Entertainment Feature of a Computer Game Using a Biological Signal to Realize a Battle with Oneself

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Abstract. A novel computer game was developed in which a player challenges him- or herself using the skin conductance response to make the player aware of his or her own agitation. This game was developed as a paradoxical system in which their desire to win makes it more difficult to win. This type of game was found to have the following characteristics. First, players find uncontrollable themselves due to viewing their biological signals. In this situation, a kind of self-reference system is constructed. Second, the environments changed how the game was enjoyed. Third, the game system reveals differences of context between player and observer. From these characteristics, it is thought that the use of biological signals is attractive for entertainment computing.

1 Introduction

In most computer games, the player challenges either the computer or another human player. Players of these games try to find an opponent's weaknesses and conquer him or her. In such situations, the basic apparatus of the game is just a controller or actuator for the player. Exploring a new relationship between man and machine from the viewpoint of entertainment computing, a battle between the first person and him- or herself is an interesting development.

Electrical signals detected from the living body are objective and quantitative data reflecting psychological states and physiological functions of the human body. These signals have been used for diagnosis and treatment in medical care and have been used for the lie detector in police questioning.[1] The biological signal used in the lie detector is the skin conductance response (SCR), where changes in the conductance on the skin surface are induced by sweating due to mental agitation, surprise and excitation. [2-6] It was considered that a battle with oneself could be realized by introducing such signals into a computer game, and the present paper reports some initial testing of such a game.

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1.1 Involuntary Biological Signals

We have little awareness of the physiological functioning of our own body because most physiological functions are involuntary, and therefore uncontrollable. The SCR is a typical example. No-one is aware of the minute amounts of sweating during mental agitation unless there is an unusually large amount of mental stress. Therefore, observing one's own SCR produces a strange feeling that this is not a feature of one's own body but rather that of another person.

It is also generally believed that inner agitation during communication in daily life can be concealed. However, the SCR can reveal concealed agitation independent of one's intention to conceal. When someone is connected to a SCR indicator in situations such as a poker game, with a 'poker face' employed in an attempt to conceal excitation, the SCR indicator greatly amplifies the amount of involuntary signaling that can take place.

1.2 Synchronization Between Action and Reaction

A useful man-machine interface is one where the human has perfect control over the interface. To realize perfect control, each reaction of the machine should correspond to each human action. Perfect control is achieved by arranging for the man-machine interface to be synchronized from outside the system. However, a man-man interface in human communication basically has no externally applied synchronization because action and reaction occur by mutual observation during communication. [7] The system described here is a man-machine interface with features of a man-man interface, which generates synchrony by use of uncontrollable biological signals, forming the basis for a novel computer entertainment system.

2 Materials and Methods

Figure 1 shows the computer game system developed in the present study. The SCR occurs due to a change in conductance on the surface of the skin due to sweating. [2-6] Since eccrine sweat glands are most dense on the palm of the hand and sweating is an autonomic response that can be triggered by emotional stimuli, [2] the palm is an ideal site from which to obtain measurements of psychophysical activity using the SCR. The player holds a controller in one hand and the palm of the other hand provides the SCR via two electrodes (disposable electrocardiogram electrode J Vitrode, Ag/AgCl solid-gel tape, Nihon-Koden, Tokyo). The signal was amplified by a SCR sensor, fed into a PC through an A/D converter and can be displayed at the foot of the game monitor (see Fig. 2). Information from the player's psychological agitation is thus fed back to the player, which tends to result in the player becoming more agitated. A loop of positive feedback of this agitation often occurs with this system and to succeed in the game a player must overcome the effects of his or her own escalating panic.

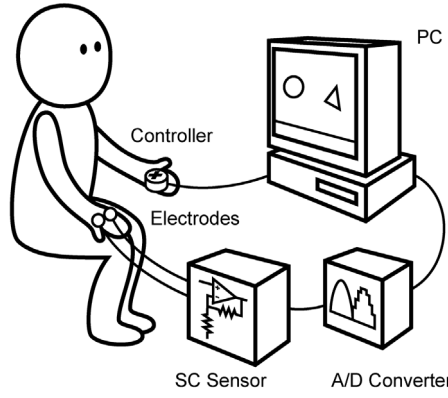

Fig. 1. System of the game

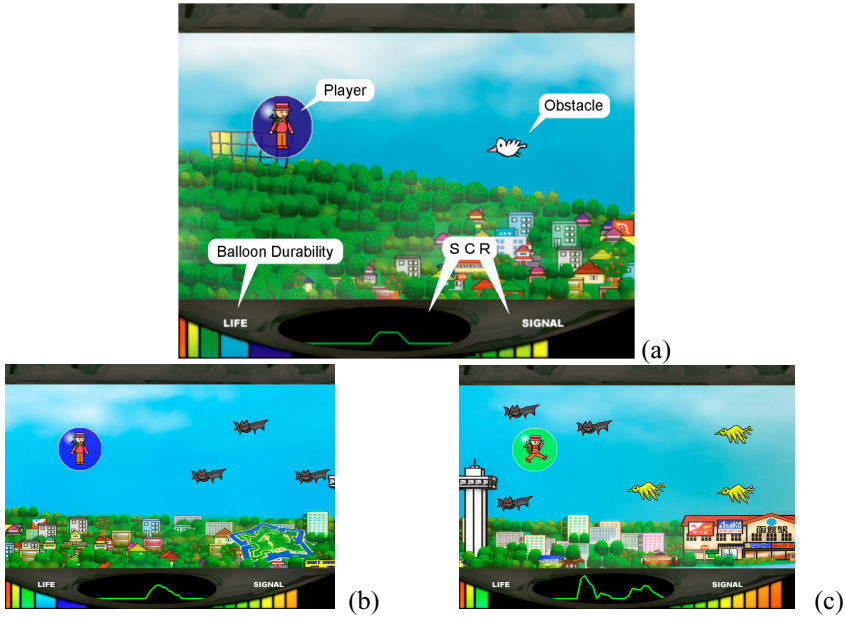

Fig. 2. Layout and progress of the game. A boy character (controlled by the player) makes a trip with a balloon that requires negotiation around various obstacles. Balloon durability and the SCR are displayed at the foot of the game monitor. The game scrolls to the right automatically. The number and kind of obstacles depend on the extent of the player's agitation. (a) start of game; (b) later in the game, showing evidence of increased agitation (SCR) and the consequent presence of more obstacles; (c) towards the end of the game, showing the player's panic due to the increased number of obstacles: the player is trapped in an escalating spiral of panic

The game developed in the present study was tested under various situations on subjects 5 to 68 years of age, with or without displaying the SCR on the game

monitor, and in the presence or absence of an observer. For most trials, the players were in a closed room. Group A subjects (n=6) played the game alone 3 times with SCR displayed, then 3 times without; group B subjects (n=6) played the game alone 3 times without SCR displayed, then 3 times with; and group C subjects (n=8) played the game 3 times in the presence of an observer with SCR displayed. The SCR was recorded during play and the number of waves of SCR ('number of SCR changes'; Table 1) was estimated for each subject from the recordings.

Additional trials were also run where the player was in a more open situation, exposed to a number of observers watching his or her progress from an elevated observation gallery. Since this represented less controlled conditions, results from this open situation are presented only in anecdotal form in the Discussion.

3 Results

The results obtained with different trial regimes in the closed-room situation are summarized in Table 1. Paired t-tests revealed no significant differences ($P \leq 0.05$) between trials 1-3 of group A (with display) and trials 1-3 of group B (without display), nor between trials 1-3 of group B and trials 4-6 of group B. However, there was a significant difference ($P \leq 0.05$) between trials 1-3 of group A and trials 4-6 of group A. This suggests that displaying the subject's SCR caused it to increase. In other words, the player's level of agitation was increased upon watching his or her own SCR.

Table 1. Mean number of SCR changes per subject under different conditions. 'D' indicates trials with SCR displayed; 'O' indicates observer present

Group	Trials 1-3	Trials 4-6
A	16.5 D	11.8
B	16.6	13.4 D
C	22.6 DO	-----

Analysis of the SCR by autocorrelation (Fig. 3) showed a strong autocorrelation from 2.5 to 3.5 seconds when the SCR was displayed but little autocorrelation when it was not. Considering that the delay time for the SCR rising is about 3 seconds, this result suggests that the agitation induced by self-observation of the subject's own SCR induced the next stage in the escalation of agitation.

4 Discussion

In answer to a post-test questionnaire, 81% of the subjects indicated that they considered the game to be interesting. The results of the present study suggest that players of this game are surprised by observing their own body reaction, and that this system creates a new mode of communication by exposing conflicts between involuntary responses of the body and a person's own conscious awareness. In other

words, players are able to simultaneously perceive their involuntary physical actions and their conscious psychological experience. The player recognizes the discrepancy by integrating these two kinds of perception as a self-reference concept, one of the characteristics of a living system. The requirement to solve the discrepancy produced here became the motivation to continue the game. This is a characteristic of game entertainment using biological signals.

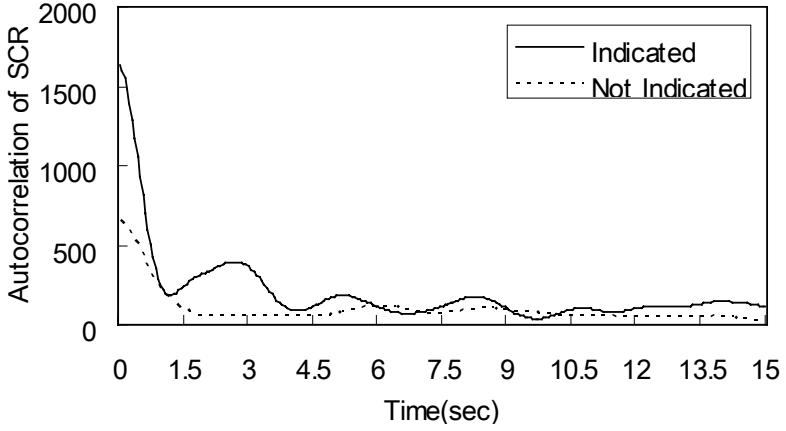

Fig. 3. Autocorrelation analysis of skin conduction response (SCR) while playing the experimental game with or without displaying the SCR on the game monitor. Solid line, with SCR displayed; broken line, without

Enjoyment of the game was different in different situations. In a closed room there were significant differences ($P \leq 0.05$) between the results of trials 1-3 of group A (Table 1) and trials 1-3 in group C, with group C showing larger SCR values. Subjects became more agitated when their SCR changes were pointed out by an observer. It was interesting to note that both player and observer found it amusing to observe the change in SCR following such comments by the observer. In this situation, the player's behavior remained consistent but the SCR showed more fluctuation.

However, in a situation where many observers were viewing the progress of a game player from a gallery, SCR changed frequently. Corresponding with this change, the number of obstacles on the screen increased (Fig. 2), raising cheers from the gallery, which in turn caused further changes in SCR. These subjects responded in questionnaires that they felt greatly agitated knowing that many people were watching them. In these experiments with several people observing from a gallery, these observers were regarded as enemies in the game context. This system therefore includes not only the computer and player, but also the environment. As such, the system involves the sharing of experiences between the player and other people and is a kind of communication system.

Generally, success at a computer game depends on the manipulative skills of the player. However, such advanced skills are not necessary in the game developed here.

A wide variety of people could enjoy this game and it is considered that such games using biological signals could form the basis for a new kind of communication.

With regard to observing and playing, the system exploited the two contexts by providing the opportunity for multimodal (physical and psychological) communication, producing an entertaining common experience (cf. Nakatsu [8, 9]). Although the effects of SCR display are expected to be complex, and interlinked with factors such as familiarization with the manipulations involved in the game, using such biological signals in a computer game enhances the entertainment experience and has opened the door to a multitude of other novel ways to combine physical and psychological experiences in the computer game context.

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