The Exploration of the Effects of Coyote Time of an Invisible Ledge on Jumping Performance in Platformer Games

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Abstract
Jumping is a game mechanic with a prominent importance. It has a rich historical background, existing since the beginning of games. Many previous research papers have defined and classified such important mechanic into various categories. Other researchers have tried to understand the satisfaction that a jump brings to a video game. However, there has not been a research where the correlation of jumping performance and "coyote time" - an extra time where a character can make action after actually not standing on a platform - or an invisible ledge (to achieve the same result) have been linked. We design our experiment into two parts - an experiment to carry out the testing of participants performance and its correlation of coyote time with it, and an additional questionnaire after to ask feelings associated with the gaming experience. With such design we aim to somewhat state or explore the relationship of coyote time and invisible ledges on jumping performance, and set a future reference to how such factors can help with the immersion or a feeling of a video game.

Author Keywords
coyote time; invisible ledge; jump performance

CSS Concepts
• **Human-centered computing~Human computer interaction (HCI)**; *Interactive games*; User studies;

Literature Review

Core mechanics and some satellite mechanics allow sustaining and enhancing a player's motivation [1]. This paper defines how game mechanics motivate a player to play. With focus on the mechanic of jumping in particular, the relationship between jumping mechanics and games is defined in such [2, 3, 4].

To find the correlation between "coyote time" mechanics and video games, an experiment will be created for the test. As the test is relatively simple and target participants were gathered in a way that it would be introductory to the genre of jumping, or more commonly referred to as "platformer" games, aspects of tutorials in gaming were researched and followed[5].

Besides performance, the interpretation of coyote tiem can be thought of as a neuromechanics of pressing a button, or a mechanic to tolerate latency, which were both defined well by previous research [6, 7]. Since the focus of the research is on the effects on player performance, the aspect that there is an extra time that might reference to the visual reaction speed was kept in mind during the experiment.

User testing is the benchmark of any playability evaluation, since a designer can never completely predict user behavior [9]. Although we tried to evaluate some other aspects besides performance with the questionnaire, authors laid out a set of guidelines that help evaluate playability of games. For the purpose of our research, Game mechanics and gameplay related heuristics seems relevant.

An additional research referenced was what players want in a game and how to deliver that like Entities, Scenarios and Goals [10]. With the goal of players having to show maximum performance in the form of high scores, behavior and interface recommendation given under entities and goals respectively were referenced in the design of the experiment.

Research Purpose

Jumping is a core mechanic for platformers and a common presence in most other games. Jumping appeal is rooted in our positive associations with height [2]. There have been numerous studies on the parameters that operationalise a jump. However, there have been no studies on the environmental characteristics that affect the jump. By focusing on coyote time, an environmental characteristic, we aim to establish it as an important aspect of game design. and give future reference to game researchers and developers alike.

The definition of coyote time and the invisible ledge is as such in this paper. Coyote Time is "the extra time after a character goes off an invisible ledge that still lets the player performs an action", in this case a jump. An invisible ledge is "an extension of a ledge where invisible to the naked eye of the player, implemented such that the action of the player beyond the boundary is possible". With the definitions, the purpose of our experiment is to see if "coyote time" and "invisible ledge" affects the performance of a player. Then, we aim to go through a survey, and check if there was any correlation between performance and the "immersion" of a game.

Research Question

The main question we aim to answer is "how does coyote time and the invisible ledge affect player performance?"

Research Methods

A sample game was created in Unity. It consists of a square mundane character, and a ledge. The player is given the task of jumping as far from the ledge as

possible. Unknown to the player, there will be an invisible ledge of various lengths . Four versions of the game with the length of the ledge being either non-existent, short, medium or long. It was defined as 0 pixels, 10 pixels, 15 pixels, and 20 pixels in length.

The interviewer then showed how to play the game, by moving the character and jumping. After understanding, the player will get 20 attempts to get the highest score as possible. The numbers are there so that there will be enough repetition for meaningful results, yet not too much that the participants go through a "mastery effect", giving a different variable to consider for the results. The Unity game will automatically log the results, and a questionnaire will be held after to ask the feelings associated with the experiment.

The target metric for the experiment are players in their 10s-30s with as minimal game experience in the genre of platform games as possible. The age group was selected for having an age with accurate reaction time, and also the target demographic of people who naturally enjoy video games. The reason for choosing those with minimal game experience is to seek to minimize any associated factors. For example, since many games have a form of coyote time including popular games such as "Super Mario", experienced gamers might seek the invisible ledge unknowingly without being told. No differentiation was made between the sexes, because there will be no meaningful difference in such a simple game of just observing of a "jump".

Figure 1: Experiment Desgin 1

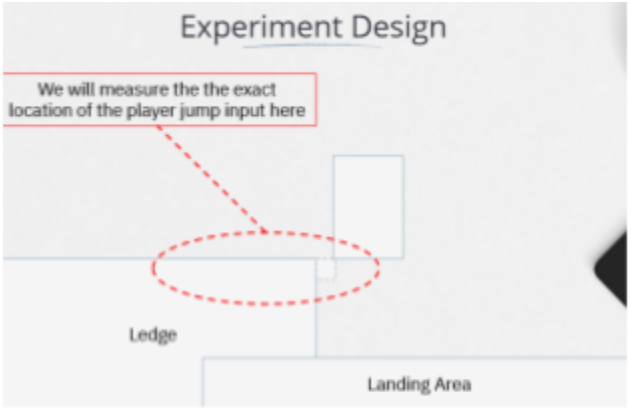


Figure 2: Experiment Design 2

The independent variables are the length of the invisible ledge across participant groups in a between

subject study design. Each length was calculated in a way so that time will be the main metric. It was 0 pixels, 10 pixels, 15 pixels, and 20 pixels long each.

Two main scales of performance was logged from the results of the game. The high score results were used as a measure of performance. The distance from the visible ledge that the player presses the jump key at was recorded. The greater this value is, the greater the player achieved and will give a relation between the ledge length and degree of success. It was measured in pixels with both positive and negative values.

Secondly, failure attempts were implemented to measure performance. Better performance in this scale would mean less tries that the player actually failed to make a jump. Besides the score of how well the player jumps, experience dictated that coyote time was implemented in many games for the convenience of the player to actually make a move. Such performance metric was used to see if this aspect of coyote time is actually true, and how the length of the ledge (hence greater coyote time) would affect the results.

Finally, in order to understand the subjective feeling associated with the game we would also get a small survey filled by the participants. The survey is filled with various questions asking about the "feelings" or the immersion of the test, such as "I felt that I did a good job." With coyote time being implemented in many games to give player satisfaction, we will use the survey to check this claim. The survey used can be found in Appendix 1.

Data Analysis

We will plot the point of jump input per attempt on a graph with attempt number as X-axis and pixel location on the Y-axis. With the resulting graphs, comparison of the shape of graphs from each group will be held to identify the patterns. The hypothesis is that there will be a meaningful correlation.

Another metric measured was the number of failed jumps. We will identify every failed jump, the attempt number of the failed jump and the number of failed jumps per group.

The survey answers was measured in a 5-point scale for 32 questions. The result of the survey will also be analyzed so as to see the direction of how the invisible ledge affects the players besides performance, but no graph or analysis in a mathematical format was done for such. The reasoning behind this was that this study focuses on the performance metric and its statistical data. An observation of relations will be looked for in the survey data, but will not be analyzed with sample size being too small and the focus of the research not being such.

Results

The following table is the average high scores of players with the highest score in the parenthesis.

	Highscore
Ledge00	842.902(848.91)
Ledge01	864.86(867.99)
Ledge02	879.102(880.56)
Ledge03	883.09(891.17)

Table 1: Average high score of players

The following data is the measurement of where the players jumped.

	Jumploc
Ledge00	11.2014
Ledge01	14.0028
Ledge02	13.5875
Ledge03	19.4606

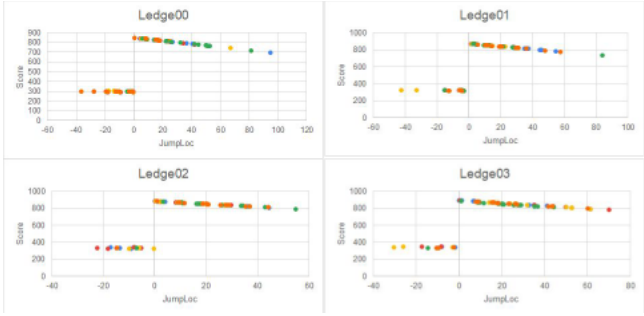
Table 2: Average Jump Location of players

The following data is the table of the average scores by ledge length.

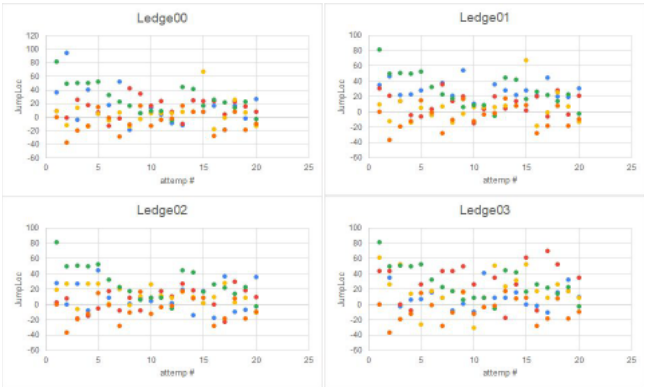
	Average score
Ledge00	642.899
Ledge01	723.4252
Ledge02	768.19609
Ledge03	772.4008

Table 2: Average score of players

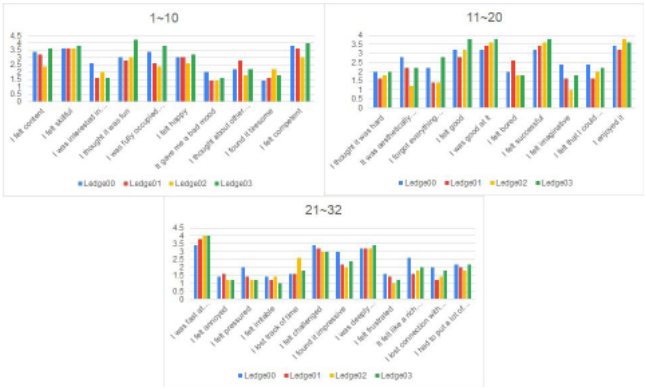
The following is the graph of scores by each player. Every player in each ledge was marked with a different color.



The following is the graph of jump location by each player. Every player in each ledge was marked with a different color.



The following are the graphs of the survey values. Notice how while ledge00 and ledge 03 makes a significant relationship, 01 and 02 does not show a noticeable relationship.



Discussion

Each of the results gave insight to multiple hypothesis. With performance first being measured as a highest score metric, we could observe that the participants with the greatest ledge length received the highest scores. However, this is somewhat obvious in the knowledge that without the ledge being invisible, a longer ledge should result in a higher score. The hypothesis was such that a greater ledge would increase the scores even higher, but the score data shows that the maximum value was just increased proportionally by the value of the ledge. Therefore, we could safely conclude that in terms of high scores, the performance of the gamer was not affected by coyote time.

The performance of the participants according to their jump failures was also measured. The results show that players with a greater invisible ledge shown greater success in terms of making the jump. Hence, performance in terms of success was accurate to the original hypothesis. We believe that the invisible ledge gives more "leeway" to the players, giving them a greater time to make the decision to jump. Therefore, this metric was hypothesized and validated with the data.

The average score data shows similar results to the highest score data. Although we observe an increase as the longer ledge, it is probably due to the ledge having greater starting advantage for the players. However, one data that could be gathered was that although we selected players with minimal knowledge of platformer genre, observation was possible that after minimal tries players made the jump near the cliff, near the edge, hence giving an average score with the same relation as the increased value of the ledge length.

The tries and the jump location along with the score was also measured. However, the graph shows no persistent relations as the result. What the hypothesis

was that in the first few tries, the players would notice the existence of the invisible ledge. After, since the goal was the greatest high score, they would seek to achieve the greatest score using such ledge to their advantage - however, this graph shows that this was not the case. Although the existence of the ledge was noticed, motivation for a greater high score was not shown to the degree expected. Our team agreed that although testing could not have been done again, giving actual dataset of previous participants, such as averages or the high score - for motivation might have changed the results.

The survey results did show a correlation of how coyote time positively benefits the players. Comparing Ledge00 data to Ledge03 data, we could see that the satisfaction and feelings of the participants were higher with a longer invisible ledge. However, we cannot provide empirical evidence, suggested by Ledge 01 and Ledge02 data. There seems to be a correlation, but not a general relation.

Conclusion

Jumping is a fundamental mechanic in gaming, with various researched elements. However, we sought to define the aspect of "coyote time" caused by an "invisible ledge", and how it affects the performance of the players playing a game with its implementation. We created a simple UNITY game with measuring data in a way such that we could measure random participants performance in a game with various different coyote time numbers. There was no meaningful relation in the terms of highest performance, but there was meaningful data in the performance of not failing the jump. A survey showed that having such invisible ledges cause the players to be more satisfied in a game. Our research, although with the limits of sample size not perfect, explored the implications of the mechanic of coyote time and how it affects performance of the players.

Research Contributions

Jumping is, and will be, a main game mechanic. Therefore, in the evolving studies of game and human interaction, one must understand every aspect to the action of jumping in order to improve our studies. As implied, by understanding coyote time and invisible ledges in the sense of their applications, we can hopefully further understand and deepen our knowledge of games. Does the leeway time help us feel good about a game? How will it be used in game design, not only in game research? This research gives future guidance to many researchers and the gaming industry alike.

Acknowledgements

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Appendix 1

The following is the questionnaire that was used, modified from The Game Experience Questionnaire [13]. All the questions were to be answered on a 5 point likert scale.

1. I felt content
2. I felt skilful
3. I was interested in the game's story
4. I thought it was fun
5. I was fully occupied with the game
6. I felt happy
7. It gave me a bad mood
8. I thought about other things
9. I found it tiresome
10. I felt competent
11. I thought it was hard
12. It was aesthetically pleasing
13. I forgot everything around me
14. I felt good
15. I was good at it
16. I felt bored
17. I felt successful
18. I felt imaginative
19. I felt that I could explore things
20. I enjoyed it
21. I was fast at reaching the game's targets
22. I felt annoyed
23. I felt pressured
24. I felt irritable
25. I lost track of time
26. I felt challenged
27. I found it impressive
28. I was deeply concentrated in the game
29. I felt frustrated
30. It felt like a rich experience
31. I lost connection with the outside world
32. I had to put a lot of effort into it