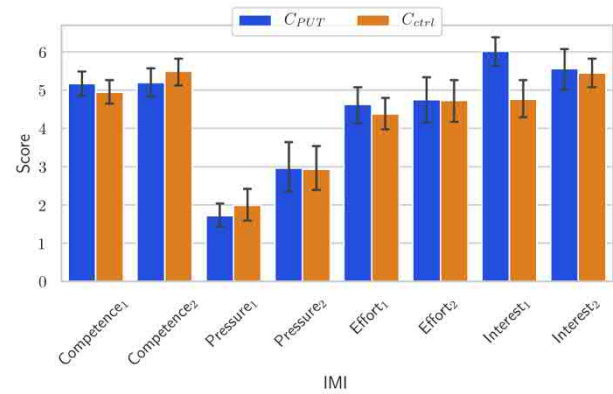


Figure 2: Bar plots of both IMI assessments. The whiskers indicate the SD.

the exposure task [40, 79, 97]. Each trial consisted of the following steps: (1) Participants pick up a ball and approach the ledge; (2) They extend their arm over the ledge so the ball is above the abyss; (3) They let the ball fall and follow it with their sight; (4) Participants read out numbers shown on the ground floor when the ball hits the ground; (5) They approach the terminal and rate their anxiety on STAI and SUDS. We assessed trait anxiety after the first trial. State anxiety was rated after every exposure. After all 3 trials, the participants filled out a second IMI and a PANAS and left VR. We then conducted a semi-structured interview with the participants to gain additional insights about their player experience. On average, participants spent 23.07 min ( $SD=3.86$ ) in VR ( $C_{PUT}$ :  $M=24.2$ ,  $SD=4.02$ ;  $C_{ctrl}$ :  $M=21.63$ ,  $SD=3.24$ ;  $t_{28,38}=2.14$ ,  $p=0.02$ , Cohen's  $d=0.76$ ), with the difference resulting from a varying duration in the first phase. A detailed analysis showed the difference was only significant in the lobby scene ( $t_{11,65}=11.65$ ,  $p<0.01$ , Cohen's  $d=0.76$ ) with 2.07 min ( $SD=2.00$ ) in  $C_{PUT}$  and 3.99 min ( $SD=0.36$ ) in  $C_{ctrl}$ . The total study duration was about 30 min.

### 5.5 Results

*Intrinsic Motivation.* For all IMI subscales, we conducted mixed-factorial ANOVAs with the respective subscale as a within (repeated-measures) factor and condition as between factor (Fig. 2). The analysis showed significant differences within subjects only on Tension-Pressure. A Bonferroni-corrected post-hoc t-test confirmed this difference ( $t_{29}=-5.80$ ,  $p<0.01$ , Cohen's  $d=-1.04$ ). The MF-ANOVA revealed a significant difference between the conditions and an interaction effect on the Interest-Enjoyment subscale. A post-hoc comparison of Interest-Enjoyment with Bonferroni-correction between the  $C_{PUT}$  and  $C_{ctrl}$  was significant ( $t_{29}=2.40$ ,  $p=0.02$ , Cohen's  $d=0.43$ ). There was a significant interaction of  $CONDITION \times INTEREST-ENJOYMENT$  between  $C_{PUT}$  and  $C_{ctrl}$  of the first assessment ( $t_{29}=3.90$ ,  $p<0.01$ , Cohen's  $d=0.70$ ) as well as between first and second assessment in  $C_{ctrl}$  ( $t_{29}=-3.17$ ,  $p=0.02$ , Cohen's  $d=-0.57$ ). The results of the MF-ANOVAs are summarized in Table 1. This indicates that significantly higher motivation potential can be achieved on the Interest-Enjoyment dimension (H1, RQ3), while the more

**Table 1: Mixed-factorial ANOVA for both IMI assesses.**

	$C_{PUT}$	$C_{ctrl}$	IMI			Condition			IMI × Condition		
	M (SD)	M (SD)	$F_{1,29}$	p	$\eta_p^2$	$F_{1,29}$	p	$\eta_p^2$	$F_{1,29}$	p	$\eta_p^2$
Competence	5.18 (0.72)	5.22 (0.71)	4.12	0.05	0.12	0.04	0.85	< 0.01	3.29	0.08	0.10
Tension-Pressure	2.34 (1.22)	2.46 (1.12)	32.87	< 0.01	0.53	0.14	0.71	< 0.01	0.63	0.43	0.02
Effort-Importance	4.69 (1.12)	4.55 (1.01)	2.25	0.14	0.07	0.15	0.70	0.01	0.53	0.47	0.02
Interest-Enjoyment	5.79 (0.97)	5.10 (0.89)	0.59	0.45	0.02	5.78	0.02	0.17	14.37	< 0.01	0.33

**Table 2: One-sample t-tests against a neutral response (4.0) for both IMIs. Top: IMI<sub>1</sub> assessment directly after terrain editing. Bottom: IMI<sub>1</sub> assessment after all 3 exposures.**

IMI <sub>1</sub>	$t_{30}$	p	mean diff.
Competence	9.14	< .001	1.06
Tension-Pressure	-15.40	< .001	-2.15
Effort-Importance	3.09	< .001	0.50
Interest-Enjoyment	7.45	< .001	1.41

IMI <sub>2</sub>	$t_{30}$	p	mean diff.
Competence	9.88	< .001	1.34
Tension-Pressure	-4.73	< .001	-1.05
Effort-Importance	3.46	< .001	0.74
Interest-Enjoyment	9.07	< .001	1.51

functional (competence / effort) and potentially negatively associated (with respect to the application scenario) Tension-Pressure dimension is not likely to differ dramatically (RQ4). The lack of differences in the exposure phase and increased Tension-Pressure after the exposure indicate some functioning of the phase as intended (RQ2, RQ4).

To determine if the IMI measures deviate from neutral, we performed one-sample t-tests against a neutral score of 4 (see Table 2). The results (all  $p < 0.001$ ) show a positive difference from neutral for Competence, Effort-Importance and Interest-Enjoyment, suggesting that the experience was perceived as challenging, enjoyable and that the participants are willing to invest effort. Tension-Pressure showed a significant negative difference from midpoint, which can be linked to the exposures not resulting in notable anxiety (as expected with non-acrophobic convenient subjects).

*Affect and Anxiety.* We measured affect using PANAS after each exposure task. We conducted independent t-tests to compare the participants' affect between the conditions. Both positive affect ( $M=37.61$ ,  $SD=4.39$ ,  $t_{29}=0.75$ ,  $p=0.46$ ) and negative affect ( $M=14.03$ ,  $SD=4.55$ ,  $t_{29}=-0.99$ ,  $p=0.33$ ) did not differ significantly. This arguably provides further corroborative evidence to comparable exposures (RQ4). For STAI (see Fig. 3) and SUDS as measures of anxiety, we conducted MF-ANOVAs with the 3 exposures (tower, high, and mid) as within factors and condition as between factor. The results show no significant differences and no interaction effects for both measurements (see Table 3). To investigate how the anxiety evolved over the course of the study, we conducted MF-ANOVAs with anxiety and assessment number (STAI and SUDS) as within factors and condition as between factor. For SUDS, we used the assessment at the end of the first phase as baseline for anxiety. Both analyses

**Table 3: Mixed-factorial ANOVA of anxiety measures SUDS and STAI for all 3 exposures.**

	SUDS		STAI	
	$F_{2,58}$	p	$F_{2,58}$	p
Anxiety	0.46	0.11	0.63	0.89
	$\eta_p^2$	0.02	< 0.01	
	$F_{1,29}$	0.82	< 0.01	
Condition	p	0.37	0.99	
	$\eta_p^2$	0.03	< 0.01	
	$F_{2,58}$	3.27	2.91	
Anxiety × Condition	p	0.05	0.06	
	$\eta_p^2$	0.10	0.09	

showed significant main effects (SUDS:  $F_{3,34,67.95}=17.69$ ,  $p < 0.01$ ,  $\eta_p^2=0.38$ , Greenhouse-Geisser corrected  $\epsilon=0.78$ ; STAI:  $F_{2,58}=4.90$ ,  $p=0.01$ ,  $\eta_p^2=0.02$ ) but no significant differences between conditions nor interaction effects. Subsequent post-hoc tests revealed significant differences between platform<sub>1</sub> and platform<sub>3</sub> on both anxiety measures (SUDS:  $t_{30}=2.73$ ,  $p=0.03$  mean diff.=3.32, see Fig. 4; STAI:  $t_{30}=2.82$ ,  $p=0.03$  mean diff.=3.58). For SUDS, all platforms were significantly more anxiety-inducing than the baseline (platform<sub>1</sub>:  $t_{30}=-5.46$ ,  $p < 0.01$ , Cohen's  $d=-0.98$ ; platform<sub>2</sub>:  $t_{30}=-4.99$ ,  $p < 0.01$ , Cohen's  $d=-0.90$ ; platform<sub>3</sub>:  $t_{30}=-5.54$ ,  $p < 0.01$ , Cohen's  $d=-1.00$ ). These results indicate that there were perceivable differences between the different levels of exposures in-line with the intended effects (RQ2), while there are no strongly notable differences in the resulting exposure phases between conditions, as intended (RQ4, H2<sub>0</sub>). There was a strong correlation of STAI and Tension-Pressure (Pearson's  $r_{29}=0.72$ ,  $p < 0.01$ ) and a medium correlation with Effort-Importance (Pearson's  $r_{29}=0.43$ ,  $p=0.02$ ). This underlines a positive applicability for ET (RQ2, RQ4).

*Qualitative Feedback.* At the end of each session, we asked the participants to comment on their experience and their relationship with the VE. We list paraphrased statements ordered by their frequency: "I felt related to the VE" ( $C_{PUT}$  15×,  $C_{ctrl}$  1×), "The terrain shaping was creative" ( $C_{PUT}$  10×), "The controls were intuitive" ( $C_{PUT}$  10×,  $C_{ctrl}$  2×), "The experience was interesting or enjoyable" ( $C_{PUT}$  9×,  $C_{ctrl}$  6×), "I had a vertigo experience when I was looking down" ( $C_{PUT}$  6×,  $C_{ctrl}$  7×), "The environment felt realistic" ( $C_{PUT}$  6×,  $C_{ctrl}$  0×), "I had difficulties with the pointer or teleporter" ( $C_{PUT}$  5×,  $C_{ctrl}$  1×), "Reading the UI was difficult" ( $C_{PUT}$  4×), "I would like to have more assets/controls" ( $C_{PUT}$  4×), "Looking down did not make me anxious" ( $C_{PUT}$  1×,  $C_{ctrl}$  7×),



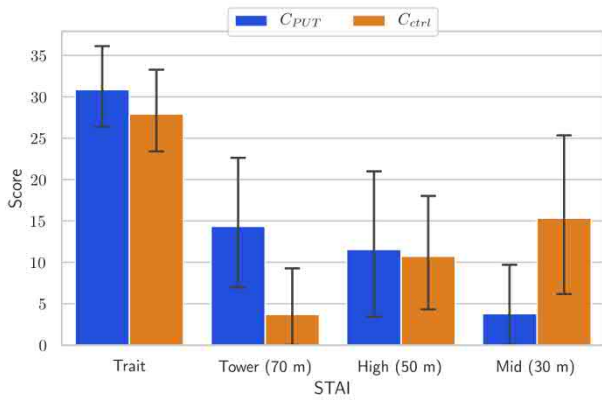


Figure 3: Bar plots of STAI. The whiskers indicate the SD.

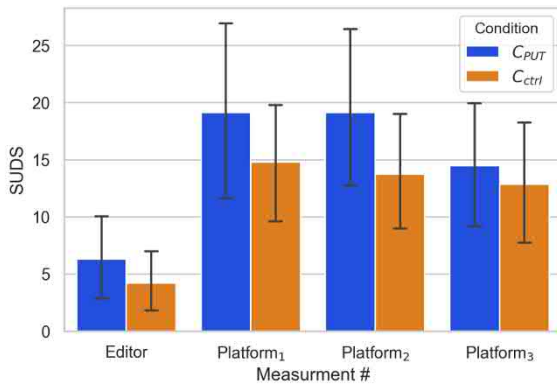


Figure 4: Bar plots of SUDS by order of exposure. The whiskers indicate the SD.

“There were too many questionnaires” ( $C_{PUT}$  1×,  $C_{ctrl}$  0×), “I learned something about myself” ( $C_{PUT}$  1×,  $C_{ctrl}$  0×), “The experience was not interesting or enjoyable” ( $C_{PUT}$  0×,  $C_{ctrl}$  6×), “I did not feel related to the VE” ( $C_{PUT}$  0×,  $C_{ctrl}$  4×), “The environment felt unrealistic” ( $C_{PUT}$  0×,  $C_{ctrl}$  2×).

### 5.6 Outcomes

The results show that the VR experience created some sense of anxiety (RQ2), although not to the point of resulting in strong perceived tension or negative affect. This is supported by the raised SUDSs of all platforms compared to baseline and relatively raised Tension-Pressure of IMI<sub>2</sub> after the exposure. Also, the significant decay in anxiety both on SUDS and STAI from first to third exposure indicates a habituation which is normal for people without acrophobia. The strong correlation of Tension-Pressure and Effort and the anxiety measurements further corroborates these outcomes. Low negative and high positive PANAS scores as well as positive ratings of IMI show that the experience was generally engaging and positively accepted by the participants (RQ2).

Regarding H1, the higher interest and enjoyment in  $C_{PUT}$  shows that user-generated content can bring up interest. This is further underlined by the qualitative comments which indicate that the process is perceived as creative and supports the forming of a personal VE. This is a positive indication for the concept of playful user-generated therapy (RQ3). Moreover, only in  $C_{PUT}$  the subjects stated that the environment felt realistic. Contrary, only in  $C_{ctrl}$  the participants stated they felt not related, had a low sense of vertigo or lack of realism. These results show evidence in favor of H1, that user-generated content facilitates aspects of intrinsic motivation. We observed a significant increase of Interest-Enjoyment in  $C_{ctrl}$  between IMI<sub>1</sub> and IMI<sub>2</sub>. This results most likely from the non-interactive experience in the lobby. Conversely, we observed a drop in Interest-Enjoyment for  $C_{PUT}$  between IMI<sub>1</sub> and IMI<sub>2</sub> to a level comparable with IMI<sub>2</sub> in  $C_{ctrl}$ . This can be explained by the simplicity of the experience in the exposure phase and by the participants’ low anxiety towards heights.

We could not find conclusive evidence to support H2. For anxiety, we only observed differences between the height levels but not between the conditions. These results, together with the qualitative comments, indicate that the exposure felt realistic and anxiety-inducing without a notable effect of the game elements on the perception of heights. We therefore reject H2 and count this as positive evidence towards the requirement that the game elements should not notably interfere with the exposure (RQ4). However, the results show fluctuations with small effect sizes and a marginal significance. Therefore, it is undue to conclude that there are no effects and these indications require further validation.

With regard to RQ2, we found that the probatory is a suitable phase of the therapy session to include game elements that do not interfere with the therapy. The self-creation of the phobic stimuli is a welcomed approach for the therapists and allows them to adjust the exposure to the patients’ individual needs; a feature that is crucial for effective computer-mediated therapy [60]. This is in line with the SMART goals [45] and with Thompson et al.’s guidelines and offers opportunities to address the *Goal Setting*, *Problem Solving*, *Motivational Statements* and *Feedback* in game design for therapy [109]. Empowering self-creation mechanics can facilitate creativity [113, 117] and interest for the therapy and address Malone’s curiosity dimension of educative game design [76] in contrast to frequently applied elements such as rewards or challenges.

### 6 ONLINE SURVEY EXPERT EVALUATION

To validate our approach regarding its potential applicability in a real-life therapy scenario, we conducted an online study with practicing therapists. For further validation, we included therapists with a wider range of expertise than in the initial interviews. This online survey was not meant to be a final evaluation of a fully functional system but a way to obtain an additional expert perspective on the PUT concept. The survey consisted of a consent form, 12 questions concerning the proposed game design and 13 items targeting the respondents’ professional background, technical expertise and other demographic data. To illustrate the design approach, the survey contained an introductory text with corresponding images and an embedded video explaining VRET in general and demonstrating the

PUT concept. The 3 min long video was compiled from several documentaries from public media on VRET and demo clips of VR games and VRET applications which corroborate the feasibility of VRET as well as a demo of the terrain editor and the exposure phase accompanied by an explanation of PUT. For copyright reasons, the video cannot be published. After perceiving the material, the therapists filled out the forms which took between 15 and 20 minutes.

## 6.1 Participants

6 therapists (5 female) filled out the online survey. The group of interviewees included 3 therapists specialized in depth psychology, 2 behavioral therapists and 1 expert in ET. Their ages ranged from 28 to 64 years ( $M=49.33$ ,  $SD=13.51$ ). 5 experts held an approximation and 1 a master's degree in psychology. Work experience as a professional therapist was reported to be between 1 and 31 years ( $M=11.17$ ,  $SD=9.91$ ). All therapists were asked to rate their experience regarding VR on a 5-point Likert-scale ranging from "No Experience (1)" to "Expert (5)". On that scale, responses lay between 1 and 2 ( $M=1.17$ ,  $SD=.37$ ). None of the experts used VR in a professional capacity or for entertainment. Responses on frequency of utilizing CBT methods in therapy included "never" ( $n=1$ ), "once a year" ( $n=1$ ), "multiple times a year" ( $n=1$ ), "once a week" ( $n=1$ ) and "multiple times a week" ( $n=2$ ). The frequency of treating acrophobia ranged from "never" ( $n=1$ ) to "once a year" ( $n=1$ ) and "multiple times a year" ( $n=4$ ).

## 6.2 Results

*Quantitative Results.* Regarding applicability in a real-life therapy scenario, the therapists rated the PUT design approach on a 5-point Likert-scale ranging from "Not Useful" (1) to "Very Useful" (5). On average, the design received a score of  $M=3.67$  ( $SD=.75$ ) (RQ2). All experts agreed that giving the patients the opportunity to create the environment for later exposure is a valuable approach. The majority of participants ( $n=5$ ) stated that separating therapy into 2 steps (design and exposure phase) may have a positive impact on the course of therapy. The remaining expert expressed it would not affect the therapy. Regarding the influence of the patient's contact with the scaled-down miniature terrain (RQ4), the experts reported that it may lead to positive effects ( $n=4$ ) or no effects ( $n=2$ ). Since non-distracting tasks were identified to be one core requirement of VRET design, we asked the experts if the design phase may distract from the actual exposure (scale ranging from "No Distraction" (1) to "Full Distraction" (5)). This item received an assessment of  $M=2.00$  ( $SD=1.15$ ) (RQ4). Regarding communication between therapists and patients, 4 therapists would like to accompany their patients during the design phase, whereas the remaining 2 experts stated this would not be necessary.

*Qualitative Feedback.* 2 experts stated that a playful approach would be beneficial in preparation to real-life exposure as the situation itself would not be perceived to be as terrifying as in the real world. However, since the virtual representation of phobia-inducing stimuli lacks in realism, 3 experts explicitly stated that it should not replace real exposure. Additionally, 2 experts pointed out that communication should be enabled by the system whereas 1 therapist wished to enter the virtual world along with the patient. 1 expert reported that PUT may lead to a higher sense of control (RQ3) and

perceived self-efficacy. Another therapist reinforced this assessment by stating that PUT design could give patients a sense of security. As a suggestion for future development, 1 therapist proposed the idea of exposing patients to virtual scenes that were not created by them in later stages of therapy.

## 7 DISCUSSION

With regard to RQ1, we identified 5 considerations for VRET game design. For an auspicious computer-mediated ET, patients should have control over the course of therapy by defining tasks, goals and situations themselves (R1). VRET should allow for direct communication between therapists and their patients during exposure (R2). Scenarios should come in rich variety but leave patients enough time to get accustomed to and reach habituation (R3). As for potential in-game tasks, they should be linked to real-life rewards but not be too distracting from the exposure or be perceived as tests of courage (R4). The system itself should not cause any additional physiological symptoms that might be wrongly attributed to exposure (R5). Most of these requirements are in line with the SMART goals [45] and existing frameworks on game design for interventions (cf. [33, 46, 109]). However, we found the combination of motivating (R1) and non-distracting game design (R4) a specific requirement for VRET that is rarely discussed in the literature on games for change. The outcomes of the user study show evidence that self-generated anxiety stimuli can raise the intrinsic motivation for a simple task (RQ3, H1) while not interfering with the sense of anxiety (RQ4, H2<sub>0</sub>) and thus, our design approach fulfills R1 and R4 explicitly. The experts involved in the online survey gave an overall positive assessment of PUT design in terms of applicability in a real therapy scenario (RQ2). A minority of the therapists was concerned that the patients would avoid challenging themselves. Most therapists acknowledged the PUT concept to be applicable, to have a positive effect on the motivation (RQ3) and not being too distracting (RQ4). Moreover, the survey identified potential for improvements for future iterations such as a communication interface between the therapists and the patients. The experts emphasized that communication between therapists and patients is crucial and should be anchored deeply in the design. They highlighted that VRET should be considered as an addition but not as a replacement for conventional ET. These triangulated results corroborate that PUT appears to be a viable concept that warrants further development and study.

### 7.1 Limitations and Future Work

Empirical user studies with phobics are ethically problematic, since they require experienced support in case of a panic. Therefore, this early-stage research evaluated the approach with convenient subjects. However, Robillard et al. [88] compared emotional reactions of phobics and non-phobics to different phobias in VR and showed that both groups react to phobic stimuli similarly but to a different degree; with phobics being affected by the VE stronger. Interestingly, the authors found no differences in the perception of game elements. This shows evidence that evaluation of game design for exposure-based VR with non-phobics should generalize to phobics as well and may be transferred to other phobias. According to Coyle et al. [33], this work is situated in the first phase

of the development cycle. In future work, we aim to investigate PUT with afflicted subjects under the supervision of therapists. In the study, we did not assess autonomy since the study was conducted with convenient subjects and therefore, we did not expect a raise on autonomy, as no deregulation compared to traditional ET would be notable to the subjects. However, literature on motivation shows that user-generated content can raise the sense of autonomy and competence [92, 113, 117] and that creativity is linked to self-empowerment [107]. As the study was mainly concerned with the interference of game design, height perception and intrinsic motivation, assessment of autonomy was beyond scope. This should, however, be addressed explicitly in future work with phobic patients and SDT. Further, the subjective ratings on anxiety (SUDS and STAI) show high variances that are likely attributed to low sensitivity towards heights. Although this work is based on validated measurements, future work should consider physiological measures of anxiety such as heart rate or galvanic skin response for clearer and more reliable data.

As fear generally embodies avoidance, it is difficult to create an intrinsic motivation to coping with one's phobias. Thus, presenting anxiety inducing stimuli in an enjoyable way is a challenging demand for game design. Our research shows that game design for non-intrusive playful experiences is rarely explored in the literature and requires further attention. Likewise, further traditional game elements could be employed, especially in the design phase, as well as game mechanics that may contribute positively to the therapeutic potential of the exposure phase, e.g. around vertigo experiences or emotional challenges associated with phobias. Both are underexplored in the literature and should be considered in future research on VRET games.

## 8 CONCLUSION

We presented a novel game design approach for VR exposure therapy: playful user-generated treatment (PUT). We investigated this concept with a multi-angled approach: a requirement analysis, the implementation of a VR-based game, a user study with convenient subjects, and an online survey with a distinct group of therapists. The requirement analysis revealed that VRET is considered to be a useful addition to conventional therapy and that VRET game design demands specific considerations, which are rarely addressed in the literature. The requirements led to the PUT design approach that separates ET in VR into design and exposure phases. Our two validation studies with the VR game show that PUT is well applicable. In particular, the user study reveals that the users' content creation leads to increased interest and enjoyment without notably influencing affective measures during the exposure session. The positive indications with convenient subjects also suggest that further study and validation in an applied therapeutic context appear warranted.

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