ATTENTION !!!

Anthony Calabresi
M.S. Game Science & Design
Northeastern University
calabresi.a@husky.neu.edu

Riddhi Padte
M.S. Game Science & Design
Northeastern University
padte.r@husky.neu.edu

Zhi Chang
M.S. Game Science & Design
Northeastern University
chang..zhi@husky.neu.edu

ABSTRACT
Attention enables us to focus on information and perceive it. However, our attentional resources are limited which restrict our ability to process large amounts of information concurrently. In this study, we designed a game called *ATTENTION !!!* which purposefully splits players' attention, in increasing degrees, each level in an attempt to measure the average person's total amount of attentional resources. We invited participants to play *ATTENTION !!!* and recorded their best performance with in-game data collection methods. The data collected clearly demonstrates that the majority of participants fail to progress past a certain level, which suggests the limit of a person's total attentional resources. Further study is needed to verify our findings.

Keywords
Attention; Competence; Perception; Top-Down Processing; Bottom-Up Processing

1. INTRODUCTION

The various sensory organs in the human body are constantly receiving information from the outside world. When these organs sense and record a stimulus it has to enter the channel of attention in order to be perceived. Attention has been a major area of interest to psychologists. It is one of the most fascinating and highly researched area in psychology. In this paper, we aim to measure to how many things at a time, the player is able to pay attention and play the game. Despite the impressive complexity and processing power of the human brain, it is severely capacity limited (Rene and Jason, 2005). While our primary focus is to measure the limit to a person's attention, we will also try to find out how many things can the mind simultaneously process taking the cognitive load especially when the attention splits in a number of things.

2. PSYCHOLOGICAL CONCEPT

Attention is a concept studied in cognitive psychology which refers to how we actively process specific information in our environment (Anderson, 2005). It is the behavioral and cognitive

process of selectively concentrating on a discrete aspect of information whether deemed subjective or objective while ignoring other perceivable information. Attention remains a major area of investigation within psychology, neuroscience and education. The term "visual attention" refers to a set of cognitive operations that mediate the selection of relevant and the filtering out of irrelevant information from cluttered visual scenes (2009, McKains and Kastner). Conscious visual experience starts with the image thrown by the scene upon the retina, where local computations immediately begin to transform the representation of stimuli according to their salience(Serences and Yentes, 2006).

Visual attention is an essential part in the mechanism of human cognition. When receiving a barrage of incoming information, individuals rely on visual attention to give order to their environment. Modern video games often provide the player graphically realistic and attentionally demanding environments, and so perhaps it is fitting that scientific interest in the medium, especially its effects on aspects of visual attention (Bjorn, Shawn Green, Daphne, 2011).

Visual cognition is limited by computational capacity, because the brain can process only a fraction of the visual sensorium in detail, and by the inherent ambiguity of the information entering the visual system(Summerfield and Egner, 2009).

3. GAME DESIGN

3.1 Inspiration

ATTENTION !!! is a 3D Skill Based Shooter which progressively introduces the player to game mechanics designed to split the player's attention. Game Level Number (Lvl 1, Lvl 2, Lvl 3, etc...) track the number of game mechanics the player must manage to be successful. For example please note the Classic Arcade Game *Defender*, depicted in Figure 1.

Figure 1: Screen Shot of Defender - Classic Arcade game

Defender forces the player to monitor a "minimap" of the game level (depicted at the top of the screen) while also monitoring their "ship" (seen on left in the game main window) as well as any/all "enemy" units (green three legged objects and purple objects in the main game window on right) as well as the "people" that the player must protect (currently being carried by a green enemy in the center of the game window). The minimap shows the location of the Player, Enemies, People, and the current area that the main game window is displaying (depicted as the vertically placed white/grey square brackets)

3.2 Overview

ATTENTION !!! follows the same structure as *Defender*. However, whereas *Defender* maintains a finite number of objects that the player is able to manage successfully, *ATTENTION !!!* operationalizes a person's attention span and attentional resources via the Game Level Number by increasing the number of *simultaneous* player management tasks on every subsequent level. For Example:

- Level 1: The player learns movement controls and is tasked with flying to a checkpoint to confirm their comprehension. The player learns to use the "Minimap" at the top of the screen to locate objects of interest.
- Level 2: The player learns that movement entails a Fuel Cost by being tasked with purposefully exhausting their fuel supply (displayed at the top left of their screen).
- Level 3: The player learns how to fire laser blasts from their ship. The player is tasked with firing their lasers 10 times.

- Level 4: The player learns that firing their lasers drains their ship's power (displayed at the top left of their screen). The player is tasked with purposefully exhausting their power supply.
- Level 5: The player is tasked with locating and destroying asteroids by: locating their position on the minimap, moving to their location, targeting the asteroids, and firing their lasers at the asteroids to destroy them. The player must complete this scenario without their ship colliding with any other objects.
- Level 6: The player is tasked with destroying all moving asteroids on the game level, without colliding with any game objects.
- Level 7: Similar to Level 6, the player is tasked with destroying 2 Alien Ships, in addition to asteroids, which pursue and fire back at the player.
- Level 8: Same as Level 7. However, the total amount of Alien Ships combatting the player increases from 2 to 5, and the total amount of asteroids increases from 5 to 10.
- Level 9: Same as Level 8. However, the total amount of Alien Ships increases from 5 to 10.
- Level 10: Same as Level 9 with the additional requirement that the player must prevent the abduction of People from the moon's surface, by Alien Ships. If all Persons on the level are abducted, the player loses.
- Level 11: Same as Level 10 with the additional requirement that the player must prevent their Base (now located in the game space) from being destroyed by Alien Ships.
- Level 12: Same as Level 11 with the additional requirement that the player must complete all tasks under a time constraint (Implemented as a timer on the HUD).

People's cognitive load increases drastically the more they try to multitask (Hodent 2017). *ATTENTION !!!* purposefully splits the player's attention between multiple tasks via increasing "lose conditions" progressively via game levels. The game's design runs contrary to current fundamental User Experience design methodology, to force a "Top-Down" (meaning - "Cognition > Perception > Sensation" - the player must first think about what they want to pay attention to and then execute physical control of the game system) attentional resource processing in the player. These situations are further co-opted by introducing "Bottom-Up" attentional events (Audio and Visual Cues which demand the player's attention) that interfere with the player's ability to locate and therefore act on pertinent information. For Example: Instructions are given to the player via voice overs which were purposefully constructed in length to interfere with the player's cognition during play, as this situation creates a split attention situation (Hodent 2017).

3.3 Controls

"A" and "D" (as well as Left and Right arrow keys) are used for Horizontal movement. Vertical movement is controlled via mouse vertical movement. The Left mouse button fires laser blasts. The control scheme was kept as minimal as possible to allow all participants to learn game mechanics quickly, as well as to minimize the amount of attentional resources devoted to managing one's own hand-eye coordination (Hodent 2017).

3.4 Game Elements and Design Methodology

3.4.1 General Overview

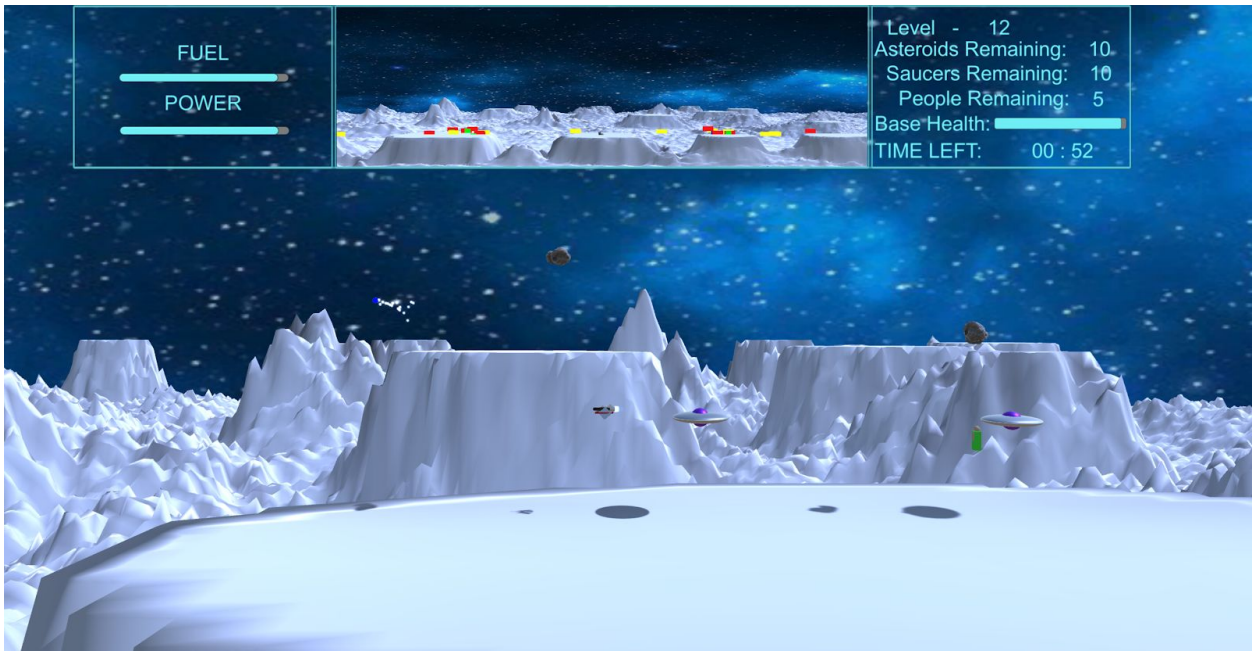

Figure 2: Screen Shot of ATTENTION !!! - Final Level

ATTENTION !!! follows the same general design of *Defender* but modifies game mechanics (Please See Figure 2). *ATTENTION !!!* uses 3D assets but game objects remain fixed to a 2D plane. This design choice limits the complexity of the game space. Thus, the cognitive load on the player is kept minimal. However, 3D elements offer visual stimulus which co-opt the player's "Bottom-Up" (Sensation > Perception > Cognition) detectional attention. One participant noted, when asked why they were seemingly unable to move their ship into firing position of an asteroid, that they believed their ship would collide with the top of a plateau that was located in the background. This was the result of the player being located in a specific location while not moving. The perspective camera created a seemingly orthogonal viewpoint in this situation. These types of visual stimuli increase the cognitive load upon the player.

Some of *ATTENTION !!!*'s elements (Asteroids, Laser Blast SFX, Energy Blast SFX, Explosion SFX, and Explosion Visual Effects) are Unity's *Space Shooter* Tutorial assets (to facilitate game development within a fixed timeframe). Player instructions are provided via voice over - to increase a person's cognitive load.

3.4.2 HUD Design and Player Placement = "Top-Down"

Figure 2 displays *ATTENTION !!!*'s last level to highlight all relevant game elements. The HUD (located at the top of the display space) depicts (from Left to Right) the player's Fuel Meter, Power Meter, Minimap, and Win/Lose Condition tracking elements. *ATTENTION !!!* maintains seven interactive game objects (of varying quantities at any one time): Player Ship (center), Player Laser Blasts (not shown), Alien Saucer (two to the right of center - Purple spheres within Silver oblong), Alien Saucer Energy Blasts (left side of screen - Blue dot with White Particle effect), Person(s)(currently being "Abducted" on right - Green object under Saucer on right), Player Base (center of the game space - not shown), Asteroids (shown at Center Top and Right of center)

The player's ship is located and fixed to the center of the screen. This is done to allow the player to easily locate their avatar as well as fix their attention to the center of the screen as often as possible. This prevents the player from monitoring all information critical to their success simultaneously from one fixed visual location. Therefore, players must quickly search the display to find important information and then refocus their attention to the center of the screen. We know that people generally do not notice visual information located in their peripheral vision, especially when focused on a task (Hodent 2017). We further capitalize on this fact by using a non-contrasting palette for HUD elements. This increases the time the player spends searching for relevant information, which further splits their attentional resources and increases the likelihood that they will fail to notice important changes in the game state; such as realizing that Fuel Reserves are about to be exhausted or that Power has drained to zero.

The HUD design forces the player to focus their visual attention to the Top Left, Top Center, Top Right, and Center of the game display repeatedly to monitor objectives as well as resources. For Example: The player's ship will expend fuel as the player moves their ship in a diagonal path. If the ship's fuel is exhausted the player loses control of their ship, which continues to move in the direction that it was previously traveling. This mechanic almost always results in the player's ship crashing and thus a restart of the current level. Therefore, the player must monitor their fuel reserves intermittently to prevent fuel exhaustion. However, the player must also

monitor their ship's location within the game space to prevent themselves from crashing. The player must also use the Minimap to quickly locate objects of interest, avoid obstacles, and travel to objectives. The player must also use the HUD's Right display to intermittently monitor lose conditions. Therefore, the player's attentional focus is split between at least four different visual elements at all times.

The HUD design increases the amount of time a player requires to gather information (Please See Figure 2). For example: The Minimap displays gameobject locations using different colored boxes. These are relatively small which increases the player's cognitive process of searching for and filtering visual information. The color of the minimap boxes do not correlate to the color of most game objects that they represent (Hodent 2017). The Minimap does not display the locations of any game objects perfectly. This is a design decision to prevent the player from only using the Minimap to navigate the game space (the player must use both the Minimap, to locate objectives, and the game display, to avoid collisions/shoot targets). The Right side of the HUD displays both Win conditions and Lose conditions as numbers, which use the law of proximity to increase the amount of time the player requires to differentiate these from one another; and therefore serves to focus their attention on that screen location. The Right hand section of the HUD presents superfluous information (the "Remaining" text). This also uses the Law of Proximity by separating the relevant text describing a Win or Lose condition from the number representing it. This increases the amount of time the player remains focused on this section of the screen, which drives up the time of cognition and attentional cost.

3.4.3 Detection Events = "Bottom-Up"

Figure 3: ATTENTION !!! - Asteroid Explosion and Player Laser Blast

The visual stimuli presented to the player in *ATTENTION !!!* was designed to distract the player from relevant information. Or, in other words, bottom-up processing events force the player to reinitialize top-down processing tasks. For Example: Figures 3-6 display a number of detectional attention events. Figure 3 displays the animation of particles evident when the player destroys an asteroid with their laser blast. It should be noted here also that the player's laser blas is red. Red

contrasts with the game's palette selection of blue. We also know that the color red itself demands people's attention more so than other colors (Hodent 2017).

Figure 4: ATTENTION !!! - Alien Saucer "RED Flash"

Figure 4 demonstrates the use of red to distract the player. When the player shoots a flying saucer, the saucer flashes red quickly to present the feedback to the player that they have damaged the saucer.

Figure 5: ATTENTION !!! - Alien Saucer Explosion 1st Phase

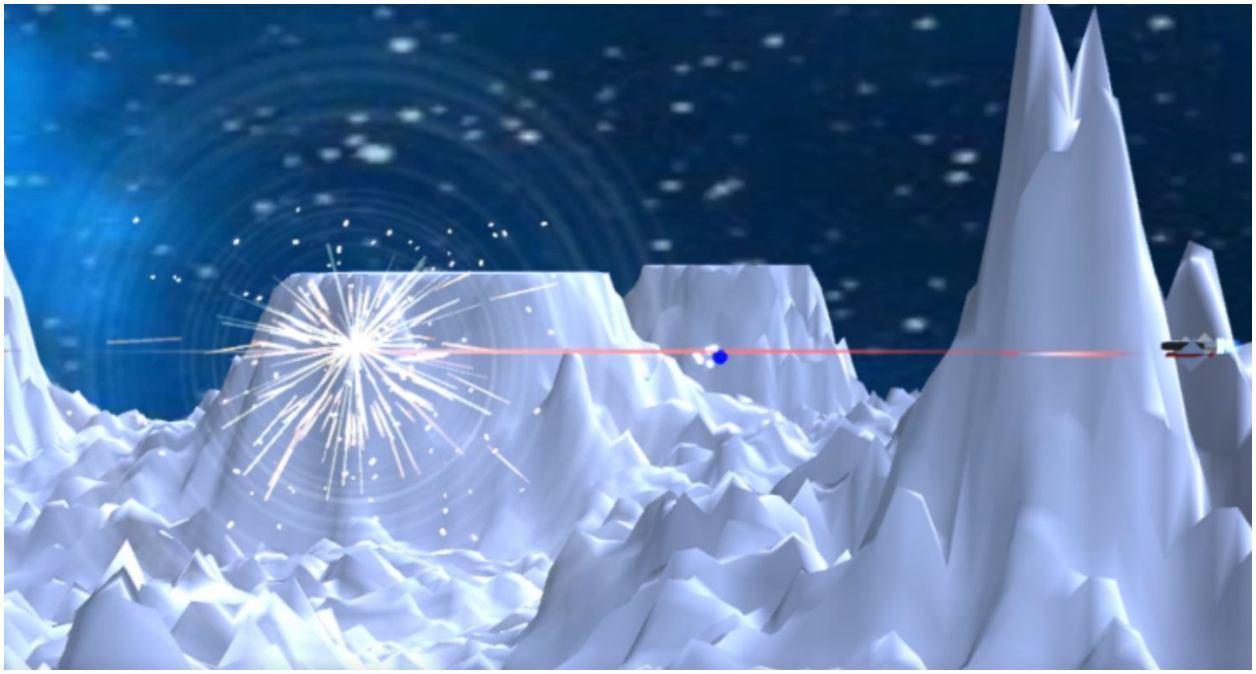

Figure 6: ATTENTION !!! - Alien Saucer Explosion 2nd Phase

Figures 5 and 6 demonstrate the animation which accompanies the player's destruction of a saucer. This animation plays in conjunction with audio cues that further distract the player, via bottom-up processing. Figures 2, and 4-6 also display the saucer's energy blasts. Energy blasts were purposefully designed as blue orbs to make them difficult to differentiate from the background. This serves to force the player to focus on their location on these locations to avoid collisions. Energy blasts also maintain a particle trail effect which serves to co-opt the players bottom-up processing.

3.4.4 One Final Note

ATTENTION !!!'s game space "wraps" such that the player (as well as all other game objects) appear on the opposite side of the game space if they move to the extreme Left or Right. Although not specifically tested for; this has the effect of recreating the phenomenon of inattentional blindness. The game's level terrain is purposely constructed to be similar on both sides of the game space. However, the background elements change drastically. It was noted during playtesting that participants who were focused on specific tasks did not notice their traversal of the game space in this manner by stating that they were momentarily unable to locate their ship.

3.5 Additional Rules

- Alien Ships fly to the moon's surface to "abduct" people upon detecting a "person" within range and then fly straight up until they are out of the game's display space. The player loses any particular game level if they fail to rescue at least one person.
    - The player can destroy an Alien ship that is in the process of abducting a person. The Person falls to the ground after the Alien ship is destroyed.
    - Alien ships return to the Game Space, after the abduction process is completed, and continue to pursue the player, or attack the player's base (if within range).
- Players are allowed to Restart any level which they fail.

4. METHODS

4.1 Context

10 Participants were invited to play *ATTENTION !!!* for as long as they wished, after a short briefing explaining that participation is completely anonymous and that the game attempts to measure the participant's attentional resources. *ATTENTION !!!* functions as the Independent Variable.

Control Variables include:

- Participant's video game familiarity
- Participant's hand eye coordination

Researchers recorded the following:
Dependent Variables include:

- Total Playing Time
- The last Game Level played
- Total amount of times the player exhausted their Fuel
- Total amount of times the player exhausted their Power
- Total amount of player "deaths"
- Total amount of times the player restarted a level

Attentional resources were operationalized via: Last Game Level played, total amount of power failure events, total amount of fuel exhaustion events. Attention Span is operationalized via the total amount of playing time. Player motivation is operationalized via the number of player deaths and the number of times the player chose to continue playing by selecting "Retry".

4.2 Procedure

Participants were briefed prior to playing *ATTENTION !!!* Participants were informed that *ATTENTION !!!* attempts to measure the total amount of management tasks that they are capable of handling in real time. Participants were informed that the study is anonymous (Participant identity is not recorded. Participants playtest data is filed using a number system). Participants are informed that they may leave the study at any time, and that they may play *ATTENTION !!!* for as long as they wish - or until they have cleared the final game level.

Participants play *ATTENTION !!!* while a researcher observes. *ATTENTION !!!* records game data.

4.3 Materials

ATTENTION !!! was produced using Unity 2017.3, Visual Studio, and C#.
The Unity Collaborate service was used to distribute game resources and as a source control system between team members. Google Drive and Slack were used for team communication and coordination. Researchers used their personal computers to produce *ATTENTION !!!* and to analyze participant data. The Unity Analytics Service was used to collect game data. MS Excel was used to tabulate and calculate study results.

4.4 Data Analysis

Player game data was collected from the Unity Analytics service and exported to a MS Excel Spreadsheet. Averages of the Total Amount of Time Played, Last Level Played, Total Fuel events, and Total Power Events were calculated. The total amount of player deaths and re-starts were used per participant to further interpret the data.

5. RESULTS

We set up data collecting programs from Unity in the game and collected eight valid data items. The detailed data can be retrieved in Appendix. From the data table, we mainly focus on the latest level the player played. The average number of levels the players could reach was 8.75. Level 8 has 5 alien ships and 10 moving asteroids.

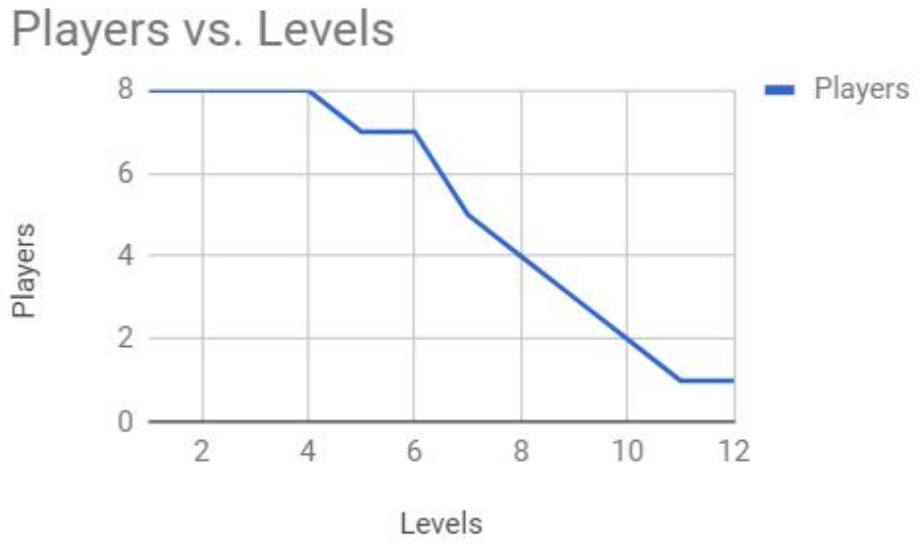

Figure 7: The number of levels played by the participants.

The above graph shows a decline in levels a player could pass in the game. There is a steep downslide after level 7 which shows for majority of the participants, level 7 was the limit to the attention resources. The results were quite consistent with all the participants. The failure rate of the participants increased as the levels kept getting difficult. As one of our aims while designing the levels was to load the player's attention progressively, load became quite heavier in the level 8 and above.

6. DISCUSSION

As video game experience plays a major role in how many things a layer can pay attention to, we made sure all our participants were experienced video game players (Celia Hodent, 2017). The original version of the game which had only 10 levels, was played by both non video game players as well as video game players. It was interesting to notice that in the earlier version both of the types couldn't play the game past level 7. Even if a few of them did, they had to retry the whole level number of times before doing that. In the next iteration of the game, we redesigned level 7 to slowly progress from level 6 to level 9, as well as adjusted the camera angle allowing for more "lead time" prior to saucers firing on the player. This was done to account for (possible) game mechanic imbalance, which may have been the cause of video game players being unable to progress. However, testing did show that video game players were able to progress after playing the game for longer periods of time. "Practice can have a dramatic positive effect on multitasking performance (as well as monotasking performance) because some processes can become automatic when practiced long enough (Celia Hodent, 2017)." This also means that, since our control scheme was non-traditional, video game players were forced to use

attentional resources to manage their hand-eye coordination, until controls became second nature. The level number was indeed tracking the attentional resources which we did not believe earlier.

7. CONCLUSION

The extent to which the players can keep up with the elements of the game surely needs to be systematically and carefully analysed before adding too many things that can split the players attention. The game Attention clearly shows that at a certain point the player has a tough time paying attention to the elements and ends up losing the level. Although, there can be a question of why the players are not able to play after a certain level. It could be attention or the learning curve too, in cases when the player is not an experienced video game player. More research can be done on that part as too specifically figure out why majority of the players fail at a certain level and only a few can surpass it, that too after several attempts. There is not denying the fact that the attention resources in our brain are quite limited and game designers always have to keep that in mind while designing a game.

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APPENDIX : Prototype Links

Link to Phase 1 Prototype
https://drive.google.com/drive/folders/1hibeoD05jTOY4rXYAeuyChDBbSbsVEpt?usp=sharing

Link to Final Prototype
https://drive.google.com/drive/folders/173ohho138ZNHlRIsQsDMRQQWa-i49Fum?usp=sharing

APPENDIX : Data Collection

No.	PlayedTime(sec)	LatestLevel	DeathTimes	NoFuelTimes	NoPowerTimes	RetryTimes
1	1461.531	9	62	6	12	56
2	518.0333	13	3	3	6	2
3	693.9803	7	24	2	1	21
4	247.3416	7	11	1	2	11
4	143.9877	11	3	2	2	1
6	323.5881	8	6	2	2	6
7	40.74457	5	2	1	1	2
8	223.0896	10	7	1	3	7