Strategy and Logic System

A Look Into Memory and Spatial Cognition

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Intent Statement

I intend to create a puzzle system which focuses on the memorization of an environment by momentarily lighting up a stage in order to complete platforming and visual challenges. This forces players to use spatial cognition and plan accordingly as they will not be able to visually see all obstacles at the same time.

Not only do I want the game to use these senses but also to improve them for the player, and improved performance within the game can be indicative as evidence of this.

Research // Thesis

Research

In my research, I wanted to focus on two very specific aspects of a strategy and logic system, one being spatial awareness and cognition as well as short term memory. The research I performed helped inform and guide my design process in order to make a successful game system. To begin my research I asked myself a few guiding questions, such as, “How reliable is our short term memory?” and “How do the visually impaired navigate a world made for those who can see?”, other inquiries were relating to the function of spatial cognition and what it actually is and does for us. Using these goading questions I was able to come across a wealth of fascinating information that helped me develop a better puzzle game.

In a journal published by the Journal of Neuroscience titled *Virtual Environmental Enrichment through Video Games Improves Hippocampal-Associated Memory,* researchers set out to find if the use of virtual environments can become enriching for humans similar to how it has been tested within animals in order to mitigate cognitive decline and enhance cognition. They theorize that though humans tend to have an already enriching environment, we quickly adapt to aspects of our daily life. It is hypothesized that the use of video games can act as environmental enrichment to humans. It should be noted that this study made a distinction that 3D games produced significantly more improvement then that of 2D games, regardless I think

the results achieved are interesting. Results from data did suggest that video games may provide meaningful stimulation to areas of the human brain that control memory.

This bodes well for my initial concept of a game that would set out to use and improve those skills within a player. Specifically, game players who explore a virtual world are better at mnemic (relating to the ability to retain memory) discrimination compared to non-video game players. The game used for testing was Super Mario 3D World, which is an open world 3D platformer. The only aspect that my game shares with this title is platforming but I do not believe that gives me any reason to doubt the design of the game.

While staying on the topic of video games and memory improvement, I came across another article published by Health titled *Yes, Brain Games Improve Memory, But Only Under Some Circumstances*. The title clearly alludes to some sort of catch that comes with improving memory using “Brain Games”, which in this article are defined as games that claim to sharpen thinking skills. It seems that there is still a lack of consensus in the scientific community about the value of memory sharpening programs. When the University of Syndey’s Brain and Mind Centre combined data from previously published trials spanning over 20 years it came up with a few patterns. For adults living with mild cognitive impairment, studies indicated that these people did experience improvement in global cognition, memory, learning and attention. However, for those tested who were experiencing dementia there was absolutely no improvement whatsoever. Amit Lampit, PhD, a research fellow in the School of Psychology, says that brain training can play an important role in helping to reduce early symptoms of memory loss. She goes on to state that, "Our research shows that brain training can maintain or even improve cognitive skills among older people at very high risk of cognitive decline,” in a press release, “and it's an inexpensive and safe treatment.”

Changing directions, I wanted to look into how memory must be taken into account when designing a game that uses it. I looked into what is called The Multi-Store Model of Memory proposed in 1968 which proposes that memory consists of three stores, sensory, short-term, and long-term. Using information about each of these models I can tweak aspects of my game to lend themselves to the forms of memory people use when experiencing stimulation. It should be noted that these forms of memory are said to behave linearly, in which

the practice of one can lead to the next respectively. Of the three forms of memory storage, short term memory is the most relevant to the intended design of the game, however, the previous form of Sensory Memory must be considered as it is what creates the foundation of all memory. The duration of Sensory Memory is exceptionally fast, it stores a constant heavy stream of information directly from our senses and are registered for a brief period, between ¼ to ½ of a second, most of the information taken in is lost by decay almost right away. Attention is the first step to remembering something and if a person's attention is focused on one of the sensory stores then that data is transferred to the next stage. What this tells me as a designer is that it is imperative to keep a player's attention, especially visually, this means that my game needs to have graphics that draw their attention, pointing to what is important and away from what isn't. When the player has only a brief window to see what the map of the game is, it is important that I take care to focus their attention on the stages, as this is what they need to remember.

Short term memory is created when sensory memory is encoded successfully. Short Term Memory (STM) has a significantly longer duration of 0 to 18 seconds but can be as much as 30 seconds. It's capacity is much smaller and an average person tends to only be able to hold 7 "items" at a time, but this is within a tolerance of +/-2 meaning it can be upwards of 9 or as low as 5 items. This gives me a good target for how many things I should be expecting my player to remember and understand. If there are more than 9 platforms, most are sure to fail. The game must be challenging but fair. This can also be used as a baseline for how long I should expect a stage to be, at absolute maximum it should take a player 30 seconds to complete, at its highest difficulty interval.

Testing

I was unable to establish a sizable sample size for testing for my game, however, in its early stages of development I was able to get a few people to perform an informal test of the core mechanics of the game and provide some feedback. I did my best to not directly guide the players in any way and let them rely on their own senses to navigate.

I sat players down with a build of the game, only telling them that it is a 2D platformer and what the controls are. I watched and observed how they experienced the game from there. I did this with four participants who are friends of mine.

Here are some of the key takeaways from this informal session.

- Most expected the game to be exceptionally more challenging then it turned out to be.
- It took each person an average of two attempts to complete the stage successfully with a few outliers.
- The understanding of the goal and the process to get there was almost immediate.

Description of Mechanics

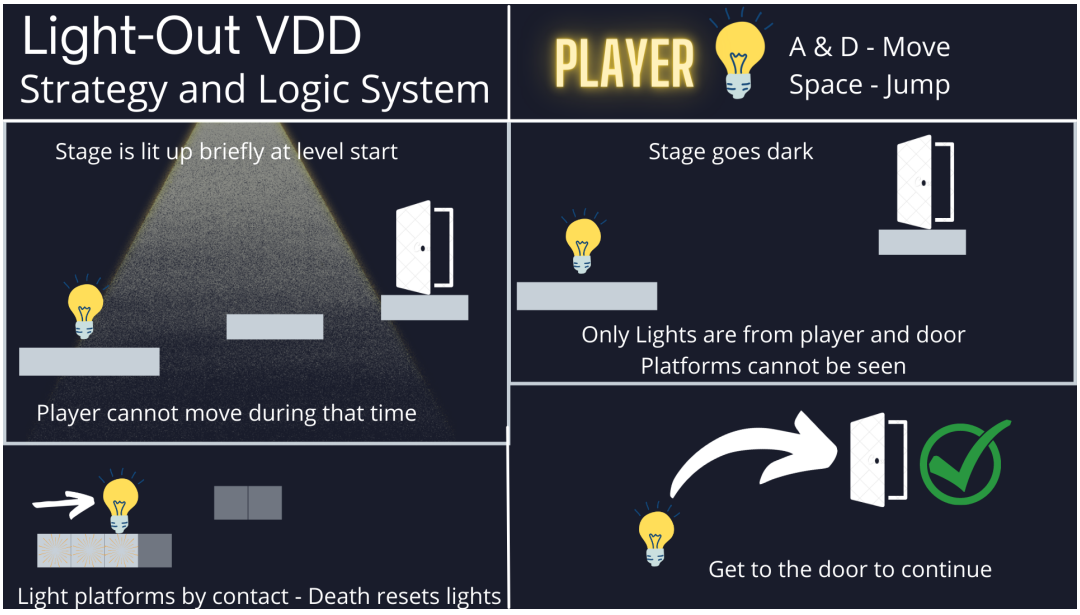
The mechanics I set out to create were meant to test the players short term memory as well as testing a players spatial cognition when they are not able to see. In order to do this I implemented the lighting system within Unity and controlled what a player can and cannot see. A light illuminates the stage for a brief moment at the beginning of the section, during this time the player cannot move so they must take in the stage visually. Once the light turns off most of the stage will be obscured in darkness except for the player character and the door to the next stage, which is the player goal to get to. The player will then have to use their memory and spatial awareness skills to navigate the level since they will not be able to see. The small light that the player gives off will be only just enough to see what is essentially directly next to you so it does not assist the player in navigation when jumping.

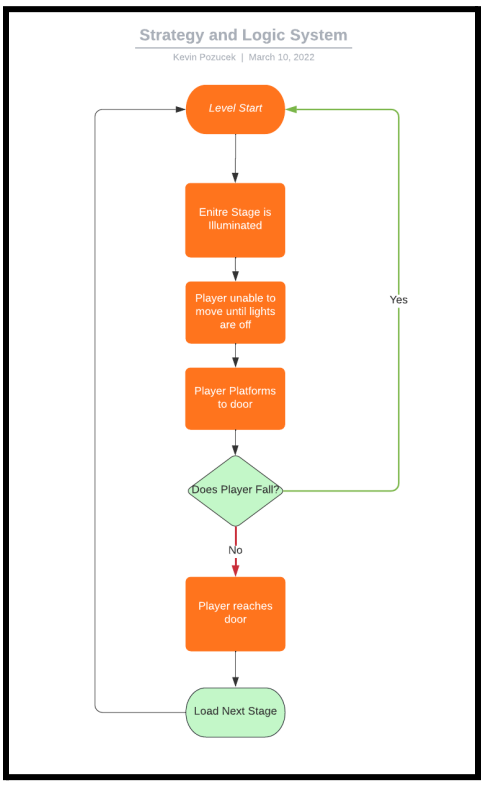
Another mechanic is lighting up the path that you have been on previously. When you make contact with platforms they will light, so you can trace your path. Tracing your path in this way is intended to solidify the stage in your memory if it takes you more than a single try to complete. The light contrasting on the darkness will create an image in the players head that they can trace on later attempts.

I have taken inspiration from many puzzle platformers and games that implement light, but none were as helpful in the development process as looking into a game called *Perception.* One of the game's core systems is Echolocation. The player-character is blind, so most of the

environment is obscured in darkness. However, she can see from any points that make sound. For example, as you walk your footsteps reveal the area surrounding you in a small area. You also have a mobility cane that you can tap on surfaces to reveal more of the area around you. These areas that get revealed do not last long so the player must quickly observe what they see and make judgements about what to do or where to go.

I felt like this was a unique system that I wanted to explore more in depth but looking through the lens of memory or how people can navigate when they cannot see.





Game System Storyboard

From the flow chart demonstrated here, we can see that the progression of the game is almost entirely linear and loops. This is understandable for a puzzle game of sorts because as puzzles become complex there are often very few and specific ways in which they can be solved.

The player enters the stage, must take in the level, and are only allowed to make progress when they are unable to see. Falling will reset the level but allow the player to get another glimpse of the layout. Through trial and error the player will reach the end of the stage and continue onward.

Post Mortem

I think I was rather successful at meeting my intended gameplay experience for this project. I think combined with the additional research and feedback from playtesting I was able to successfully create a puzzle system which focuses on the memorization of an environment. Though, of course, the game is not without its flaws. For instance some players found minor success in using the small amount of light to “cheat” and potentially see what is up ahead, instead of relying on memory. This wasn’t an exceptionally good strategy but worked in some cases. I also think that for the starting stage I could have toned down the difficulty, maybe starting with a simple tutorial level where a player only needs to remember the location of a single platform would help slowly get players accustomed to the mechanics.

The “data” i received from playtesters in the form of feedback was useful in making further tweaks to the game but a much more formal test should have been done, that would have required the prototype of the game to be finished earlier which is my own fault for not accomplishing. I think the most valuable piece of information from testing was seeing how quickly people were able to understand the objective without needing to be told through visual aid. I also wish I could have included more auditory feedback, something that is important in the development of short term memory according to some of the research I have done.

Overall, I was able to complete a successful prototype of a game system that could be further expanded upon at a future date with additional features, a much more solid foundation with room to grow.

Bibliography

Clemenson, Gregory, and Craig Stark. “Virtual Environmental Enrichment through Video Games Improves Hippocampal-Associated Memory | Journal of Neuroscience.” Journal of Neuroscience, JNeurosci, 9 Dec. 2015, https://www.jneurosci.org/content/35/49/16116.full.

A study published by The Journal of Neuroscience involving the effects of environmental enrichment for humans through the use of video games. Researchers had participants play a 3D video game in order to see if they performed better on demanding memory tasks. The team hypothesized that because the hippocampus has been associated with episodic memory and relying on neuroplasticity to adapt to changing environments, that animals exposed to more stimulating environments could also stimulate neuroplasticity and improve memory functions and performance in memory tasks. The act of training humans using video games would be to achieve the same effects. I want to use the information from this study to inform the direction of the design of my game, more specifically to get an insight into if and how videogames can be used to stimulate memory development

Key Takeaways:

- 3D games may in some capacity significantly improve mnemonic descrimination ability
- 2D games were used as a control and subjects showed no such improvements
- The results suggest that modern 3D video games may provide meaningful stimulations of the human brain's memory system.

MacMillan, Amanda. “Brain Games Improve Memory, But Only Under Some Circumstances | Health.Com.” Health.Com, Health.com, 17 Nov. 2016, https://www.health.com/condition/alzheimers/brain-games-improve-memory.

New research finds promising evidence for computer programs designed to sharpen thinking skills. Through testing adults who are in a stage of dementia developments called Mild Cognitive Impairment (MCI) and those who are already diagnosed with dementia, researchers were attempting to see if playing specific types of “brain games” helped slow or repair cognitive decay. Overall, there is a lack of consensus amongst the scientific community as studies tend to be no more than random clinical trials. After the University of Sydney attempted to organize all

data on the subject they found that there was minor improvement in adults with MCI who played these games but absolutely zero improvement for those already diagnosed with dementia. I wanted to use the information from this article to see how memory games affect those with poor or deteriorated mental functions. Also to understand more about the use of video games to treat such things.

Key Takeaways:

- Brain training to adults experiencing MCI led to improvements in cognition, memory, learning and mood.
- Brain training for adults diagnosed with dementia showed no signs of improvement what-so-ever.
- Trials relating to this form of research are largely inconsistent and information is scattered across the world and over a long period of time, making it difficult to draw solid conclusions.

Mcleod, Saul. “Multi Store Memory Model | Simply Psychology.” Study Guides for Psychology Students - Simply Psychology, SimplyPsychology, 2021, https://www.simplypsychology.org/multi-store.html.

Breakdown of the multi store memory model. The Multi-Store Model of Memory is an explanation proposed by Atkinson and Shiffrin in 1968 which assumes how our brains process and store memory in the short and long term. The model consists of three types of main memory stores that develop linearly over time and each type encodes information in different ways at different paces. I felt that knowledge of how our brains process memory was imperative to developing a game based around the use of memory. Focusing on Sensory Memory and short term memory.

Key Takeaways:

- Sensory Memory has a duration of ¼ to ½ seconds of and stores all sensory experience (a very large capacity of information) and is encoded through each sense.
- Short Term Memory has a typical Duration of 0 - 18 seconds and a capacity of 7 +/-2 items. Encoding is mainly auditory.

“Short-Term Memory | Facts, Types, Duration & Capacity - Simply Psychology.” Study Guides for Psychology Students - Simply Psychology, SimplyPsychology, 2009, https://www.simplypsychology.org/short-term-memory.html.

Breakdown of Short Term Memory. I wanted to take a deep dive into Short Term Memory in order for me to use it within the systems of my game design. It would seem that the concept of what constitutes an “item” of encoded memory can rank and we tend to store memories as chunks, so patterns can fit together easier and more can be stored at a time in such a way. I can use this to create interesting combinations of platforming puzzles, where a player can memorize similar groups of platforms to extend the effective range of what they remember from playing.
Key Takeaways:

- Limited Capacity - only about 7 “items” can be stored in a short term memory at a time.
- Limited Duration - Storage is very fragile and most information decays over time.
- Encoding - Primarily translation visual information into sounds.

Deep End Games, *Perception,* Windows 10 Version, Feardemic, 2017.

Perception is a first person survival horror and puzzle game developed and published by The Deep End Games. It was initially released on Windows PC but later had Xbox One, Playstation 4 and Nintendo Switch releases in the same year, 2017. Several developers on the project had been former Irrational Games employees who worked on the Bioshock franchise. The player takes on the role of blind woman named Cassie Thornton who is exploring a mansion in Gloucester, Massachusetts. The game has you exploring the mansion using echolocation to perceive the environment and avoid being detected yourself by a spectral entity. The main gameplay experience is searching the abandoned manor for clues about the building's history.