

Time Perception in Different Gaming Environment with the Application of the Internal Clock Model

Hanxue Li*

Department of Sports Psychology, Sungkyunkwan University 16419
South Korea

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Abstract: Even though extensive work has been done in the area of time distortion in computer games, those focusing on the implicit phenomenon were quite limited. Integrating attention and arousal mechanism in the internal clock model, the current study broadened the scope of prior work on the theory of flow to further examine whether the emotion of creativity and aggression triggered by different modes of computer games influences time perception differently. And if so, whether it is due to arousal, attention, or both. We found that participants tended to overestimate time both during and after the game session. However, no significant differences were found between creative and aggressive conditions. Implications of these findings on time perception in gaming environment are discussed.

Keywords: Time perception; Internal clock model; Game, Attention, Arousal, Emotion

1 Introduction

Computer games have become popular during the last few decades. Under such circumstances, there has been an ever-increasing phenomenon of computer game addiction among players worldwide. Extremely unhealthy screen time not only has a negative effect on individual's physical health, but may also lead to poor mental health conditions of varying degrees[1]. How to manage game time reasonably has become one of the top-ranked concerns for PC gamers.

There is now a general consensus that playing computer games can cause time distortion. And in most studies of time perception in gaming environment, attention has been given to the theory of 'flow'. 'Flow' is a well-established term used to describe the mental state in which an individual is fully enjoyed and involved in an ongoing activity [2]. Several reports have shown that flow in games can increase players engagement and motivation, which then gives them a sense of 'time flies' [3]. However, the 'flow theory' only works for explaining the "time loss" under the state of being fully engaged [4], and it fails to explain the time distortion towards the games that individuals show no or little interest in.

As the theory of 'flow' only looked specifically at the outcome of time distortion, the internal mechanisms to explain this phenomenon had been a largely under explored domain. Time perception paradigms influenced by non-substance addiction is often explained by the internal clock. The most well-known internal clock model was introduced by Gibbon (1977[5]) in the scalar timing theory, which is divided into three main stages: clock, memory and decision. The clock stage includes a pacemaker and a mode switch, which are used to generate pulses throughout an ongoing event, and to control their entry into the accumulator respectively. Afterwards, the content of the accumulator is stored in working memory in the memory process, while the previously experienced time duration is stored in the long-term memory. Finally, the comparator in the decision process judges whether the time duration is short or long by comparing with the standard duration in the long-term memory.

A number of factors can mediate time perception based on previous findings, among them includes attention and arousal. According to Zakay and Block's attention-based theory (1995[6]), the mode switch in the internal clock will be turned off when one's attention on time passing is distracted from an ongoing event. In this case, fewer pulses will be generated by the accumulator, therefore the time duration is judged as shorter. Additionally, time duration would also be

*Corresponding author. E-mail address: jjmmzw@126.com

perceived as shorter when less attention has been paid to time processing due to the compromise of temporal pulses. For the arousal-based mechanism, a large amount of previous work has indicated that the internal clock speeds up when ones arousal level increases [7]. To clarify, high arousal level can increase the effectiveness of dopamine in the brain, which in turn accelerate the pacemaker, and allow more pulses to be accumulated by the accumulator. Contrary to attention, in this way, individuals will feel that time becomes longer [8], please refer to Figure 1 for more detail.

Moreover, attention and arousal can be mediated by individuals' mood state. Past studies have demonstrated that different emotions can affect individuals' perception of time in different directions[9]. Individuals generally focus more on emotional stimuli, both positive and negative, compared with neural or no stimuli. To be more specific, emotion can draw one's attention more rapidly and enhance the engagement for a longer period of time. Once attention has been elicited by emotional factors, it may stay at that level for longer during the event. On this condition, people's attention can be distracted from time processing more precisely, and further shortens their time perception.

Comparatively, the effect of emotional stimuli on raising arousal level has been examined by investigators recently [10]. Existing research recognizes that negative high-arousing stimuli would lead to an overestimation of time compared with positive and neutral stimuli. Nevertheless, Lui et al. (2011[11]) cast doubt on this idea by suggesting that participants perceived time as shorter when exposed to both positive and negative emotional stimulus. This suggests that the influence of emotion on time perception does not exclusively rely only on the pacemaker, instead, it might be due to the attention mechanism. Yet, in particular no study, to our knowledge, has attempted to investigate it, to further distinguish between the effects of arousal and attention in explaining time perception.

Until now, few studies have applied the internal clock model to explain the emotional effects on time distortion in gaming environment, this remains an open problem in the area. To fill the research gap, the present study attempts to find out whether the mood triggered by different game types would cause time to be sensed differently, and if so, whether it is due to arousal, attention or both. Different types of games can lead to different impacts on time perception [12]. For instance, violent games have been proved to significantly increase peoples aggressive emotion and physical arousal level. To make the game more controllable to stimulate different emotions, the two modes of Minecraft has been applied (creative and survival) in the current study to test whether being creative or aggressive in gaming environment would influence peoples time perception differently. We were expecting to see a difference in both temporal and subsequent time perception as before. Based on the internal clock model, if the time distortion is due to the role of arousal, people in the aggressive group should have an overestimation of time compared with the creative group. If the effects are caused by attention, we shall see an underestimation of time for both of the two groups (Research model see Figure 1).

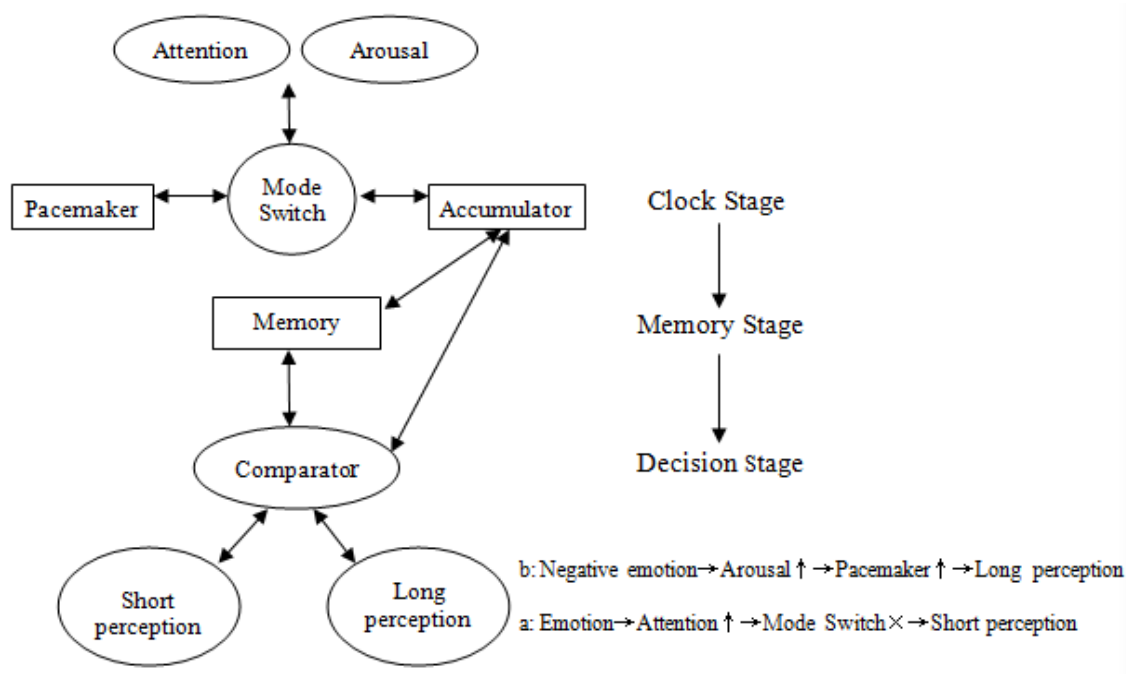


Figure 1: The research internal clock model

2 Method

63 University of Kent psychology undergraduates participated in the study. They were randomly assigned into either creative or aggressive group, 52 valid data was collected ($M=19.31$, $SD=2.21$).

The experiment employed a 227 mixed-subjects design, with group (Creative, Aggressive), session (Pre, Post), and duration (400, 600, 800, 1000, 1200, 1400, 1600ms) being the independent variables. Group was designed between-subjects while session and duration were within-subjects. The dependent variables were the proportion of long responses $p(\text{long})$ and the time duration perception within the gaming session. The $p(\text{long})$ value is an indicator of an overestimation or underestimation of time, which is calculated as the ratio of long responses divided by the total response number. There were totally 6 types of images in this experiment: 3 squares, and 3 circles coloured in red, blue and green. All figures were presented in Appendix with black background, and appeared in a random order on the screen. The temporal bisection task was played on PsychoPy v1.83 (Peirce, 2009), and the visual stimulus were presented on a 19 screen connected to an Intel-i5 PC. Minecraft was delivered through a 13-inch MacBook Pro connected with a mouse. Participants used online Qualtrics to complete the questionnaires.

Minecraft (Version 1.13.2) is a game about placing blocks and going on adventures. Players can craft tools, build houses and kill animals in this game. It has two main modes: creative (where players are given limitless resources to build whatever they can imagine) and survival (players explore the world by themselves). We used the survival mode for both of the two groups. The creative group could do anything expect for killing animals, while the aggressive group could only kill animals.

Participants game experience was tested using question, How aggressive/ creative do you think the game is. The answers ranged from 1 (strongly disagree) to 5 (strongly agree). For the excitement level, the question was based on a 7-point Likert scale (ranging from very boring to very exciting). Pleasure was measured using the question: Overall, my mood is:, answers ranged from -5 (very unpleasant) to 5 (very pleasant).

In case that participants hold a sense of time in mind, the research title was shown as How do people perform tasks in gaming environment instead of the true aim. The study consisted of one training task, two temporal bisection tasks, before and after playing Minecraft, ended with a questionnaire. The training task introduced subjects how to distinguish between short (400ms) and long (1600ms) standards. The instructions were shown ahead in the middle of the screen, then a series of shapes in red, green and blue would appear with either short or long interval in a fixed alternative order. Participants were required to press S (for answer short) and L (for answer long) on the keyboard to respond. Feedback would be shown on the screen (either correct or incorrect) after each response for one second. The formal temporal bisection task followed the same instructions as before, but with random internal interval from 400ms to 1600ms. In the next part, participants would play Minecraft for ten minutes, the experimenter would show them how to play if they did not know. In the creative group, participants could do anything (e.g. crafting, collecting and building) except for killing and feeding animals, while for the aggressive group, subjects could only kill animals. During the gaming session, the experimenter would time and asked participants how long he/she has been playing for three times, in a random order of 2, 3 and 5 minutes after beginning/ last interruption. Afterwards, participants repeated the same test phase temporal bisection task. Finally, they completed an online questionnaire, which included personal information, game experience and current mood.

3 Results

3.1. P(long) Analysis : There was a main effect of duration; participants $p(\text{long})$ values significantly increased as time duration increased, $F(6, 306) = 582.98$, $p < .001$, $p_2 = .92$. There was also a main effect of session, $F(1, 51) = 20.10$, $p < .001$, $p_2 = .28$. This suggests that participants judged time as longer after playing computer games ($M = .57$, $SD = .20$), compared with before ($M = .51$, $SD = .14$). These results were qualified by a statistically significant interaction between session and duration on time perception, $F(6, 306) = 6.73$, $p < .001$, $p_2 = .12$. The main effect of Group was not significant, $F(1, 51) = .67$, $p = .42$, $p_2 = .013$. This indicates that there was no statistically significant difference in time perception between the creative and aggressive group. Besides this, no Group Session Duration interaction was found, $F(1, 6) = .61$, $p = .72$, $p_2 = .012$, see Figure 2.

3.2. Time duration perception: A mixed-design ANOVA was conducted to analyse participants time perception during the gaming session. There was a main effect of duration, $F(1, 49) = 227.98$, $p < .001$, $p_2 = .82$, indicating that as time interval increased, subjects time perception increased as well. There was no effect of group, $F(1, 49) = .001$, $p = .98$, $p_2 = 0$, suggesting almost no difference in time duration perception between creative and aggressive groups within the gaming session. Three one-sample t-tests were conducted to determine whether participants time estimation

was significantly different from the actual time duration for all the three intervals. As shown in Table 1, both groups significantly overestimated all the three time intervals throughout the gaming session, see table 1.

3.3.Game experience: Overall, subjects had a pleasant mood after playing computer games ($M = 2.17, SD = 1.72$). For gaming experience, some people felt very bored and no one felt very excited ($M = 3.33, SD = 1.45$). This shows that participants felt slightly less than medium excitement after the game. A further independent t-test was run to see if there was any difference on the violence and creation level between two groups. Results revealed that the feelings of violence and creation were not significantly different between the creative and aggressive groups (with $t(50) = -.96, p = .342$ and $t(50) = .072, p = .943$, respectively). This suggests that there is little difference between levels of creation and violence between the two groups, however, it did not reach the statistical significance level, see table 2.

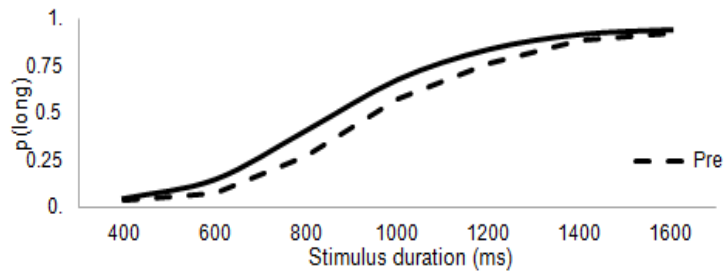


Figure 2: Interaction between Session and Perception of Duration

Table 1: t-test results of comparison of time perception in each group

Interval	Creative		Aggressive	
	MSD	t	MSD	t
2 mins	2.801.25	11.62*	2.901.01	14.04*
3 mins	3.911.00	20.30*	4.151.71	11.08*
5 mins	6.431.70	19.61*	6.101.62	18.37*

* $P < .001$

Table 2: descriptive statistics of mood and game experience

Group	Mood	Experience
	MSD	MSD
Creative	2.231.55	3.431.48
Aggressive	2.171.82	3.281.38

4 Discussion

The current study was the first to examine both arousal and attention effects towards time judgments in gaming environment. Our work builds on previous research to further investigate whether being creative or aggressive while playing computer games will lead to a different perception of time with the application of the internal clock model. We employed the temporal bisection task and the two modes of "Minecraft" to look at the emotional effects triggered by computer games on time perception. To be specific, whether the sense of time distortion is caused by arousal, attention or both. According to the operative mechanisms of the internal clock model, attention and arousal can distort individuals' time perception in opposite directions. Attention to an ongoing event can result in an underestimation of time due to the loss of attention on time processing, while arousal can lead to an overestimation of time when exposed to negative emotional stimuli notably, as a result of the acceleration of the pacemaker letting more pulses to be accumulated. Overall, statistics illustrated that participants in both conditions overestimated the time during, and after the game session.

In general, these basic findings are consistent with the statement that arousal mediates time perception. This is supported by the findings of the main effects of session and $p(\text{long})$ values that increased significantly after the game compared with before; together with the significant longer time duration perception within the gaming session. This overestimation of time could be due to the rise in arousal level triggered by emotions through playing "Minecraft". This results ties well with previous arguments published out by Drew et al., that arousal can influence the pacemaker and let more pulses to be generated, thus lead to an overestimation of time. However, as this is an undergraduate final year project, it is difficult to investigate the effects of arousal on time perception more deeply, due to its complexity and time limits. The Webers Ratio should be taken into account in the future where possible.

One concern about the findings was that we did not see a significant difference in time judgment between the creative and aggressive groups both before and after the game session as expected. Instead, only a slight difference in time estimation was found between these two groups, which contradicts the results given out by Grummuch that different types of game could lead to a significant difference in sense of time flow. Possible explanations include that playing the two different modes of "Minecraft" (survival and creative) failed to trigger the feelings of aggression and creativity. Referring to the questionnaire, participants from both groups tended to experience similar levels of aggression and creativity. This indicates that the two modes of "Minecraft" may not be used as suitable creation or aggression eliminators. Thus, future research may use a more appropriate game which can trigger both positive and negative emotions of players.

A different explanation towards the current finding is that the increase in time perception of players in both aggressive and creative conditions was due to the sense of boredom developed through "Minecraft". This could be the reason why the subjects from the aggressive group only slightly overestimated time relatively to the creative group. As we can see from the game experience questionnaire, overall, participants felt somewhat bored about playing "Minecraft". Previous research has illustrated that boredom can slow down the flow of time, and make people judge time as longer [13]. When a person feels bored, he/she will pay more attention to the passage of time, resulting in a longer perception of time. Of course, this is not absolute. Troutwine and Oneal (1981)[14] challenged Nielsen's statement by suggesting that performing interesting tasks were found to shorten one's time perception; nevertheless, no change in time perception was found in the state of boredom.

As a relatively preliminary research, the findings still have extended our knowledge of using the internal clock model to explain time perception in gaming environment. Moreover, it has provided implicit information to extend the internal clock model by adding arousal and attention effects to help us better distinguish between these two different internal operating mechanisms of time distortion, as well as theoretical basis for future research to further investigate time perception in gaming environment with the application of the internal clock model.

Although there are important discoveries revealed by the current study, there are also some limitation. The major limitations of the present study is the lack of control group. As a result we cannot draw firm conclusion of whether this overestimation of time was caused by arousal or boredom. If it was due to boredom, attention can be used to explain this phenomenon. Less attention will be driven by the ongoing event when people feel it boring; therefore, more attention will be put on time processing, resulting in a temporal overestimation of time [15]. On the other hand, if it was due to arousal, more pulses will be generated which causes similar results as boredom. Future research can add a control group listening to mindful music, to see whether arousal was the key influencing factor of time perception in gaming environment.

Second, although the statistics illustrated a significant overestimation of time in the post game session, the effect size was quite low. It suggests that there was a low effect towards this phenomenon. This is a serious problem as the effect size is strongly associated with the power of statistical tests. In order to increase the effect size, future study should find a more precise way to measure this. For instance, in addition to $p(\text{long})$ values, the bisection point can be included, to further distinguish long responses over short responses.

Another limitation of these methods however is that there was a lack of control over participants' ability to play "Minecraft". It can take a while for a rookie to get fully understood with this game, especially for the creative condition, as "Minecraft" has certain requirements for operation which may take some time to master. People are more likely to become bored when exposed to tough work[16]. Similarly, for participants who did not know how to build different architectures, this game may be hard for them to some extent. In the case, there was greater possibility for them to develop boredom. As mentioned earlier, boredom can lead to an overestimation of time based on attention-based theory. An requirement over game mastery can be included in future study.

Fourth, due to the reason that the experiment was conducted in the psychological laboratory, and participants were accompanied by the instructor while playing computer games, it may invisibly bring burden to them of various degrees. Under such circumstances, it is difficult for players to devote themselves to the game, especially for rookies in such a short period of game time. Therefore, the time distortion based on the attention mechanism was accordingly hard to detect. At the same time, the repeated interruptions from the instructors may also bring players pressure to some extent, the stressful

emotion may in turn raise participants' arousal level which therefore lead to a longer perception of time.

What is more, with the rapid development of mobile game APPs, the number of mobile game players has increased dramatically in recent years. Thus, it is necessary for future research to further investigate mobile game users time distortion with the application of internal clock model in addition to computer games. Besides, for the inquiry about the time estimation during gaming sessions, future study can use computer or mobile program to automatically prompt instead of instructors' personal questions in order to reduce the possible negative impacts on participants' emotions as far as possible. In this way, it can help us better distinguish between attention and arousal effects in time distortion in gaming environment.

5 Conclusion

From the above discussion, unfortunately, we cannot draw firm conclusion of whether participants' overestimation of time across the game in the current study was due to arousal, attention, or both based on the current methodologies and findings. This suggests that time bisection task may not be the most suitable way to investigate time distortion in computer games, one important future direction of this area is to develop a more appropriate approach. Despite its preliminary character, this study still provides an advantage over implicit measurements for studying time perception. Furthermore, the experimental research results will hopefully serve as useful feedback information for improvements for game addiction work. For example, which type of computer games are more addictive to players, especially for minors. In this way, players can selectively choose games that cause less harm to their physical and mental health, as the side effects of game can be extremely distressing.

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