Developing of Video Game Controller Button Operation Recording System and Its Application to Video Game Play Archiving

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Abstract

This article presents the emergence and development of the Video Game Controller Button Recording System and its application in examining game play behavior and associated psychological processes. Research results exhibited in this article depict how both qualitative and quantitative analyses were conducted using the system. Under the supervision of Masayuki Uemura, scholars at various career stages were able to conduct a series of examinations using the system. The findings presented in this chapter characterize optimal ways to use this system. For qualitative analysis, combining data from gameplay video, interviews and graphic charts of controller button signals allows researchers to interpret player behavior from a multi-faceted perspective. Quantitative analyses revealed that there can be significant differences in various game play behaviors based on gender, frequency of use of games in daily life, the refreshing score, and the relative value of the Lyapunov exponent. The data also revealed that for inexperienced game players, there can be a learning effect in more effective operation of the game controller as participants go through rounds of game playing sessions. A series of experiments further strengthened the importance of archiving game play in a comprehensive manner.

Introduction

When Ritsumeikan University initiated the Game Archive Project (GAP) in 1998 to preserve and utilize video games, it was decided the project would use three preservation methods, namely, 1) physical preservation (preserving actual game hardware, software, and accompanying materials such as instruction manuals), 2) emulation (running an emulator that has the same functions as the game hardware on a general-purpose computer, and preserving that emulator software and game software as data), and 3) recording video preserving footage of actual game use and controller button signals as digital data (Hosoi 2019). Masayuki Uemura led a project team that work on recording video footage of game play since 2006.

This article focuses on how Uemura and his team conceived the way to "preserve the game play," and came up with a device to fulfill the conditions required. This article also introduces some of the key findings from the data collected from video game play.

Defining "Video Footage" From Video Game Research

Initially, video games were played on computer displays, but the idea of using television receivers, which had begun to spread in households, became viable, and video games became a fun tool for the masses. In addition, the development of microcomputers, the greatest achievement in the advancement of semiconductor technology, transformed video games them into playthings with functions unparalleled in the history of toys, which is why they are still played today.

In Japan, it has already been over three decades since the introduction of the Family Computer or Famicom (NES) in 1983. The Famicom spread so rapidly that it affected the viewership of TV programs, and various games were developed and sold in competition with each other. The Famicom reached its peak sales in 1986, but its most ardent users were the upper grades of elementary school students. The children who were the core users of the NES are now in their 40s, and video games have become a common topic of conversation when discussing the memories of the past.

Because of their innovative nature at the time, video games have been criticized in many ways. Particularly in comparison with traditional games there is an underlying anxiety around the overuse of the audiovisual during game play. However, with the advent of video games, it is becoming clear that the audiovisual-centric play realized by video games is not a transient phenomenon of childhood but the experience of the gameplay seems to contain certain elements which attract people of all ages and across cultural boundaries.

Thus, the archiving (preservation and utilization) of video games including the NES has emerged as an important issue. The majority of traditional games are mainly handed down orally and can be distributed in the form of text or simple figures. Therefore, it was not possible to accurately reproduce how the preserved play related artifacts were used. With video games, on the other hand, it is possible to preserve precisely how they were played since everything is stored as a computer program. The issues come with the preservation of the hardware or the game platform by which the software is operated since the manufacturers of the platform rarely provide maintenance services. Therefore, if a game platform or medium such as a cassette or disk is damaged, it may be virtually impossible to repair them to replay the game. Which is why recording video footage is mandatory for preserving video games as a form of playing experience.

Our project, then, focused on recording video footage of gameplay where “video footage” was defined as “image sequences for the purpose of playing (yūgi eizō)” and the definition of ‘play’ in video games was “repetition of the display of game images by making play decisions to an existing game image through the controller interface processed by a video game platform.” Furthermore, in order for a player to make decisions in their game play, the following information might influence the players: 1) information about play gathered from game play images, 2) sound played along with game play images, 3) the player's playing condition (e.g., availability of advice from friends during the session), and 4) the player's experience or knowledge regarding the game being played (Uemura and Obana 2009, 103). Figure 1 depicts the concept of game play process.

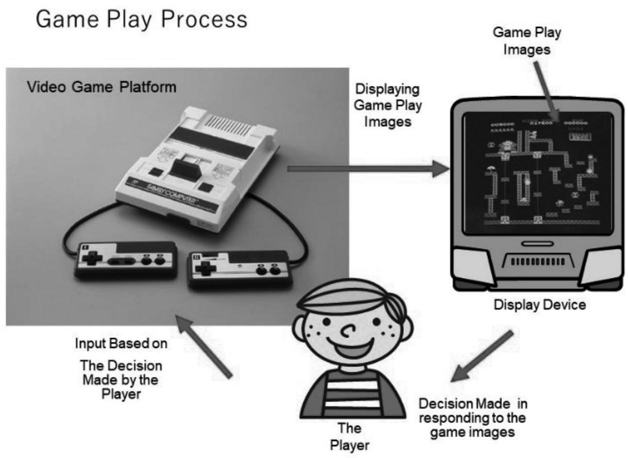


Figure 1: Game Play Process Defined by Uemura

Variables that Need to be Collected During Gameplay From Research Perspectives

In examining various types of gameplay objectively, the following four variables need to be recorded during gameplay: 1) the sequence of game playing images and sounds of gameplay, 2) the sequence of how control buttons were pushed during the sessions, 3) the record of the game player’s countenance, mainly facial expressions during the game play, and 4) the sequence of pulse waves of the player during the game play session. Furthermore, it was considered ideal if semi-structured interviews as well as survey questionnaires could be conducted immediately after the play sessions with the player recorded (Uemura and Obana 2010).

Developing Devices that Could Meet These Criteria

Based on these research archiving objectives, the specifications of the device, the Video Game Controller Button Operation Recording System were determined, and we began developing the device from May 2006. During this process, the attempts to add functions which record pulse waves was omitted due to the fact that our team lacked experts in this field and the development cost for the device was estimated to dramatically increase if such a measurement was to be integrated into the device.

Thus, the final output on the monitors needed to display the following: 1) the gameplay video images themselves, 2) input signal logs, 3) graphical representation of how buttons are pushed during the gameplay, and 4) facial as well as body expressions of the player (Uemura and Obana 2009). Additionally, all of the data described above needed to be displayed along with game playing sounds.

In order to achieve this, several devices were created. The overall schematic of this system is described in Figure 2.

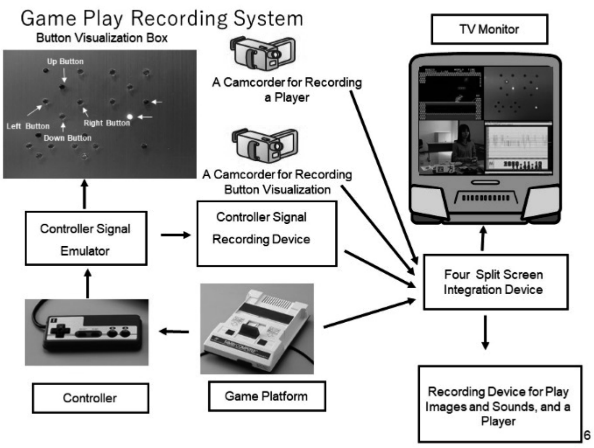


Figure 2: Game Play Recording System Conceived by the Author

The "Controller Signal Emulator" transmits the data to the Controller Signal Recording Device, which creates the input log of the controller signal from the player pushing various controller buttons during the gameplay. The emulator also transmits the data to a visualization display called the 'Button Visualization Box'. Figure 3 is a close-up of the button visualization display.

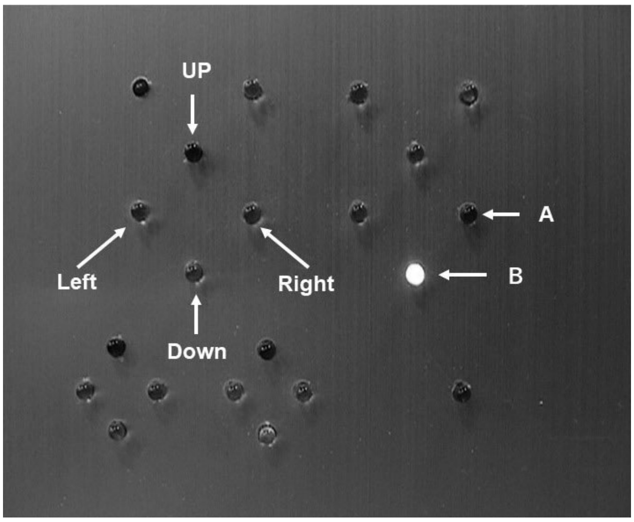


Figure 3: Display Design of Button Visualization Box

When input was received from a button from the game controller, the LED light designated for the button will be lit up. The LED light will stay on so long as the button is pushed down by the player. The LED light is programmable so when different game platforms are used, the LED lights can be assigned based on the button allocation of the game controller. The designation of the LED lights in Figure 3, example, represents Famicom's controller.

The display portion of Button Visualization Box, then, is recorded by a camcorder to verify how buttons are pushed in sequential order during the gameplay. Another camcorder also records the facial expressions as well as upper body and hand gestures of the player during the session.

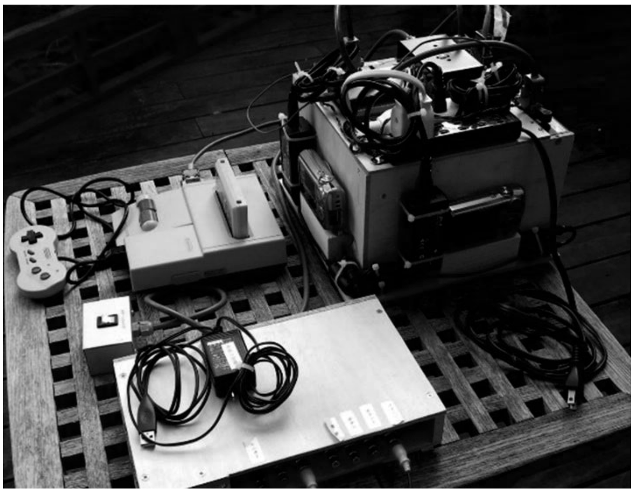


Figure 4: Overview of Actual Device

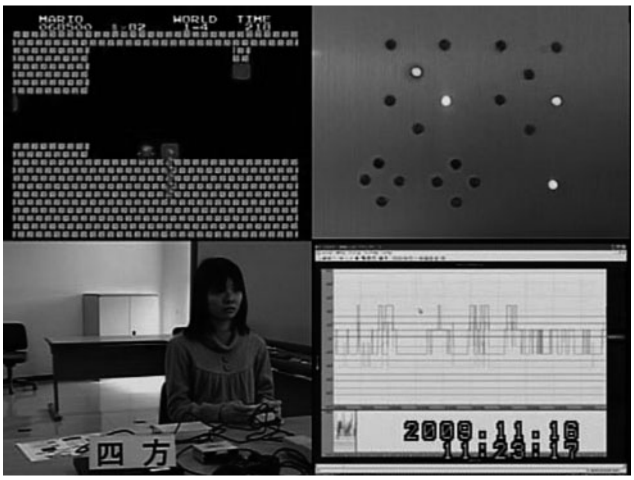


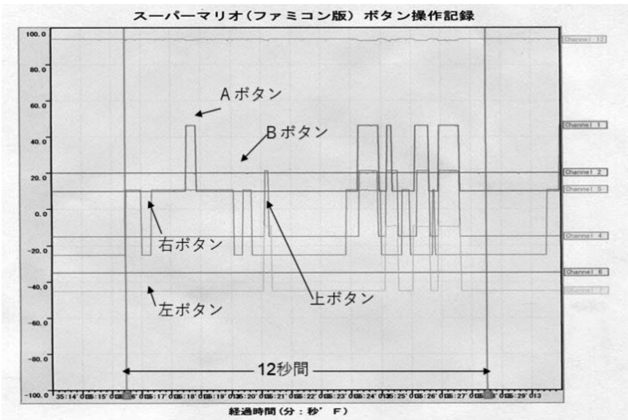
Figure 5: Actual Output of Gameplay Images

The first prototype system was completed in October 2006. Figure 4 shows the physical Game Play Recording system while Figure 5 depicts the final output of the recording of the gameplay.

Gameplay images and sounds originating from the game platform, along with aforementioned data from the Controller Signal Recording Device as well as the data recorded on two camcorders, are then processed by the Four Split Screen Integration device. The device is connected to TV monitor that shows all four screens simultaneously, and this combined final output is also recorded using an HDD recorder.

For Analyzing Controller Input

Preservation of game play should not only have cultural value but needs to capture variables which allow researchers to analyze behavioral patterns during the gameplay of the subject players. The Controller Signal Recording Device was conceived for this purpose. Graph 1 shows the data collected by this device.



Graph 1: Close-up of Graphic Chart Exhibited by Controller Signal Recording Device

The horizontal axis depicts the time sequence during the game play. The vertical axis is divided into sections allocated to each button and the lines show whether the button is in ‘ON’ status or ‘OFF’ status. The status of the button stays ‘OFF’ status by default. If a button is continuously pushed, it will stay as ‘ON’. Thus, this chart allows researchers to collect data on how often and how long each button is pushed during the gameplay session. Combining this data with gameplay images provides various possibilities for how game play can be examined. The following examples are a glimpse of possible ways to study the game play. 1) Quantification of individual differences in "game play" (mastery and habituation). 2) Quantification of changes in gameplay over time (presence or absence of temporal changes in skill and familiarity). 3) Quantification of the relationship between video and control information. 4) Relationship between player's subjective impression of the gameplay and the objective data regarding game play specification. 5) Research on the rhythmicity of game controller operation, and 6) the relationship between game sound and controller operation.

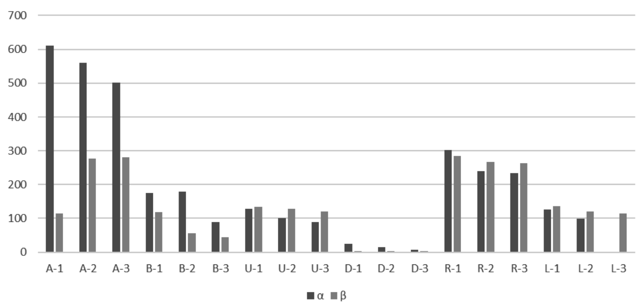
Research Results Using the System

After the system had been built, researchers studied under my guidance, conducting a series of studies using the system. Just as any other research, some of them were published through various academic venues, a majority of studies, however, were published domestically. For the following paragraphs, the research findings, using this system are explained.

Preliminary Studies on a Player and a Viewer of GTA III Gameplay

The first experiment using this system was conducted by Tomomi Matsuda under the supervision of myself as a part of the Preparatory Doctoral Thesis titled “the Intersection of Visual Play and Reality: The Existence of Video Games that Contain Violent Expressions” (Matsuda 2008). The experiment took place from May 25, 2007 to December 18, 2007. During this period, a total of 51 college students from Tokyo Polytechnic University and Ritsumekan University participated: 20 of them female, and 31 of them male. Each participant was paired with another and one was to play the game for 20 minutes while the other watched. The game selected for the study was “Grand Theft Auto III” for its action-oriented nature and a sand box design, which allows players to play the game disregarding “mission” presets by the game designer. The research results in this study mostly drew from semi-structured interviews and survey questionnaires rather than the data collected from the system. Nevertheless, one of the notable results from this study was when the players were asked to view their own gameplay video images. Among 50 subjects (for one subject left the question unanswered), 28 felt there was a difference between what they had experienced during the gameplay and the viewing of their own session afterwards. Furthermore, among those who felt there was a difference, those who had a positive impression viewing the gameplay were 2 while the other 26 had negative impressions. Those who had negative impressions felt guilt regarding their violent actions during the gameplay. While they were playing, they tended to perform 'violent actions' inconsiderate of their very deeds since they tend to think they were a part of this gaming experience themselves. Furthermore, for those who watched the others playing the game 37 viewers felt they wanted to play the game themselves after the session. Due to its preliminary research design, the results from this experiment were still inconclusive without conducting further examination. The fact that the explorative examination was conducted with game play images themselves, however, is something of significance considering the fact that this was done years before 'Let's Play' video achieved global popularity.

Preliminary Studies on a Player Behavior of Super Mario Bros.



Graph 2: Comparison of Player Alpha and Beta for Three Sessions

The second experiment using this system was conducted by myself and Takashi Obana in 2009. A total of 15 college students playing Super Mario Bros was archived with the system (7 males and 6 females). All of participants were asked to play the games for 11 minutes and were asked to play the game three times. At the end of each session, they had a one minute break and then played the game consecutively. For this preliminary study, the results of two participants were randomly selected for further study. Graph 2 shows the playing results of the two selected participants. The number of times they push each button are compared session by session.

In the graph, A and B represent as they are while for cross key, U represents UP, D represents DOWN. R is for right button and L for left button. For Super Mario Bros. A function is for Jump or Swim. B is Run or Throwing Fireballs if Mario was in Fire Mario mode. For Cross Key, Left and Right represent the direction where Mario is headed with DOWN representing Crouch. UP, however, is not assigned officially as it is only used for secret mode. Although button A or the JUMP button is the most frequently used button for Super Mario, player alpha seems overly use it compared to player beta. The fact that usage of A decreases over time seems to further indicate that player alpha gradually learns how to play the game, learning more efficient ways of using the JUMP button. It is also interesting to note that both players alpha and beta pushed UP buttons quite frequently. The UP button is not assigned with any functions. Despite that, this button was used more often than the DOWN button which is assigned to Crouch. Since we did not realize this phenomena until we actually examined the graph, there was no way that we could ask any questions regarding this mystery. Observing actual gameplay footage that is archived provided a key to unravel this mystery. In many cases, the player alpha, pushed UP when she intended to jump around an area when there was some object above the Mario, implying that the player alpha erroneously believe that UP could cause some actions to these objects. Figure 6 represents such a case.

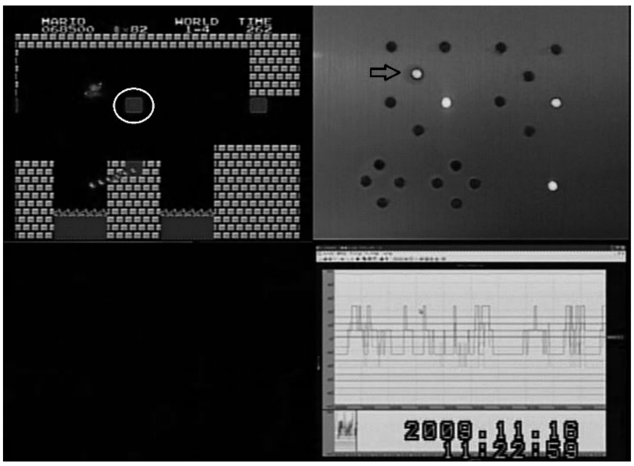


Figure 6: A Case When a Player Pushed the Up Button

Thus, archiving game play footage along with the button visualization record allows the researcher to pursue more in-depth observations.

Methodology for Utilizing the System for Analyzing the Gameplay

The system was fully utilized when Yasuhira Komago, who already had a Ph.D from the Graduate School of Human Informatics, Tohoku Gakuin University and a Professor at Kogakkan University at the time, sought to pursue a second Ph.D at the Graduate School of Core Ethics and Frontier Sciences, Ritsumeikan University under the supervision of Masayuki Uemura. He was already specialized in physiological psychology, and thus he was able to produce several peer reviewed academic papers using the system. In this section, some of his work, using the system is introduced. One of the early studies conducted by Komago using the system was conducted with 13 college students (7 males and 6 females). He examined the psychological condition of the players and their usage of game controllers from the perspective of chaotic analysis of finger plethysmogram (Komago 2011). For the analysis, players were asked to play two games which were used for preliminary studies: “Grand Theft Auto III” and “Super Mario Bros.” Each participant was asked to play the game for 18 minutes as the system recorded the game play.

After the gameplay, they were asked to evaluate their own emotions as they emerged from gameplay. Evaluation criteria consisted of Hostility, Pleasure, and Emptiness and for each criteria, the participants were asked to choose between 1 to 6 on a scale, with 6 being “I felt strongly about this emotion.” Then a total score of the items constituting each scale was divided by the number of items to come up with the average score for each criteria.

Findings From Analyzing Gameplay of Grand Theft Auto III

For “Grand Theft Auto III,” an independent sample t test indicated that there was a significant difference in mean number of collisions ($t=2.66$, $p<.05$), and collisions with non-vehicle objects ($t=2.47$, $p<.05$)between male and female players (Komago 2011, 4). The mean number indicates that males generally tend to cause collusions while playing Grand Theft Auto III. As for the number of the buttons pushed during the game play, an independent sample t test indicates that there was a significant difference between males and females in mean number of using the triangle button ($t=3.19$, $p<.05$), right button ($t=3.20$, $p<.01$), and left button ($t=3.39$, $p<.01$). In the mean times there was no statistical difference in the number of uses for the rest of the buttons, which are mostly used for attacking or acceleration and braking while in the vehicle. An independent sample t test was also conducted for two group samples, one being inexperienced players of GTAIII and the other previously experienced players. The results showed that there was a significant difference in the mean number of those using the right ($t=3.28$, $p<.01$) and left ($t=2.51$, $p<.05$) buttons. This indicates that males generally tend to ride on vehicles during the gameplay and are more active than females.

Table 1 Average Number of Collisions, Collisions with Non-Vehicles Running Over Human Avaters Based on Gender Differences

	Male	Female	t scores
Average Number of Collisions	43.1(14.8)	> 22.3 (13.0)	2.66*
Collisions to Non-Vehicles	15.4(6.6)	> 7.2 (5.2)	2.47*
Running Over Human Avaters	12.0(8.2)	> 5.2 (4.4)	1.82+

* $p<.05$ + $p<.10$ the numbers within ( ) represents standard deviation

Those who have previous experience of the game tend to be more actively or effectively using buttons since they knew what they were doing, while there were no differences for their decisions in using vehicles. Table 1 summarizes the results of these findings.

Findings From Analyzing Gameplay of Super Mario Bros.

The results of studies for Super Mario Bros. by Komago (2011, 7) were consistent with preliminary studies regarding the erroneous usages of UP buttons. Among 13 participants, they divided into two groups based on frequency of playing video games, those who play games 3-4 times a week or higher were categorized as high frequency users (5 participants) while 1-2 times a week or lower were categorized as low frequency users (8 participants). A two-factor analysis of variance was conducted for the frequency of use group condition (2) and frequency of play condition (3). The results showed that the interaction tended to be significant for the upper button, which was not used except for climbing the beanstalk ($F(2, 22)=3.43$, $p<.1$) (Komago 2011, 7). The result from simple main affect was also at $p<.1$ level with $F(1,11)=3.39$ for the 1st round of game play. The mean score implies that low frequency users tend to push the UP button more than high frequency users, for the 1st round of game play (Komago 2011, 7). Fisher’s least significant difference (LSD) method for multiple comparisons verified that the number of Up button usages for low frequency video game users in the 1st round of game play was significantly more than the

2nd and the 3rd round of gameplay ($p<.05$) (Komago 2011, 7).

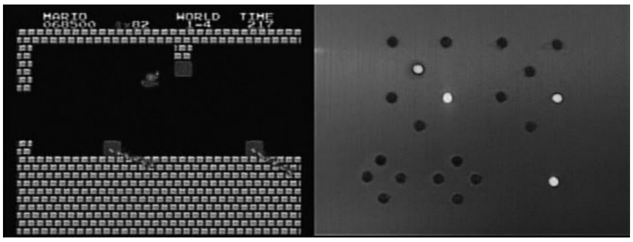


Figure 7: Game Images and Actual outputs

Another erroneous usage showed similar patterns, namely simultaneous button pushing behavior, namely UP and A (JUMP) buttons (Komago 2011, 8). 13 participants divided into three groups based on the average score of the Pleasure scale. Those whose score was higher than the mean + 50% of SD were categorized as the High group (5 participants) while those whose score was lower than the mean - 50% of SD (3 participants) were categorized as the Low group. The rest (5 participants) were categorized as the Middle group.

The result from simple main effect for groups based on the Pleasure scale was significant ($F(2, 10)=6.47$, $p<.05$). Fisher's least significant difference (LSD) method for multiple comparisons verified that the means of the number of simultaneous uses of Up and A buttons for the Low group was significantly more than and rest of the two groups ($p<.01$).

These results confirm that those who play Super Mario Bros at a novice level or those who do not have pleasure playing the game tend to erroneously assume that UP buttons are to be used to navigate the avatar in the upper direction but eventually cease to do so as they realize that their assumption was in error.

Findings From Combining the Results of Chaotic Analysis of Finger Plethysmogram and Video Game Controller Button Operation Recording System

With Finger Plethysmogram (FPG) being noninvasive, several studies have been conducted to apply chaos theory to analyze the Lyapunov exponents of the time series from finger plethysmogram in order to determine human physio-psychological status. Komago has been using this method to examine physio-psychological status in various conditions. The current investigation on video game players is one of such efforts. In his studies, various findings were presented for the psychological status of video game players and playing conditions. For this section, the analysis that used both FPG and the Video Game Button Operation Recorder is introduced for analyzing video game play. For this study, due to the fact that the absolute value of the Lyapunov index varies greatly among individuals, the mean of Lyapunov index at non-playing time was set to 1 and then the mean value of the Lyapunov exponent during the game play session was compared for each participant. The value is named "the relative values of Lyapunov exponents." For the scrutiny of players' behaviors on the Super Mario, usages of the Left button were analyzed in relation with the relative values of Lyapunov exponents. 13 participants were divided into three groups based on the relative values of Lyapunov exponents; those whose score is more than the mean plus 50% of SD (4 participants) were labeled as Upper Tier, those whose score was less than the mean score minus 50% of SD as Lower Tier (5 participants), and the rest were grouped as Middle Tier (4 participants). The result of the two-way ANOVA indicates that the simple main affect was statistically significant for the means of Left button usages ($F(2,10)=9.66$, $p<.01$). Fisher's least significant difference (LSD) method for multiple comparisons verified that the means count of Left buttons usages for Low Tier group game users was significantly more than Upper Tier and Middle Tier group game users ($p<.01$). The low score of relative values of Lyapunov exponents implies that they are more relaxed while those in the Upper Tier usually imply that they have tension or stress. Furthermore, being side-scrolling games players are directed to move right rather than left. The left button is often used when certain skills are required for maneuvering the avatar such as making adjustments before a long jump and extending the length for a running start to jump higher. In other words, those who are already familiar with game control of Mario are likely to use the left button more frequently and therefore, the subjects are relaxed.

Implication And Future Perspective of Video Game Controller Button Operation Recording System

The various research results discussed in this article indicate the potential of what the Video Game Controller Button Operation Recording System can do for user analyses. This will take game play archive research beyond the realm of cultural artifacts. In order to fully reach the potential, however, the video archive needs to be accompanied with information as to how controllers are manipulated during play and the results of surveys as well as semi-structured interviews, where it is possible. For the current system developed by our team, we were able to collect a limited number of game play archival datasets as it takes substantial time recording just one play. But since academics tend to be a neutral witness, the data collected should be impartial and thus can be used for various objective studies on the psychological, societal and ethical meaningfulness of play. It must be noted, however, that it will be necessary to include a process to eliminate elements that can identify personal information. Gameplay archives are only meant to archive playing situations and human characteristics involved, not individuals. Researchers will need to keep these points in mind as they promote the expansion of the archive.

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