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A Palette of Deepened Emotions: Exploring Emotional Challenge in Virtual Reality Games

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ABSTRACT
Recent work introduced the notion of 'emotional challenge' promising for understanding more unique and diverse player experiences (PX). Although emotional challenge has immediately attracted HCI researchers' attention, the concept has not been experimentally explored, especially in virtual reality (VR), one of the latest gaming environments. We conducted two experiments to investigate how emotional challenge affects PX when separately from or jointly with conventional challenge in VR and PC conditions. We found that relatively exclusive emotional challenge induced a wider range of different emotions in both conditions, while the adding of emotional challenge broadened emotional responses only in VR. In both experiments, VR significantly enhanced the measured PX of emotional responses, appreciation, immersion and presence. Our findings indicate that VR may be an ideal medium to present emotional challenge and also extend the understanding of emotional (and conventional) challenge in video games.

CSS Concepts
• **Human-centered computing → User studies**

Author Keywords
Player Experience; Emotional Challenge; Virtual Reality; Games; Emotion

INTRODUCTION
Challenge is arguably the core element that shapes player experiences (PX) [6,9,10,2]. Without a certain type of challenge, players would not be so fond of playing digital games [24,27]. Recent work introduced the notion of emotional challenge as a fertile ground to explore more unique and diverse PX in digital games [2]. Emotional challenge "*confronts players with emotionally salient material of the use of strong characters, and a captivating story, and wherein the core pleasure is the resolution of tension within the narrative, emotional exploration of ambiguities within the diegesis, or identification with characters*" [6]. The concept of emotional challenge holds great promise in many aspects including eliciting a wider range of emotions beyond the frustration-fiero cycle typical of more 'conventional' challenge, understanding game challenge more sufficiently and inspiring the design of games that mirror real-world issues [2]. With this promise, it has immediately attracted HCI researchers' attention, particularly in empirically surveying players' emotional responses of emotional and conventional challenge [2] and creating a more distinguished challenge measurement [10].

Digital gameplay experience depends not only on the type of challenge that the game provides, but also on how the challenge be presented [35]. The recently released VR head-mounted display provides a new interface for playing digital games. Many traditional desktop games, especially the first-person shooter [48,51] and horror-adventure types [49,41], have quickly been ported to VR. This has aroused new efforts to learn PX in VR but the main attention is kept on PX of traditional types of game challenge. One important fact is that, increasing VR games are exposing players to emotionally challenging characteristics such as narrative materials, strong characters or emotional ambiguities. VR's strength in offering great realism and immersion may endow it great potential to present the type of emotional challenge. However, emotional challenge in VR has so far received little attention and, to our knowledge, the concept has never been experimentally explored.

As emotional challenge may be mutually exclusive [6] or coexist with conventional challenge [2], we conducted two experiments to explore how the two forms of emotional challenge affect player experiences (PX). Specifically, to study how relatively separate emotional or conventional challenge affects PX and how VR acts on the effects, we selected two game scenarios with each provides typical emotional or conventional challenge from a commercial game *Fallout 4* [52] and then conducted a mixed-subjects experiment (N=28) to compare the effects of each game scenario on multiple PX related survey scales in VR and desktop PC. We found that the emotionally challenging game elicited a wider range of different emotions than those induced by the conventionally challenging game and VR

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significantly deepened the emotions elicited by either game scenario.

To explore how PX be influenced when emotional and conventional challenge joint together and the impact of VR, we selected a new game scenario of *Fallout 4* [52] and manipulated it into two versions: one with additional emotional challenge and the other without. Results of a between-subjects experiment (N=40) showed that the adding of emotional challenge changed the types of dominant emotional responses in PC and VR and only in VR, the additional emotional challenge made players' emotional responses broader and deeper.

RELATED WORK

Challenge often refers to tasks that players need to accomplish in games [1,44]. People enjoy playing digital games mainly because they can struggle to overcome a certain type and degree of challenge [24,27]. Different type of challenge may evoke different player experiences (PX) [9,10,32] and an appropriate level that matches the player's skills will provide the optimal experience [9,15]. Generally, two prominent types of challenge are established in digital games [9,10,1,44]. One is labelled *physical challenge* which demands a player's physical skills with respect to speed and accuracy, physical endurance, dexterity, coordination and strength [9,44]. The other is *cognitive challenge* that requires the player's mental abilities including memory, observation, reasoning, planning and problem solving capacities [9,10,44]. With the manipulation of a desktop game, Cox et al. [9] experimentally showed that adding cognitive challenge to physical challenge increased players' immersion while simply increasing physical challenge did not. Comparatively, a recent study founded that, in Mixed Reality games, both physical and cognitive challenge lead to enhanced immersion [19], indicating that digital gameplay experience depends not only on the type of challenge, but also on how the challenge be presented.

Emotional challenge

The notion of emotional challenge was first proposed by Cole et al. [6] as a complement to more 'conventional' or 'functional' physical and cognitive challenges. In their work on analyzing professional game critics' reviews, they found that the aspects linked to emotional challenge provided by avant-garde games (e.g., To the Moon, Gone Home) are mutually distinguished from those linked to functional challenge offered by core games (e.g. Gears of War 3, Grand Theft AutoV) [6]. Emotional challenge requires players to deal with emotionally salient material or comprehend ambiguous elements by using cognitive effort rather than skill and dexterity [6,10,2]. It elicits very different PX from functional challenge. Functional challenge generally induces few emotions other than the feelings of frustration and pride characteristics of hard fun [2,24]. In contrast, emotional challenge involves resolving the tension within narrative, identifying characters, and exploring emotional ambiguities, which consequently results in a more reflective state of mind and a greater range of emotional experiences [6,2]. With the notion of emotional challenge, game designers may work towards engaging with a broader range of affect and a deeper resonance with the players' emotions similar to other art forms such as literature and film [6].

Regarding emotional challenge, Denisova et al. [10] include it as an important complement to cognitive and physical challenge to create a more systematic, complete, and reliable challenge measurement in digital games. Bopp et al. [2] conducted an online survey to empirically compare emotionally challenging and conventionally challenging experience of everyday game-players. They concluded that emotional challenge mainly manifested itself in confronting players with difficult themes and letting them make uncertain decisions or actions [2]. Besides, they found that compared with conventional challenge, emotional challenge evoked a wider range of negative emotions and was appreciated more by players [2]. Particularly, they indicated that, although emotional and conventional challenge need not always be mutually exclusive, one interesting avenue for future research could be experimentally exploring the tension between emotional and conventional challenge [2], which constitutes one focus of our work.

Effects of VR on PX

With the release of the first consumer head-mounted-display-based VR in 2016 [37], player experiences (PX) in VR has aroused new discussion and attention. Pallavicini et al. [32] and Yildirim et al. [51] explored PX when playing first-person shooter games and they both found that players' sense of presence was higher in VR than in desktop setup. With the playing of the horror video game "Resident Evil 7", Wilson and McGill [49] also reported a higher sense of presence in VR than in TV condition. Shelstad et al. [46] found that playing "Defence Grid 2" with VR resulted in moderate increases in user enjoyment and aesthetic appreciation versus playing with non-VR. Lin [26] used a survival horror zombie VR game to investigate players' fright reactions and coping strategies. Meuleman and Rudrauf [28] explored the potential of using several VR games to evoke multi-componential emotions whereas the emotional types were finally limited to joy and fear clusters. More recently, by asking participants to play the horror-adventure game "The Vanishing of Ethan Carter", Rogers et al. [41] found that VR group showed more emotional involvement than monitor-display group and audio dimensionality had little impact on PX in VR. Although PX in VR has aroused increasing attention, main efforts were put on investigating very limited emotional experiences induced by traditional types of challenge. One important fact is that increasing current VR games, such as Fallout 4 [52] and "The Vanishing of Ethan Carter" [41], include quite a number of emotionally challenging characteristics: narrative materials, strong characters, emotional ambiguities and etc. However, none of the aforementioned work has explicitly explored emotional challenge in VR games.

MEASURES

In this study, we conducted two experiments where we adopted multiple survey scales to explore player experiences. The scales include measurements of players' perceived challenge type, their emotional responses, their feelings on several important interactive digital narrative dimensions [42], as well as their perceived immersion and presence.

Challenge Measurement

Until our experiment being conducted, there is not yet a systematically instrument to measure the challenge type a game provides or how challenged players feel [10]. To measure the main type of challenge players may perceive, we designed four descriptive items and asked players to rate each item on a 7-point Likert scale ranging from strongly disagree (0) to strongly agree (6) according to their gameplay feelings. Specifically, item 1 and 2 were formed exactly based on the definitions of physical challenge [9,44] and cognitive challenge [9,10,44] respectively. Item 1 "The game demands my physical skills with respect to speed, accuracy, physical endurance, dexterity, coordination or strength" is for measuring the level of physical challenge players felt. Item 2 "The game requires my mental abilities such as memory, observation, reasoning, planning or problem-solving skills" is for assessing perceived cognitive challenge. Item 1 and 2 were averaged to indicate player's sense of general conventional challenge. With respect to emotional challenge, we adopted both its definition [6] and main characteristics [6,2] to form two other descriptive items. As emotional challenge was found to manifest itself by confronting players with difficult themes and letting them make uncertain decisions or actions [2], item 3 and item 4 were set as "The game confronts me with a relatively difficult theme or a captivating story which involves related narrative, emotional ambiguities and strong characters" and "The game involves some alternatives and requires me to make some tough or uncertain in-game decisions that may affect results in a non-discernible way". Again item 3 and 4 were averaged for measuring emotional challenge.

Usability, Appreciation, Enjoyment and Suspense

As usability is a precondition for any enjoyable experience [42], we used the abbreviated three-items version [25] of the widely used system usability scale [5] to assess usability first. Appreciation, enjoyment and suspense were measured with the scales developed by Oliver and Bartsch [29] with three items which were successfully applied for evaluating games [47,3]. Appreciation refers to the experience of feeling moved, meaningful and thought-provoking [29]. Enjoyment and suspense have often been considered as the common reasons why players enjoy being challenged in games [22,36]. Particularly, appreciation, enjoyment and suspense have been recently adopted to measure emotionally challenging game experience [2]. Each item here was also rated on a 7-point Likert scale.

Emotional Responses

Players' discrete emotional responses were measured through Gross's rating method by asking participants to rate each emotional state on 9-point scales ranging from did not feel even the slightest bit (0) to the most you have felt in your life (8) [17]. Considering that emotional challenge has the potential to induce more diverse emotional experiences, to shape participants' emotional responses as fully as possible, we adopted the Emotion Annotation and Representation Language (EARL) proposed by the Human-Machine Interaction Network on Emotion which classifies 48 kind of emotions [45]. We supposed that rating the 48 EARL emotions on 9-point scales would be a comprehensive way to measure the potentially wide range of emotional responses induced by emotionally challenging games.

Immersion and Presence

Immersion and presence have long been considered to be very important player experiences. We employed the 31-item Immersive Experience Questionnaire (IEQ, 7-point Likert scale ranging from not at all (0) to a lot (6)) [21] to measure players' sense of immersion. The IEQ consists of five factors measuring different components of immersion including cognitive involvement, challenge, control, real-world dissociation and emotional involvement. The 14-item I-group Presence Questionnaire (IPQ) [50] was adopted to measure participants' sense of presence. IPQ is a scale for measuring the sense of presence experienced in a virtual environment. IPQ has three subscales for measuring special presence, involvement and experienced realism, as well as one additional item to measure the general "sense of being there". IPQ is rated on 7-point Likert scale ranging from strongly disagree/not at all (0) to strongly agree/a lot (6).

STUDY 1: EXCLUSIVE CHALLENGE IN VR

To explore how relatively separate emotional or conventional challenge affects PX and how VR acts on the effects, we first selected two game scenarios of the game *Fallout 4* [52] to provide each challenge type respectively and then conducted a mixed-subjects experiment (N=28) to compare PX of the two game scenarios in VR or PC, as measured using multiple commonly used PX questionnaires.

Game

The game chosen for this study was Bethesda Softworks' *Fallout 4* [52], which is a popular first-person role-playing game initially released in late 2015. Two years after its first release on a PC, the game became available in VR. There were a number of reasons why we chose this game amongst other available options. First, the richness of its game content allows for a wide selection of scenarios suitable for experimental comparison within the same game. Second, the game supports modification, enabling us to modify scenarios for specific experimental requirements. The last reason was its lower levels of motion sickness reported than many other game candidates in our pilot test (the pilot test included 5 players to test all candidate scenarios to adjust game settings, questionnaire length, time duration and etc.). Specifically, in the PC version, players use a mouse and a keyboard to play the game. In the VR, players wear HTC VIVE's head-mounted display and interact with the virtual world using controllers. When playing the game, participants were not

allowed to use other functions such as looting items, changing equipment, upgrading skills, and the VATS [53].

Figure 1. Screen shots of the playing in PC and VR settings.

Scenarios

Following the definition of emotional and functional challenge [6], three experts in the research team who have a fully understanding of each type of challenge played the major storyline of the game and then selected the scenario of "*Refuge*" as an example of emotional challenge and "*Gunplay*" as a matching to the description of physical and cognitive challenge types [9,10,44].

Refuge

The attributes of the *Refuge* scenario closely matched the description of emotional challenge. *Refuge* is a prologue of a main story quest named "War Never Changes" in *Fallout 4* [52]. The scenario starts on a seemingly normal day at the player's house. While the player is enjoying their family time with the spouse and son, they suddenly learn from TV news that the world nuclear war has just broken out. The player, with their family, then rush toward the nearby shelter to take refuge. The shelter, named "vault 111", is built by the Vault-Tec company to take refuge from the possible world nuclear war. After the player and their family enter the vault, they, together with several other residents, are instructed to step on a lifting platform that will take them down into the vault.

When enter the vault, they are instructed by Vault-Tec staff to enter some chambers for decontamination. But just after the doors of these chambers being closed, they begin to lose consciousness. After a period of cryosleep, the player is jostled awake by the automated voice, seeing the spouse holding their son inside their chamber. Three mysterious men appear, open the spouse's chamber, and demand to have their son. The spouse refuses, but in an instant, one of these men shoots the spouse with his pistol and takes their son. Another man gave the player an unfriendly look and then the player re-enters cryosleep. After a period, the player wakes again as the automated voice announces a malfunction, falls out of the chamber and stands up, shivering, finding the spouse frozen and dead inside their chamber.

Refuge includes many interactions between the player and Non-Player Characters (NPCs). When having a conversation, the player can choose what they want to say from multiple options. The options may be different decisions or different tones of reply. For example, when being asked whether to go to the park, the player can answer "yes" or reject the proposal in a sarcastic manner. A series of player's choices push the game forward despite that they do not really influence the main gameplay sequences and outcomes. In our experiment, by using a written instruction before gameplay, players were told that any choice or decision they made in the game might affect the outcomes of the characters and events.

Gunplay

Gunplay was chosen as a scenario that focuses primarily on the conventional challenge. *Gunplay* is a Minutemen main quest named "When Freedom Calls" in *Fallout 4* [52]. The player starts the game by entering a three-story building, which is filled with gunmen as enemies. The player's task is to shoot and kill all the enemies and go up to the top floor of the building. Once the gunmen see the player, they start targeting and shooting the player. Besides, as the building includes many rooms, chaotic passages and obstacles, the player also needs to put efforts to find the way to the third floor of the building. The player is equipped with a pistol, with 100 bullets and 5 healing chances. The difficulty of the game was set to the normal level, as demonstrated in the pilot study-this setting was most balanced for players with moderate gaming expertise levels.

Figure 2. Screen shots of *Refuge* and *Gunplay*.

Participants

Twenty-eight participants (14 female, age M=24.4, SD=1.90), evenly divided by gender in VR and PC groups, took part in study 1. Each group played *Refuge* and *Gunplay* in a counterbalanced order. All of them reportedly had digital gameplay experience and the amount of time each one spent playing games weekly did not differ between the two groups ($t(13)=0.30$, $p=0.77$). Twelve had previous VR experience, however, the amount of experience with VR between the two groups was not significantly different ($t(13)=0.47$, $p=0.64$). Each got $30 for their participation and only applicants who had never played *Fallout* series previously were allowed to participate in the experiment.

Procedure

Each participant played *Refuge* and *Gunplay* in only one kind of setting: VR or PC. After a basic introduction, a written consent was obtained. For each game scenario, the experiment proceeded as follows: (1) Participants read a written introduction of the game scenario and practiced related controls and mechanics for 10 minutes. (2) They played the game scenario (*Refuge*: only one time; *Gunplay*:

up to three times which means participants can restart up to two times after they die in the game). (3) They filled out the multiple survey scales according to their gaming experiences and took part in a short interview. (4) After that, they had a 30 minutes' break and then continued the experiment with the other game scenario. *Refuge* was completed in roughly 26 minutes (M= 25.9, SD=3.74) and *Gunplay* was completed in about 15 minutes (M=14.5, SD=3.05). We also reminded participants to inform the experimenter if they experienced any motion sickness.

Results

GLM repeated measures ANOVAs were conducted to evaluate the effects of the game scenario (*Gunplay* vs. *Refuge*), equipment (*VR* vs. *PC*), and the interaction effect. For all the reported variables, no interaction effect exists.

Variable	Cronbach's α	Equipment	M Gunplay (SD)	M Refuge (SD)	η^2 scenario	η^2 equipment
Conventional challenge	0.57	PC	4.18 (1.18)	2.18 (0.97)	0.72*	0.07
		VR	4.50 (0.78)	2.71 (1.05)		
Emotional challenge	0.75	PC	1.25 (1.07)	3.68 (0.58)	0.77*	0.18*
		VR	2.11 (1.44)	4.32 (0.93)		
Usability	0.73	PC	4.60 (1.22)	4.43 (0.93)	0.00	0.04
		VR	4.69 (0.85)	4.95 (0.60)		
Appreciation	0.89	PC	2.05 (1.23)	3.52 (1.28)	0.36*	0.17*
		VR	3.26 (1.36)	4.19 (1.53)		
Enjoyment	0.86	PC	3.93 (1.11)	3.57 (0.91)	0.19*	0.27*
		VR	5.12 (0.96)	4.40 (1.17)		
Suspense	0.58	PC	3.31 (1.18)	3.09 (0.53)	0.10	0.02
		VR	3.74 (1.14)	3.14 (1.28)		
Intensity of emotion	0.94	PC	1.92 (0.97)	2.19 (1.20)	0.19*	0.20*
		VR	2.59 (0.60)	3.22 (1.15)		
Range of emotion		PC	9.9 (10.1)	14.8 (12.6)	0.30*	0.15*
		VR	16.5 (6.5)	23.4 (12.3)		
Immersion	0.94	PC	3.17 (1.13)	3.32 (1.17)	0.00	0.26*
		VR	4.24 (0.60)	4.15 (0.64)		
Presence	0.89	PC	2.64 (0.82)	2.72 (0.93)	0.00	0.46*
		VR	3.90 (0.56)	3.87 (0.68)		

Table 1. Results of study 1.

Based on the game scenario the participants interacted with, their perceived emotional or conventional challenge were significantly different. Specifically, the main effect of the game scenario on perceived emotional challenge was significant ($F(1,26)=88.59$, $\eta^2=0.77$, $p<.05$). Similarly, the conventional challenge differed significantly between the two scenarios ($F(1,26)=65.44$, $\eta^2=0.72$, $p<.05$). As expected, *Refuge* (M=4.00, SD=0.83) induced much higher emotional challenge than *Gunplay* (M=1.68, SD=1.32) and *Gunplay* (M=4.34, SD=0.99) evoked greater conventional challenge than *Refuge* (M=2.45, SD=1.03). Interestingly, participants reported higher emotional challenge in *VR* (M=3.21, SD=1.64) than in *PC* (M=2.46, SD=1.50): $F(1,26)=5.78$, $\eta^2=0.18$, $p<.05$). However, no main effect of equipment was found on conventional challenge.

Usability, Appreciation, Enjoyment and Suspense

Participants generally perceived the system as easy to use and there was no significant effect of the game scenario or the equipment on perceived usability.

Main effects of game scenarios were found on both appreciation ($F(1,26)=14.49$, $\eta^2=0.36$, $p<.05$) and enjoyment ($F(1,26)=5.94$, $\eta^2=0.19$, $p<.05$). Participants demonstrated more appreciation towards *Refuge* (M=3.86, SD=1.43) than for *Gunplay* (M=2.65, SD=1.42), but enjoyed *Gunplay* (M=4.52, SD=1.18) more than *Refuge* (M=3.99, SD=1.11). Equipment also had main effects on the level of appreciation ($F(1,26)=5.37$, $\eta^2=0.17$, $p<.05$) and enjoyment ($F(1,26)=9.57$, $\eta^2=0.27$, $p<.05$). Participants appreciated and enjoyed *VR* (appreciation: M=3.73, SD=1.50; enjoyment: M=4.76, SD=1.11) more than *PC* (appreciation: M=2.79, SD=1.45; enjoyment: M=3.75, SD=1.01). No main effects were found regarding the level of suspense.

Emotional Responses

To examine how game scenario and equipment affect the range of participants' emotional responses, we evaluated the number of emotions that each participant scored higher than a moderate level of 4 (rating from 0 to 8), as ratings above 4 generally indicate strong emotional responses. Results showed a main effect of game ($F(1,26)=10.88$, $\eta^2=0.30$, $p<.05$) on the number of emotions scored greater than 4. Participants playing *Refuge* (M=19.11, SD=12.99) reported a much wider range of emotions than playing *Gunplay* (M=13.21, SD=8.98). A main effect of equipment ($F(1,26)=4.44$, $\eta^2=0.15$, $p<.05$) was also significant. Participants in *VR* group (M=19.96, SD=10.26) had a broader range of emotional responses than those in the *PC* group (M=12.36, SD=11.49).

To further shape what kind of emotional responses each game scenario elicited in a certain equipment, we first found mean ratings of participants' emotional type. We then identified those emotions with an average score higher than 4 as the dominant emotional responses. As shown in Figure 3, in *PC*, *Gunplay* induced emotions of tension and amusement while *Refuge* evoked very different emotions of worry, powerlessness and helplessness. Comparatively in VR, *Gunplay* elicited emotions of tension, amusement, excitement, courage, fear, stress and empathy; *Refuge* induced anxiety, sadness, helplessness, worry, shock, powerlessness, trust, relaxation, surprise, guilt, tension, despair, love and empathy.

In addition, ratings of all 48 EARL emotional responses were averaged to indicate the general intensity of participants' emotional responses. Both main effects of game scenarios ($F=6.17$, $\eta^2=0.19$, $p<.05$) and equipment ($F(1,26)=6.56$, $\eta^2=0.20$, $p<.05$) were found on the general intensity. Participants had stronger emotional responses with *Refuge* (M=2.71, SD=1,26) than in *Gunplay* (M=2.25, SD=0.86). The emotional responses were also stronger in *VR* (M=2.91, SD=0.95) than in *PC* (M=2.05, SD=1.08).

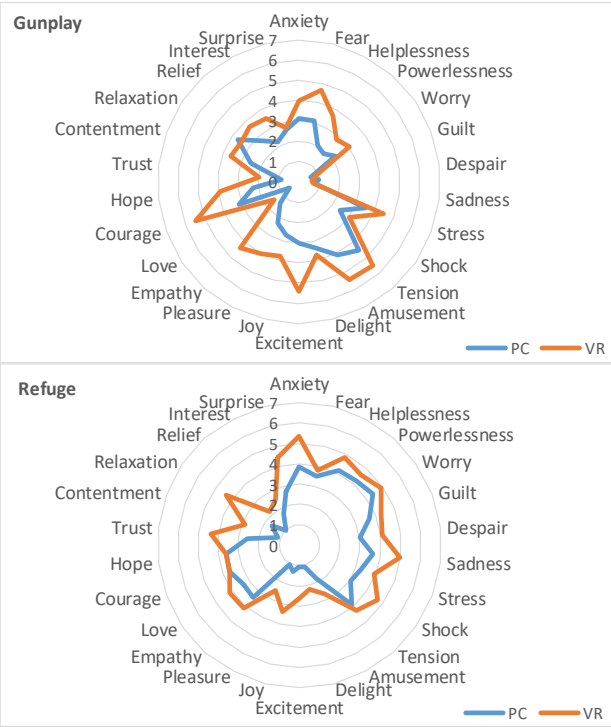

Figure 3. Dominant emotions of *Gunplay* and *Refuge*.

Immersion and Presence

Total immersion scores were calculated as an average of all 31 IEQ items. Although no game scenarios effect was found on the total immersion, participants reported significantly greater emotional and cognitive involvement in *Refuge* than in *Gunplay*. Results showed a main effect of equipment on the total immersion level ($F(1,26)=9.13$, $\eta^2=0.26$, $p<.05$). The *VR* group ($M=4.20$, $SD=0.61$) reported a deeper immersion than the *PC* group ($M=3.25$, $SD=1.13$), which was manifested with all but one IEQ factors: cognitive involvement, control, real-world dissociation and emotional involvement. Scores of the three IPQ factors were averaged to indicate the total presence. A main effect of equipment was found on the total presence ($F(1,26)=22.28$, $\eta^2=0.46$, $p<.05$). The VR group ($M=3.89$, $SD=0.61$) reported a higher sense of presence than the PC group ($M=2.68$, $SD=0.86$), which was manifested with all three IPQ factors. No main effect of game scenarios on presence was found.

Study 1: Discussion

Study 1 tested how relatively separate emotional or conventional challenge affects PX. With respect to players' emotional responses, our experimental results showed that the emotionally challenging game scenario of *Refuge* did induce a wider range of emotional responses than those evoked by the conventionally challenging *Gunplay*. This result is on par with the empirical findings of Bopp et al. [2] and Cole et al. [6]. In *Refuge*, even without different choices which actually affect the outcomes, players' ability to freely roam around, interact with NPCs, and seemingly affect the outcome of the game based on the dialogue choices play a major part in their perceived range of emotional responses. In *Gunplay*, on the other hand, players had a more linear interaction with the game world with almost binary outcome – the players either wins the fight against enemies or they lose and get to try again. This kind of gameplay provide limited kind of emotional experiences. Furthermore, Bopp et al. [2] concluded that emotions that emotional challenge evokes tend to be more negative, which was also manifested in our results. The dominant emotional responses of participants playing *Refuge* are generally more negative than those elicited by *Gunplay*. According to Gowler and Iacovides [16] who investigate how discomfort manifests during gameplay, the worry, powerlessness, anxiety and sadness induced by *Refuge* attributed mainly to the high-pressure environment of vault 111 with uncertain outcomes and the experience of the loss of the player's spouse.

In line with the findings of Bopp et al. [2], participants appreciated the emotionally challenging game scenario of *Refuge* more than the conventionally challenging *Gunplay*. This maybe because that *Refuge* was mainly characterized with themes of family and death, with the narrative mirroring instances of participants' own lives. This result also further supports the notion that players often value emotionally complex experiences [3,20]. As for enjoyment, the picture is somewhat different. Participants enjoyed *Gunplay* more than *Refuge*, considering *Gunplay* more fun and entertaining. This is perhaps not surprising, considering that explicitly positive experiences such as fun are most commonly found in conventionally challenging games [24], while emotionally challenging games elicit much wider range of negative emotional responses from players [2].

Additionally, *Refuge* induced greater emotional and cognitive involvement than those induced by *Gunplay*. This is somehow different from the finding of Bopp et al. [2] who concluded that traditional challenge evoked the same level of emotional involvement with and greater cognitive involvement than emotional challenge. This difference in findings might be due to the prevalence of physical challenge in *Gunplay* as opposed to cognitive challenge. No game effects were found on other IEQ factors and IPQ factors.

Study 1 also showed how VR influences the effects on PX. According to our experimental results, the types of perceived emotional responses were mainly influenced by the two somewhat exclusive challenge types provided by the game. Although VR significantly enhanced and broadened players' emotional feelings, interestingly, it did not have a major effect on the dominant types of emotional responses induced by either game scenario. Participants appreciated and enjoyed their VR experience more than playing on PC. This may be to some extent attributed to the novelty effect thus more work needs to be done to explore whether this effect is durable. Unsurprisingly, we also found that players felt more present in the game world and immersed themselves more when in VR as opposed to playing the same game scenario on a PC, which is consistent with most findings related to perceived immersion and presence in VR [48,51,32].

STUDY 2: COEXISTING CHALLENGE IN VR

To investigate how PX be influenced when emotional and conventional challenge joint together and the impact of VR, we selected a new game scenario of *Fallout 4* [52] and modified it into two versions: one with additional emotional challenge and the other without (titled *Gunfight-EC* and *Gunfight* respectively). A between-subjects design experiment (N=40) was conducted to compare PX of *Gunfight* and *Gunfight-EC* in VR and PC using the same survey scales in study 1.

Manipulations

The new game scenario was a side quest named "Out of the Fire", where emotional challenge jointly with conventional challenge. To obtain the version without additional emotional challenge (*Gunfight*), we used *Fallout 4*'s official game modifier, Creation Kit, to move all emotionally challenging features, such as the conversations, strong characters and emotional ambiguities out of the original scenario. Comparatively, the version with additional emotional challenge (*Gunfight-EC*) was exactly the original scenario by re-adding those emotionally challenging features.

Gunfight-EC

In *Gunfight-EC*, the player starts the game by talking to a father, Abraham, in his farm. From the conversation, the player finds out that his son, Jake, stole his heirloom sword, and ran off to join up with the faction named Forged. Abraham wants the sword back, and does not appear to care about his son. The player promises to help Abraham retrieve the sword. In a further conversation with Jake's mother, the player learns that the family still cares about their son. However, as we will discuss in detail later, the player can selectively help Jack return to his family.

Forged occupy an ironworks which mainly consists of two workshops guarded by many gunmen. The gunmen will shoot when they spot on the player. The player has to cross the two workshops and finally enter a blast furnace room. In the blast furnace, the player sees the leader of Forged Slag and Abraham's son Jack, and engages in a conversation with Slag, who encourages Jake to kill an innocent prisoner to prove that Jake is strong enough to become one of them. Jake is feels conflicted and tries to back down from the proposal.

At that point, the player has several options: they can choose to tell Jake the truth about coming there just for the sword, encourage Jake to kill the prisoner, or persuade Jake to go home with the player. If Jake is persuaded to go home, he will fight Slag on the player side. Otherwise, he will perceive the player as enemy. If Jake survives the fight, the player will bring Jake and the sword back to Abraham, and Jake will eventually be reunited with his family. Otherwise, the player goes back to Abraham only with the sword, and has to explain Jake's death to Abraham, who finds the news about his son's death incredibly difficult to deal with.

The game difficulty was again set to the normal level. To be able to take on the powerful enemies in this scenario, the player is set to be equipped with three weapons: a pistol with 500 bullets, a rifle with 100 bullets, a rocket launcher with 10 warheads, and 20 healing chances.

Gunfight

Gunfight is the same scenario as *Gunfight-EC*, except for all conversations being removed. The player was asked to eliminate all men in the ironworks without knowing the story and the characters of the original scenario. When the player enters the blast furnace, Slag and his accomplices, as well as Jake, will attack the player when they see them. The game ends right after the fight is over.

Figure 4. Screen shots of *Gunfight-EC* and *Gunfight*.

Participants

Forty-two participants (20 female, age M=23.7, SD=1.23) were recruited for study 2. The gender split was equal amongst the four groups. Each group of participants played *Gunfight* or *Gunfight-EC* in VR or *PC*. Two participants in PC did not finish the experiment due to motion sickness, so their data were omitted from the analysis. The rest all reported having previous digital gameplay experience, and their weekly gaming time did not different amongst the four groups ($F(3,27)=0.38$, $\eta^2=0.03$, $p=0.77$). Twenty-three had previous experience with VR content and the time with VR content did not differ amongst the four groups ($F(3,27)=0.07$, $\eta^2=0.00$, $p=0.97$). Each got $15 for their participation and only applicants who had not played *Fallout* series previously were invited to participate.

Procedure

Most steps are the same as those in study 1, except that each participant played only one version of the game scenario and the *Gunfight-EC* was also allowed to play up to three times (participants can restart up to two times after they die in the blast furnace). *Gunfight* was completed in roughly 16 minutes (M=16.3, SD=3.70) and *Gunfight-EC* took about 25 minutes (M=25.1, SD=4.24).

Results

MANOVAs were conducted to evaluate the effects of equipment (*VR* vs. *PC*), game scenario (*Gunfight* vs. *Gunfight-EC*), and the interaction effect. No interaction effect was found on most variables reported in study 2, except for some variables related to emotional responses.

The game scenario with additional emotionally challenging characteristics induced higher perceived emotional challenge in participants. Results showed a significant main effect of

game scenario on perceived emotional challenge ($F(1,36)=34.82$, $\eta^2=0.49$, $p<.05$). *Gunfight-EC* (M=3.33, SD=1.08) induced higher emotional challenge than *Gunfight* (M=1.32, SD=1.07) and the conventional challenge evoked by the two games kept at the same level. Unlike the findings in study 1, participants' perceived emotional challenge did not differ significantly based on the equipment: $F(1,36)=1.763$, $\eta^2=0.047$, $p=0.19$ (in *VR* (M=2.55, SD=1.54) and on *PC* (M=2.10, SD=1.39)). Similarly, no main effect of equipment was found on conventional challenge.

Variable	Cronbach's α	Equipment	M Gunfight (SD)	M Gunfight-EC (SD)	η^2 scenario	η^2 equipment
Conventional challenge	0.7	PC	4.15 (1.03)	4.30 (1.08)	0.01	0.00
		VR	3.95 (1.04)	4.30 (0.82)		
Emotional challenge	0.8	PC	1.20 (0.89)	3.00 (1.22)	0.49*	0.05
		VR	1.45 (1.26)	3.65 (0.85)		
Usability	0.64	PC	4.70 (0.53)	4.60 (0.70)	0.00	0.02
		VR	4.50 (0.97)	4.43 (0.65)		
Appreciation	0.89	PC	2.43 (1.42)	2.63 (0.85)	0.03	0.16*
		VR	3.20 (1.35)	3.73 (0.80)		
Enjoyment	0.82	PC	4.07 (0.72)	3.93 (0.78)	0.04	0.22*
		VR	4.93 (0.54)	4.53 (0.86)		
Suspense	0.72	PC	3.33 (1.56)	3.80 (1.08)	0.01	0.03
		VR	3.07 (1.39)	3.17 (1.34)		
Intensity of emotion	0.93	PC	1.89 (0.91)	1.86 (0.81)	0.06	0.24*
		VR	2.34 (0.81)	3.14 (0.66)		
Range of emotion		PC	5.3 (4.1)	5.0 (4.2)	0.12*	0.49*
		VR	10.4 (5.1)	17.2 (5.1)		
Immersion	0.91	PC	3.15 (0.79)	3.48 (0.95)	0.04	0.13*
		VR	3.77 (0.90)	4.05 (0.61)		
Presence	0.89	PC	2.24 (0.92)	2.61 (0.89)	0.02	0.38*
		VR	3.51 (0.67)	3.58 (0.50)		

Table 2. Results of study 2.

Usability, Appreciation, Enjoyment and Suspense

No main effects were found on usability. Unlike the findings in study 1, there were no significant main effects of game scenarios on appreciation and enjoyment. While consistently, the main effects of equipment on appreciation ($F(1,36)=6.67$, $\eta^2=0.16$, $p<.05$) and enjoyment ($F(1,36)=9.95$, $\eta^2=0.22$, $p<.05$) were significant. Participants appreciated and enjoyed *VR* (appreciation: M=3.47, SD=1.12; enjoyment: M=4.73, SD=0.73) more than *PC* (appreciation: M=2.53, SD=1.15; enjoyment: M=4.00, SD=0.73). No main effects were found on suspense.

Emotional Responses

With respect to the range of emotional responses (indicated by the number of emotions scored above 4), main effects of game scenario ($F(1,36)=4.86$, $\eta^2=0.12$, $p<.05$) and equipment ($F(1,36)=34.44$, $\eta^2=0.49$, $p<.05$) were found. Participants playing *Gunfight-EC* (M=11.10, SD=7.75) had a wider range of emotions than those playing *Gunfight* (M=7.85, SD=5.21). The *VR* group (M=13.80, SD=6.08) reported a broader range of emotions than the *PC* group (M=5.15, SD=4.04). Particularly, an interaction effect ($F(1,36)=5.80$, $\eta^2=0.14$, $p<.05$) also existed.

The type of emotional response each game scenario elicited in *VR* or *PC* (indicated by the kind of emotion with average rating above 4) is showed in Figure 5. In *PC* condition, *Gunfight* induced the emotion of amusement while *Gunfight-EC* evoked different emotions of tension and stress. Comparatively in VR, *Gunfight* elicited emotions of amusement, delight, relaxation, interest, fear, excitement, joy and contentment; *Gunfight-EC* induced hope, courage, love, tension, worry, anxiety, stress, relief, amusement, trust, contentment, excitement, joy, empathy, delight and pleasure.

The main effect on the general intensity of the 48 EARL emotions was not significant. Consistently with study 1, the main effect of equipment on the general intensity was significant: ($F(1,36)=11.57$, $\eta^2=0.24$, $p<.05$). *VR* group (M=2.74, SD=0.82) had stronger emotional responses than *PC* group (M=1.88, SD=0.84). Note that an approximate interaction effect existed, ($F(1,36)=2.71$, $\eta^2=0.07$, $p=0.11$).

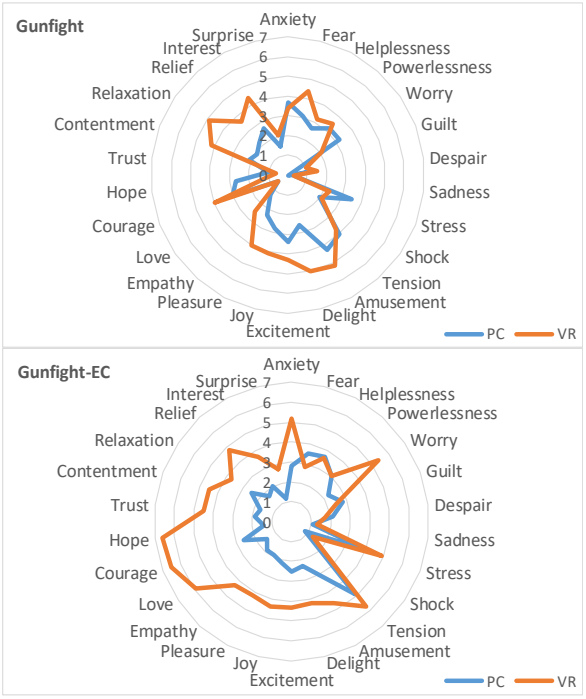

Figure 5. Dominant emotions of *Gunfight* and *Gunfight-EC*.

Interestingly, we found that in *PC* condition, the range and general intensity of emotional responses when playing *Gunfight-EC* were analogous to those when playing *Gunfight*. Considering the low level of interaction effects with these two variables, two simple effect analysis were further conducted. Results showed that, for either the range or the general intensity of emotional responses, the significant differences between *Gunfight-EC* and *Gunfight* existed only in *VR* (range: $F(1,36)=10.64$, $p<.05$; intensity: $F(1,36)=5.01$, $p<.05$) but not in *PC* (range: $F(1,36)=0.02$, $p=0.89$; intensity: $F(1,36)=0.00$, $p=0.93$). Specifically, in VR,

participants had a wider range of emotional responses when playing *Gunfight-EC* (M=17.20, SD=5.11) than playing *Gunfight* (M=10.40, SD=5.13); as well as stronger emotions with *Gunfight-EC* (M=3.14, SD=0.66) than with *Gunfight* (M=2.34, SD=0.81).

Immersion and Presence

No main effect of game scenario was found on immersion and presence. *VR* group (M=3.91, SD=0.76) were reportedly more immersed in the game than *PC* group (M=3.32, SD=0.87), $F(1,36)=5.17$, $\eta^2=0.13$, $p<.05$, which was manifested by two factors of control and real-world dissociation. VR group (M=3.55, SD=0.58) also reported a higher total sense of presence than *PC* group (M=2.42, SD=0.90), $F(1,36)=21.71$, $\eta^2=0.38$, $p<.05$, which was manifested by all three IPQ factors.

Study 2: Discussion

Study 2 explored how PX be influenced when emotional and conventional challenge joint together and the impact of VR. Interestingly, with respect to players' emotional responses, adding emotional challenge to the conventionally challenging *Gunfight* changed the types of dominant emotional responses and induced a wider range of emotional responses only in VR but not in PC. In PC condition, the amusement and excitement induced by *Gunfight* appears to be suppressed by the additional emotional challenge. Meanwhile, the multi-dimensional emotions that we anticipated to be evoked by the added emotional challenge also seem to be restrained by the presence of conventional challenge. Nevertheless, this phenomenon was not observed in VR where the two types of challenge appear to complement experiences of players. With the added emotional challenge, participants not only felt more entertained with the conventional challenge, but also experienced the wider range of and more meaningful emotions evoked by the added emotional challenge.

In *Gunfight-EC*, there are several different choices with different outcomes. When playing in PC, five participants took Jack back to home, two killed Jack purposely and three killed him by mistake. In VR, nine took Jack back to home and only one killed Jack by mistake. Based on these gameplay outcomes and according to Bopp et al. [4,2] who emphasized players' emotional attachment to game characters, the hope, courage and love induced by *Gunfight-EC* in VR would be highly correlated with players' deep concern for the well-being of the additional in-game characters (Jack and his family). Moreover, these induced positive experiences also involve strong uncomfortable emotions of tension, worry and anxiety, which could be an good example of the broad range of complex emotional experiences inspired by Gowler and Iacovides [16].

Different from our earlier findings in study 1, additional emotional challenge did not induce more appreciation for and enjoyment with the game. This may be due to the experiences in both conditions being largely influenced by the conventional challenge being dominant in both versions of the game scenario. The additional emotional challenge also had no effect on immersion or presence. On par with the findings in study 1, VR significantly deepened and broadened the emotional responses of players and enhanced their perceived appreciation, enjoyment, as well as immersion and presence.

GENERAL DISCUSSIONS

Challenge in video games is a complex concept. Traditionally, challenge is a kind of subjective experience described as one's perception of video game difficulty [22,7,14]. So far, research has mostly focused on the qualitative studies of challenge as player experience (PX). However, the actual challenge presented by games has begun to be examined by Qin et al. [39] and then further aroused increasing attention on studying how traditional challenge type [9] and gameplay environment [19] affects PX. The type of emotional challenge has only recently been introduced into the field of games user research [6,2]. Our aim was to experimentally test some of the previous claims made about emotional challenge [6,2] and also probe further into the tension between emotional and conventional challenge as well as the impact of the latest gaming environment of VR.

We consider that the type of emotional challenge provides the avenue to study diverse player experiences featured far more than negative emotions. In our study 1, the emotionally challenging game did evoked a wider range of negative emotions, which is consistent with the claim of Bopp et al. [2]. Whereas in study 2, with VR settings, the additional emotional challenge induced much more complex emotional responses (both positive emotions of hope, courage and love and negative emotions of tension, worry and anxiety). Hence, beyond the efforts to study uncomfortable or negative player experiences with related to emotional challenge [2,3], future research could target more positive and complex emotional experiences created by emotional challenge. In addition, as emotionally challenging games often embedded with a storyline, it would also be interesting to track players' experiences in different stages, such as the emotional responses produced in the gaming process as well as those elicited by desired or undesired outcomes. Potentially, we believe that by involving more emotionally challenging characteristics, video games may break the 'win/lose' logic underlined in goal oriented type games and finally elicit a wide spectrum of emotions similar to those appreciated by readers of other art forms such as literature and film.

It seems that the latest gameplay environment of VR serves as an ideal expressive medium for emotional challenge. Particularly, in PC environment, the emotionally challenging game induced a wider range of different emotions while a combination of emotional and conventional challenging did not. Comparatively in VR settings, both presentations of emotional challenge elicited a wider range of different emotional responses. Moreover, we also found that players perceived significantly higher immersion and presence in VR. Although the mutual correlations between immersion, presence and emotion are still rather complex [11], there is a

commonly regarding that presence is a necessary mediator that allows real emotions to be activated by a virtual environment [33,38,40]. Therefore, we argue that the significantly higher presence (the sense of being there) maybe the key factor to lead to the deeper and broader emotional responses in VR. This argument is in consistent with Ding et al. [12] who found that cinematic VR induced stronger emotions than 2D film. Other causes such as the wide viewpoint and the natural and novel interactive mode in VR may also affect the results. In addition, as gameplay is a complex psychological process, it is also possible that the emotional responses found in our study may not be directly matched with the game events or game environment but be evoked by more psychological and neurobiological emotion-cognition interaction [28,30]. For example, VR setting may demand the player lower cognitive effort to combine and understand both the information of emotional and conventional challenge. With VR's advantage in fully engaging mental and bodily components [28], future work could use VR as a fundamental tool to probe into the possible psychological processes during gameplay in VR.

The tension between emotional and conventional challenge seems complicated but is valuable to be further studied. Unlike the effects of relatively separate challenge on players' emotional responses, when the two types of challenge combined together, some complex interaction may happen between them, thus leading to different player experiences. With this respect, future work may locate in exploring how emotionally challenging characteristics can be integrated into conventional challenge to create richer emotional responses for the players both in traditional or novel game environments. Moreover, similarly to other studies on controlling the level of conventional challenge [39,9], emotional challenge level could also be manipulated for studying the impacts on player experiences.

Games can be designed or manipulated in different ways to arouse the player's diverse emotions which may be roughly classified into three classes: the pervasive kind of the binary feelings of "the thrill of victory and the agony of defeat", feelings of suspense, surprise, fear and etc. which can be controlled by using darkness, sudden noises, disgusting imagery and etc., as well as the emotions produced by using storytelling techniques, such as involving deep ethical dimension and creating characters that players care about [1]. One example was that Felnhofer et al. [13] and Riva et al. [40] modified users' emotional experience associated to the different virtual parks by manipulating sound and music, shadows, lights and textures. However, we believe that the story-telling based emotions constitute the major part that emotional challenge evokes. Games that rely more heavily on emotionally challenging characters such as difficult themes and actions [2], game uncertainty [23,18], virtual characters [4,34], interactive narratives [8] and etc. can offer much richer emotional content that deeply affects the player.

Our work also has several limitations. First, the emotionally challenging game scenario selected in study 1 focused more on difficult themes but involved few explicit choices and the additional emotional challenge in study 2 was manipulated mainly by re-adding important in-game characters and interactive narratives, which may restrict the understanding of emotional challenge featured by other factors such as various decisions and outcomes. Second, due to possible individual difference in empathy, emotional intelligence, perspective and reappraisal ability, the relatively small sample of participants in our experiments may to some extent affect the validity of the results. Third, the unrevised challenge measurement we developed according to the challenge definitions maybe too simple to show properties of participants' perceived experience about challenge. Fourth, gameplay time is also important for games user research. In our study, the different time durations for playing the game scenarios may also exert some influence on the player experience evoked by different challenge type. Lastly, the players in VR group might feel excited about the relatively new VR interaction. This kind of novelty effect might make them appreciate and enjoy VR more than PC. All these aspects should be carefully considered in the future work.

CONCLUSION

Emotional challenge is believed to offer more diverse and unique gaming experiences, beyond what conventional challenge in games can afford. However, little is yet known about this experience experimentally in video games, as to date this concept has not been studied in much depth, especially in the popular VR gaming environment. We conducted two experiments (N=68) to explore how emotional challenge relates to different player experiences when presented separately to or together with conventional challenge in both PC and VR conditions.

We found that when emotional challenge is presented separately from conventional challenge, it elicits a wider range of different emotions in players than when interacting with a scenario that presents exclusively conventional challenge to the players. If, however, emotional challenge is present alongside conventional challenge in a game, players' emotional responses become richer, particularly in VR. In both experiments, VR significantly enhanced and broadened participants' emotional responses, appreciation, immersion and presence. Neither presentations of emotional challenge in a game significantly affected perceived immersion and presence of players. All things considered, our findings indicate that VR may serve as an ideal expressive medium for emotional challenge and also extend our understanding of emotional (and conventional) challenge in video games.

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REFERENCES

[1] Ernest Adams. 2014. *Fundamentals of Game Design*. Pearson Education.

[2] Julia Ayumi Bopp, Klaus Opwis, and Elisa D Mekler. 2018. “An odd kind of pleasure”: differentiating emotional challenge in digital games. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18). Apr. 2018: 41. http://dx.doi.org/10.1145/3173574.3173615

[3] Julia Ayumi Bopp, Elisa D Mekler, and Klaus Opwis. 2016. Negative emotion, positive experience?: emotionally moving moments in digital games. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). May 2016: 2996-3006. http://dx.doi.org/10.1145/2858036.2858227

[4] Julia Ayumi Bopp, Livia J Muller, Lena Fanya Aeschbach, Klaus Opwis, and Elisa D Mekler. 2019. Exploring Emotional Attachment to Game Characters. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '19). Oct. 2019: 313-324. http://doi.org/10.1145/3311350.3347169

[5] John Brooke. SUS-A quick and dirty usability scale. *Usability Evaluation in Industry* 189.194 (1996): 4-7.

[6] Tom Cole, Paul Cairns, and Marco Gillies. 2015. Emotional and functional challenge in core and avant-garde games. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '15). Oct. 2015: 121-126. http://dx.doi.org/10.1145/2793107.2793147

[7] Thomas Constant and Guillaume Levieux. 2019. Dynamic difficulty adjustment impact on players' confidence. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI '19). May 2019: 463. http://dx.doi.org/10.1145/3290605.3300693

[8] Larry Cutler, Eric Darnell, Nathaniel Dirksen, Michael Hutchinson, Scott Peterson, Robert Schiewe, and Wei Wang. 2019. Making you matter: creating interactive VR narratives through experimentation and learning. In *Proceedings of the 2019 Digital Production Symposium* (DigiPro '19). Jul. 2019. http://dx.doi.org/10.1145/3329715.3338883

[9] Anna L Cox, Paul Cairns, Pari Shah, and Michael Carroll. 2012. Not doing but thinking: the role of challenge in the gaming experience. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12). May 2012: 79-88. http://dx.doi.org/10.1145/2207676.2207689

[10] Alena Denisova, Christian Guckelsberger, and David Zendle. 2017. Challenge in digital games: towards developing a measurement tool. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17). May 2017: 2511-2519. http://dx.doi.org/10.1145/3027063.3053209

[11] Julia Diemer, Georg W Alpers, Henrik M Peperkorn, Youssef Shiban, and Andreas Muhlberger. 2015. The impact of perception and presence on emotional reactions: a review of research in virtual reality. *Frontiers in psychology*. 6: 26. http://doi.org/10.3389/fpsyg.2015.00026

[12] Ni Ding, Wen Zhou, and Anthony Fung. 2018. Emotional effect of cinematic VR compared with traditional 2D film. *Telematics and Informatics*. 35(6): 1572-1579. http://dx.doi.org/10.1016/j.tele.2018.04.003

[13] Anna Felnhofer, Oswald D Kothgassner, Mareike Schmidt, Annakatharina Heinzle, Leon Beutl, Helmut Hlavacs, and Ilse Kryspinexner. 2015. Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International Journal of Human-computer Studies*. 82: 48-56. http://dx.doi.org/10.1016/j.ijhcs.2015.05.004

[14] Julian Frommel, Fabian Fischbach, Katja Rogers, and Michael Weber. 2018. Emotion-based dynamic difficulty adjustment using parameterized difficulty and self-reports of emotion. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '18). Oct. 2018: 163-171. http://dx.doi.org/10.1145/3242671.3242682

[15] Clive Fullagar, Patrick A Knight, and Heather S Sovern. 2013. Challenge/skill balance, flow, and performance anxiety. *Applied Psychology.* 62(2): 236-259. http://dx.doi.org/10.1111/j.1464-0597.2012.00494.x

[16] Chad Phoenix Rose Gowler and Ioanna Iacovides. 2019. "Horror, guilt and shame"--Uncomfortable Experiences in Digital Games. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '19). Oct. 2019: 325-337. http://doi.org/10.1145/3311350.3347179

[17] James J Gross and Robert W Levenson. 1995. Emotion elicitation using films. *Cognition & Emotion.* 9(1): 87-108. http://dx.doi.org/10.1080/02699939508408966

[18] Jin Huang, Feng Tian, Xiangmin Fan, Xiaolong (Luke) Zhang, and Shumin Zhai. 2018. Understanding the Uncertainty in 1D Unidirectional Moving Target Selection. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18). Apr. 2018: 237. http://dx.doi.org/10.1145/3173574.3173811

[19] Gang Hu, Nabil Bin Hannan, Khalid Tearo, Arthur Bastos, Derek Reilly. 2016. Doing while thinking: physical and cognitive engagement and immersion in mixed reality games. *Designing Interactive Systems* (DIS '16). Jun. 2016: 947-958. http://dx.doi.org/10.1145/2901790.2901864

[20] Katherine Isbister. 2016. *How Games Move Us: Emotion by Design*. Mit Press.

[21] Charlene Jennett, Anna L Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. 2008. Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies.* 66(9): 641-661. http://dx.doi.org/10.1016/j.ijhcs.2008.04.004

[22] Madison Klarkowski, Daniel Johnson, Peta Wyeth, Mitchell Mcewan, Cody Phillips, and Simon S Smith. 2016. Operationalising and evaluating sub-optimal and optimal play experiences through challenge-skill manipulation. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). May 2016: 5583-5594. http://dx.doi.org/10.1145/2858036.2858563

[23] Shringi Kumari, Sebastian Deterding, and Jonathan Freeman. 2019. The Role of Uncertainty in Moment-to-Moment Player Motivation: A Grounded Theory. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '19). Oct. 2019: 351-363. http://dx.doi.org/10.1145/3311350.3347148

[24] Nicole Lazzaro. 2009. Why we play: affect and the fun of games. *Human-computer interaction: Designing for diverse users and domains,* 155.

[25] James R Lewis, Jeff Sauro. 2009. The factor structure of the system usability scale. *International conference on human centered design* (HCD '09) *Lecture Notes in Computer Science,* vol 5619: 94-103. http://dx.doi.org/10.1007/978-3-642-02806-9_12

[26] Jih-Hsuan Tammy Lin. 2017. Fear in virtual reality (VR): Fear elements, coping reactions, immediate and next-day fright responses toward a survival horror zombie virtual reality game. *Computers in Human Behavior*. 72: 350-361. http://dx.doi.org/10.1016/j.chb.2017.02.057

[27] Thomas W Malone. 1981. Toward a theory of intrinsically motivating instruction. *Cognitive Science*. 5(4): 333-369. http://dx.doi.org/10.1016/s0364-0213(81)80017-1

[28] Ben Meuleman and David Rudrauf. 2018. Induction and profiling of strong multi-componential emotions in virtual reality. *IEEE Transactions on Affective Computing*. 1-1. http://dx.doi.org/10.1109/taffc.2018.2864730

[29] Mary Beth Oliver and Anne Bartsch. 2010. Appreciation as audience response: Exploring entertainment gratifications beyond hedonism. *Human Communication Research.* 36(1): 53-81. http://dx.doi.org/10.1111/j.1468-2958.2009.01368.x

[30] Hadas Okonsinger, Talma Hendler, Luiz Pessoa, and Alexander J Shackman. 2015. The neurobiology of emotion–cognition interactions: fundamental questions and strategies for future research. *Frontiers in Human Neuroscience*. 9: 58. http://dx.doi.org/10.3389/fnhum.2015.00058

[31] Mary Beth Oliver, Nicholas David Bowman, Julia K Woolley, Ryan Rogers, Brett Sherrick, and Munyoung Chung. 2016. Video games as meaningful entertainment experiences. *Psychology of Popular Media Culture.* 5(4): 390-405. http://dx.doi.org/10.1037/ppm0000066

[32] Federica Pallavicini, Alessandro Pepe, and Maria Eleonora Minissi. 2019. Gaming in virtual reality: what changes in terms of usability, emotional response and Sense of presence compared to non-immersive video games? *Simulation & Gaming* 50(2): 136-159. http://dx.doi.org/10.1177/1046878119831420

[33] Thomas D Parsons and Albert Rizzo. 2008. Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of behavior therapy and experimental psychiatry*. 39(3): 250-261. http://dx.doi.org/10.1016/j.jbtep.2007.07.007

[34] Xiaolan Peng, Hui Chen, Lan Wang, and Hongan Wang, 2018. Evaluating a 3-D virtual talking head on pronunciation learning. International Journal of Human-Computer Studies, 109, 26-40. https://doi.org/10.1016/j.ijhcs.2017.08.001

[35] Xiaolan Peng, Jin Huang, Linghan Li, Chen Gao, Hui Chen, Feng Tian, and Hongan Wang. 2019. Beyond Horror and Fear: Exploring Player Experience Invoked by Emotional Challenge in VR Games. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI EA '19). May 2019: LBW1616.

[36] Serge Petralito, Florian Bruhlmann, Glena Helen Iten, Elisa D Mekler, and Klaus Opwis. 2017. A good reason to die: how avatar death and high challenges enable positive experiences. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '16). May 2017: 5087-5097. http://dx.doi.org/10.1145/3025453.3026047

[37] John J Porter, Matthew Boyer, and Andrew Robb. 2018. Guidelines on successfully porting non-immersive games to virtual reality: a case study in minecraft. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '18), Oct. 2018: 405-415. http://dx.doi.org/10.1145/3242671.3242677

[38] Matthew Price, Natasha Mehta, Erin B Tone, and Page L Anderson. 2011. Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia. *Journal of Anxiety Disorders*. 25(6): 763-770. http://dx.doi.org/10.1016/j.janxdis.2011.03.004

[39] Hua Qin, Peiluen Patrick Rau, and Gavriel Salvendy. 2009. Effects of different scenarios of game difficulty on player immersion. *Interacting with Computers*. 22(3): 230-239. http://dx.doi.org/10.1016/j.intcom.2009.12.004

[40] Giuseppe Riva, Fabrizia Mantovani, Claret Samantha Capideville, Alessandra Preziosa, Francesca Morganti, Daniela Villani, Andrea Gaggioli, Cristina Botella, and

Mariano Alcaniz. 2007. Affective interactions using virtual reality: the link between presence and emotions. *Cyberpsychology, Behavior, and Social Networking*. 10(1): 45-56. http://dx.doi.org/10.1089/cpb.2006.9993

[41] Katja Rogers, Giovanni Ribeiro, Rina R Wehbe, Michael Weber, and Lennart E Nacke. 2018. Vanishing importance: studying immersive effects of game audio perception on player experiences in virtual reality. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18). Apr. 2018: 328. http://dx.doi.org/10.1145/3173574.3173902

[42] Christian Roth and Hartmut Koenitz. 2016. Evaluating the user experience of interactive digital narrative. In *Proceedings of the 1st International Workshop on Multimedia Alternate Realities* (AltMM '16). Oct. 2016. http://dx.doi.org/10.1145/2983298.2983302

[43] Richard M Ryan, C Scott Rigby, and Andrew K Przybylski. 2006. The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion.* 30(4): 344-360. http://dx.doi.org/10.1007/s11031-006-9051-8

[44] Jesse Schell. 2014. *The Art of Game Design: A Book of Lenses*. AK Peters/CRC Press.

[45] Phillip R Shaver, Judith Schwartz, Donald Kirson, and Cary Oconnor. 1987. Emotion knowledge: further exploration of a prototype approach. *Journal of personality and social psychology.* 52(6): 1061-1086. http://dx.doi.org/10.1037/0022-3514.52.6.1061

[46] William J Shelstad, Dustin C Smith, and Barbara S Chaparro. 2017. Gaming on the rift: how virtual reality affects game user satisfaction. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. 61(1): 2072–2076. http://dx.doi.org/10.1177/1541931213602001

[47] Sharon T Steinemann, Elisa D Mekler, and Klaus Opwis. 2015. Increasing donating behavior through a game for change: the role of interactivity and appreciation. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '15). Oct. 2015: 319-329. http://dx/doi.org/10.1145/2793107.2793125

[48] Chek Tien Tan, Tuck Wah Leong, Songjia Shen, Christopher Dubravs, and Chen Si. 2015. Exploring gameplay experiences on the Oculus Rift. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '15), Oct. 2015: 253–263. http://dx.doi.org/10.1145/2793107.2793117

[49] Graham Wilson, Mark Mcgill. 2018. Violent video games in virtual reality: re-evaluating the impact and rating of interactive experiences. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '18). Oct. 2018: 535-548. http://dx.doi.org/10.1145/3242671.3242684

[50] Bob G Witmer and Michael J Singer. 1998. Measuring presence in virtual environments: a presence questionnaire. *Presence: Teleoperators and Virtual Environments*. 7(3): 225-240. http://dx.doi.org/10.1162/105474698565686

[51] Caglar Yildirim, Michael Carroll, Daniel Hufnal, Theodore Johnson, and Sylvia Pericles. 2018. Video game user experience: to VR, or not to VR? *Games Entertainment Media Conference* (GEM). Aug. 2018: paper No. 18201205 http://dx.doi.org/10.1109/GEM.2018.8516542

[52] https://fallout.fandom.com/wiki/Fallout_4

[53] https://fallout.fandom.com/wiki/Vault-Tec_Assisted_Targeting_System