Measuring the effect of distractions in a gaze-tracked video-game

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Abstract

Eye-tracking in video-games is proven to be a rapidly growing technology amongst developers and researchers, but is yet to reach the average video-game consumer. Largely used as an optional supportive element, eye-tracking affords game-play mechanics such as enemy tagging and interaction at gaze. Video-games often offer a multitude of tasks to navigate, which can be difficult to navigate utilizing only eye-tracking input. In an attempt to explore the eye-tracking technology further, a gaze-controlled Breakout game was developed to reveal how different levels of distractions impact users' task-load, performance and game experience. The game is evaluated utilizing within subject design and self-reported questionnaires which are collected in-between each distraction spawn-rate. The results indicated that the user might be more aware of the key-objects of the game once simultaneously presented with a large number of distractions. It can therefore be concluded that ones focus will differ at a higher distraction rate, hence ignoring the distractions to a degree. Further preliminary study would have to be done in order to unveil the threshold of when participants' task-loads and game experiences change significantly.

1 Introduction

Eye-tracking technology has undergone rapid growth in terms of both popularity and refinement amongst researchers and developers. Used for a variety of different disciplines, eye-tracking has among them been introduced into video-games [28]. It is often utilized as an optional setting to support various features e.g. aim at gaze and enemy tagging. Eye-tracking in video-games can be described as a supportive element to the main intention of the system as opposed to a main feature in and of itself. Examples of commercial video games that utilize eye tracking as an optional feature include Assassins Creed Valhalla, Shadow of the Tomb Raider, Far Cry 5 and The Division 2 [1].

In terms of research, many findings exist on the topic of eye-tracking hardware and its utilization. Investigations into eye-tracking as a game mechanic, and the effect of utilizing it as such, has been explored in different studies, either by modifying an existing commercial game or by creating entirely new games with eye-tracking as a main mechanic. However, its utilization in commercial video-games can still be addressed as being under-explored [9].

Research suggests, that eye-tracking, and gaze-based interactions in general, have a compelling future in video-game. A survey by Velloso et. al. investigated the future of eye-interaction in video-games, which highlights the possibilities for gaze-enabled games. They focus on the relevance of continuing to study and investigate the topic of eye-tracking and gaze-enabled games, especially with eye-tracking as the main game mechanic. This includes studies on the limitations and disadvantages which follow, compared to traditional input modalities such as mouse and keyboard, or a controller [25].

Gaze-controlled games have also been proven to yield a heightened sense of immersion and flow for the players. Several studies have investigated and utilized between-subjects design for their evaluation. Here the eye-tracking input has consistently yielded more positive results compared to traditional mouse and keyboard controls, in terms of immersion, presence and flow [23, 24, 15].

However, games are also known to present a plethora of simultaneous tasks to players. Whether tactical or strategical, players are invariably presented with multiple mental processes at once and expected to manage them in order to progress. Taking traditional first-person shooting combat as an example, players are required to keep track of their own health, aim their gun at moving enemies, tracking enemies in the surrounding environment and move their character

accordingly etc. In essence, players are required to multitask - a process which according to Huestegge takes its toll on performance costs [7].

Connecting multitasking to increased response times and error rates, Huestegge also found that saccades can trigger the multitasking phenomena, treated as a task in itself by the human mind for all intents and purposes. Faced with multiple tasks in multiple places, participants were slower to initiate a saccade or manual response when they were planning another movement at the same time [7].

This highlights an issue in video-games where eye-tracking is used as a main mechanic; if several distractions that might require attention are presented, the player must utilize multitasking to stay focused on the goal of the game, which may lead to a performance cost.

This paper aims to contribute with a further look into what limitations and disadvantages there might be with gaze-enabled games. We investigated the influence of distractions in gaze-controlled games, for which we developed a gaze controlled Breakout game with the goal of distracting the player with several positive and negative power-ups. The effects on the players gaze and performance will be measured through questionnaires and through observing their scores, amount of loses and objects logging.

2 Related Work

Multitasking is described as the performance of multiple tasks concurrently [13] [10]. This definition originates from computer terminology but has been applied to human behavior for multiple tasks at once, such as driving and talking on the phone or attending a class and taking notes [10, 13].

It has been proposed by Pashler, that during the process of multitasking, a mental process will occur in one task. While this process transpires, a similar process cannot occur in any other task simultaneously; a bottleneck effect [3][17].

Eye-movements can cause multitasking issues, for example Huestegge et al. states that saccades both exhibit and cause dual-task costs in the context of other actions and should thus also be regarded as a response modality - A conveyor of information from the body as well as a gatherer of visual information from the world [7]. This dual-task cost should be observed and kept in mind during our own evaluation, as this might result in a lower performance by the players.

Saccade is a term used to describe a type of eye movement, some of the most common ones being the following [21]:

- Saccades: Describes rapid eye movements used in re-positioning the fovea as the eyes jump from one fixation to the next.
- Fixations: Describes stabilizing the retina over a stationary object, keeping it directly in view.
- Smooth pursuit: Describes keeping the eye fixated on a moving target.

Velloso et. al. compiled and classified game mechanics that involve eyes from three different perspectives, which contribute with a practical toolbox which game designers can utilize for their games [25]. They describe game design solutions to (human computer interaction (HCI) problems, where they state that even though game interaction design can be seen as a subset of HCI, designing interaction techniques for video-games follows a different set of rules and goals. This is because an interaction technique can't necessarily be evaluated by measuring completion time and error rates. This is due to these metrics not necessarily capturing social factors, the users' state and other sensory, cognitive and behavioural factors which may affect the game experience [25]. They also state that challenging the players natural eye behaviour can create fun game mechanics, such as forcing players to utilize their peripheral vision.

However, it is important to recognize that a natural mapping does not necessarily result in a positive game experience. Utilizing a paper by Dorr et. al. as an example, as they created a gaze-tracked Breakout game for a comparative study, where the player was controlling the paddle to bounce a ball and break bricks [4]. Here they found that by mapping the paddles x-coordinates to the player's gaze x-coordinates, all the players had to do was follow the ball with their gaze in order to progress in the game, which removed all challenge [4, 25].

At a trade fair show, Dorr et. al. presented their game to a visitor who had to experience with computer games. After performing very well, two minutes into the game, she asked when the game was starting as she was just following the ball with her gaze, hence not noticing the paddle following her gaze [4].

However, Dorr et. al. did find eye-tracking to be the superior input modality. Comparing the gaze-tracked version of their Breakout game to mouse-controlled game-play, the study revealed that the participants who played the gaze-controlled version not only yielded higher scores, but also reported higher enjoyment of the controls. They conclude, that Breakout has a particularly simple and intuitive game play that makes it ideally suited for gaze playing. [4].

We will base our implementation on the findings of Dorr et. al, as they proved it was a game that was able to get positive feedback from their evaluation utilizing eye-tracking [4]. However, 1:1 mapping with not be implemented, but instead a delay on the paddle will be utilized in order to expectantly avoid the issues that occurred in their implementation. Furthermore, a Breakout game will provide a solid foundation where the power-up distractions can easily be altered, as well

as the spawn-rate thereof and level layout. It lays the groundwork for good and simple premise, which we can easily be adjusted and wont need much explanation, in regards to game-play, to the participants.

Furthermore, Velloso et al. examined how the games interprets eye-movements, which they describe as input types, and they provide an overview of different game mechanics which makes use of these modalities. Due to our implementation being based on real-time eye-based interaction, we will be using the continuous-only input from their categorization, in which the X and Y coordinates of the users' gaze-point are tracked continuously [25].

Gomez et al., argue for 5 different themes covering their reflections of eye-tracking, provided by the results of their games, and related to other eye-tracking enabled games. The themes consisted of attention to interaction, attention dilemmas, anti-intuitive gaze interactions, the role of metaphors and gaze identity and control. In the first theme, attention to interaction, Gomez et al., argue that in gaze interaction one should avoid using tension or only present one major interaction at a time. They do provide a counterpoint, in which the mobile game, Flappy Bird, one might also quickly lose, but they are encouraged to try harder in another attempt, in which they assume the same to be true if the game was gaze-controlled, stating that sometimes what is not intuitive and natural can be fun and engaging [22]. In a game of Breakout, it can be argued that the only major interaction the player has, is moving the paddle. However, having to navigate different distractions in terms of power-ups which the player can utilize in order to strategize can also be argued to be an interaction in itself, hence leaning towards to example of Flappy Bird.

Gomez et al. also investigated and described different types of gaze aversion of how this is utilized in video-games. They proposed a spectrum of five discrete categorizes for unexpected use of the eye-tracking hardware, which are “might not look, “cannot look”, “should not look”, “must not look” and “does not look”. The aim of their study was to unveil under-explored aspects of HCI through unexpected actions, and argues for a higher peripheral awareness through such uses [22]. Gaze aversion also draws parallels to the concept of distracting the player utilizing game elements, which the player should attempt to avoid in order to focus on the task they have been given. Furthermore, this theory can be utilized in context of distractions in a gaze-tracked version of Breakout, as the player has to focus the majority of their attention on the paddle in order to not lose the game. Hence, the various distractions can be argued to fall in the category "should not look".

Gaze controlled games has also shown to increase the players feeling of immersion. Vidal et al. investigated immersion in a gaze-tracked game by developing a video-game where the characters were designed to be reactive to the players gaze, which yielded an increase in immersion due to the interactive gaze-controls [26]. Bee et al. also made a similar implementation, investigating gaze behaviours in an interactive story-telling application. They tested the application with two groups, one of which tried the interactive version of the application and one which tried the non-interactive application where the characters would not react to the players gaze. They found that the interactive model afforded higher levels of immersion [2]. Other researchers have gotten similar results in their studies, where both immersion, engagement, entertainment, and sense of presence are positively affected by gaze-based interactions in their applications [18, 5, 8, 15, 16, 27, 19, 11, 14].
However, this is not the focus of our investigation, as we are investigating the effect of distractions at different spawn-rates.

3 Design and Implementation

A game called "Eyekanoid" was developed utilizing a Tobii Eye Tracker and the Unity game engine. Based on the critically acclaimed "Arkanoid", Eyekanoid has the player controls a paddle horizontally utilizing their eyes, bouncing a ball towards bricks in order to destroy them. Whenever a player destroys a brick, they are awarded 100 points and whenever the ball falls off the screen, 500 points are detracted from their score. These score values were determined through internal testing. The speed of the ball will gradually increase throughout the level, making each level harder and harder as it progresses as players must evaluate the game state more rapidly with every speed increment.

The paddles x-coordinates is mapped to the x-coordinate of the players' gaze, however, a delay, which is relative to the movement, has been implemented in order to avoid the issue encountered by Dorr. et. al. where the participants were simply following the ball with their eyes in order to win the game [4].

For test-purposes, we define four tasks which may take up cognitive capacity within a game of Eyekanoid:

- **Paddle positioning:** Positioning the paddle to catch the ball as it falls.
- **Target identification:** Identifying where the ball is intended to go next. Tracked by looking at how long players looked at the bricks.
- **Ball tracking:** Tracking the position of the ball and its trajectory
- **Power-up tracking:** Identifying what power-ups are and evaluating whether they are worth going for.

As play progresses, power-ups will periodically fall slowly from the top of the screen. Catching these power-ups with the paddle will modify the game-state either positively or negatively, depending on the power-up caught. The spawn-rate of these power-ups is determined by setting a number X as the spawn-rate. Once the game starts, the game will pick a float Y at random between 0 and X and subsequently start a timer. When the timer reaches or exceeds Y, a random power-up from among the six available is spawned, weighted slightly towards the 'Slow ball' power-up. Once this occurs, the timer is reset and a new Y is picked. The random nature of the power-ups is particularly worth noting as the game experience each participant had, while similar to that of their peers, was not identical. This was deemed a necessity to ensure that the power-up tracking task was always performed as a reaction instead of as a learned response. For the power-up design there are 6 different types of power-ups, each with their own pros and cons which players had to weigh in accordance with the current game-state:

Figure 1: *Top-left to bottom right: Slow ball, Fast ball, Small paddle, Large paddle , Destructor, Sticky Paddle.*

- **Slow Ball / Fast Ball:** Decreases/Increases ball speed. Makes the ball easier/harder to catch but slows down/speeds up the process of breaking bricks.
- **Small Paddle / Large Paddle:** Decreases/Increases paddle width. Makes the ball harder/easier to catch but decreases/increases likelihood of picking up unwanted power-ups.
- **Destructor:** Makes the ball to pass through bricks when destroying them instead of bouncing off. This effect lasts for 9 seconds. Allows for the destruction of multiple bricks in quick succession. Almost exclusively beneficial.
- **Sticky Paddle:** Makes the ball stick to the paddle for two seconds before firing. This effect lasts for 12 seconds. Allows a much larger degree of control over ball positioning but slows down brick destruction significantly.

The time which the effects lasts was determined through internal testing.

The exact design of this effect line-up had multiple purposes. Firstly, power-ups were intended to be an integral game-play mechanic which players would periodically require to attain a good performance. The option to ignore the power-ups completely would eliminate them as "distractions" for the purposes of our experiment. To ensure evaluation of the power-ups, the gradual speed increase of the ball was set high enough to necessitate periodic pick-ups of the "Slow ball" power-up in order for the participants to continue playing, without the speed of the ball being too fast. To further ensure that power-ups were evaluated, some power-ups were made almost strictly negative. The "Fast ball" power-up would speed up the ball-breaking process in the short run, but, as the ball grew faster and players picked up more "Faster balls" over the 80 second playing period, would end up being a detriment as players would in some cases not be able to catch the ball at all. Similarly, the 'Smaller paddle' power-up would decrease the chance of catching the ball and catching the all-important 'Slow ball' power-up, making it an ill-advised power-up to catch. These negative power-ups further necessitated constant evaluation, as players could not simply catch all power-ups caught in their peripherals, at the peril of catching some of the more negative ones. To further ensure active evaluation power-ups were all visually represented as green circles with only differing black icons on top. These icons depicting metaphors for the effects of the power-up.

Based on this, three builds with different distraction spawn-rates were created:

- Build 1 (Slow): One Power-up every 5 seconds
- Build 2 (Medium): One Power-up every 3.5 seconds
- Build 3 (Fast): One Power-up every 2 seconds.

In addition, a system was implemented in each build to track the gaze activity of the participant. This system is implemented by each frame measuring the vector going from the player's gaze point to the closest point on each game object present in the level. While this system is roughly accurate, it depends on Tobii Eye-tracker gaze-point data, which is an average of an aggregation of possible points where the eye-tracker has determined the player may be looking. While accurate, this may have had an influence on the eye-tracking data gathered during the evaluation.

4 Evaluation

The evaluation was done using within subjects design, where all subjects are exposed to all conditions.

Figure 2: *Eyekanoid*

In our case, all participants were playing the same version of Eyekanoid utilizing the Tobii Eye Tracker 5, but were exposed to the changing amount of distractions and level layouts in a different order. The order of the distraction spawn-rates was created using Latin-square design. This was done to balance out the order in which the participants were exposed to the distractions and to avoid a potential learning curve. The order looked like the following:

1	Slow spawn-rate	Medium spawn-rate	Fast spawn-rate
2	**Slow spawn-rate**	Fast spawn-rate	Medium spawn-rate
3	**Medium spawn-rate**	Slow spawn-rate	Fast spawn-rate
4	**Medium spawn-rate**	Fast spawn-rate	Slow spawn-rate
5	**Fast spawn-rate**	Slow spawn-rate	Medium spawn-rate
6	**Fast spawn-rate**	Medium spawn-rate	Slow spawn-rate

Figure 3: *Table of testing segments*

Utilizing this testing method, a minimum of 12 participants were needed to have data from two participants on each order.

4.1 Evaluation method

The implementation was evaluated through both data and observations from the participants playing the game. These observations will consist of observing if the participants are seeking or avoiding the power-ups, eventual signs of frustration or enjoyment of the system, as well as verbal feedback during the duration of them playing the game.

Our data was based on a demographic questionnaire, the NASA task load index (NASA-TLX), the in-game iGEQ questionnaire by Kort et. al. and a system usability test [12, 6, 20]. All questionnaires were self-reported by the user.

The NASA-TLX questionnaire is a subjective multidimensional assessment tool, which rates the perceived workload of a task, system, performance or the effectiveness of a team [6]. This questionnaire was utilized to measure if the task-load is reported to be different when the participants are presented with a higher distraction spawn-rate.

The IGEQ questionnaire was be utilized to evaluate the participants game-play experience. The iGEQ questionnaire is a shorter in-game version of the GEQ questionnaire, which was developed in order to measure player experience multiple times during a game session [20].

Lastly, the system usability test was used to evaluate the system itself. It can be an addition to evaluate the overall experience of playing the game. For example, if a user has low performance and reports low enjoyment of the system, the system usability scale might be useful to determine if it is a fault of the system.

The total time participants looked at various objects in the scene was also tracked and logged. The objects tracked are the following:

- The ball
- The Paddle
- The bricks
- Each type of power-up

Their score for each segment of the game was logged as well.

The game was played in 80 second segments, with the given order of the distraction rates, with the NASA-TLX and iGEQ questionnaire reported in-between each segment. The structure looked like the following:

- Participant plays the first segment of 3 levels with one distraction spawn-rate.
- Participant answers the NASA-TLX and iGEQ questionnaires.
- Participant plays the second segment of 3 levels with one distraction spawn-rate.
- Participant answers the NASA-TLX and iGEQ questionnaires.
- Participant plays the third segment of 3 levels with one distraction spawn-rate.
- Participant answers the NASA-TLX and iGEQ questionnaires, as well as the SUS-test.

This structure was utilized to ensure we got data on how each participant experienced the spawn-rate for the power-ups and how they were affected by them as distractions. On the basis of this, we created the following hypotheses:

Hypothesis 1 For hypothesis 1 we theorize that there will be a difference in players' performances when faced with different levels of distractions. This will be measured by looking at player scores for each of the three game versions. Based on Huestegge's research on distractions and their influence on gameplay, it is expected that as distraction levels rise, player score decreases.

$$H_{0_1} : \mu_{highspawnrate} = \mu_{mediumSpawnrate} = \mu_{lowSpawnrate}$$

$$H_{1_1} : \mu_{highspawnrate} \neq \mu_{mediumSpawnrate} \neq \mu_{lowSpawnrate}$$

Hypothesis 2 For hypothesis 2 we theorize that there will be a difference in the perceived physical and mental task load when facing players with different levels of distraction. This will be investigated through the NASA task load index questionnaire. Based on the research of (?) we expect the mental task load to increase as the level of distractions increase.[6].

$$H0_2 : \mu_{highspawnrate} = \mu_{mediumSpawnrate} = \mu_{lowSpawnrate}$$

$$H_{1_2} : \mu_{highspawnrate} \neq \mu_{mediumSpawnrate} \neq \mu_{lowSpawnrate}$$

Hypothesis 3 For hypothesis 3 it is theorized that there is a significant difference between player's gameplay experiences when faced with different levels of distraction. This will be measured through the in-game Gameplay Experience Questionnaire (iGEQ) which inquires about a player's experience playing the game. It is here expected that a higher level of distractions will yield a more frustrating or engaging experience due to a difference in difficulty. This is expected as a result of the player's flow fluctuating. [20].

$$H_{0_3} : \mu_{highspawnrate} = \mu_{mediumSpawnrate} = \mu_{lowSpawnrate}$$

$$H1_3 : \mu_{highspawnrate} \neq \mu_{mediumSpawnrate} \neq \mu_{lowSpawnrate}$$

4.2 Participants

Our evaluation group was young males and females who are familiar with video-games, as this target group will most likely already be familiar with the concept of Breakout as well as having experience with multitasking in video-games. We had a total of 12 participants between 20-27 years of age. They consisted of 10 males and 2 females, all playing video-games 25,75 hours per week on average. All participants were reported to be familiar with the concept of eye-tracking but to have little firsthand experience with it. Three participants reported to have utilized it before to varying degrees.

4.3 Procedure

At the beginning of each testing session, the participant was asked to fill out a consent form stating that the data will only be saved for the purpose of this project. Once signed, they were asked to fill out a demographics questionnaire, in which they would state their age, how many hours they play video-games per week, as well as their familiarity and experience with eye-tracked games. Once finished, the participants would get an introduction to what the game is about and how to play it. They would also be told that the speed of the ball would increase linearly and that they could use the "Slow Ball" power-up to manage the speed of the ball. The only power-ups not explained were the "Sticky Paddle" and "Destructor" power-ups to keep a sense of exploration in the game. The participant was also encouraged to think aloud whilst playing. Afterwards they would be set to play the game, answer the self-reported questionnaires after each segments and at the end of the evaluation answer a SUS-test.

4.4 Results

The data gathered from the evaluation was averaged for each participant across all segments for more efficient analysis. These averages were then utilized to perform a statistical analysis utilizing a two-factor ANOVA-test with the distraction level acting as the independent variable.

Measure	Variance (Slow)	Variance (Medium)	Variance (Fast)	P-value
Scores	1279	3475	1233	0.46
Ball	71.80	52.38	168.97	0.0000005
Racket	170.19	445.08	675.45	0.0000021
Slow	0.85	0.95	12.99	0.09
Fast	0.14	0.30	13.77	0.06
Enlarge	0.21	0.39	0.26	0.051
Shrink	0.32	0.37	0.97	0.06
Destructor	0.65	0.27	0.36	0.82
Sticky	0.04	0.07	0.24	0.08
Brick	63.97	115.58	88.85	0.17

Figure 4: *Data of object logging and scores*

The low P-value (P ¡ 0,05), which can be observed for the ball, paddle, the large paddle power-up, means that there is not enough evidence to prove that the distraction spawn-rates are not equal. For the remaining logged gaze-points, a significance is proven, which suggests that there is a significance difference in what the participants were looking at, at the different spawn-rates.

The averages across all of the participants' object logging and scores showed that the participants in general looked at the objects more, specifically the paddle and the ball, and also yielded the highest scores at the fastest distraction spawn-rate.

Slow SP	ball	paddle	block	slow	fast	enlarge	shrink	destructor	sticky	score
Mean, μ:	13,73 s	29,13 s	40,025 s	1,39 s	0,72 s	0,88s	0,67s	0,33s	0,14s	3058,33
Std. Deviation, σ:	8.113	12.490	7.658	0.884	0.361	0.548	0.445	0.279	0.204	3424.776

Figure 5: *Average result for the low spawn-rate*

Medium SP	ball	paddle	block	slow	fast	enlarge	shrink	destructor	sticky	score
Mean, μ:	14,91 s	37,32 s	41,31 s	3.015 s	0.922	0.867	0,98s	0,5s	0,249 s	2383,33
Std. Deviation, σ:	6.929	23.947	10.293	5.272	0.524	0.583	0.573	0.503	0.269	5644.441

Figure 6: *Average results for the medium spawn-rate*

Fast SP	ball	paddle	block	slow	fast	enlarge	shrink	destructor	sticky	score
Mean, μ:	29,10 s	67,77 s	47,00 s	3,09 s	2,69 s	1,24s	1,17s	0,63s	0,42s	3925
Std. Deviation, σ:	12.445	24.883	9.025	3.450	3.553	0.944	0.494	0.582	0.473	3362.321

Figure 7: *Average results for the fast spawn-rate*

The two-factor ANOVA-test with the distraction level acting as the independent variable, was also performed on the iGEQ-questionnaire and the NASA-TLX. But significant difference was found in either of the questionnaires.

For both of the questionnaires, we have p-values higher than our significance value (0,05), which means that means that we don't have enough evidence to prove that the distraction spawn-rate means are not equal.

The SUS-test yielded a score of 61,75, which can be interpreted as an average system usability score.

5 Discussion

5.0.1 Hypothesis 1: Their scores

This hypothesis aimed at investigating the difference in the participants score, and assumed that the participants will yield a lower score in the segment with the high spawn-rate of distraction. For the slow distraction spawn-rate segments the mean of the participants scores was 3058,33 points with a standard deviation of 3424,776. For the medium spawn-rate segments the participants got a mean of 2383,33 points with a standard deviation of 5644,441. The high standard deviation indicates that the values are spread out on a higher range and that the data may not be normally distributed. Lastly, for the fast distraction spawn rate the participants got a mean of 3925 points with a standard deviation of 3362,321.

This can be due to the participants being more focused on the objects around them in the game, as the results indicate that the participants spent a lot more time gazing at the ball and the paddle. Once too many distractions were present on the screen at once, the participants seemed to change their strategy to focus on the game-elements required to succeed. Participants acquiring a higher score through this method could indicate a flaw in the game design as the "slow" power-up was intended to be essential. For the slow distraction spawn-rate they averagely gazed at the ball and the paddle for 13,73 seconds and 29,13 seconds respectively. In the medium spawn-rate segment they gazed at the ball for averagely 14,91 seconds and the paddle for 37,32 seconds. However, in the fast distraction spawn-rate segment they gazed at the ball and the paddle for 29,10 seconds and 67,77 seconds respectively, which is a significant increase. While difficult to decisively conclude, it is believed that when faced with a sufficient number of power-ups, players prioritized elements most essential to a good performance; the ball and the paddle. The occurrence of logging numbers similar to other distraction levels is thus theorized to be a result of increased power-up frequency corresponding to more power-ups entering players' focuses by chance.

5.0.2 Hypothesis 2: NASA-TLX questionnaire

Hypothesis 2 assumed that it will be more physically and mentally demanding for the participants to play the game with a higher spawn-rate of distractions, which was investigated through the NASA-TLX questionnaire. The NASA-TLX questionnaire proved that there was no significance between the different spawn-rates, meaning that the participants reported no significant difference in the task-load. This is could be due to an issue in our methodology, as the difference in the spawn-rates were not big enough to impact their task-load significantly. This could be avoided by doing more in-depth preliminary testing with more participants, testing the threshold of where ones' task-load changes more extensively. However, adding more power-ups may not make a significant change to what objects the participants are looking at or for how long, but could have had an impact on their performance by giving them access to more instances of the positive power-ups such as "Destructor".

5.0.3 Hypothesis 3: iGEQ in-game questionnaire

This hypothesis assumed that the participants would feel more challenged playing the game with the higher distraction spawn-rate, which was unveiled through the iGEQ in-game questionnaire. The iGEQ in-game questionnaire yielded no significant difference between the

different spawn-rates, which means that the participants feelings doesn't change significantly throughout the different segments. This could also have been avoided through more extensive preliminary testing, learning at what spawn-rate the participants feels the most skillful and challenged. This could also have helped us establish a better flow in the game overall, as well as pointing to at which spawn-rate the most sense of flow occurs for the participants.

5.0.4 Other findings

During the evaluation, it was observed, that despite being encouraged to think aloud during the testing process, most participants were quiet and focused on the game. This could have been due to the game being challenging to the participants, but according to the analysis done on the iGEQ in-game questionnaire, there was no significance regarding their feelings or challenge towards the different spawn-rates. Only five times out of the total 36 segment reports from all the participants, was it reported that they felt "extremely" challenged.

It was also observed, that the participants were mostly seeking the "slow" and "Destructor" power-up and avoiding the "fast" and "sticky" power-up. Seeking the "slow" power-ups, which decreases the speed of the ball, is a good strategy against the linear increase in the speed of the ball. Collecting the "fast" power-up could lead to a perpetual inability to catch the ball later in the game, which makes sense to why it was avoided. The "Destructor" power-up was also particularly useful for the participants, as it allowed them to gain more points, as the ball would not bounce off the bricks. This power-up might also have been a determining factor as to why the participants yielded a higher score for the fast distraction spawn-rate. All of the power-ups would spawn more often, leading to the participants also being able to pick up this power-up more often.

The insignificant data could be caused by issues in our methodology. Having participants being a part of our preliminary testing could have helped us determine the values of the distractions rates with more participants, as we would be able to measure at what distraction spawn-rates one's task-load increases or decreases. These values could then have been used in the evaluation, which most likely would have given us more significant results, whilst providing us with the data needed to conclude when an amount of distractions has a significant impact on ones task-load and game experience.

Overall, the data that was gathered from the questionnaires was very subjective to each participants experience, and could therefore not describe when an amount of distractions affects ones task-load or enjoyment of the game.

6 Conclusion

The aim of this project was to investigate the impact of several levels of distractions in a gaze-controlled Breakout game. The distractions was presented as both positive and negative power-ups, which the player would have to navigate through and strategize which to pick up to their benefit of yielding a higher score. The participants score, how long they looked at the game objects was logged, and the participants task-load as well as their feelings towards the game experience was reported through the NASA Task Load Index and the iGEQ in-game questionnaire respectively. The results showed, that whilst no statistical significance was found through either of the questionnaires, the object logging did show a significantly higher value in terms of how long the participants looked at the paddle and the ball when playing at the highest distraction spawn-rate. Therefore, it may be concluded that the participants were more focused on those two key game-objects that are crucial in order to succeed, but that the spawn-rates did not differ enough from each other to demonstrate when the amount of distractions had a significant impact on the participants' perceived task-load and game experiences.

7 COVID-19 disclaimer

Due to the current state of society during the COVID-19 pandemic when this projects was conducted, the experiments had to be changed accordingly. This yielded a number of of negative-effects on the process of design and implementation of the product. The campus of Aalborg University was shut down for the majority of the project and student were encouraged to work separately from home. This had an impact on our group coordination and collaboration, as all communication had to be conducted online. An example of this, is that only one member of the group had access to the one eye-tracker we were given for the project, making the implementation especially difficult. This also meant that more or less all the tasks and work of this project had to be divided between the members, thus minimizing the amount of collaboration between the members of the group. This resulted in a lot of planning and internal testing, to make sure that everyone's expectations and visions for the final product was reached. This was done through screen-sharing and giving the other member frequent updates on their work progress, as well as adjusting game-play values along the way. It also affected the evaluation of the project, as one member is due to pre-existing conditions, a high-risk for COVID-19, meaning that the evaluation was mostly carried out by the other

member, at university campus, when it was opened for a short period of time. It also resulted in lower amount of participants than what would be desired under normal conditions as well as limiting our preliminary testing, thus making it difficult to draw any meaningful conclusions. This method of working, in general led to a lot of pre-planning and meetings, doing our best to keep each other updated, so that the quality of the project was maintained. .

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A Appendix A

A.1 Participant Results and Data

Participants – Raw logged data:

Participants raw logged data for the number of seconds they were looking at game elements
All units are in seconds.

Participant 1 – slow:

```
Level 1 Gaze Logging
Ball: 8.393653
Racket: 25.28928
Blocks: 13.34774
Slow: 0.6831629
Fast: 1.015843
Enlarge: 1.61639
Shrink: 0
Destructor: 0
Sticky: 0


Level 1 Gaze Logging
Ball: 6.289587
Racket: 45.83272
Blocks: 8.100111
Slow: 1.150546
Fast: 2.966203
Enlarge: 0.3838165
Shrink: 0
Destructor: 0
Sticky: 0.8160867


Level 1 Gaze Logging
Ball: 11.60126
Racket: 40.49958
Blocks: 80.00227
Slow: 3.28428
Fast: 0.2815178
Enlarge: 2.081458
Shrink: 1.666226
Destructor: 1.100046
Sticky: 0
```

Participant 1 – Medium:

```
Level 1 Gaze Logging
Ball: 18.94375
Racket: 42.89381
Blocks: 5.799256
Slow: 3.769356
Fast: 0.1673606
Enlarge: 0.0820847
Shrink: 0.6163186
Destructor: 1.000601
```

Sticky: 2.317075

Level 1 Gaze Logging
Ball: 13.51487
Racket: 43.94612
Blocks: 80.0102
Slow: 0
Fast: 1.0674
Enlarge: 0.3834044
Shrink: 0.8500188
Destructor: 2.250339
Sticky: 0.2326647

Level 1 Gaze Logging
Ball: 10.38087
Racket: 41.88626
Blocks: 15.5827
Slow: 0.7815382
Fast: 2.650429
Enlarge: 1.582641
Shrink: 0.3993519
Destructor: 0
Sticky: 0.0165161

Partcipant 1 - fast:

Level 1 Gaze Logging
Ball: 31.49242
Racket: 8.40009
Blocks: 59.2073
Slow: 5.470974
Fast: 1.300836
Enlarge: 0.4004512
Shrink: 3.098726
Destructor: 0.7323367
Sticky: 0.4500434

Level 1 Gaze Logging
Ball: 32.94662
Racket: 73.21638
Blocks: 22.3974
Slow: 5.647902
Fast: 2.284136
Enlarge: 2.383301
Shrink: 0
Destructor: 1.899534
Sticky: 2.200315

Level 1 Gaze Logging
Ball: 32.84812
Racket: 92.92934

Blocks: 13.24673
Slow: 3.115646
Fast: 1.799756
Enlarge: 4.084972
Shrink: 1.434316
Destructor: 0
Sticky: 0.2168911

Partcipant 2 – slow:

Level 1 Gaze Logging
Ball: 5.16715
Racket: 0
Blocks: 19.997
Slow: 0.4325026
Fast: 1.517021
Enlarge: 0.4988995
Shrink: 1.48338
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 8.407804
Racket: 0
Blocks: 80.01009
Slow: 0.3164963
Fast: 0
Enlarge: 0.61663
Shrink: 0
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 4.493901
Racket: 0
Blocks: 15.90282
Slow: 0.2501278
Fast: 0.7001745
Enlarge: 0
Shrink: 0.250158
Destructor: 0.0168506
Sticky: 0

Participant 2 – medium:

Level 1 Gaze Logging
Ball: 9.004568
Racket: 0
Blocks: 19.34712
Slow: 0.9669013
Fast: 1.449938
Enlarge: 0.3662705

Shrink: 0.9336085
Destructor: 0.6002329
Sticky: 0

Level 1 Gaze Logging
Ball: 9.738883
Racket: 0
Blocks: 15.33011
Slow: 0.4505052
Fast: 0.4002005
Enlarge: 0.6008443
Shrink: 1.366842
Destructor: 0.7009124
Sticky: 0

Level 1 Gaze Logging
Ball: 4.41079
Racket: 0
Blocks: 80.01275
Slow: 1.015855
Fast: 0.4995959
Enlarge: 0.4338197
Shrink: 1.466489
Destructor: 0.4500207
Sticky: 1.098477

Participant 2 – fast:

Level 1 Gaze Logging
Ball: 15.83397
Racket: 7.986393
Blocks: 79.71999
Slow: 0.8169758
Fast: 0.6997507
Enlarge: 1.134616
Shrink: 1.449276
Destructor: 0.3340891
Sticky: 0.1833477

Level 1 Gaze Logging
Ball: 18.57607
Racket: 0
Blocks: 61.13648
Slow: 1.698052
Fast: 0.7329782
Enlarge: 0.500637
Shrink: 2.599958
Destructor: 1.316194
Sticky: 0

Level 1 Gaze Logging

Ball: 19.33537
Racket: 10.08981
Blocks: 17.01433
Slow: 4.215042
Fast: 0.4163074
Enlarge: 0.099514
Shrink: 0.1662122
Destructor: 0.1004815
Sticky: 0

Participant 3 – slow:

Level 1 Gaze Logging
Ball: 13.39751
Racket: 13.36672
Blocks: 79.90398
Slow: 0.8338404
Fast: 1.299283
Enlarge: 1.166661
Shrink: 0
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 22.5318
Racket: 36.81059
Blocks: 62.93246
Slow: 0.1833613
Fast: 0.5335769
Enlarge: 0
Shrink: 1.099615
Destructor: 0.3662709
Sticky: 0

Level 1 Gaze Logging
Ball: 15.60279
Racket: 21.49318
Blocks: 18.39465
Slow: 1.55021
Fast: 0
Enlarge: 0
Shrink: 0.0326381
Destructor: 1.882113
Sticky: 0

Participant 3 – medium:

Level 1 Gaze Logging
Ball: 14.86653
Racket: 27.7726
Blocks: 79.90369
Slow: 2.032989

Fast: 1.183092
Enlarge: 3.464406
Shrink: 1.315056
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 19.48988
Racket: 41.68676
Blocks: 6.136158
Slow: 3.015706
Fast: 1.216265
Enlarge: 1.702738
Shrink: 2.016008
Destructor: 0
Sticky: 0.9842538

Level 1 Gaze Logging
Ball: 17.25334
Racket: 75.47806
Blocks: 58.56461
Slow: 2.118085
Fast: 0.6342602
Enlarge: 0.5832416
Shrink: 2.715107
Destructor: 0.3002183
Sticky: 0.316857

Participant 3 – fast:

Level 1 Gaze Logging
Ball: 47.13136
Racket: 46.78366
Blocks: 8.081146
Slow: 1.250741
Fast: 0.9828895
Enlarge: 0.8182472
Shrink: 1.948415
Destructor: 0.9507852
Sticky: 0

Level 1 Gaze Logging
Ball: 49.06231
Racket: 60.46688
Blocks: 80.00274
Slow: 1.398796
Fast: 0.9342638
Enlarge: 2.167299
Shrink: 1.033012
Destructor: 0.3497688
Sticky: 0.6339062

Level 1 Gaze Logging
Ball: 24.80988
Racket: 133.86
Blocks: 67.83218
Slow: 1.264122
Fast: 0.682645
Enlarge: 1.800957
Shrink: 0.2004393
Destructor: 5.700058
Sticky: 0.4338903

Participant 4 – slow:

Level 1 Gaze Logging
Ball: 20.09122
Racket: 66.06065
Blocks: 7.332118
Slow: 0.7836357
Fast: 0.5831311
Enlarge: 1.382845
Shrink: 0.1834548
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 14.47509
Racket: 37.06368
Blocks: 6.984249
Slow: 1.684294
Fast: 0.335488
Enlarge: 0.3993584
Shrink: 0.4669737
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 17.1918
Racket: 46.9268
Blocks: 80.00251
Slow: 0.2343945
Fast: 0
Enlarge: 0
Shrink: 2.949878
Destructor: 0
Sticky: 0

Participant 4 – medium:

Level 1 Gaze Logging
Ball: 6.033322
Racket: 68.67223

Blocks: 5.449038
Slow: 0.3173081
Fast: 0.2159255
Enlarge: 0
Shrink: 0.2670631
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 33.31586
Racket: 93.9619
Blocks: 1.749849
Slow: 0.7990263
Fast: 1.132668
Enlarge: 0.0840389
Shrink: 0.1357304
Destructor: 0.8833668
Sticky: 0.6990635

Level 1 Gaze Logging
Ball: 25.46096
Racket: 66.86402
Blocks: 80.00698
Slow: 0
Fast: 0.333962
Enlarge: 0.799778
Shrink: 2.532837
Destructor: 0
Sticky: 0

Participant 4 – fast:

Level 1 Gaze Logging
Ball: 38.70448
Racket: 120.285
Blocks: 4.865451
Slow: 3.150663
Fast: 0.2339665
Enlarge: 1.549518
Shrink: 0.3491181
Destructor: 0.0333123
Sticky: 0

Level 1 Gaze Logging
Ball: 45.92964
Racket: 116.6909
Blocks: 80.00664
Slow: 1.216228
Fast: 1.850111
Enlarge: 0.4171427
Shrink: 0.1333098
Destructor: 0.5502037

Sticky: 0.0337018

Level 1 Gaze Logging
Ball: 30.90442
Racket: 79.86823
Blocks: 48.50605
Slow: 0.1993779
Fast: 1.91812
Enlarge: 0.4316317
Shrink: 1.001471
Destructor: 0.5669097
Sticky: 0.5004727

Participant 5 – slow:

Level 1 Gaze Logging
Ball: 10.92375
Racket: 75.93484
Blocks: 5.924689
Slow: 0.6990487
Fast: 0
Enlarge: 0.1677857
Shrink: 0.2840989
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 9.893981
Racket: 22.17497
Blocks: 80.00244
Slow: 2.887215
Fast: 0.7486459
Enlarge: 0
Shrink: 0.0339605
Destructor: 0.666799
Sticky: 0

Level 1 Gaze Logging
Ball: 8.748375
Racket: 24.37075
Blocks: 4.780408
Slow: 2.300848
Fast: 3.033147
Enlarge: 1.567938
Shrink: 0.8661237
Destructor: 0
Sticky: 0

Participant 5 – medium:

Level 1 Gaze Logging

Ball: 16.27177
Racket: 56.53201
Blocks: 53.45752
Slow: 0.9998881
Fast: 1.86753
Enlarge: 2.084124
Shrink: 2.465982
Destructor: 1.066103
Sticky: 0.450186

Level 1 Gaze Logging
Ball: 20.94051
Racket: 46.65269
Blocks: 80.0137
Slow: 2.596123
Fast: 1.132361
Enlarge: 0.1666943
Shrink: 0
Destructor: 1.065641
Sticky: 0

Level 1 Gaze Logging
Ball: 17.71045
Racket: 33.02407
Blocks: 63.42382
Slow: 3.201142
Fast: 2.983593
Enlarge: 0
Shrink: 1.065506
Destructor: 0.1832867
Sticky: 0

Participant 5 – fast:

Level 1 Gaze Logging
Ball: 36.49709
Racket: 41.98351
Blocks: 17.53145
Slow: 3.236687
Fast: 0.6998728
Enlarge: 3.164567
Shrink: 1.783449
Destructor: 0.2827328
Sticky: 1.484315

Level 1 Gaze Logging
Ball: 19.92422
Racket: 31.21228
Blocks: 11.3348
Slow: 2.88246
Fast: 1.031228
Enlarge: 0.4498506

Shrink: 1.033586
Destructor: 0.1661672
Sticky: 0

Level 1 Gaze Logging
Ball: 29.74369
Racket: 80.89175
Blocks: 80.01077
Slow: 2.571244
Fast: 4.184511
Enlarge: 3.563781
Shrink: 1.000167
Destructor: 1.032236
Sticky: 0.2480672

Participant 6 – slow:

Level 1 Gaze Logging
Ball: 5.762348
Racket: 25.52998
Blocks: 79.90336
Slow: 0.0667832
Fast: 0.8166052
Enlarge: 0
Shrink: 0.1002014
Destructor: 0.08323471
Sticky: 0

Level 1 Gaze Logging
Ball: 8.010356
Racket: 26.19433
Blocks: 5.198756
Slow: 0.282753
Fast: 0
Enlarge: 0.6835723
Shrink: 0.1671642
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 2.449667
Racket: 25.90156
Blocks: 56.69009
Slow: 0.6830505
Fast: 0.8823397
Enlarge: 0
Shrink: 0.0333528
Destructor: 0.3165933
Sticky: 0

Participant 6 – medium:

Level 1 Gaze Logging
Ball: 4.882896
Racket: 31.05025
Blocks: 3.432292
Slow: 0.899954
Fast: 0.0667287
Enlarge: 0
Shrink: 0.1000329
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 8.217857
Racket: 26.29244
Blocks: 80.00655
Slow: 0.0333997
Fast: 0.9134892
Enlarge: 0.5832729
Shrink: 0.0332779
Destructor: 0.033465
Sticky: 0

Level 1 Gaze Logging
Ball: 7.870317
Racket: 57.54198
Blocks: 7.29739
Slow: 2.23294
Fast: 0.1666537
Enlarge: 0.5833737
Shrink: 0
Destructor: 0.0503647
Sticky: 0

Participant 6 – fast:

Level 1 Gaze Logging
Ball: 8.638738
Racket: 69.07999
Blocks: 61.35606
Slow: 1.549967
Fast: 0.7005693
Enlarge: 0
Shrink: 0.5658283
Destructor: 0
Sticky: 0

Level 1 Gaze Logging

Ball: 12.74884
Racket: 61.85991
Blocks: 80.0077
Slow: 1.151771
Fast: 0.1673731
Enlarge: 0.2499718
Shrink: 1.415162
Destructor: 0.1169666
Sticky: 0

Level 1 Gaze Logging
Ball: 15.03252
Racket: 120.474
Blocks: 37.84387
Slow: 0.06644219
Fast: 0.3333974
Enlarge: 0.1157416
Shrink: 2.166272
Destructor: 0.0832302
Sticky: 0

Participant 7 – slow:

Level 1 Gaze Logging
Ball: 11.4158
Racket: 17.56759
Blocks: 10.99857
Slow: 0.5168582
Fast: 0.4487092
Enlarge: 1.150221
Shrink: 2.36504
Destructor: 0.4172213
Sticky: 0

Level 1 Gaze Logging
Ball: 15.81886
Racket: 24.63872
Blocks: 20.24716
Slow: 0.7660826
Fast: 1.581759
Enlarge: 0.2002085
Shrink: 0.0999067
Destructor: 0.5665728
Sticky: 0

Level 1 Gaze Logging
Ball: 11.65063
Racket: 27.76486
Blocks: 80.00526
Slow: 3.218412
Fast: 0.1997543
Enlarge: 0.8331487

Shrink: 0.1504697
Destructor: 0.0663428
Sticky: 0.8998984
Participant 7 – medium:

Level 1 Gaze Logging
Ball: 7.659086
Racket: 22.40442
Blocks: 35.11121
Slow: 0
Fast: 0.9845469
Enlarge: 0.0326443
Shrink: 0.6323675
Destructor: 0.2004961
Sticky: 0

Level 1 Gaze Logging
Ball: 12.16181
Racket: 24.81977
Blocks: 29.92715
Slow: 1.466349
Fast: 1.599524
Enlarge: 0.7829133
Shrink: 0.3664988
Destructor: 0.4997461
Sticky: 0

Level 1 Gaze Logging
Ball: 8.188521
Racket: 38.10017
Blocks: 80.01109
Slow: 0.2171079
Fast: 0.583716
Enlarge: 0.1834325
Shrink: 0.0832498
Destructor: 0.4500753
Sticky: 0

Partcipant 7 – fast:

Level 1 Gaze Logging
Ball: 20.90649
Racket: 102.2894
Blocks: 3.149002
Slow: 1.664937
Fast: 1.216445
Enlarge: 1.332771
Shrink: 0.216484
Destructor: 0.0992367
Sticky: 0

Level 1 Gaze Logging

Ball: 12.99492
Racket: 76.39504
Blocks: 80.0144
Slow: 1.18353
Fast: 2.216555
Enlarge: 0.2328176
Shrink: 1.801541
Destructor: 0.116574
Sticky: 0

Level 1 Gaze Logging
Ball: 11.42855
Racket: 32.60067
Blocks: 32.79946
Slow: 2.350371
Fast: 0.1991624
Enlarge: 0.1001905
Shrink: 0.8668844
Destructor: 0.1662654
Sticky: 0

Participant 8 – slow:

Level 1 Gaze Logging
Ball: 1.331248
Racket: 32.60218
Blocks: 3.551302
Slow: 0
Fast: 0.7499442
Enlarge: 0.1165165
Shrink: 0
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 2.742418
Racket: 47.84989
Blocks: 80.006
Slow: 0.4167093
Fast: 0
Enlarge: 0
Shrink: 0
Destructor: 0.2004816
Sticky: 0

Level 1 Gaze Logging
Ball: 3.413892
Racket: 32.43032
Blocks: 47.85797
Slow: 0
Fast: 0.0166463
Enlarge: 0.5830404

Shrink: 0
Destructor: 0.399938
Sticky: 0
Participant 8 – medium:

Level 1 Gaze Logging
Ball: 12.98289
Racket: 36.27109
Blocks: 79.95308
Slow: 0.1672215
Fast: 0.5161715
Enlarge: 1.148201
Shrink: 0.250504
Destructor: 0.0336961
Sticky: 0

Level 1 Gaze Logging
Ball: 5.829711
Racket: 38.96655
Blocks: 21.54684
Slow: 0
Fast: 0
Enlarge: 1.333836
Shrink: 0.0664073
Destructor: 0.1163423
Sticky: 0

Level 1 Gaze Logging
Ball: 3.399004
Racket: 48.82169
Blocks: 1.131288
Slow: 0.4818965
Fast: 0.419059
Enlarge: 0
Shrink: 0
Destructor: 0
Sticky: 0

Participant 8 – fast:

Level 1 Gaze Logging
Ball: 18.95342
Racket: 113.4843
Blocks: 79.90336
Slow: 0.5676556
Fast: 0.5991066
Enlarge: 0.4667195
Shrink: 0.065514
Destructor: 0
Sticky: 0.0337237

Level 1 Gaze Logging

Ball: 10.3534
Racket: 97.62351
Blocks: 2.232723
Slow: 0.9334871
Fast: 1.797069
Enlarge: 0.1829404
Shrink: 0.265853
Destructor: 0.4337209
Sticky: 0

Level 1 Gaze Logging
Ball: 15.13697
Racket: 94.81552
Blocks: 56.37408
Slow: 0.4814266
Fast: 0.0335142
Enlarge: 0.5011484
Shrink: 0.3328279
Destructor: 0.4504337
Sticky: 0

Participant 9 – slow:

Level 1 Gaze Logging
Ball: 11.44697
Racket: 23.79382
Blocks: 5.999184
Slow: 1.149784
Fast: 0.0334366
Enlarge: 0.9334643
Shrink: 1.165761
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 7.308985
Racket: 18.69383
Blocks: 42.20686
Slow: 1.466367
Fast: 0
Enlarge: 0.1329726
Shrink: 1.84825
Destructor: 0.2498755
Sticky: 0

Level 1 Gaze Logging
Ball: 5.678749
Racket: 21.99479
Blocks: 80.00219
Slow: 1.74885
Fast: 1.533193
Enlarge: 0.8826805

Shrink: 0
Destructor: 0
Sticky: 0.1337693

Participant 9 – medium:

Level 1 Gaze Logging
Ball: 9.952309
Racket: 25.70806
Blocks: 79.88667
Slow: 1.918098
Fast: 3.798785
Enlarge: 0.1163619
Shrink: 0.2337773
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 7.305156
Racket: 27.39979
Blocks: 27.76144
Slow: 1.481549
Fast: 0.7992561
Enlarge: 0.6336225
Shrink: 0.7829956
Destructor: 0.033341
Sticky: 0.1504655

Level 1 Gaze Logging
Ball: 4.182069
Racket: 29.92155
Blocks: 7.532586
Slow: 0.4498656
Fast: 0.9164044
Enlarge: 1.383181
Shrink: 1.517018
Destructor: 0
Sticky: 0.2496184

Participant 9 – fast:

Level 1 Gaze Logging
Ball: 19.29976
Racket: 83.0322
Blocks: 59.33986
Slow: 2.816068
Fast: 1.350517
Enlarge: 0.2324947
Shrink: 0.0331377
Destructor: 0.4676907
Sticky: 0.5330722

Level 1 Gaze Logging
Ball: 18.10292
Racket: 50.2337
Blocks: 80.00499
Slow: 0.4176506
Fast: 1.616292
Enlarge: 0.5495446
Shrink: 2.998482
Destructor: 0.0504447
Sticky: 0.71663

Level 1 Gaze Logging
Ball: 28.18307
Racket: 63.61323
Blocks: 5.067404
Slow: 3.485107
Fast: 0.6669638
Enlarge: 1.631471
Shrink: 2.898001
Destructor: 0.1497366
Sticky: 0

Participant 10 – slow:

Level 1 Gaze Logging
Ball: 19.64212
Racket: 20.28986
Blocks: 79.95374
Slow: 1.632546
Fast: 0
Enlarge: 2.955282
Shrink: 0.7669034
Destructor: 1.931401
Sticky: 0

Level 1 Gaze Logging
Ball: 21.44183
Racket: 26.42944
Blocks: 14.25012
Slow: 0.2658803
Fast: 2.615088
Enlarge: 0.8498118
Shrink: 1.216327
Destructor: 0.1836949
Sticky: 1.068611

Level 1 Gaze Logging
Ball: 36.04441
Racket: 21.6061
Blocks: 11.06443
Slow: 3.881307
Fast: 1.032955

Enlarge: 0
Shrink: 0.8499538
Destructor: 0
Sticky: 0

Participant 10 – medium:

Level 1 Gaze Logging
Ball: 12.10839
Racket: 82.86877
Blocks: 79.90364
Slow: 3.616464
Fast: 0.6006816
Enlarge: 0.1170498
Shrink: 0.816817
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 16.90644
Racket: 52.30312
Blocks: 41.21085
Slow: 1.900996
Fast: 1.133301
Enlarge: 0
Shrink: 4.798335
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 24.90568
Racket: 50.64729
Blocks: 8.047902
Slow: 1.4011
Fast: 0.6495919
Enlarge: 1.632385
Shrink: 0.4835296
Destructor: 1.000572
Sticky: 0

Participant 10 – fast:

Level 1 Gaze Logging
Ball: 54.94739
Racket: 62.66701
Blocks: 57.34034
Slow: 1.717786
Fast: 1.699365
Enlarge: 2.11679
Shrink: 0
Destructor: 0.9829948
Sticky: 0.7658422

Level 1 Gaze Logging
Ball: 45.62025
Racket: 67.95138
Blocks: 80.00251
Slow: 1.932049
Fast: 1.233037
Enlarge: 0.6832553
Shrink: 0
Destructor: 0
Sticky: 0.416629

Level 1 Gaze Logging
Ball: 55.56848
Racket: 50.47579
Blocks: 57.25661
Slow: 2.648495
Fast: 0.7495916
Enlarge: 0.5833156
Shrink: 2.599191
Destructor: 0.6502873
Sticky: 0

Participant 11 – slow:

Level 1 Gaze Logging
Ball: 22.62223
Racket: 26.48476
Blocks: 22.53077
Slow: 5.066495
Fast: 0
Enlarge: 0.0333037
Shrink: 0.7985107
Destructor: 1.499757
Sticky: 1.415226

Level 1 Gaze Logging
Ball: 27.28844
Racket: 40.16528
Blocks: 80.00893
Slow: 2.682215
Fast: 1.666193
Enlarge: 5.503611
Shrink: 1.65126
Destructor: 0.1506102
Sticky: 0

Level 1 Gaze Logging
Ball: 18.09153
Racket: 11.45298
Blocks: 55.47356
Slow: 0.283357

Fast: 0.5338491
Enlarge: 0.8676678
Shrink: 2.098196
Destructor: 0.9497247
Sticky: 0.6343929

Participant 11 – medium:

Level 1 Gaze Logging
Ball: 22.62223
Racket: 26.48476
Blocks: 22.53077
Slow: 5.066495
Fast: 0
Enlarge: 0.0333037
Shrink: 0.7985107
Destructor: 1.499757
Sticky: 1.415226

Level 1 Gaze Logging
Ball: 27.28844
Racket: 40.16528
Blocks: 80.00893
Slow: 2.682215
Fast: 1.666193
Enlarge: 5.503611
Shrink: 1.65126
Destructor: 0.1506102
Sticky: 0

Level 1 Gaze Logging
Ball: 18.09153
Racket: 11.45298
Blocks: 55.47356
Slow: 0.283357
Fast: 0.5338491
Enlarge: 0.8676678
Shrink: 2.098196
Destructor: 0.9497247
Sticky: 0.6343929

Partcipant 11 – fast:

Level 1 Gaze Logging
Ball: 41.36404
Racket: 97.41636
Blocks: 25.23033
Slow: 5.281194
Fast: 3.381054
Enlarge: 0.5004089
Shrink: 1.183462
Destructor: 2.166671

Sticky: 0

Level 1 Gaze Logging
Ball: 45.32401
Racket: 75.98265
Blocks: 30.97778
Slow: 3.231428
Fast: 3.733148
Enlarge: 3.96674
Shrink: 2.065669
Destructor: 0.2668878
Sticky: 1.232843

Level 1 Gaze Logging
Ball: 46.86933
Racket: 47.54942
Blocks: 80.0077
Slow: 3.266431
Fast: 0.433123
Enlarge: 4.547896
Shrink: 0.1003677
Destructor: 0.1334698
Sticky: 0.7656317

Participant 12 – slow:

Level 1 Gaze Logging
Ball: 11.4115
Racket: 5.063105
Blocks: 13.52827
Slow: 2.445259
Fast: 0.9318228
Enlarge: 0.8835701
Shrink: 2.065989
Destructor: 1.066896
Sticky: 0

Level 1 Gaze Logging
Ball: 8.14743
Racket: 12.38761
Blocks: 80.00331
Slow: 0.2166822
Fast: 0.7167906
Enlarge: 0.0327854
Shrink: 0.5325366
Destructor: 0
Sticky: 0

Level 1 Gaze Logging
Ball: 14.24117
Racket: 13.00076

Blocks: 18.76003
Slow: 1.031622
Fast: 0
Enlarge: 1.265518
Shrink: 0.0662475
Destructor: 0
Sticky: 0.399987

Participant 12 – medium:

Level 1 Gaze Logging
Ball: 24.90568
Racket: 50.64729
Blocks: 8.047902
Slow: 1.4011
Fast: 0.6495919
Enlarge: 1.632385
Shrink: 0.4835296
Destructor: 1.000572
Sticky: 0

Level 1 Gaze Logging
Ball: 27.26564
Racket: 21.82124
Blocks: 79.8867
Slow: 6.002906
Fast: 0.6172082
Enlarge: 1.997235
Shrink: 0.3498529
Destructor: 0
Sticky: 0.1505951

Level 1 Gaze Logging
Ball: 33.09294
Racket: 49.56408
Blocks: 13.96683
Slow: 1.699397
Fast: 0
Enlarge: 0.4166989
Shrink: 3.254223
Destructor: 0.1821044
Sticky: 0.3332804

Participant 12 – fast:

Level 1 Gaze Logging
Ball: 51.03405
Racket: 75.16602
Blocks: 79.90376
Slow: 4.64929
Fast: 0
Enlarge: 1.066603

Shrink: 3.034614
Destructor: 0.1832571
Sticky: 0

Level 1 Gaze Logging
Ball: 55.40553
Racket: 46.2388
Blocks: 10.76914
Slow: 2.94781
Fast: 0.6997057
Enlarge: 4.166424
Shrink: 0.9663248
Destructor: 0.6997743
Sticky: 0

Level 1 Gaze Logging
Ball: 36.40891
Racket: 46.71301
Blocks: 42.02892
Slow: 3.149061
Fast: 2.09996
Enlarge: 2.899125
Shrink: 1.765733
Destructor: 2.099781
Sticky: 0.6156248

Evaluation data analysis:

Disclaimer: All numbers here are the average of the raw data in this link:
https://drive.google.com/drive/folders/1mYRvpkvEPytdrRP6BhV4CSlZxqPxjKIA

Slow Average:
5 second spawn rate on powerups:

Par.	**ball**	**racket**	**block**	**slow**	**fast**	**enlarge**	**shrink**	**destructor**	**sticky**	**Score**
1	8.75s	37,2s	33,81s	1,70	1,41s	1,35s	0,55s	0,36s	0,27s	3200
2	6,01s	0s	38,63s	0.33s	0,73s	0,36s	0,55s	0,003s	0s	7900
3	17,17s	23,88s	53,74s	0,85s	0,60s	1,16s	0,37s	0,74s	0s	-3500
4	17,25s	50,01	31,33s	0,89s	0,30s	0,59s	0,52s	0s	0s	1700
5	9,85s	40,82s	30,23s	1,95s	1,25s	0,57s	0,39s	0,22s	0s	5000
6	5,4s	25,87s	47,26s	0,34s	0,56s	0,22s	0,09s	0,13s	0s	4300
7	12,95	23,31s	37,07s	1,49s	0,73s	0,72s	0,86s	0,34s	0,29s	5900
8	2,49	37,62	43,8	0,13	0,25	0,23	0s	0,19	0	-800
9	8.13	21,49	42,73	1,44	0,52	0,64	1	0,08	0,04	-2400
10	25,70	22,76	35,08	1,92	1,21	1,26	0,93	0,70	0,35	4500
11	22,66	26,03	52,66	2,67	0,73	2,13	1,51	0,86	0,68	4800
12	28,41	40,67	33,96	3,03	0,41	1,34	1,35	0,39	0,16	6100

Medium Average:
3.5 second spawnrate on powerups:

Par.	**ball**	**racket**	**block**	**slow**	**fast**	**enlarge**	**shrink**	**destructor**	**sticky**	**Score**
1	14,27s	42,90s	33,79s	1,51s	1,29s	0,68s	0,61s	1,08	0.85s	4200
2	7,71s	0s	38,22s	0,79s	0,77s	0,46s	1,25s	1,75s	0,36s	6900
3	17,19s	48,30s	48,19s	2,38s	1,00s	1,91s	2,01s	0,1s	0,43s	-4500
4	21,6s	76,49s	29,06s	0,36s	0,54s	0,29s	0,97s	0,29s	0,23s	5700
5	18,30s	45,4s	65,62s	2,23s	1,99s	0,74s	1,17s	0,76	0,15s	4300
6	6,98s	8,70s	30,24s	1,05s	0,37s	0,38s	0,04s	0,02s	0s	1700
7	9,33s	28,43s	48,34s	0,55s	1,05s	0,33	0,35s	0,38	0s	5700
8	7,39	41,35	34,20	0,21	0,30	0,82	0,31	0,04	0	1700
9	7,14	27,67	38,39	1,27	1,83	0,75	0,84	0,01	0,13	-12100
10	17,96	61,93	43,05	2,30	0,79	0,58	2,02	0,33	0	2400
11	22,66	26,03	52,66	2,67	0,73	2,13	0,84	0,86	0,68	1600
12	28,41	40,67	33,96	3,09	0,41	1,34	1,35	0,39	0,16	11000

Fast Average:
2 second spawn rate on powerups:

Par.	**ball**	**racket**	**block**	**slow**	**fast**	**enlarge**	**shrink**	**destructor**	**sticky**	**Score**
1	32,42s	58,17s	31,61s	14.1s	1.76s	1,36s	1,49s	0,83s	0,93s	6900
2	17,91s	6,02s	52,61s	2,23s	14,14s	0,57s	1,39s	0.58s	0.06s	3400
3	40,33s	80,36s	51,97s	1,3s	2,59s	1,59s	1,05s	2,33s	1,68s	1300
4	38,50s	105,61s	44,45s	1,51s	1,33s	0,79s	0,49s	0,38s	0,17s	8800
5	28,71s	51,36s	36,29s	2,89s	1,96s	2,38s	1,27s	0,49s	0,57s	4700
6	12,13s	83,79s	59,73s	0,91s	0,39s	0,11s	1,37s	0,06s	0s	-3000
7	15,10s	70,42s	38,64s	1,73s	1,20s	0,16s	0,95s	0,12	0s	7600
8	14,81s	101,97	46,16s	0,65	0,80	0,38	0,21	0,29	0,01	1200
9	21,85	65,62	48,13	2,23	3,57	0,8	1,97	0,21	0,40	1200
10	52,04	60,36	64,86	2,09	1,22	1,12	0,86	0,54	0,39	5500
11	44,51	73,64	45,4	3,91	2,51	3	1,11	0,85	0,66	2000
12	30,94	56,03	44,22	3,57	0,92	2,70	1,91	0,98	0,20	7500

Ultimate averages:

Averages of all participants performance in each segment:

Slow SP	**ball**	**paddle**	**block**	**slow**	**fast**	**enlarge**	**shrink**	**destructor**	**sticky**	**score**
Count, N:	12	12	12	12	12	12	12	12	12	12
Sum, Σx	164.77	349.66	480.3	16.74	8.7	10.57	8.12	4.013	1.79	36700
Mean, μ:	13,73s	29,13s	40,025 s	1,39s	0,72s	0,88s	0,67s	0,33s	0,14s	3058,33
Std. Deviation, σ:	8.113	12.490	7.658	0.884	0.361	0.548	0.445	0.279	0.204	3424.776
Variance, σ^2:	65.825	156.0151	58.645	0.782	0.130	0.300	0.198	0.078	0.041	11729097.222

Medium SP	**ball**	**paddle**	**block**	**slow**	**fast**	**enlarge**	**shrink**	**destructor**	**sticky**	**score**
Count, N:	12	12	12	12	12	12	12	12	12	12
Sum, Σx	178.94	536.97	495.72	39.2	11.07	10.41	12.75	6.01	2.99	28600
Mean, μ:	14,91s	37,32s	41,31s	3.015 s	0.922	0.867	0,98s	0,5s	0,249s	2383,33
Std. Deviation, σ:	6.929	23.947	10.293	5.272	0.524	0.583	0.573	0.503	0.269	5644.441
Variance, σ2:	48.021	573.489	105.949	27.804	0.275	0.340	0.328	0.253	0.072	31859722.22

Fast SP	ball	paddle	block	slow	fast	enlarge	shrink	destructor	sticky	score
Count, N:	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**
Sum, Σx	**349.25**	**813.35**	564.07	37.12	32.39	14.96	14.07	7.66	5.07	47100
Mean, μ:	29,10s	67,77s	47,00s	3,09s	2,69s	1,24s	1,17s	0,63s	0,42s	3925
Std. Deviation, σ:	12.445	24.883	9.025	3.450	3.553	0.944	0.494	0.582	0.473	3362.321
Variance, σ^2:	154.892	619.166	81.452	11.908	12.628	0.892	0.244	0.339	0.224	11305208.333

- They looked more at every single object and yielded the highest score at the fastest spawn-rate
- They generally looked more at the objects around them in the medium spawn rate, but got a lower average score than the low spawn-rate
    - There was an outlier that managed to get -12100
    - Participant 3 was “trolling” in their first run, which was *“medium, slow, fast”*

Participant scores:

Participant 1
- 3200 slow
- 4200 medium
- 6900 fast
14300

- Did not have knowledge of power-ups or core game mechanics (Gradual speed increase, score death decrease, timed level) during slow segment

Participant 2
- 7900 Slow
- 6900 Medium
- 3400 fast
17800

Participant 3
- -3500 Slow
- -4500 Medium
- 1300 Fast
- messed around during 1st level of 1st run
-5700

Participant 4
- 1700 Slow
- 5700 Medium
- 8800 Fast
16200

Participant 5
- 5000 Slow
- 4300 Medium
- 4700 Fast

Participant 6
- -3000 Fast
- 1700 Medium
- 4300 Slow
3000

Participant 7
- 5900 Slow
- 5700 Medium
- 7600 Fast
19200

Participant 8
- -800 Slow
- 1700 Fast

- 1200 Medium
2300

Participant 9
- -12100 Medium
- -2400 Slow
- 1200 Fast
-13300

Participant 10
- 4500 Slow
- 2400 Medium
- 5500 Fast
12400

Participant 11
- 2000 Fast
- 4800 Slow
- 1600 Medium
8400

Participant 12
- 7500 Fast
- 11000 Medium
- 6100 Slow
24700

B Appendix B

B.1 Two-way ANOVA data

Two-way ANOVA data

Data calculated from the two-way ANOVA test:

Scores and gaze logging:

Measure	Variance (Slow)	Variance (Medium)	Variance (Fast)	P-value
Scores	1279	3475	1233	0.4678829001
Ball	71.80911742	52.38688788	168.9734629	0.0000005
Racket	170.1983788	445.0811841	675.4546629	0.0000021
Slow Ball	5.333011364	1.93990569	12.99073333	0.3384662064
Fast Ball	0.8923295455	0.6122495362	13.77651742	0.3156764545
Small Racket	1.355151515	0.7966604824	0.2668022727	0.2842405788
Large Racket	2.050961174	0.7569990724	0.9734060606	0.001138442212
Destructor	4.083688447	0.5635791589	0.3699787879	0.1504905714
Sticky	0.2852793561	0.1618351886	0.2445840909	0.9095531916
Brick	63.97671818	115.5807636	88.85675379	0.1703812528

iGEQ questionnaire:

Measure	Variance (Slow)	Variance (Medium)	Variance (Fast)	P-value
Success Feeling	2.27	1.45	2.02	0.90
Bored	0.79	0.97	0.42	0.13
Impressive	1.30	1.36	0.99	0.66
Forgot Surroundings	1.17	1.90	1.90	0.86
Frustration	1.45	1.24	1.24	0.86
Tiresome	0.73	0.88	1.17	0.52
Irritable	1.90	1.70	2.15	0.34
Skillful	1.52	1.36	1.24	0.81
Absorbed	2.73	1.84	2.09	0.29
Contentment	0.81	0.79	1.48	0.81
Challenge	0.55	0.27	0.45	0.90
Stimulated	1.33	1.00	0.97	0.75
Felt Good	1.88	1.90	1.33	0.94

NASA task load manager:

Mental Demand	1.424242424	0.9318181818	1.151515152	0.1573148387
Physical Demand	0.9090909091	1.174242424	1.356060606	0.1765911004
Task Pace	0.6287878788	0.9924242424	0.7272727273	0.8312054341
Feeling of Success	1.787878788	1.295454545	0.9924242424	0.9120588647
Workload	0.2424242424	0.2727272727	0.5151515152	0.2737299079
Negative Emotion	1.901515152	1.696969697	2.151515152	0.3386321712

C Appendix C

C.1 Code snippets

Code snippets:

Paddle movement:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class RacketMovement : MonoBehaviour
{
    public float speed = 150;
    // Update is called once per frame
    void FixedUpdate()
    {
        float horizontalInput = Input.GetAxisRaw("Horizontal");
        GetComponent<Rigidbody2D>().velocity = Vector2.right * horizontalInput * speed;
    }
}
```

Ball movement:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class BallMovement : MonoBehaviour
{
    public float speed = 100.0f;
    // Start is called before the first frame update


    void Start()
    {
        GetComponent<Rigidbody2D>().velocity = Vector2.up * speed;
    }

    float hitFactor(Vector2 ballPos, Vector2 racketPos,
                float racketWidth)
    {
        // ascii art:
        //
        // 1  -0.5  0  0.5   1  <- x value
        // ==================  <- racket
        //
        return (ballPos.x - racketPos.x) / racketWidth;
    }

    void OnCollisionEnter2D(Collision2D col)
    {
        //Increase Speed on block collision
        if(col.gameObject.name != "border_right" || col.gameObject.name != "border_left" || col.gameObject.name != "border_top" || col.gameObject.name != "racket")
        {
            speed += 0.5f;
        }
        //Direction setting on hitting racket
        if (col.gameObject.name == "racket")
        {
            float x = hitFactor(transform.position, col.transform.position, col.collider.bounds.size.x);
            Vector2 dir = new Vector2(x, 1).normalized;
            GetComponent<Rigidbody2D>().velocity = dir * speed;
        }

    }
```