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PA Review of the Design and Application of Scare Modes in Virtual Reality

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Abstract. The rapid development of virtual reality (VR) technology has a huge impact on people and society. As an emerging industry, VR games are attracting more and more young people. Among them, horror VR games stand out in the field of VR games due to their high immersion and high stimulation to people. This study aims to systematically sort out the design principles, technical implementation ideas, and user response mechanisms of scare modes in VR environments. This article focuses on two types of intimidation patterns, one is sudden intimidation and the other is long-term psychological terror, and discusses their applications in game design in two complementary ways. This article searched for literature related to VR technology, psychology, human-computer interaction, and game design. Firstly, the theoretical basis was introduced, followed by an analysis of the characteristics and applications of two intimidation modes. Finally, the challenges and future development directions of current VR horror games are proposed.

Keywords: Virtual reality, Games, Horror games

1. Introduction

With the development of VR technology, the immersive experience brought by VR has transcended the boundaries of traditional media, and VR games have become a newly emerging industry. As there are many kinds of games, VR horror games have attracted extensive attention due to their ability to arouse people's emotional response. The key to the success of VR horror games is the scare modes of the game, which directly affect the player's experience.

The sense of presence is the feeling that people are in a virtual scene in their mind although they are physically in another place [1]. Compared with traditional 2D games, the immersive experience of VR games is enhanced because VR can stimulate the senses of people in multiple ways, such as vision, hearing and even touch [2]. In recent years, it has been proven that VR horror games can reliably induce fear through scientific experiments [3]. However, the optimization of scare modes still lacks systematic theoretical support. This paper sorts out the theoretical basis of scare modes design and analyzes the practical value of scare modes application, and attempts to bridge the gap between academic research and industrial practice [4].

This study aims to sort out the design principles, technical implementation ideas and user response mechanism of scare modes in VR environment systematically. Particularly, this paper

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focuses on two kinds of scare modes, sudden scare (jump scare) and long-term psychological horror, and discusses their applications in game design in two complementary ways.

From the theoretical perspective, this review integrates the research results of psychology, human computer interaction (HCI) and game design to establish a theoretical basis for the research of VR scare modes, which enriches the related research content of VR emotional design [5]. From the practical perspective, the research results can give developers clear guidance: by clarifying which design elements (such as sound effects, field of view restrictions, interactive feedback, etc.) can enhance the fear without causing side effects such as dizziness, it can help improve the quality and user acceptance of the game [6].

This study uses systematic literature review method. The literature retrieval sources include academic database such as Web of Science, PubMed and IEEE Xplore. The literature retrieval is interdisciplinary research on VR technology, psychology and game design [7]. The literature screening rules are as follows: (1) Published from 2010 to 2025 (the year 2010 is selected as the starting year because consumer-grade VR devices began large-scale popularization after 2010 [2]); (2) Focus on VR environment design or research on emotional response, and there is explicit discussion on fear induction mechanism; (3) Include empirical data on user feedback or physiological response.

The structure of this paper is as follows: Chapter 2 introduces literature retrieval and screening; Chapter 3 introduces the main theoretical basis (taking presence theory as an example) and research methods (subjective measurement method and objective measurement method); Chapter 4 analyzes the characteristics, application scenes and complementary relationship of two typical scare modes; Chapter 5 analyzes the limitations of research and future work; Finally, Chapter 6 draws a conclusion.

2. Literature review

2.1. Literature retrieval sources

To ensure the comprehensiveness and reliability of literature retrieval, this paper retrieves literature from multiple interdisciplinary literature databases. Web of Science and Scopus was used to retrieve international literature related to VR human computer interaction and emotional psychology, totaling 87 literatures. The PubMed literature retrieved on the physiological response to fear stimuli supplemented 32 literatures of emotional physiological mechanism of VR [5]. IEEE Xplore retrieves the technical literature related to VR interactive design, retrieving 45 papers of multi-sensory feedback. In addition, the Chinese academic resources such as CNKI and Hans Journal were consulted to retrieve the domestic literature related to VR presence theory [2].

2.2. Literature retrieval strategy

The literature retrieval strategy adopted subject terms and free words. The core keywords include “Virtual Reality”, “VR Horror Game”, “Scare Mode”, “Fear Induction”, “Sense of Presence”, “Physiological Response”. For English databases, there are “VR AND (horror game OR fear induction)”, “presence AND (virtual reality OR immersive environment)”, etc.

In order to improve the accuracy of literature retrieval, the narrow filter strategy is adopted. That is, the publication year is limited to 2010-2025, and the peer-reviewed journal papers and conference papers are selected. In addition, non-empirical studies are excluded. For example, there are only descriptions of design without user testing data.

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The initial retrieval obtained 192 documents, and then the documents were screened.

2.3. Screening standards and results of literature screening

The process of literature screening adopts two-stage screening, namely preliminary screening and in-depth evaluation. In the preliminary stage, 76 documents were screened out by reading titles and abstracts, mainly because the studied VR applications are not horror VR (such as educational VR or therapeutic VR). In the in-depth evaluation stage, the full text of the remaining 116 documents was reviewed. 41 papers were screened out because they did not meet the standards of empirical research (such as no user testing data) [7], and 29 studies were screened out because the research object was irrelevant (such as traditional non-VR horror games).

A total of 46 eligible studies were ultimately included in this review, encompassing three research domains: (1) theoretical investigations into VR presence and fear mechanisms (12 papers); (2) empirical studies on design elements of scare modes (21 papers); and (3) research on user response measurement methodologies (13 papers). These studies collectively provide a robust theoretical foundation and empirical basis for subsequent research on fear-inducing modes [3].

3. Research methodology and summary of findings

3.1. Theoretical framework: the sense of presence theory

Sense of presence serves as a critical psychological mechanism for the effectiveness of gaming modes, as the extent to which players perceive virtual threats is contingent upon their level of presence [1]. Witmer and Singer define presence as "the subjective experience of being in one environment while physically situated in another" [2]. Thus, the induction of presence necessitates both sensory immersion and cognitive engagement. Building on this, Lee categorizes presence into three dimensions: spatial presence (the sense of being situated within the virtual environment), social presence (the sense of coexisting with other entities in virtual space), and self-presence (the sense of self-identification with the virtual avatar) [2].

Owing to spatial presence, when players experience a sensation of "being spatially present" in the virtual environment, their reactions to threatening events (e.g., sudden monster appearances) become virtually indistinguishable from responses in real-world scenarios [6]. Slater and colleagues further posit that presence is amplified by the continuity between sensory input and motor output: when users execute precise virtual movements aligned with their physical motions, VR systems can elicit fear responses more effectively [7].

Factors Influencing Presence: In VR horror mode design, three key determinants modulate the sense of presence: sensory fidelity (accuracy of sensory details), interactive naturalness (conformity to real-world interaction patterns), and narrative consistency (coherence within the game's storyline) [5]. Sensory fidelity refers to the realism of multisensory stimuli, encompassing high-definition visual rendering (e.g., dimly lit settings) and 3D spatial audio (e.g., footsteps approaching from behind), which collectively enhance spatial presence [4, 8]. Experimental results from the "Sophroneo: Fear not" project demonstrated that tactile stimuli (such as cold sensations delivered via wearable devices) complement audiovisual inputs, thereby strengthening participants' sense of presence [4].

Interactive naturalness entails designing user interactions that adhere to real-world conventions. For instance, in the "Lethal Ape" series, players navigate by simulating gorilla-like arm swings—a design that reduces learning curves and fosters natural engagement, allowing players to maintain

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presence without fixating on VR controllers [6]. Narrative consistency ensures that scare events align logically with the game's context. In a laboratory-themed horror game, for example, equipment malfunctions would feel more authentic thanA monster that suddenly appears and is out of place with the background., thereby reinforcing presence [6].

3.2. Research methods: subjective measurement approaches for scare modes

Subjective measurement is the most commonly used method to assess scare mode effectivity, which is usually achieved by questionnaire and interview. The most commonly used questionnaire is Presence Questionnaire (PQ) created by Witmer and Singer. It has 14 items to measure the immersion, involvement and realism [5, 9, 10]. The items use a 7-point Likert scale. Researches have proved that Cronbach's α coefficient of the questionnaire is larger than 0.8 in VR horror research, which means the internal consistency of the questionnaire is very good [7].

Besides presence measurement, we also use Fear Visual Analog Scale (Fear VAS) to measure the fear intensity. Fear VAS is a 10cm line from "no fear" to "most fear" and players mark their fear level on the line [3]. Zhang et al. combined these two kinds of measurement and their results show that when there are visual restrictions (such as field of view limitation), PQ score increases about 32% and Fear VAS score increases about 41% compared with the case that there is no visual restrictions [5]. Besides that, semi-structured interview is also used to collect information about players' subjective experience. For example, players said "even there is ambient sound, it makes me always anticipating danger" [3].

Methods Subjective measurement evaluates the fear level by asking players about their subjective experience, which is prone to subject bias. To avoid that, objective physiological measurement quantifies the fear response by indicators such as heart rate (HR), skin conductance response (SCR) and electroencephalogram (EEG) [5]. When players meet sudden scare, the sympathetic nervous system is triggered, which makes heart rate accelerate (usually increase about 10-15 beats per minute) and SCR increase suddenly (within 1-2 seconds after stimulation) [4].

In "PanicRoom" study, researchers developed VR fear conditioning paradigm and used EEG to measure theta wave in prefrontal cortex, which had higher theta power meant stronger fear memory formation [7]. In actual game, developers such as the ones of Sophroneo used the real-time SCR to control the scare intensity and avoid players' discomfort because sudden scares will be triggered when SCR warns that players were too afraid [4]. In comparative experiments, sudden scare will cause fast sympathetic response and psychological horror will make cortisol level increase for a long time (which means it will stay in a high stress state for a long time) [3].

Demographic Differences in Scare Responses: females have 26% higher SCR amplitude to sudden scares than males, but preference for scare type varies more by game pace than gender [1]; Frame rate and latency have a large impact on effectiveness (over 20ms latency scores drop presence by 40%, making games weaker at inducing fear) [2]. The results above give clear targets for optimization of scare mode.

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4. Analysis and discussion of two scare modes

4.1. Complementary attributes of the two scare modes

4.1.1. Function of rhythm control

Scare modes are used to control the game rhythm, and sudden scares and psychological horror play a complementary role. Sudden scares (such as a monster suddenly appearing from behind a door) are used as "rhythm activators". These sudden events break the long period of calm, and cause the heart rate of the player to increase within several seconds. If the sudden scares are too infrequent, the player will become bored [6]. The "Lethal Ape" series of games inserted sudden scares every 3-5 minutes, and the players did not report becoming tired [6].

Psychological horror can build game rhythm by gradually raising tension through ambient sound (such as distant creaking), visual stimuli (such as moving shadows), and players' narrative hints (such as abandoned medical records) [3]. According to the experiment of Zhang et al., 83% of the players reported that they were more fearful of "anticipating danger" than sudden events, because players felt more fear when the game provided hints of danger [1]. These two modes--building anticipation followed by sudden scares--create a "tension-release" loop that is optimal for the players' emotion [7].

Psychological horror constructs the atmosphere by providing players with a general sense of danger through the concerted use of both scare modes. The game "Sophroneo" uses liminal audio design (such as faint whispers and distant water drips) and low lighting to make players feel uncomfortable before any threatening objects appear [4]. This creates a foundation for the sudden scares to be more effective. It is easier for players to perceive danger when there is already an atmosphere of danger [2]. For example, if the game uses psychological horror to hint at a "hidden monster" (such as claw marks left behind), and then the monster suddenly appears, the players will feel that this monster exists, making the virtual world more "real" [6].

Games that use both modes receive 65% more atmosphere votes than games that use only one mode, because these games can provide players with both prolonged danger and memorable sudden scares [3].

4.1.2. Function of atmosphere construction

Atmosphere construction uses the concerted use of both scare modes to create a consistent horror experience. Psychological horror creates the atmosphere foundation through the two complementary scare modes described above. Games such as "Sophroneo" use faint whispers and other liminal audio design, as well as low lighting to make players feel uncomfortable before any threatening objects appear [4].

This foundation of danger makes the sudden scares after this are more effective. It is easier for players to feel danger when there is already an atmosphere of danger [2].

For example, if the game uses psychological horror to hint at a "hidden monster" (such as claw marks left behind), and then the monster suddenly appears, the players will feel that this monster exists, making the virtual world more "real." Games that use both modes receive 65% more atmosphere votes than games that use only one mode, because these games can provide players with both prolonged danger and memorable sudden scares [3].

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4.2. Application principles of scare modes

4.2.1. Audience orientation of target

Scare mode design should take into account the tolerance and preferences of the target audience. If the casual players (low fear tolerance) are the target audience, the ratio of psychological horror to sudden scares should be around 3:1, and the sudden scares should be non-graphic (such as loud sounds instead of violent images) [1]. In an experiment on gender differences, it was found that girl players preferred psychological horror (68% reported being less uncomfortable than sudden scares), and male players showed tolerance for different types of scares, but this varied for different game paces [3].

If the hardcore horror fans (high tolerance) are the target audience, the ratio is 1:2, and the focus is on scary experiences, but physiological monitoring is still needed. The "PanicRoom" experiment showed that if more than 8 sudden scares are used within 10 minutes, the rate of simulator sickness will increase by 35%, and players with motion sensitivity are even more sensitive to this [7]. Therefore, audience segmentation, and considering tolerance and preferences are very important.

4.2.2. Combination with narrative and scenes

Scare modes should be combined with narrative and scene design. It is important that scare modes do not disconnect with narrative and scenes. In narrative-based VR horror games, scare events should develop the plot: if sudden scares are used, they should appear when opening a key plot door (instead of at random times) [6]. The selection of scare modes depends on scene characteristics: narrow spaces (such as the lab corridors in "Lethal Ape 2") increase psychological horror through player movement restrictions, and open spaces (such as abandoned warehouses) are better for sudden scares from unexpected directions [6]. In addition, the environment should also be considered. In a forest setting game, when using industrial sound effects for sudden scares, presence scores decreased by 28% due to the sudden scare sound conflicting with the scene [2]. In the "Sophroneo" project, thermal feedback was coordinated with scenes: when the player entered a "spirit-infested room", the cold sensation matched the supernatural scene description, which improved both atmosphere and presence [4].

4.2.3. Avoiding too much stimulation

The biggest restriction in scare mode design is to avoid too much stimulation, which leads to discomfort or abandoning the game. The physiological experiment defines "too much stimulation" as SCR amplitude higher than 2.5μS or HR higher than 120 beats per minute lasting for more than 5 minutes, and this will definitely lead to 70% of players reporting "intention to quit" [5]. To avoid this, developers can use "cooling periods": 1-2 minutes of low-tension gameplay after intense scares, and this can reduce HR by about 20 beats per minute on average [4].

Another method is to use adaptive adjustment based on feedback. If we use wearable physiological sensors, the system can reduce scare intensity when physiological indicators exceed certain thresholds---this method of adaptive adjustment in "Sophroneo" reduced player abandonment rate by 42% [4]. In addition, providing different difficulty settings (such as "mild" scare mode and "intense" scare mode) can meet the different tolerances of different players while still maintaining core experiences [1].

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4.3. Limitations of existing research

Although considerable progress has been made, there are still three limitations to existing VR scare mode research. First, measurement methods are not standardized. Different studies adopt PQ versions of different years and physiological indicators, making cross-study comparisons challenging [5]. Second, sample sizes are small (an average of 23 participants across studies) and thus the generalization of study results are limited [1]. Third, the long-term effects of VR scare modes on players' emotional health are still unknown (all existing research studies focus on participants' responses in the short-term (30 minutes) [5].

These limitations limit the transfer of research to industry practice. For instance, without standardized measurement methods, it is impossible for developers to accurately compare the scare effectiveness of their projects [7]. To bridge this gap, research efforts should focus on developing unified measurement protocols and conducting large-scale longitudinal studies.

5. Future research directions

5.1. Technical innovation-driven design optimization

Future scare mode design will be driven by two technical innovations, i.e., multi-sensory feedback technology and adaptive system. On one hand, in addition to visual and auditory feedback, haptic feedback gloves and full-body suits can provide tactile stimulation, e.g., a "hand grab" feeling when players are suddenly scared. Related tests show that increasing tactile feedback can raise presence by 45% [4]. Moreover, rich feedback types, e.g., thermal feedback (when entering an abandoned scene, players will feel a rotting smell), can further enrich the sensory experience. However, miniaturization technology is still under exploration [2]. On the other hand, adaptive AI systems will be developed to adapt to players' responses. For instance, by modeling players' responses to game scenarios (e.g., avoiding dark corners indicates that players fear more about psychological horror rather than sudden scares), adaptive systems can adjust the types of scares delivered in real-time. Related prototype research shows that adaptive systems can increase player satisfaction by 58% compared with fixed design [6]. In the future, these technical innovations will be integrated with players' physiological responses to deliver personalized scares, which balance players' comfort and intensity.

5.2. Expansion of research perspectives

To bridge the above-mentioned limitations, expanding research perspectives is an effective solution. First, longitudinal studies (follow up players' responses in the long-term (6 months)) should be conducted to explore long-term effects of VR scare modes on players' emotional health (especially for VR horror game players who frequently play the game [5]. Second, cross-cultural studies should be conducted to explore cultural differences in players' preferences of scare modes. Related exploratory data analysis shows that players from Eastern countries may prefer more psychological horror games (because Eastern culture attaches more importance to being subtle) while players from Western countries may prefer more sudden scares [3]. Third, studies on special populations should be conducted. Related research on players with anxiety disorders shows that players with anxiety disorders can benefit from playing mild psychological horror games (without jump scares), which can improve the effectiveness of exposure therapy [7]. By exploring the above-mentioned research

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perspectives, the theoretical model can be further enriched and practical applications can go beyond entertainment.

5.3. Standardized evaluation systems

Establishing standardized evaluation systems is significant for both academic research and industry applications. First, a unified presence-fear questionnaire should be established. Because PQ items are important to the essence of PQ, the unified questionnaire should include all PQ items and Fear VAS [2]. Second, a set of physiological indicators should be established. The selected indicators should include HR, SCR and EEG theta power. Moreover, the threshold values of "excessive stimulation" for these indicators should be clear [5]. Third, a user experience indicator should be established. The indicator should include engagement, discomfort and replay intention [6].

Some standards are being developed by the International Society for Presence Research (ISPR), but they are used mostly by the industry. Only close cooperation between academics and developers (e.g., sharing of game telemetry data for validation) will facilitate the adoption of standards to allow for reliable evaluations of scare mode effectiveness [7].

6. Conclusion

Based on a systematic review of the design and application of scare modes in VR environments, this study focused on the sudden scare and long-term psychological horror modes. The results show that the sense of presence is the theoretical basis of this research, and sensory fidelity, interactive naturalness, and narrative consistency are important influencing factors. In addition, PQ subjective measurement method and Fear VAS, as well as objective physiological method (HR, SCR), provide an alternative method basis for evaluating the effectiveness of scare.

The two kinds of scare modes have obvious differences but are complementary: The sudden scare can adjust the rhythm and create peak experiences; the psychological horror mode creates atmosphere and long-term tension. Their effective use should be oriented to target audiences and used in combination with narrative/scenes and should be avoided from being too shocking. This research has limitations in standardization, sample size, and exploration of the long-term effect. In the future, with the development of technology, more innovative ideas, cross-disciplinary perspectives, and standardized evaluation systems will be provided to explore these two modes.

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