Design of Virtual Reality Scenes with Variable Levels of Fear Evocation

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Abstract. Fear is one of the basic emotions of human which are comprehensive representations of human psychology and consciousness. The evocation of emotion has been applied to many fields, such as mental diseases diagnosis, mental health assessment, study of cognitive science and game design. The present methods for affective stimuli mainly include texts, pictures, sounds, odors and computer games. However, they have some limitations in terms of inefficient emotion elicitation and high susceptibility to ambient interferences. Virtual reality technology is a potential technology to solve some of these problems by providing immersive and realistic experience in terms of emotion elicitation. Therefore, in this study we set up a systematic approach for the design of emotion evocative VR scenes, using fear as an example. Firstly, we extracted fear evocative elements from the International Affective Picture System (IAPS), the Chinese Affective Digital Sound System (CADS), the Chinese Affective Video System (CAVS), horror films and video clips. Secondly, we developed three virtual reality fear scenes using the classified evocative elements. At last, we used the Self-Assessment Manikin (SAM) scale to test the effectiveness of fear evocation using these VR scenes. In conclusion we have built up a series of fear evocative VR scenes, which can induce different levels of fear with high effectiveness of fear elicitation in the VR environment.

Keywords: Virtual reality · Scenes design · Fear evocation

1 Introduction

Emotions are the psychological and physiological states associated with cognitive and epistemological processes and play a very important role in human communication. Fear is considered as one of the basic emotions of human.

In term of fear, there are various definitions made by many scholars. King et al. [1] considered that fear is a normal reaction to real or imaginary threats in psychology, which is considered as an integral part of development and adaptability. In physiology,

J. Y. C. Chen and G. Fragomeni (Eds.): VAMR 2018, LNCS 10910, pp. 103–115, 2018.
https://doi.org/10.1007/978-3-319-91584-5_9

Johansen et al. [2] believe that fear is a motivational state that has a strong biological drive, driving organisms to choose external stimuli in their environment, especially those with dangerous signals. In 1991 Izard [3] put forward that relative to other basic emotions, fear has huge potential. That is why the fear becomes one of the most widely studied emotions. Since Hall started to study fear [4], researches on fear have attracted great attention. Especially after 1980s, the study of fear has become a field which is concerned and interested in various disciplines.

The evocation of emotion has been applied to the diagnosis of mental illness, mental health assessment [5], cognitive science research [6], game design [7] and many other areas. Emotional evocation can also be used as a tool to enhance user experience in design process [8]. As emotion have a significant impact on many cognitive activities, such as perception, attention, memory and decision making, an important way to study emotions is to induce desirable emotion, so as to observe and measure physiological, psychological and behavioral changes of subjects under the corresponding emotional state.

At present there are several ways to evocate different emotions in the laboratory:

Visual stimuli **-** Visual stimuli induce emotions by pictures of various contents. Related databases include the International Affective Picture System (IAPS) [9] established by the National Institute of Mental Health (NIMH) and the Chinese Affective Picture System (CAPS) launched by Bai et al. [10].

Auditory stimuli **-** Auditory stimuli induce emotions by nature's voice recordings, nonverbal syllables and music material. Related databases include the International Affective Digital Sounds (IADS) [11] and the Chinese Affective Digital Sounds (CADS) [12].

Video stimuli **-** Video stimuli are combinations of visual and auditory stimuli. The main materials are movie clips based on the study of Gross and Levenson [13] and Chinese Emotional Visual Stimulus (CEVS) established by Xu et al. [14].

Olfactory stimuli **-** Olfactory stimuli induce emotions by having the subjects smell sniffing either intentionally or unconsciously. A large database called the Consumer Fragrance Thesaurus is such a kind of system [15].

Imagination stimuli **-** In imagination stimuli, subjects are guided to imagine or recall a certain situation to induce emotions. Related materials are the Affective Norms for English Words (ANEW) [16] and the Affective Norms for English Text (ANET) launched by Bradley and Lang [17].

Expression stimuli **-** Subjects are instructed to control their own facial muscles, making their facial expressions consistent with the reference facial expressions reflecting the target emotions, thereby inducing the target emotions [18].

Situational stimuli **-** Situational stimuli induce emotions by placing the subjects in a simulated or real life situation, such as public speaking, mock exams, parachuting, and surgery [19].

In above methods, visual and auditory stimuli are single channel stimuli with low ecological effect. Situational stimuli create virtual environments for the subjects, but the effects will be greatly affected once the subjects know the purpose of the experiment. Expression stimuli have greater limitations because they demand the subjects have some performance skills, and it is not easy to take the sample. Imagination stimuli are greatly influenced by individual's imagination ability. Video stimuli combine the image

and music to induce the mood of the subject, which could be effective. But the number of related material is small and the generated fear level is not clear.

Therefore, in this study we analyzed the design elements from existing materials which can evocate fear, and then built up a series of fear evocative VR scenes, which can evocate different levels of fear with improved efficiency of elicitation.

About the research of emotion measurement, Ekman [20] believes that nine characteristics can distinguish one emotion from another. However, his method can hardly provide a quantitative definition for an emotion, including fear. Many scientists have tried to develop a quantitative reference range for fear and other emotions. Kim and André [21] establishes the two-dimensional emotion model of valence and arousal, according to which an emotion with high arousal and negative valence may be fear. The Self-Assessment Manikin (SAM) [22] is a non-verbal pictorial assessment technique that directly measures the valence, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli. The SAM scale is a 1–9 scale. Two critical dimensions used to measure emotions are valence and arousal. Valence is the degree of pleasure; for instance, pleasure has high valence and disgust has low valence. Arousal is the degree of activation, for instance, surprise has high arousal and sadness has low arousal.

In this paper, we defined fear as the emotion with valence of no more than 4 and arousal greater than 4. And the level of arousal could be further classified as 4 classes: slight fear (4–5), mild fear (5–6), moderate fear (6–7) and severe fear (>7).

This study consists of three parts: the first part is the extraction of features of fear evocative elements, the second part is design of VR fear scenes, and the last part is the assessment of the effectiveness of VR fear scenes using the SAM scale.

2 Feature Extraction of Critical Element for Fear-Evocation

VR technology is a combination of visual media and audio media. Therefore, we extracted fear evocative elements from emotional evoked material libraries which can provide visual stimuli, auditory stimuli and video stimuli. Fear evocative elements are extracted from the International Affective Picture System (IAPS), the Chinese Affective Digital Sound System (CADS), the Chinese Affective Video System (CAVS) and other horror films and video clips.

2.1 Fear Feature Analysis of International Affective Picture System (IAPS)

International Affective Picture System (IAPS) is made by National Institute of Mental Health (NIMH). It is a standardized picture system of stimulating the target mood. IAPS is widely used in the study of all kinds of emotional problems abroad such as the physiological mechanism of emotion, emotion regulation, and relationship on the memory of emotion and other cognitive activities. The way of using it is to identify mental state of subjects by showing them the emotional picture materials.

With the classification above, we analyzed the features of the elements in each class of evocation from three aspects: attributes, semantic features and expressive features. Specific contents are shown in Table 1.

Attribute is the nature of the element; for instance, a decaying corpse and a skull share the same attribute of human body. Semanteme refers to the meaning of the element; for instance, a decaying corpse means a horrible death and a sharp knife means hurt. Expression means the morphological character of the elements; for instance, a decaying corpse is designed to be twisted and incompleteness.

Table 1. Features of the elements in IAPS.

Level of arousal	Attributes	Semanteme	Expression
Severe fear (>7) 	Severely bloody, deformed human body	Horrible death, Extremely Severe hurt	Blood red, incompleteness, deformity
Moderate fear (6-7) 	Bloody or deformed human body, aggressive animal, lethal weapon or tool, severe catastrophe	Severe hurt, Death threat	Sharp, medium saturation colors, strong light and shade contrast, incompleteness
Mild fear (5-6) 	Wounded human body, mummification, wounding weapon or tool, catastrophe	Hurt, pain	Abnormality
Slight fear (4-5) 	Skull, graveyard, disgusting animal	Death, plague, dinginess	Low saturation color, chaos

2.2 Fear Feature Analysis of the Chinese Affective Digital Sound System (CADS)

In the establishment of CADS, Liu et al. [12] sums up the sound materials into 6 categories: surprise, neutrality, activation, pleasure, disgust and fear. We analyzed the

sound materials of the type of fear. According to the sources of the sounds, we divided these voices into the sound of role and the sound of environment.

The Sound of Role. The sound is mainly made by the narrative subjects itself with clear meanings. It contains the sounds of the process of violence, such as the sound of shrill cry and the unusual sound, such as strange noises and grinning sound. The specific classification information is shown in Table 2:

Table 2. Features of the sound of role in CADS.

Level of arousal	Attributes	Semanteme	Expression
Severe fear (>7)	Heartrending scream and moan, sound of hitting human body	Torture, pain, hurt	Sudden and intermittent voice, sharp yell
Moderate fear (6–7)	Moan and wail, weird sound made by human	Sorrow and unluckiness, unknown and abnormal situation	Trembling faint voice, fierce cry and wail

The Sound of Environment. The environmental sound could be helped to set the mood and narrate. It can be divided into natural sound, artificial sound and background music. The specific classification information is shown in the Table 3:

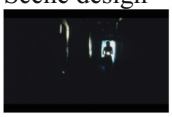
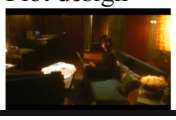
Table 3. Features of the environmental sound in CADS.

Level of arousal	Attributes	Semanteme	Expression
Severe fear (>7)	Alarm, sound of accident	Severe disaster	Sudden and intermittent voice
Moderate fear (6–7)	Alarm, sound of dangerous object	Danger, disaster	Sharp and hasty sound
Mild fear (5–6)	Sound of dangerous object	Danger	Sudden sharp sound

2.3 Fear Feature Analysis of the Chinese Affective Video System (CEVS) and Other Horror Films and Video Clips

The Chinese Affective Video System (CEVS) [14] contains 30 film clips, which can induce six emotions including anger, fear, sadness, happiness, disgust and neutrality. There are five film clips which could induce fear. We also analyzed a number of horror films and television works. We analyzed the feature elements in the following aspects: role design, scene design, rhythm design and plot design, as shown in Table 4:

Table 4. Fear features of the elements in CAVS, horror films and video clips.

Level of arousal	Attributes	Semanteme	Expression
Character Design 	The symbol of abnormal death, such as deformed body	Abnormal death, undead retaliation,	Bloody body, pale body, twisted and incomplete body
Scene design 	Sealed space, endless space, dusky space	Loneliness , helplessness, confinement, unknown	Colors of cold hue and low saturation; cold and hard material
Rhythm design 	Fast, slow, alternating rhythm,	Nervous, Perturbed, calm, complicated	Rhythm alternating, the horror scenes are usually set after a person feels safe.
Plot design 	Escape, mystery, numinous phenomena	Unknown, precarious, creepy	Escape, suspense, confrontation, break taboos

2.4 Summary of Fear Feature Analysis

Based on abovementioned analysis, we found that the fear features of different levels can be clearly distinguished. This regularity can be used as a rationale for further design of VR fear provoked scenarios that can evoke different levels of fear.

3 Development of Virtual Reality Fear Scenes

3.1 Fear Scenes Development Process

The development of virtual reality fear scene was divided into three steps. At first, we selected appropriate music fragments, such as character settings, theme colors, scenes settings. Then we consequently finished the scripting, role design, interactive interface design and scene design. At last, we integrated models in Unreal Engine 4 and created special effects for the scenes. Main components of the development process are shown in Fig. 1.

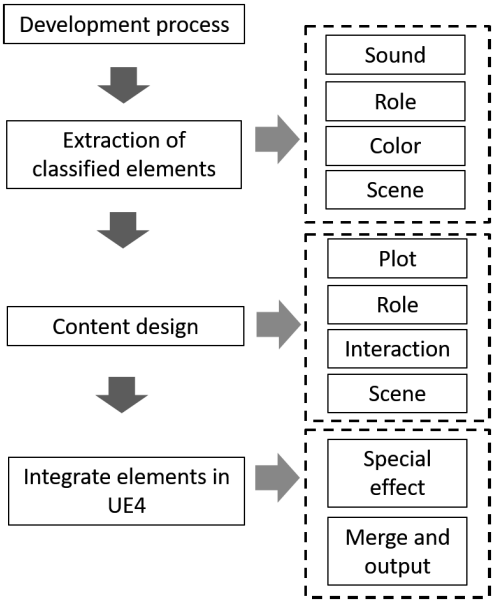


Fig. 1. Schematics of VR scene development process

3.2 Fear VR Scenes Design

According to our research, we designed three fear VR scenes. The contents of the scenes are shown in Table 5. Snapshots of the designed scenes are shown in Figs. 2, 3 and 4.

Dilapidated Basement. The Snapshot of the scene as shown in Fig. 2.

0–81 s: The scene begins in a narrow dingy corridor on the first floor of a two-story building. The height of camera is low and in a creeping perspective. The camera advances at a slow pace and the slow background music creates a mysterious and horrible atmosphere. Sudden lightning (5 s) illuminates a twisted body monster standing by the window. The corridor is covered with mosaics and other construction waste shedding from the broken wall (Fig. 2a). A male corpse in a suit with a heavy makeup mouth and a grin lies on the ground. The camera moves forward slowly, the lightning suddenly flashes again (36 s) and the monster standing by the window roars backwards and falls in front of the camera (Fig. 2b). The camera bypasses the fallen monster slowly, approaching the window. A blood soaked woman flashes through the window (55 s), accompanied by a shrill scream. The camera accelerates slightly towards the door of a red room in the front and a horned head zombie in a prison uniform suddenly falls from the broken ceiling onto the ground in front of the camera (75 s).

81–97 s: The camera moves slowly towards the door, and cries of a girl and singing of a soprano appear, which echo in the room (81 s). The camera goes through the door into the red and confined staircase. A strong ghost walks toward the camera, chasing the camera (Fig. 2c) and at the same time the background music switches to fast-paced music (88 s). The camera accelerates again, begins to escape and races up the shabby stairs.

Table 5. Description of three fear scenes.

	1	2	3
Name	Dilapidated Basement	Horrible Underground Palace	Abandoned Factory
Scene	Basement	Palace	Factory
Element	Zombies, Residual limbs, a broken stair, construction rubbishes	Zombies, skulls, a bat, torches, snakes	Centipedes, mosquitoes, black bugs, construction rubbishes
Color	Black, red, green	Brown, grey, red, blue	Green, grey
Lighting effect	Low brightness	Medium brightness	High brightness
Dynamic effect	Crawl forward, capture	Creep and attack	Creep and attack
Plot	Chase and escape	Guide and observe	Guide and observe
Rhythm	An alternating rhythm	An alternating rhythm	A smooth rhythm
Sound	Cries of a girl, Soprano singing, roars of monsters	Sound of water, sound of zombies	Sound of insects
Sound effect	Asymptotically increasing	Surrounding sound	Asymptotically increasing
Camera perspective	Low height	Normal height	Low height

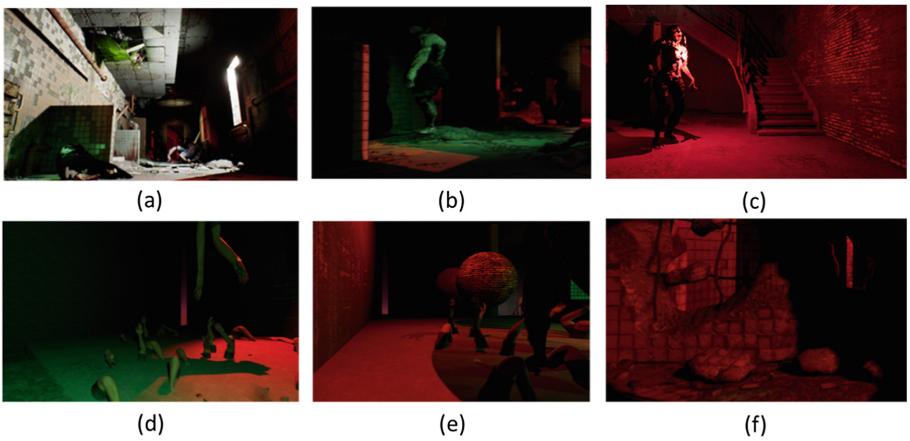


Fig. 2. Snapshot of fear Scene 1: Dilapidated Basement. (See text for the detailed description of different sub-figures) (Color figure online)

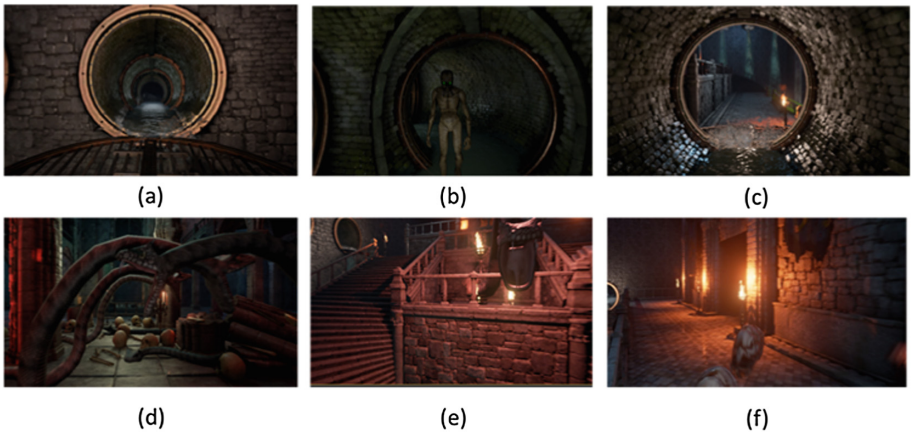


Fig. 3. Snapshot of fear Scene 2: Horrible Underground Palace. (See text for the detailed description of different sub-figures) (Color figure online)

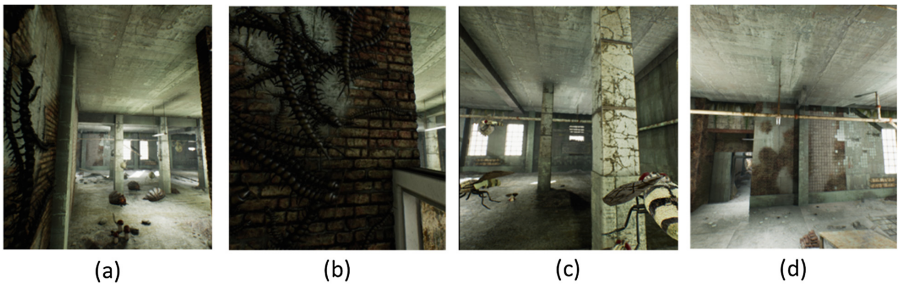


Fig. 4. Snapshot of fear Scene 3: Abandoned Factory. (See text for the detailed description of different sub-figures)

97–115 s: The camera enters the second floor, which is a dark and confined cement space. Some areas are illuminated with red and green lights and some are dark areas with no light. Three huge brick balls are hung on the ceiling and many moving hands and feet are out from the concrete floor and ceiling (Fig. 2d). Suddenly a woman screams (110 s), and the shadow of a dancing ghost appears on the wall (Fig. 2e). Looking down the direction of the light, a ghost has come to the camera, ready to throw the camera down. A dancing shadow of a ghost appears on the wall, moving forward. Looking down the direction of the light source, the ghost has come to the camera, trying to catch the camera. (Figure 2f).

Horrible Underground Palace. The Snapshot of the scene as shown in Fig. 3.

0–21 s: The scene sets in a darkened three-story confined castle and the scene begins under the steps of a palace. The underground palace is dimly lit by candle-light in the distance and the height of the camera is normal. The camera slowly moves to the stairs, suddenly neon lights come on and a fierce snake comes out behind the guardrail

(Fig. 3a), making a sound and tearing at the camera (5 s). The camera moves upstairs, and water sound becomes louder and louder. The camera enters the second floor, where there are sewer exits on the wall, flowing water, and forming waterfalls. The camera turns left into one of the sewer exits.

21–49 s: The camera enters the brick sewer and the sewer has shallow water (Fig. 3b). The camera moves forward in the sewer, and cries of a little girl appear (28 s). The camera turns right into another channel of the sewer, which is blocked by a steel bar gate. Cries continue and the camera turns away in the opposite direction (35 s). Footsteps sound (38 s), and a green-eyed zombie walks past the camera (Fig. 3c). The camera turns left to leave the sewer in the original way. The little girl's cry gradually disappears, the sound of water getting stronger. The camera leaves the sewer and enters the second floor platform of the palace (49 s).

49–103 s: The camera moves to the stairs on the other side of the second floor platform. The camera goes up the stairs (65 s), into the third floor platform of the palace. In the torchlight, a huge group of worm-like monsters creep toward the camera (70 s) (Fig. 3d). The camera turns right (76 s) and goes through a narrow, dark aisle into the magnificent main hall of the palace. The sound of water disappears and the sound of monster sounds. There are many skulls on the huge stone paving slabs. The camera continues to advance and there are many snakes dancing under the vault (Fig. 3e). The red candlesticks shine the stone columns to red. The camera goes through mouths of the snakes, with fangs and eyes of the snakes being clearly visible. The camera moves forward to a dry well (104 s) in the middle of the main hall, suddenly accelerates, climbs over the guardrail, turns over the railing and then jumps into the dry well, hitting a bat-like monster (Fig. 3f).

Abandoned Factory. The Snapshot of the scene as shown in Fig. 4.

0–40 s: The scene sets in a single layer bright and dirty abandoned factory, and the height of the camera is very low. The scene begins at the corner of the factory. When the camera moves out of the corner, the picture becomes brighter and shrill mosquitoes vibrate its wings (4 s) (Fig. 4a). A lot of trashes, a couple of wood boards and a broken table are on the floor. A group of mosquitoes are hovering above the table. After the camera goes through the table (10 s), a large, white spider can be seen, crawling back and forth on the ground and rubbing against the ground (Fig. 4b). The camera passes through the spider and a huge centipede are creeping on the front wall. The camera gradually approaches the door of a room filled with centipedes.

40–56 s: The camera enters the room where hundreds of centipedes are creeping on the floor, wall and ceiling, making a loud noise. The camera moves forward into the middle of the room, above a dense group of centipedes (Fig. 4c), turns around and returns in the same way.

56–86 s: The camera leaves the room and the sound of centipede gradually disappears. There are a few dancing centipedes on the ground, and a few huge worms wriggling in the ground not far away, making loud noise. Several white spiders are crawling back and forth on a distant pillar. The camera passes by the giant worms and the sound of the worms gradually disappears. Suddenly the sound of the mosquito wings sounds (77 s) and a huge mosquito hovers over the left front of the camera (Fig. 4d).

4 Evaluation of Designed Fear VR Scenes by Self-Assessment Manikin (SAM)

4.1 Experiment

We used the Self-Assessment Manikin (SAM) scale to test effectiveness of the designed VR scene. 30 subjects with no history of mental disorders (15 males and 15 females, age: 21–37 years) were recruited for tests.

At first, we introduced the SAM scale test process to the subjects, and illustrated its usage with some examples. Then we asked the subjects wore the experimental equipment on the subjects, including VR glasses and multi-channel physiological recorder. The subjects were requested to rest, including thirty seconds with eyes closed and ten seconds with eyes open for rest. Three VR scene videos were played to subjects in random order, and the subjects completed the corresponding SAM scale after each VR scene video was played. The experimental procedure is shown in Fig. 5.

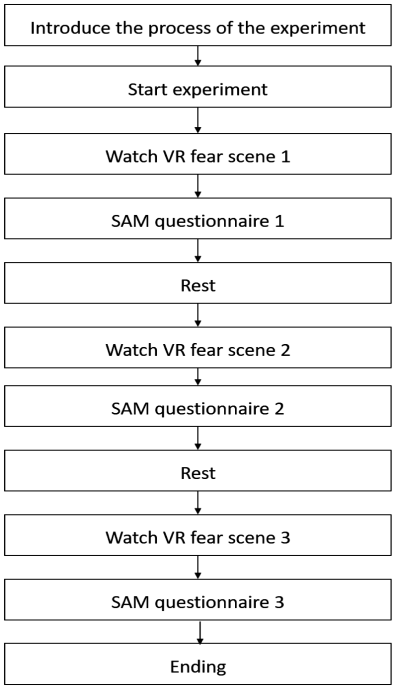


Fig. 5. Flowchart of the experimental process.

4.2 Results

Table 6 shows the mean score of valence, arousal and dominance. The arousal scores are 7.4, 7.0 and 6.4. According to the predefined levels of fear, the main factors that affect evocation of emotion are valence and arousal. When valence <4, arousal >7, the

Table 6. The mean score of valence, arousal and dominance.

No.	Scene	Valence	Arousal	Dominance
1	Dilapidated Basement	2.6	7.4	4.2
2	Horrible Underground Palace	2.7	7.0	5.0
3	Abandoned Factory	3.1	6.4	5.0

evocation of emotion is severe fear. When valence <4, arousal between 6–7 is moderate fear. The reason why Scene 1 got the highest arousal and Scene 3 got the lowest arousal mainly lay in the color and lighting effect of the scenes. Higher contrast of the color in environment could induce higher arousal. Another important reason for the difference in arousal among three scenes is the sound with the narrative rhythm. Scene 1 has the sound of weeping of people with escape. Scenes 2 and 3 have more natural sounds and noises.

5 Conclusion

According to the result, the Dilapidated Basement has reached the level of inducing severe fear, and the Horrible Underground Palace and the Abandoned Factory has reached the level of inducing moderate fear. The experimental results above show that designed fear VR scenes can evocate different levels of fear. Our design approach is effective, which can be used as guideline principles for designing more fear scenes or other types of emotional scenes.

In future work, we will continue to refine design principles and design more scenes to enrich the library of emotional VR scenes, in order to bring a new and more effective tool for both research and clinical applications in the field of emotion study.

Acknowledgement. This work is supported by "The Project of Research and Reform based on Undergraduate Education in South China University of Technology in 2017" (Y1171080) and "Science and Technology Program of Guangzhou" (201704020043).

References

1. King, N.J., Hamilton, D.I., Ollendick, T.H.: Children's Phobias: A Behavioural Perspective. Wiley, Hoboken (1988)
2. Johansen, J.P., Tarpley, J.W., Ledoux, J.E., et al.: Neural substrates for expectation-modulated fear learning in the amygdala and periaqueductal gray. Nat. Neurosci. **13**(8), 979–986 (2010)
3. Izard, C.E.: The Psychology of Emotions. Springer, Berlin (1991). vol. 6, no. 61, pp. 198–209
4. Hall, G.S.: Thanatophobia and immortality. Am. J. Psychol. **26**(4), 550–613 (1915)
5. Young, M.E., Bemak, F.: The role of emotional arousal and expression in mental health counseling. J. Ment. Health Couns. **18**, 316–332 (1996)
6. Salterspedneault, K., Gentes, E., Roemer, L.: The role of fear of emotion in distress, arousal, and cognitive interference following an emotional stimulus. Cogn. Behav. Ther. **36**(1), 12–22 (2007)

7. Ravaja, N., Salminen, M., Holopainen, J., et al.: Emotional response patterns and sense of presence during video games: potential criterion variables for game design. In: Nordic Conference on Human-Computer Interaction, pp. 339–347 (2004)
8. Piqueras-Fiszman, B., Jaeger, S.R.: The impact of the means of context evocation on consumers' emotion associations towards eating occasions. Food Qual. Prefer. **37**(37), 61–70 (2014)
9. Center for the Study of Emotion and Attention (CSEA-NIMH).: The International Affective Picture System: Digitized Photographs. Center for Research in Psychophysiology, University of Florida (1995)
10. Bai, L., Ma, H., Huang, Y.X., Luo, Y.J.: The development of native Chinese affective picture system–a pretest in 46 college students. Chin. Ment. Health J. **19**(11), 719–722 (2005). (in Chinese)
11. Bradley, M.M., Lang, P.J.: The International Affective Digitized Sounds Affective Ratings of Sounds and Instruction Manual. University of Florida (2007)
12. Liu, T.S., Luo, Y.J., Ma, H., et al.: The compilation and evaluation of localized emotional sound library. Psychosoc. Sci. **29**(2), 406–408 (2006). (in Chinese)
13. Gross, J.J., Levenson, R.W.: Emotion elicitation using films. Cogn. Emot. **9**(1), 87–108 (1995)
14. Xu, P.F., Huang, Y.X., Luo, Y.J.: Preliminary compilation and evaluation of Chinese emotional image materials library. Chin. J. Ment. Health **24**(7), 551–554 (2010). (in Chinese)
15. Warrenburg, S.: Measurement of emotion in olfactory research. In: ACS Symposium, vol. 825, pp. 243–260 (2002)
16. Bradley, M.M., Lang, P.J.: Affective norms for English words (ANEW): instruction manual and affective ratings. J. Roy. Microsc. Soc. **88**(1), 630–634 (1999)
17. Bradley, M.M., Lang, P.J.: Affective norms for English text (ANET): affective ratings of text and instruction manual, pp. 1–25. Technical report D1. University of Florida (2007)
18. Xin, W., Jingna, J., Li, S., et al.: Study on the early metaphase component difference of ERP induced by scene situation and facial expression picture. Chin. J. Biomed. Eng. **34**(3), 257–263 (2015). (in Chinese)
19. Siemer, M., Mauss, I., Gross, J.: Same situation–different emotions: how appraisals shape our emotions. Emotion **7**(3), 592 (2007)
20. Ekman, P.: An argument for basic emotions. Cogn. Emot. **6**(3–4), 169–200 (1992)
21. Kim, J., André, E.: Emotion recognition based on physiological changes in music listening. IEEE Trans. Pattern Anal. Mach. Intell. **30**(12), 2067–2083 (2008)
22. Bradley, M.M., Lang, P.J.: Measuring emotion: the self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry **25**(1), 49 (1994)