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Physiological Evaluation of the Players' Emotions in Different Educational Games

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Abstract The player's personality in games has been studied in recently. This study explored whether the game types could affect learner's learning emotions in educational games or not and inferred which kind of game has the potential in education. As a sample, 40 players were recruited to evaluate three electronic games on training players' abilities to use the games. In this paper, the players' heart rate variability (HRV) was recorded through Biofeedback instrument to explore learner's emotions. After evaluating the games' scores by the related scales, three different kinds of games ("Balance", "Rescue" and "Gates of Logic.") are chosen as test materials. The experiment results show three games all arouse the players' an overall positive emotions. The increasing HF and the unchanging LF/HF show the different types' games can arouse the different degrees of pleasure.

Keywords: *game types, emotions, educational games*

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1. Introduction

Recently, the player's personality, game types and learning effect have been studied. Pillay's findings suggest that playing recreational computer games may influence children's performance on subsequent computer-based educational tasks [1]. Game type would be related to children's gender-based peer preference: boys' preference for same-sex peers would be especially pronounced in a more competitive /physical game, and girls' preference for same-sex peers would be especially higher in a less competitive /physical game [2]. Ruben Puentedura figure out that Narrative-Based game are very useful in an educational environment, which includes role-playing games, massively multiplayer online game, alternate reality games, they are better suited to different players. Action games could not be directly used in education, but simulation games is particularly rich category for education, which may map on the educational contents. On the other hand, the play's personality is also the important factor in game-based learning. Especially, the player's emotion is one of most relevant dimensions for game assessment [3]. Emotions can affect attention, creation, and the formation of memory channels. Emotional status and learning are strongly correlated [4]. The players' emotional state will evolve according to the events of the game [5]. However, the emotional reactions are not introduced by the designers on purpose [6]. Therefore, it is necessary to consider players' emotion in assessing the learning effect and what types of educational games can influence students' emotions [7].

Emotion assessment is also a rapidly growing research field, especially in the human-computer field. In emotion assessments, spontaneous and less controllable reactions can be more reliable. Physiological signals can be captured by the peripheral nervous system and those coming from the central nervous system [7]. Based on the research results above, this study aims to explore the different games and players' emotional states. In this research, the players' emotions are obtained by recording physiological signals, which can be analyzed and then estimated which kind of game has the potential in learning.

1.1. Game Types

As the Internet becomes popular, the newer games are emerging. Many studies have focused on different aspect about kinds of games but there has not been much consensus on game types. However it's possible to use some popular classifications for defining different games [8]. For example, Lindsay Grace divided games into six categories [9]. Wang divide electronic games into eight types: Linguistic (L), Musical (M), Logical (R), Visual-Spatial (V), Kinesthetic (P), Social (S), Introspective (I), and Watchable (W) [10]. In this article, based on the Wang's electronic classification above, we chose different electronic games as experiment materials.

1.2. Emot*ions*

People's moods heavily influence their ways of communicating and acting and Emotions can affect attention, meaning creation, and the formation of memory channels. Hence, emotional status and learning are strongly correlated [4].

A lot of prior researches explored in recognizing emotions with computers, such as recognizing emotion from speech, facial expressions or other. Measuring emotion from brain activity is a relatively new method, although some valuable conclusions have been published [11]. As it is important to recognize the learners' emotional states, people have attempted to use artificial intelligence techniques to build appropriate human emotion-recognition models. Thus, the following four methods have been used to recognize learner emotions: voice (prosody) analysis ; observable behavior such as user actions in a system interface; facial expression analysis; and, analysis of physiological signs. Specially, in recent years, emotion-recognition technologies based on human physiological signals have been developed for practical application, for example, Chen and Lee integrated sensors, signal processing, wireless communication and machine-learning technologies to construct an embedded human-emotion-recognition system [12].

On the emotional learning, previous research had typically used dichotomous conceptions of emotions (i.e. positive affect vs. negative affect) and a few kinds of discrete achievement emotions. But some researchers also used the Classification of positive emotions, neutral emotion and negative emotion [13]. The methods for assessing learner's emotional states are usually post hoc subjective emotion assessments by learner's self reporting on a set of questions. These methods are often not sensitive to changes in emotion. However, the heart rate variability (HRV) patterns are directly responsive to changes in emotional states, then the heart rate variability (HRV) was used as the emotion index in some researches [14,15]. In this paper, based on the methods above, player's heart rate variability is recorded by Biofeedback instrument (Spirit-16) to reflect participants' emotional states. That is to say, use HRV physiological signals to identify player's emotion reaction in educational games.

2. Research Goals

This study will explore how different types of games affect participates' emotion in game-based learning environment, and then infer which kind of game has the potential in the education. Therefore, in this paper, the research hypotheses are as followings: The players have experienced the positive or negative emotions in different educational games and the degree of the emotions is different when the players faced different educational games.

3. Methodology

3.1. Materials

Our research chose electronic games according to "Grading and Classification of Electronic Games in Educational Perspective". This evaluation system divides electronic games into eight types: Linguistic (L), Musical (M), Logical (R), Visual-Spatial(V), Kinesthetic (P), Social (S), Introspective(I), and Watchable (W). Thirty-six graduate students from Nanjing Normal University who are interested in playing educational games were chosen randomly to evaluate six electronic educational games that trained each of the eight types of players' abilities. The researchers averaged their evaluation scores and compared this to the corresponding rating scale that we determined as classifications of electronic games in educational perspective. The result presents that "Balance" (game1) is a "visual" electronic game, "Rescue" (game2) is an "introspective" electronic game, and "Gates of Logic" (game3) is a "watchable" electronic game.

3.2. Participants

Steinberg's research shows that there are significant differences in cognitive skills and affective experiences between different ages [16]. Therefore, the study recruited 100 undergraduates from Nanjing Normal University, Hehai University, and Nanjing Xiaozhuang College for ensure that they are in the same age group. They completed the "Basic Information Questionnaire" before the experiment which asked basic information such as gender, age, experience, and preference for the games. The mean age was 20.34 years (SD =2.29). Forty (19 female and 21 male) participants were selected who did not play the three games before and they all had a similar preference for the games. Thus, we could exclude the interference of the players' experience and preferences.

3.3. Measures

Research has shown that heart rate variability (HRV) patterns, also known as heart rhythms, are directly responsive to changes in emotional states [15]. HRV is often used as a noninvasive test of integrated neurocardiac function, because it can help distinguish sympathetic from parasympathetic regulation of the sinoatrial node. They divided the power spectrum into three major frequency ranges (low frequency [LF], medium frequency [MF], and high frequency [HF]. The integral of the power spectrum within each region was calculated. The LF region (0.01 to 0.08 Hz) is primarily considered a measure of sympathetic activity with a minor parasympathetic component. In contrast, the HF region (0.15 to 0.5 Hz) is associated with respiratory sinus arrhythmia and is almost exclusively due to parasympathetic activity. The LF/HF ratio has been used as a measure of sympathovagal balance. the two emotional states produced different effects on sympathovagal balance. Anger resulted in a significant increase in LF power (p ~0.01) with no change in HF power. In contrast, appreciation produced an increase in LF and HF power. The LF/HF ratio was significantly increased during anger and remained unchanged during appreciation [15].

Also, research referred that the low-frequency zone of the power spectral density represents a change in sympathetic activity; according to analysis results, it also represents a negative emotional state. The medium-frequency zone of the power spectral density indicates the changes in parasympathetic nervous activity or in a peaceful emotional state. The green part is the high-frequency zone of the power spectral density, representing parasympathetic nervous activity changes, or a positive emotional state [12]. Therefore, in our research, HF and LF/HF are chosen as participants' emotional states.

3.4. Procedure

Before performing the formal test, the experiment and the three games are introduced to each participant in a Biofeedback laboratory. Then the participants are given several minutes for being familiar with the experiment process. For every participant, there are three steps to be complied: keeping calm and relax for at least 1 min and 30 s, playing the game for 15 min in one of the three experimental games, and then having a break rest for three min. The first step was used to return the physiological signals to a baseline level, to record a baseline activity, and to provide a rest period for the participants. The second step was kept the participants to play the games without interference. Each game is about 15 minutes in length. Then, the participants played three games at three minutes intervals between every two games, The biofeedback instrument recorded their heart rate variability (HRV) while the participants playing the games, at the same time, the mark of the beginning and end of every game are signed in order for post-processing data.

4. Results

Biofeedback instrument (Spirit-16)can record people's biofeedback quickly, including electroencephalogram (EEG), blood volume pulse (BVP), and heart rate variability (HRV), which can be used to measure human emotions and so on. Biofeedback measure and record HRV raw data with its instrument, at the same time, the system has an easy-to-use software program with a heart rhythm monitor and an emotion-recognition algorithm for identifying emotional states. Figure 1 shows the heart rate power spectral density analysis for identifying human emotion (15).

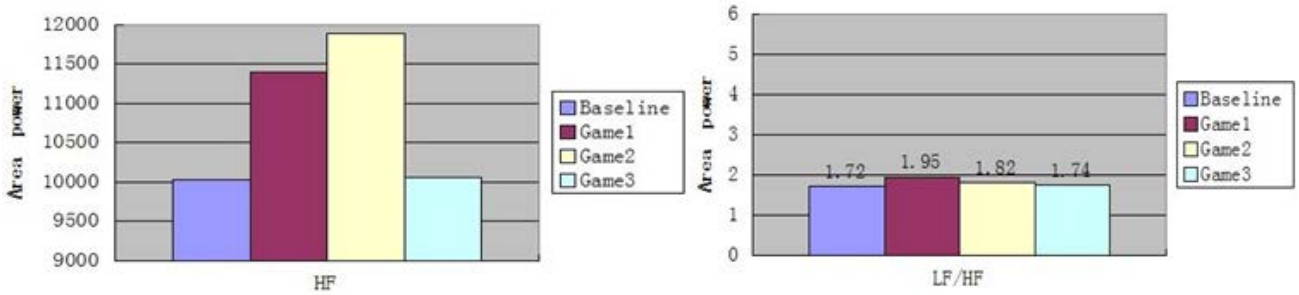

Figure 1. Players' emotional expression changes in high-frequency power and in LF/HF ratios

According to the test, we can get the data of LF, HF and LF/HF for all participations, after filtering thirty persons' data, the average of these data are presented in the following Figure1.

Just as the McCraty's study, the positive emotion generated with an increase in HF power. The LF/HF ratio was significantly increased during anger and remained unchanged during appreciation. Therefore, results show that three games all caused the player's an overall positive emotions with an increase in total mean HF and remaining unchanged on LF/HF in the Figure 1. It was still seen that different types of games caused the players' different emotions. The introspective type electronic game (game2) caused the players the highest positive emotion, and the watchable type game (game3) caused the lowest.

5. Discussion

5.1. Three Games can All Arouse the Players' Positive Emotions in Varying Degrees

Just as the Figure 1 above, we can see the data of HF measured and calculated for the three games all increased to varying degrees. In the Figure1, the purple part indicates the HF's average data while one is in calm state. The red part indicates the average data of "balance" game which is a "visual-spatial" electronic game, and the yellow part indicates the average data of "rescue" game which is an "introspective" electronic game and the blue part indicates the average data of "Gates of Logic" electronic game which is a "watchable" electronic game, respectively.

Rollin McCraty verified that anger resulted in no change in HF power; in contrast, appreciation produced an increase in HF power. We can conclude that all three games can arouse positive emotion. Moreover, the yellow part is higher than the red part, and blue part is lowest among three, we can conclude that the participates are most happy when they are playing the "rescue" game than the others, and the "balance" game is second, the blue part is higher than the purple part, but the two value have a little difference, we can assume that the "Gates of Logic" electronic game arouse less happily experience than the other.

We can see the data of LF/HF measured and calculated for the three game all increased to varying degrees from the Figure 1 above, but compared to the date of calm state, the increase of anther three part is very small, which can be seen have no change. Rollin McCraty verified that the LF/HF ratio was significantly increased during anger and remained unchanged during appreciation. We can also conclude that all three games can arouse positive emotion. Because the red part is higher than the yellow part, we can also conclude that the participate is most happy when they are playing the "rescue" game than the others, and the "balance" game is second, this result are same as the conclusion draw by HF. The blue part is lowest among three, compared with baseline, we should think it has no change, and it should arouse most happy experience, this result are not same as the conclusion draw by HF. The reason may be the participant began to get bored with playing after they have finished two games, which need to be further confirmed. All in all, different types of games do arouse students' positive emotions in varying degrees. And the "introspective" element has more chance to

arouse positive emotion than the "visual-spatial" element, the effect of "watchable" element on positive emotion need to be further research.

5.2. The Reason for the Controversial Conclusion

This paper proposes an approach based on emotion recognition to emotional state of players in three different types of games. Seen from the conclusion above, all three different games all arouse positive emotion which this conclusion consistent with previous findings. However, in our results, the conclusions for "Gates of Logic" electronic game from the HF and LF/HF are different. The reason can be explained as follows.

On the one hand, the participants may be begun to get bored with playing after they have finished two games. Both physiological and self-report analyses have lead to the conclusion that playing at the same level of difficulty several times elicits boredom [17]. Although we do not know the difficulty between these three games, we cannot rule out this reason, when one played the third game after finished two, the participant's emotional state has begun to be influenced by their own mental state, but without much relationship with games. On the other hand, the competence of the player has increased, although the game are different, his operation skills and speed would achieve a higher level, which potentially giving rise to boredom [5]. It may also make an unexpected emotional state change. In addition to the conclusion above about the third game need to be further study, we should explore what is the main reason affect people's emotion, when one person plays different games. Although different patterns of emotional responses have been found in psycho physiological studies for different type games, Stemmler argues that they are also might due to context deviation specificity [18], so we should acknowledge what played a decisive role in human emotions, the game type or game content, or the other. At the same time, the learner's own conditions should be taken into consideration, such as motivations and learning styles. Different gaming motivations and learning styles can affect learner's engagement and learning outcomes [19].

5.3. Future Work

We came to the conclusion that three different types of educational games can all arouse positive emotions of players through strict experimental design and advanced measurement by biofeedback, but there are still much respects need to be further explored for the importance of emotions of players. We can consider the following aspects in subsequent studies, Firstly, the range of test subjects, our experimental samples selected college students, college students' mental development is relatively mature, their management capacity has been developed well relatively which can affect the experimental measurements, so we can select the students of lower grades in subsequent studies, or by increasing the number of test samples to make the conclusion more convincing. Secondly, as for the methods of measurement, there are many in psycho physiological field. Facial electromyography (EMG), which measures the electrical activity of facial muscles, can be also used for assessing positive and negative emotional valence. Electro dermal activity (EDA) or skin conductance (often misleadingly called galvanic skin response, GSR) is associated with emotional arouse [20]. Electroencephalography (EEG) for measuring the electrical activity along the scalp and, more specifically, measuring the voltage fluctuations resulting from current flows within the neurons of the brain. Depending on the actions performed by the player of a game, differences in the EEG can be detected [21]. We can use more than one method to assess emotional state of every participant in studies. Thirdly, Wang divide electronic games into eight types: Linguistic (L), Musical (M), Logical (R), Visual-Spatial (V), Kinesthetic (P), Social (S), Introspective (I), and Watchable (W) [10], In our study we only chose three different types of games as experiment materials due to the limited resources. We should evaluate other types of games to draw a more accurate conclusion.

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