


Spring 2023

The Feeling of Control: The Psychology Behind Immersive Controls in Video Games and Their Real World Effects

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Recommended Citation

Carrasco, Atom Orbit, "The Feeling of Control: The Psychology Behind Immersive Controls in Video Games and Their Real World Effects" (2023). *Senior Projects Spring 2023*. 134.

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FEELING OF CONTROL

**The Feeling of Control: The Psychology Behind Immersive Controls in Video Games and
Their Real World Effects**

Senior Project Submitted to
The Division of Social Studies
of Bard College

by
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Annandale-on-Hudson, New York
May 2023

FEELING OF CONTROL

Acknowledgments

To shout out every individual who helped and inspired me to reach graduation would be to make a list double the length of this project. So to my parents who supported me, my professors who pushed me, Tom Hutcheon for helping me shape my project, my friends both at and away from Bard who gave me a break from academics, and my 10th grade English teacher Ms. Rose who helped me escape high school two years early, I thank you all.

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Abstract

There is a phenomenon that can occur while playing video games where the player begins to feel similar sensations to the player character. This phenomenon, unnamed until now, has very little research directly related to it. There is plenty of indirect research that can be applied to this phenomenon, now called sensation mirroring. A review of both cognitive and psychobiological literature allows for major connections between human functions and how they interact with video game control schemes to be drawn. These connections help form a potential theory on the mechanisms of sensation mirroring and provide directions for future research on the topic.

Keywords: Body Illusions, Illusions, Video Games, Video Game Controls

Introduction

These days it's very hard to avoid video games. Even older generations who hold no interest in them seem to hear about them in some capacity. From advertisements you skip on the TV, to direct interaction with them, there's no doubt that they're everywhere now. It seems as though they're here to stay. It's been nearly half a century since they first became a well-known pastime. Back then one video game could fit on one very expensive machine that could weigh hundreds of pounds and take up half of a room. Now though, you can embark on hundreds of adventures on devices that can fit in your pocket. It'd be an understatement to say video games have gotten better as the years wore on. There's no way they would have made it this far if there was no passion behind them either.

In the modern day there are thousands of games that all have a community around them, sometimes even two or more. There are even more people within those communities than there are communities themselves. Some of these gamers have dedicated thousands of hours to just one video game. Some see it as a waste of time, but the creativity and dedication many gamers have to their hobby is a testament to how much of an impact they can have on someone. But what is it exactly that draws so many different people to build pantheons out of codes and shapes? To that, there's no single answer, not even when asking a single person.

While there are many aspects one can judge video games on, the most popular of those are story, visuals, gameplay, and music. Each of these four aspects requires immense skill in their own right. Good writers, good artists, competent computer programmers, and good musicians. Each of these people needs to work with each other as well. Programmers need to properly rig an artist's model of each character, Composers need to craft melodies that fit with the narrative of the story and the style of the art. All of these together create the experience that a player is

seeking. But experiencing art, music, and interactivity blended well is only scratching the surface of the thrill that can be found in video games.

There are times when playing video games that the experience of controlling the character transcends that of simply manipulating the object in your hand. While playing video games, there are times when you become so immersed you are no longer sitting on your couch puppeteering a pile of polygons. During these times you seemingly become your avatar, whoever (or whatever) that may be. At this point, it becomes easier to sympathize and empathize with your avatar. When you are in this state it seems like when your avatar is hit by an enemy, it can feel as if you've been hit. It doesn't necessarily cause physical pain, but you feel the same emotional reaction to it that your avatar may express. What this feels like can be best explained with an example. One of the best comes from the game *Metal Gear Solid V: The Phantom Pain* (*MGSV*) (2015).

In *MGSV* you play as "Venom Snake", a man who was once known as the greatest soldier in the world. After a difference in opinion with your comrades from previous operations, you disappear into Central America where you form what you call an "army without a nation". After achieving nuclear warfare capabilities the base of your military is attacked by the allies you left behind. The result of this is many dead comrades, a lost arm, and a coma lasting nine years. The game begins immediately after you awaken when an unknown enemy begins to raid the hospital you've been hidden away in, and as it is crumbling around you a mysterious patient known only as "Ishmael" begins to guide you to your escape. This begins the tutorial where newcomers to the series are taught the basic controls for the first time, and veterans are given a refresher. Unlike previous entries in the *Metal Gear* series, you find that moving in this tutorial is incredibly difficult, narratively due to your near decade of inactivity. Both Ishmael and the game

itself are urging you to run as flames and armed soldiers ready to shoot you on sight close in around you, however no matter how much you hold the left stick forward you can only seem to drag yourself weakly across the floor, inch by inch. You are directed to a nearby stool to help yourself stand, but you only slip off of it and continue to make your way as you are. By the end of this opening sequence, you reacquire not only the ability to walk but full mobility allowing you to properly defend yourself and engage with enemies you encounter. It is when you are barely able to crawl that you feel this phenomenon. It feels as if you the player are unable to move properly, rather than you as Venom Snake. While you are, in reality, lounging around only moving your thumbs this sequence induces the sensation of being too weak to even support yourself. If you are utilizing your fully functioning body in reality to react to this scenario then why do you feel the weakness that Venom Snake is experiencing?

This is simply one of many scenarios in the rich history of video games where an illusory phenomenon such as this occurs, and it isn't necessarily about feeling weak. The way your controls are formatted or altered promotes feelings of power as well. This commonly comes with gaining power-up, though they may not always be permanent. This is not an illusion every game can achieve though, no matter whether you're in danger or you *are* the danger. Scenarios similar to *MGSV*'s opening where your movement is heavily impaired are in many games, but not all of them promote the same types of sensation. Unfortunately, there hasn't been any research dedicated to uncovering the reasons and mechanisms behind this phenomenon. There isn't even a proper name for it, which is why from here onward it will be known as "Sensation Mirroring". There are several possible explanations for what could be happening in relation to how a player is controlling a game when sensation mirroring occurs.

A number of different theories for what sensation mirroring is can be proposed. On a cognitive level, it may be that the interactivity of the game is engaging the player in certain ways. Emotional engagement combined with the design and features of the controller you use may allow for finger movements to become something more. Cognition is not the only thing that happens in the brain though. It's possible that the cause behind sensation mirroring may be biological. What's happening in your brain while you're playing? What neuron systems are firing and how does your body react? These answers may also hold the key to what's behind this phenomenon. It's very possible that Cognition and biology intersect with one another, working together to create this illusion. It's a puzzle, and it's just a matter of putting all the right pieces in all the right places to create a theory as to why you can feel the sensations of avatars through your controller worth testing.

The other issue that comes up with exploring immersion-caused illusions is the immersion itself. There isn't even a universally understood and operationalized definition of immersion due to its highly subjective and personal nature. It's even fluid depending on the medium. In the realm of video games, several sources give several definitions; Some consider it the scale at which someone is mentally and emotionally involved with a game (E. Brown & Cairns, 2004). Another definition of immersion given is more about the personality behind the avatar- the virtual representation of the player within the environment of the game. This definition relies more on embodying the character that the avatar represents, the person you are supposed to "be", as opposed to projecting your self-conception outward onto the avatar (Tu et al., 2022). For the sake of operationalization, Brown & Cairns' definition will be used, even though they do not believe it is necessary to enjoy a game. It just goes to show just how nebulous a concept immersion actually is, which only complicates its importance to sensation mirroring

and video games in general. While a guide to creating immersive video games is not the goal, it is necessary to explore some of these aspects in order to better understand immersion.

As mentioned before, prior research on sensation mirroring is scarce, if it exists at all. All research has to start somewhere though. Ideas and theories build off of each other, and things that may seem completely removed from one another may actually be related. There may not be any research on sensation mirroring, but there is a treasure trove of research on illusions, cognition, and brain activity under various circumstances (Polito & Hitchens, 2021). Additionally, since video games continue to become more prominent with time more and more studies have begun incorporating video games both as a direct subject, and a medium for research. There is a very real possibility that sensation mirroring may just be one of the great Mysteries of Life. There could be no apparent reason why these kinds of illusions occur, but it is impossible to know for sure if no research is conducted. With so many leads to follow it can be difficult to come up with a hypothesis capable of being tested, but it's always easier when there is a point to start from.

The History of Video Games and Their Controllers

Video game controllers have significantly changed over the several decades games have been popularized. Their shape, their button layouts, and how they connect to a video game console have all evolved rapidly to meet the new ideas that developers are constantly coming up with. The progression of conventional video game controllers' evolution is nearly inseparable from the history of video games themselves. This rings especially true the closer to the modern day we get.

The Grandfather of Video Games

Before what we call the “first video game” was created there were three predecessors that, while contributing greatly to the original idea, are not considered video games. In 1948 Thomas T. Goldsmith Jr. and Estle R. Mann created the “Cathode-Ray Tube Amusement Device” which they patented (*BNL | History: The First Video Game?*, n.d.). While a computer was used to play the game, the visual component of the game required an illustrated overlay. Because they were not generated by the computer, it is not considered the first video game. Three years later the *Nimrod* computer was built and displayed by Ferranti International at the 1951 Festival of Britain’s Exhibition of Science. Designed to play the mathematical strategy game *Nim*, the *Nimrod*’s main purpose was to showcase its processing power through the complex computations required by *Nim*, a sort of spiritual precursor to the *Chess* program written by Alex Bernstein for the *IBM 704* computer in 1957 (billwall, 2017). The computer generated its own visual components, however, the display used simple light bulbs to represent the visuals rather than making something appear to move in a field (*BNL | History: The First Video Game?*, n.d.). Since the *Nimrod* was neither for entertainment nor made use of a display to create dynamic visuals, it was not considered to be the first video game. The last major

predecessor, like the *Nimrod*, was not counted as a video game despite being a game run on a computer. A. S. Douglas designed what he called *OXO* (also known as “*Noughts and Crosses*”) at the University of Cambridge in 1952.

What video game historians now recognize as the true first video game comes from a surprising place. It starts with William Higinbotham, a Cornell graduate and the head of the electronics team in the Manhattan Project (Tretkoff, 2008). He is the man who is widely considered the “Grandfather of Video Games”. Higinbotham got his start as a lab technician while studying physics at Cornell University. In 1941 he moved over to the Massachusetts Institute of Technology and worked on developing radars that used cathode ray tubes as a method of display. Just two years later he became the head of the electronics team at the Los Alamos National Laboratory where he developed several electronic systems for the atomic bomb in World War II (Sullivan, 1994). In 1948, a few years after the bombs were dropped in Hiroshima and Nagasaki, Japan, Higinbotham took a position at the Brookhaven National Lab in Long Island. This was the lab where the first video game would be born (Tretkoff, 2008).

Ten years later, in October of 1958, Brookhaven held its annual open house. In preparation for the event, Higinbotham wanted to create an interactive attraction for those who came through. *Tennis for Two* (1958) took approximately two weeks to create. The lab had an analog computer that used an oscilloscope as a display. The display could show curves, such as the trajectory of a simulated ball. As fun as watching a ball bounce back and forth on a computer screen is, it wouldn't be very interactive without a way to influence the ball's movement. Thus, Higinbotham also designed ways to change its trajectory.

The controller for the first video game was extremely simplistic (Figure 1). From the perspective of someone who had never even thought of a computer game before, it would merely

look like two plastic bricks plugged into the computer. One brick was held by each player. The bricks were outfitted with knobs on its face that let the player change the angle at which the ball would bounce off their side of the court when twisted. Next to the knob was a button that, when pushed, would “hit” the ball to the other player’s side. Because the game was rudimentary, the court was represented on the oscilloscope by one long horizontal line on the bottom of the screen bisected by a short line to represent the net. The ball was represented by a dot that bounced between the sides. There were no representations of the players on the screen, so players had to intuit the angle they were hitting the ball based on “up” and “down” labels adjacent to the knob. Once the ball was on their side of the court they could press the “hit” button to send the ball to the other side based on the angle at which they had turned the knob. If the ball flew too far to one side or bounced too many times the players could hit a reset button to begin a new round. A simple control scheme on a simple controller for a simple game. While we know it was engaging (*BNL | History: The First Video Game?*, n.d.), it’s hard to know just how engaging it was so long ago. But what we do know is that people liked it enough that, even after being retired and dismantled in 1960, the experience stuck with people enough to spawn a whole industry around it.

The Rise to Fame

After a brief absence from the public consciousness the company Sanders Associates was issued the first patent for a video game in 1964 (Tretkoff, 2008). The company Magnavox then bought it and began producing them in the early 1970s. Competitors attempted to break the patent, resulting in a court case that Higinbotham had been called to testify in, however, the matter was settled out of court. As time went on video game development began for both

consoles and arcade cabinets, but never really hit the big time until one of the most well-known games to date finally hit the market: *Pong* (1972).

While *Pong* got the ball rolling on video games' popularity, there was one prior that began the commercial sales of arcade cabinets. *Computer Space* (1971) was an adaptation of the 1962 computer game *Spacewar!* (1962) developed at MIT (Wardrip-Fruin, 2021), which also included the first "gamepad" classification of controller ("Get a Grip!!!," 1996) (Figure 2). Playing as a rocket ship, the goal of the game was to eliminate as many flying saucers as possible within the 99-second time limit. There was also a multiplayer mode in which two players engage in a dogfight with each other. *Computer Space*'s controls were quite simple: two buttons to rotate your rocket ship (clockwise and counterclockwise), one to thrust your ignition in the direction you're facing, and one to fire your gun (Figure 3). While turning *Spacewar!* into an arcade cabinet was a good concept, it didn't take off nearly as much as *Computer Space*'s developers, Nolan Bushnell and Ted Dabney had hoped. Within the next year, Bushnell and Dabney left Nutting Associates and founded their own company Atari (Smith, 2019), which went on to be one of the powerhouses of early video games. This is where *Pong* would be created and published by Allan Alcorn on November 29th, 1972. When *Pong* was made the controllers on the cabinet went back to basics. Similar to *Tennis for Two*, the controllers attached to the cabinet were merely two knobs, one for each player (Figure 4). They turned back and forth to readjust the position of the player's paddle to knock the ball back and forth. This time, however, *Pong* adopted an overhead view of the court and had a visual representation of each player's paddle. This meant players no longer had to approximate the angle at which they were hitting the ball, they could adjust it with accuracy to make the perfect shot and score a point off of their opponent.

Just a few months prior to the publishing of Pong, in September 1972 the first commercial video game console, the *Magnavox Odyssey*, was released (Herman et al., 2010). Still sticking to the knob-based interface, the first commercially available controller was a small box with one knob on either side (Figure 5). The left knob controlled horizontal movement, while the right controlled vertical. On the top face of the box was a single “reset” button. The *Magnavox Odyssey* also sold the first commercially available light gun as a video game controller (Smith, 2019) (Figure 6). The light gun is a type of controller that plateaued in evolution and innovation not long after its first commercial release. As the name implies it interacts with a video game based on the light emitted from the picture on the television screen. This is done by rapidly changing the picture on the screen so that the target area and the rest of the screen contrast, which is then read through a sensor inside the barrel of the gun (Nelson, 2017). If the sensor reads the target area, then the gun hits, if it’s anywhere else, it misses. While the technology for light guns has improved over the years, the actual design and handling of one as a controller stagnated very quickly, only changing based on how a developer wanted one to look and feel. That is not to say it has not changed at all since the *Magnavox Odyssey*, but those changes happen in tandem with other evolutions of standard controllers. Different versions of the knob-based interfaces had sprung up and evolved, such as the steering wheel arcade game *Death Race* (1976) (Figure 7). The same year of *Death Race*’s release a brand new console was released and took one of the first steps into what we know controllers to look and feel like now.

Before the Fall

In November 1976 the *Fairchild Channel F* was released to the public (“Fairchild Channel F,” 2023). Its controller looked like a stick with a triangular cap on the top. This cap served several functions: it could be twisted to be used as a knob like many controllers before it,

but it could also be tilted in eight directions like a joystick. Lastly, this cap could both be pushed down and pulled up as extra button inputs. Many of these features would come to be a standard for most controllers but not for another 20 years. In 1982 a new version of the *Channel F*'s controller was released called the *Channel F Jet-Stick*, on which another button was added to the side of the controller (Figure 8). From the *Channel F*, the joystick was expanded on. Past joysticks had a feature that was lost in this joystick model, which was a proper base to place it on. This was regained on the *Atari 2600*'s controller, the *Atari CX10*. The *CX10* consisted of a small square-shaped platform with a joystick in the center and a button on the corner of the face. The *Atari 2600* and its accompanying controller were launched in September 1977 (Forster, 2005). While the *CX10* worked well, an updated version titled the *CX40* was released a year later. The cosmetic differences were minor, but the main difference was internal: the joystick of the *CX40* could be manipulated with less physical effort on the player's part, with the added bonus of being easier to mass produce (Goldberg & Vendel, 2012) (Figure 9). Because of the ease of mass production, the *CX40* became the standard model for what all home console controllers should be (Ahl, 1983). In November 1982 Atari updated this standard with an unnamed controller released alongside the *Atari 5200* in order to compete with the consoles being released by rival companies Mattel and Coleco ("Atari," 2003) (Figure 10). This controller boasted 360° movement rather than eight-directional, seven buttons including one that allowed players to pause the game they were playing, and a numeric keypad. Unfortunately for Atari, this controller wasn't made with high quality.

The *Atari 5200*'s controller kept being improved upon as the standard as more companies got into the video game market. Arcade cabinets had not fallen behind though. Their controllers were similar to those of home consoles, however there was only so much developers could do to

improve them seeing as they were attached to the cabinet. Light guns were eventually added to arcade games that involved shooting, as well as a new type of gun controller that was developed. This controller allowed a mounted “gun” to act as a joystick in its own right.

By 1983 controller innovation became stagnant. This was the year the video game market crashed (Kent, 2001). A multitude of factors contributed to this. Personal computers (which had their own video games) were gaining the edge in the home electronics market. On top of this, there was an oversaturation of video games and consoles, and the games were being made for them in declining quality. This issue came to a head with the video game *E.T. the Extra-Terrestrial* (1982) for the Atari 2600, widely regarded as the worst game of all time. The excess of video games got to the point where to prevent warehouse overstocking, Atari buried approximately 700,000 video game cartridges in a pit in a New Mexico landfill (Penn, 2014). But as Atari was (literally) going under, another company stepped up to save video games.

The Early Modern Era

Nintendo, a Japanese entertainment company, already had their hand in the video game and electronic entertainment market as early as 1974 (Gorges & Yamazaki, 2012). They had found some success in the arcade business, and in 1983 they released a new video game console in Japan. This console was called the *Famicom*, short for “Family Computer”. They found success in Japan despite a rocky start, so they decided to aim for North America next. They completely overhauled the external design of the system, and two years later launched it in the West with the name “*Nintendo Entertainment System*” (*NES*). They managed to break through the devastating Video Game Crash of 1983 and establish the “gamepad” controller type as the standard. Though cosmetically different both the *Famicom* and *NES*’s controller layouts were the same: a slim rectangle with all of its buttons on its face (Figures 11 & 12). On the left was a

D-Pad, four buttons representing the cardinal directions designed in a cross shape. In the middle were two small, pill-shaped buttons labeled “Select” and “Start” mainly used to do just that: select the mode of the game you wanted to play and then start it, though start also functioned as a “pause” button. Finally on the right were two thumb-sized circular buttons. The left was labeled “B”, and the right “A”. These two buttons allowed players to take actions in the game. When the *NES* became popular it also popularized peripherals; Alternate controllers that add features or change how a player interacts with the game. While most peripherals were redesigned controllers, there were some games that could only be played with the *NES Zapper*. It was released in North America just a few months after the *NES* (DeMaria & Wilson, 2002). Shaped like a pistol (Figure 13), it was used for games such as *Duck Hunt* (1985a) and *Hogan’s Alley* (1985b) which involved the player shooting at targets on the screen with speed and accuracy.

The D-Pad was revolutionary to gamers of the time, in large part due to the fact that you could press all four clearly defined buttons with just your thumb rather than moving your whole arm with a joystick. Once competitors understood the popularity of the D-Pad, they all rushed to incorporate it into their own controllers. There was one issue though: that realization came too late. Despite being created by Gunpei Yokoi in 1982 the D-Pad was not patented by Nintendo until August 1987 (Gaming Historian, 2017). Though many had the chance to incorporate their own they ultimately had to adjust it to avoid lawsuits resulting in circular designs with a cross in the middle becoming commonplace among competitors, starting with the *TurboGrafx-16* which launched in October of that year (“TurboGrafx-16,” 2023) (Figure 14).

The *Sega Genesis* hit the North American market in 1989 (Kent, 2001). Though Sega had made both arcade cabinets and home consoles in the past they never reached the height of fame that the *Genesis* would propel them to. While it didn’t happen immediately, the *Genesis* would

go on to spark an industry-shaking rivalry with Nintendo, commonly known as the “Console Wars” (Greene, 2015). Until then, Sega focused on making the *Genesis* viable for competition. It’s seemingly the first console to take into account that the gamepad design that the *NES* established is meant to be supported in two human hands, not one (Figure 15). While this is not confirmed, it was the first gamepad to have a curvier design meant to be more comfortable when held. The main feature hardware-wise that the *Genesis* had over its competitors was more face buttons. It took the number of buttons labeled with letters on the NES and tripled them, resulting in six rather than two buttons for the right finger to press. The larger bottom three were labeled A-C, and the smaller three above were labeled X-Z. It would be many years before the placement and number of buttons for the right thumb on a gamepad would be standardized but the *Genesis* was the first to pose this question.

The *Sega Genesis* was not the first to revise the modern standard for video game controllers, and it was certainly not the last. Nintendo’s response to the *Genesis*, their *Super Nintendo Entertainment System (SNES)* posed another question: Why only use your thumbs (Figure 16)? The *SNES*’s face was similar to that of the *NES*. The major technical differences were its shape and the four letter buttons rather than the original two. They were also arranged in a cross shape, though they were separate. What was once “B” on the left and “A” on the right became “Y, A, B, X” in a clockwise direction from the top. Labels for them differed, but by the 2010’s this would become the standard layout of buttons pressed by the right thumb. But what made the *SNES* controller stand out from the rest were the shoulder buttons. Two buttons, one on each side of the controller, that were on the side that faced out and away from the player holding the controller. These buttons, (labeled “L” and “R” for their respective sides), also known as

“bumpers” were meant to be used with the index finger, which opened the way for more fleshed out control schemes.

While Sega and Nintendo dominated the majority of the '90s, Sony decided it was time to throw their hat into the ring. Sony had collaborated with both Nintendo and the Dutch tech company Phillips earlier in the decade to produce a failed multimedia player called the *Phillips CD-i* (Grundhauser, 2016). Learning from their failed venture and other business deals gone awry, they began to develop their own home console that used CDs rather than cartridges like all consoles before it (Swearingen, 2008). Thus the original *PlayStation (PS1)* was born. Launched in North America in 1995 (IGN Staff, 1998) the *PS1* was one of the spearheads of 3D gaming with titles like *Crash Bandicoot* (1996) and *Resident Evil* (1996). More importantly though, the *PS1*'s several controller iterations made many advancements that have become staple features in modern video games. A majority of these advances were in response to the innovations of Nintendo.

Nintendo made the jump to 3D with the *Nintendo 64 (N64)* in 1996, coming to North America on September 26th (IGN Staff, 1996), just two months after its Japanese release. Its controller is considered a black sheep to this day, as it was a strange trident shape (Figure 17). It reversed the addition of the “X” and “Y” buttons from the *SNES* but hosted several changes that were new to the industry at this point. It added an extra set of buttons titled the “C” buttons that granted some control over the camera in 3D games. More importantly however, the D-Pad became a secondary feature as it was replaced by the first analog stick on a gamepad. The analog stick's inclusion allowed for 360° movement rather than the eight-directional mode previous controllers had provided. Additionally, Nintendo later released a peripheral that could attach to the controller to add haptic feedback, suitably named the *Rumble Pak* (“Rumble Pak,” 2023)

(Figure 18). Sony saw these new features and decided to improve on them. The original controller for the *PS1* (which was released prior to the *N64*) was similar to the *SNES* but with the addition of handles for easier grip and two more shoulder buttons below the initial two (Figure 19). Because of how it felt pressing them, the top two became known as “bumpers”, and the bottom two were called the “triggers”. To avoid a lawsuit from Nintendo they designed their own D-Pad that was similar but just different enough cosmetically to get by. They also changed the letter buttons to symbols, being a green triangle, red circle, blue “X”, and pink square in clockwise order. After the *N64* was released they came up with a design for a new controller, titled the *Dual Analog*. This controller added not one, but two analog sticks directly beneath the “select” and “start” buttons. The left stick mimicked the *N64*’s single analog stick, and the right took the place of the “C” buttons. The leg both of the *PS1*’s sticks had over the *N64* was that these sticks could be clicked inwards as additional inputs. Though the placement of them changes between controller models, the *Dual Analog* became synonymous with gamepads as we know them today. When the *Rumble Pak* was released, just like with the *Dual Analog*, Sony decided to take it a step further. They took the *Dual Analog*, added motors to the handles to provide more detailed haptic feedback, and released it under the name “*DualShock*” (Figure 20). The *DualShock* wound up becoming the first iteration of standard video game controllers as we know them today.

Contemporary Controllers

The evolution of controllers began to slow down in the early 2000s. A few years after the *Dreamcast* was released Sega exited the console market to focus exclusively on making games (Parish, 2014). Around the same time, Microsoft made their debut in the home console industry with the *Xbox* (Ackerman, 2021). Both of its controllers, the “*Duke*” (Figure 21) and the smaller

(and more comfortable) “*Controller S*” (Figure 22) followed the template for gamepads that the *DualShock* established, though the analog sticks were placed above the D-Pad and below the letter buttons. A new feature was introduced on the *Xbox* controllers, as well as the *DualShock 2* and *3* for the *PlayStation 2 (PS2)* and *3* (which both looked extremely similar to the original *DualShock*). The feature was pressure sensitive buttons. Many games included functions that responded to how hard a button was pressed, but this feature was excluded from *Xbox 360*, the successor to the *Xbox*. It has become mostly obsolete after the release of the *PlayStation 3 (PS3)*. As an extension of that, Sony added haptic feedback to simulate resistance on the triggers of their controller for the *PlayStation 5 (PS5)*, the *DualSense* (Figure 23), which also included the large touch-sensitive pad near the top of the face which was introduced in the *DualShock 4*.

While Sony and Microsoft’s attitudes when it came to their controllers was “if it ain’t broke don’t fix it”, Nintendo has been notoriously experimental in their controller designs. Nintendo’s biggest experiment, the *Wii Remote*, completely changed how controls for games were designed. A major selling point for Nintendo’s 2006 console, the *Wii*, was its heavy integration of motion controls (Sinclair & Torres, 2005). Rather than a traditional gamepad, the *Wii Remote* was shaped more like a wand (Figure 24). It was able to be held both vertically and sideways for different modes of control. Most notably, it controlled the console and games with its combined setup of an internal accelerometer and an infrared sensor that interacted with the console. An extra attachment called the *Nunchuck* also came with the *Wii Remote* that added an analog stick and two extra shoulder buttons (Figure 24), meant to be held in the hand opposite of the *Wii Remote* when it was in vertical mode. Later improvements on the motion controls also included an additional gyroscope that started a peripheral that could be attached to the *Wii Remote* (Buckleitner, 2009). The games that fully showcased the capabilities of the motion and

gyro controls were *Wii Sports* (2006) and its sequel *Wii Sports Resort* (2009). Both, as the titles imply, hosted a variety of simulated sports such as baseball, tennis, swordplay, and boxing. The success of the *Wii*'s motion controls inspired the other two powerhouses to include gyroscopes and accelerometers in just about every controller since, starting with the *Sixaxis* (a revised version of Sony's *DualShock 3*) and the controller for the *Xbox One* (released in 2013).

Nintendo still tends to experiment with the design and functions of their controllers and systems, such as the secondary touchscreen on the *Wii U Gamepad* (Figure 25) and the hybrid handheld/home console nature of the *Nintendo Switch* requiring its main controllers (the *Joy-Cons*) to be able to detach from the console itself (Figure 26). Despite this, they also release more traditional controllers to preemptively answer the calls for them, much like they did with the *Nintendo Switch Pro Controller* (Figure 27). In the end, even the most unorthodox controllers released these days still have features that have been standardized like haptic feedback, analog sticks, and gyroscopes, and all these features continue to improve with every new generation of home console released.

Other Controllers

In the current day, gamepads generally lead the pack when it comes to advancements in video game interface technology. Despite this, there are still a myriad of controllers that are prevalent. While gamepads have had a significant influence on the development of many of them, gamepads are not the right kind of controller for every circumstance.

Home consoles have become a mainstay in entertainment, but they've far from driven arcades out of business. Arcade cabinets now have many different types of controllers, and more often than not they have the freedom to think of the technological limitations second, and the actual games first. Many arcade cabinets, both retro and modern, still have joysticks

accompanied by a few buttons as their controllers since they are relatively simple. More complicated games have pushed the development of light guns even further. Games like the *Time Crisis* series now have light guns with more accurate aim than ever before (Figure 28). Games with the “gun” analog stick design, like *Halo: Fireteam Raven* (2018), have also improved (Figure 29). Buttons other than “fire” have been added to allow more actions to be taken, as well as the overall accuracy of the sticks. Controllers based on inputs via feet as opposed to hands were also developed for many games. One of the most recognized arcade games in this format is the rhythm game *Dance Dance Revolution* (1999) (Figure 30). Rather than pressing buttons in time with the music, players step on arrows on the platforms they’re standing on when prompted. This type of controller has also been designed and distributed as a peripheral from home consoles (especially in home console releases of later games in the *Dance Dance Revolution* series).

Aside from the *Dance Dance Revolution* pads for home, peripheral controllers are still a major part of video games. Peripherals can truly be anything, ranging from the aforementioned light guns, an addition to normal controllers (i.e. the ring-shaped *Ring-Con* for *Ring Fit Adventure* (2019) (Figure 31)), or even a completely different object designed to function as a controller, much like the guitar-shaped controllers for the *Guitar Hero* series (Figure 32). Newer technology and types of systems also sometimes get integrated into home consoles as a peripheral, like Sony did with the *PlayStation VR (PS VR)* on the *PlayStation 4 (PS4)* (Figure 33).

Virtual reality (VR) has slowly become more prominent as home entertainment in the 21st century. So much so that there are several different companies with their own lines of VR hardware. The major players in the market thus far have been Meta with their *Oculus* line (which

is undergoing a transition to being called *Meta*), Sony's aforementioned *PS VR* line, and the *HTC Vive* line by HTC Corporation. The controllers for each brand have all been based around motion controls, similar to Nintendo's *Wii Remote*. Initially, most VR console controllers held a wand shape as well (Figure 33). They had similar buttons to gamepads, and any option they had for movement was limited since each controller had a circular trackpad similar to the kind found on laptops. As VR technology became more common and better developed for commercial entertainment the controllers underwent standardization as well. The current design of VR controllers is more comparable to Nintendo's *Joy-Cons*, with one unit consisting of an analog stick, shoulder buttons, and letter buttons being held in each hand (Figure 34). They are not exactly the same though, as different hardware calls for more tailored controllers, even if it matches a similar standard.

There are two more major ways to play video games that controllers have been tailored for: PC gaming, and handheld gaming. Making controllers for PC gaming isn't very difficult. The two options are either a mouse and keyboard or a gamepad from a different console. Most clients for PC games are built to accept other consoles' controllers as acceptable input methods since most PC games are built similarly to console games. On the other hand, the evolution of handheld game controllers is more involved. It follows a similar pattern to the evolution of gamepads. Similar to arcade cabinets, handheld video games were built not to host the means to play many games. The hardware and software were all part of the same system, with the controllers hosting buttons based on the needs of the games. Unlike arcade cabinets and eventually home consoles, they had the additional challenge of packing a display into the hardware along with the power source, controller, and motherboard. Despite these additional challenges developers seemed to follow the same path as they did with home consoles.

Eventually, the standard Nintendo had created with the *NES* followed into the handheld market, with manufacturers adapting their gamepad designs to their handheld consoles. The patterns of evolution, the addition of shoulder buttons, analog sticks, and so on, also followed those of the home console albeit delayed. Though analog sticks had been established as the standard in 1996, handhelds (which had not even incorporated shoulder buttons yet at that time) did not develop analog sticks until the release of the *Nintendo 3DS* (Figure 35) and Sony's *PlayStation Vita* (*PS Vita*) (Figure 36). Interestingly, it even followed the advancements of each specific company. Sony included two analog sticks on the *PS Vita* after Nintendo included one on the *3DS*. Nintendo only included a second, significantly smaller analog stick in an upgraded version of the handheld called the *New Nintendo 3DS* (Figure 37), but they did create a peripheral soon after the original *3DS*'s release called the *Circle Pad Pro*, which added a second analog stick (Figure 38). With the handheld market retracing the steps of the home console market, it's likely that the next feature they might implement is haptic feedback, but for the moment gamepads are still evolving to make video games a more immersive and engaging experience.

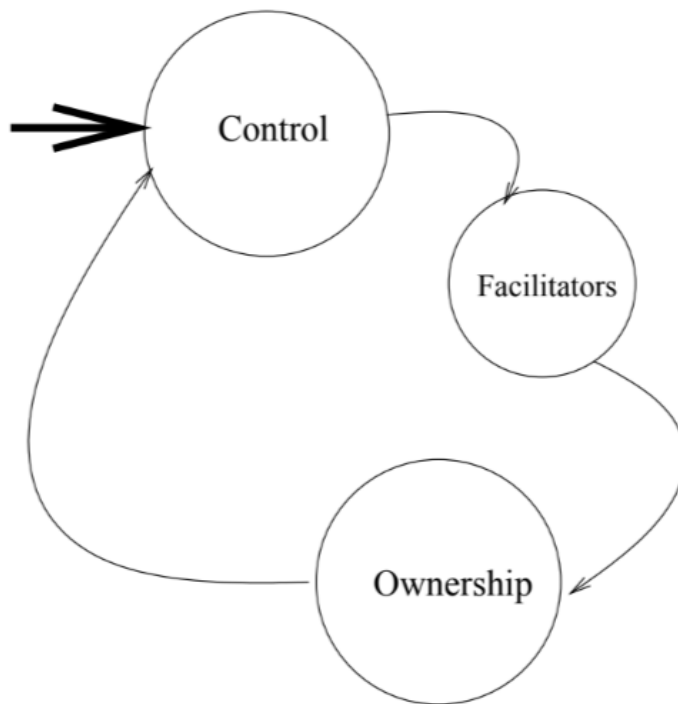
The Big Puppet Show

Taking control of a character to play pretend is an ancient practice. Puppets have been around for at least 4000 years, if not longer (Blumenthal, 2005). Taking control of your avatar in a video game can be likened to taking control of a puppet. At least, that's the main idea behind the Theory of Puppetry (Calvillo-Gómez & Cairns, 2008). It is a theory that likens playing a video game to the art of puppetry. It stems from the two schools of thought in Human-Computer Interaction; phenomenology and pragmatism, the relationship between the human and the object beyond sensory experiences, and the "truth" revealed through actions and consequences. Puppets in this case are defined as mediums that allow the artist to take actions in a fake world and yield no real consequences. The most common use of puppets is for performance. A puppeteer can act out tripping and falling in a scenario, but they face no risk of harm whatsoever because they have a medium to perform this action. Any stunt they perform with a puppet in the fake world they are in poses no threat to them in reality. Of course, for good reception to a puppet show the audience also has some weight to bear. Both the puppeteer and the audience need what Calvillo-Gómez & Cairns call "double-vision"- the ability to see the puppet as an object, but also alive. While the puppeteer manages this because they are playing a character through it, it's up to the audience to suspend their disbelief to achieve this. When a video game is booted up, the player is performing for themselves, taking on the role of both puppeteer and audience.

The Theory of Puppetry for video games centers around three aspects: control, ownership, and facilitators. Each aspect informs the other and contributes to the mental relocation from one reality to another. If a player has a high level of control over their avatar they will feel more ownership for their actions, resulting in proper "puppetry". If the player has a low level of control, puppetry can still be facilitated by the virtual environment they're in. Each

aspect has its own role in creating an enjoyable experience with video games (Figure 39), Table 1), but more importantly, they also have their own layers and theories driving them which must create the perfect storm to induce sensation mirroring.

Figure 39: The process of puppetry



“The process of puppetry: Good control leads to a high ownership, if the player does not have a good control, then it is still possible [to] have high ownership if the facilitators are strong enough. The player increases the control as the ownership also increases.” (Calvillo-Gómez & Cairns, 2008)

Table 1: Elements of puppetry

Elements	Members	
Control	Mechanical	Controllers Memory Point of View
	Virtual	Small Actions Goal Something to do
Facilitators	Aesthetic Value Previous Experiences Time	
Ownership	Big Actions Rewards Personal Goals You but not You	

(Calvillo-Gómez & Cairns, 2008)

Control

Control over what you're interacting with is what makes a game a game. Calvillo-Gómez & Cairns specify two different types of control: mechanical and virtual control (Table 1).

Mechanical control relates to what you directly manipulate in reality. These include manipulating the controller, changing the point of view in the virtual environment, and the ability to remember what does what. An example of this would be retaining the muscle memory that a certain button has the ability to rotate the camera so you can look at your avatar's face rather than the back of its head, and being able to press or push whatever you're required to do so. Virtual control refers to how you affect the game through your real life actions. Making your avatar walk in a direction as a result of pushing the analog stick that way, what your in-game actions accomplish, and what actions you're taking to get there. Mechanical control would be the hand inside of a puppet moving it, and virtual control is what you are making the puppet do. Mechanical control can be

enacted even if you're not actually playing a game since it is mostly rooted in the real world. Virtual control on the other hand requires cooperation with the limits of what you can and can't do that the developers set for you.

Agency

While a movie may have you on the edge of your seat or empathizing with the emotions of the characters, it's not often that you feel as if you're a part of the action. Video games not only make you feel as if you're part of the action but in most cases, you *are* part of it (though to varying degrees depending on what you're playing). Not all video games are built with the purpose of doing so, but many video games are built with the intent to maximize how much say you have in their worlds. It's very hard to play a video game passively. You have to act and react as your avatar. Thus, the controller acts as a bridge between your will in reality and your actions in the game world. For all intents and purposes, you are in the virtual world, moving and interacting within it. This is known as "agency".

Agency is best described as autonomy, or the capabilities one has to take action within a space of possibility (Hammer, 2007; Madsen, 2016). Virtual control is the dominant form of control in agency since a player can fiddle with the controller all they want at any time. Jessica Hammer (2007) describes several types of agency, but the main type to focus on is what she calls "participant agency". Participant agency is best demonstrated in many games in which you play as a powerful deity. One such game is the 2006 adventure game *Ōkami*. Amaterasu, the main character of the game, is based on the Shinto goddess of the same name ("Amaterasu," 2023). Like her Shinto counterpart, Amaterasu is the Sun Goddess in the mythology of *Ōkami*'s world which means she is immensely powerful. The gameplay does not allow you to exercise this power though, in part due to a loss of followers limiting her power, but mainly because there

simply would not be a game if you could press one button and immediately decimate any foe in your path. Even when she is returned to full power for the final fight in the game, the gameplay doesn't change all that much. When playing as Amaterasu, no matter how powerful she is, you as the player are restricted to certain actions by the developers for various reasons. A similar restriction is demonstrated in *MGSV*. The opening sequence only allows the player to walk properly once they reach a certain point. No matter what they attempt, both as themselves and as Venom Snake, they are only able to drag themselves across the floor because that is what the developers made possible at that point in the game.

Sensation mirroring involves alterations of your sense of self. It comes from immersing yourself in a game and placing yourself within it, which a feeling of voluntariness in your actions aid (Polito & Hitchens, 2021). Agency is one of the biggest factors in achieving that alteration, though it does this in a very roundabout way. Participant agency and the ability to control the actions of the main character in a scenario do not directly create a feeling of presence in the game. Instead, it places more weight on the emotions behind them by giving players an idea of what their capabilities are and what they should be- especially poignant when the two are not the same. When compared, those who played a horror game reported higher emotion than those who watched footage of someone else playing (Madsen, 2016). The emotional difference was not in fear, however. It was in entertainment. Additionally, the players showed higher heart rates and blood pressure than watchers. This is a sign of some link between entertainment and stress response, though because it was a horror game that might not necessarily be the same for a genre that is not specifically designed for stress activation like fantasy. This does not subtract from the finding that agency in a game does have an effect on emotion intensity though.

While most cases of sensation mirroring aren't about a character having more power than the player can access like in *Ōkami*, manipulation of participant agency can be theorized to be one of the driving factors behind sensation mirroring. Without the emotion and intent behind pulling the strings on your avatar, your "puppet", you can't feel the difference when the agency of the player is altered at the whim of the developers. Apathy about your participant agency may be a barrier to achieving sensation mirroring. But where does the emotion that supports your agency come from? What makes your attack go from the mundane action of pressing "Y" to deal damage to the thrill of bringing your sword down on your adversary to deal a final blow?

Ownership

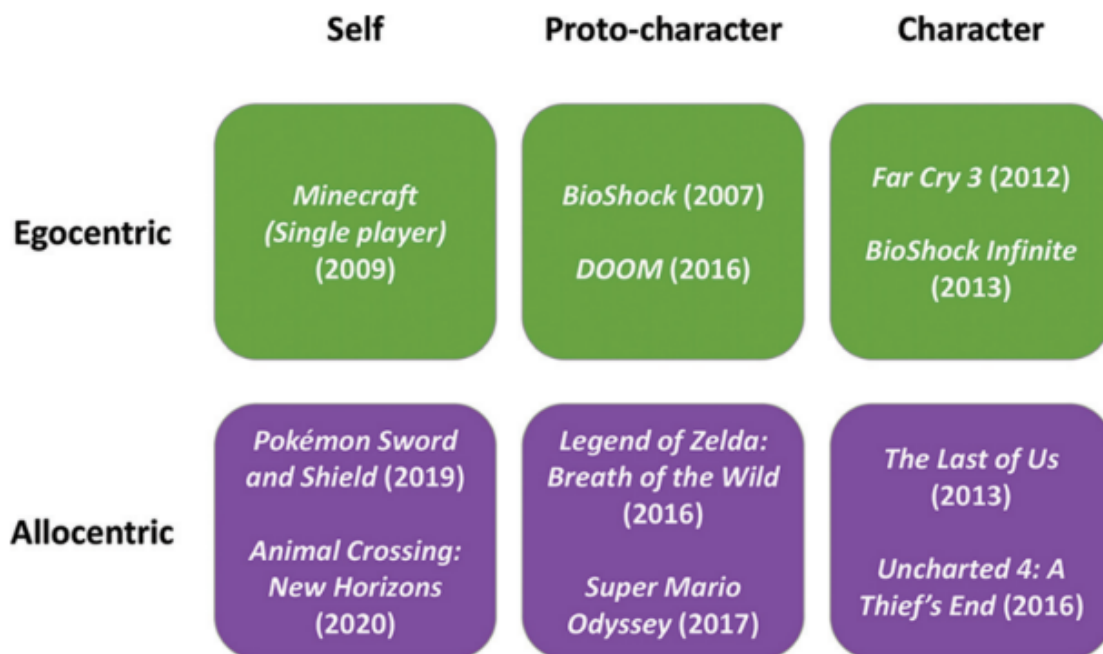
Ownership is the second of the three aspects of the Theory of Puppetry. Initially, ownership is described as feeling responsible for the actions an avatar takes (Calvillo-Gómez & Cairns, 2008). It's about the influence a player has over their actions, which is directly fed by agency level. Table 1 provides several examples of what the major components of ownership are. Direct influence on major actions taken by the avatar and being rewarded for them, achieving goals set for yourself as well as the game, and having a shift of self-perception into the avatar. These are all pieces of a larger phenomenon that defines ownership: character immersion, also known as embodiment. Embodiment is essentially taking on a character and acting as if you were them (or vice versa). It is difficult to discuss embodiment and what it takes to embody a character without first discussing the several classifications of character type first.

Character Type

With the sheer volume of video games that exist, variety in player characters was inevitable. Some video game avatars are simply meant to be a stand-in for the player, a bridge that allows a player to cross into the virtual world. Others are entirely their own person. Someone

who has thoughts and feelings independent from your own. You are experiencing their life from their point of view. There are many ways to categorize character types. Because of this it's necessary to strike a balance between simplicity and diversity. This can be done by dividing games into two categories based on the point of view the game is typically played from, and then further dividing those categories into three levels based on “characterness”, or how present the avatar is narratively (Figure 40) (Tu et al., 2022).

Figure 40: Six Game Categories, as Organized According to the Two Game Dimensions of “Characterness” (From Left to Right) and Spatial Perspective (From Top to Bottom)



(Tu et al., 2022)

Egocentric games are from a first-person perspective while Allocentric are seen from the third. While it is obvious what “Self” and “Character” characters are, a “Proto-character” is a little more difficult to grasp immediately. A proto-character is everything between self and character characters. Whereas self-characters are complete stand-ins for the player and characters are like those you would find in a book or movie, proto-characters are predefined with their own personality and goals, but they are not fleshed out. They’re akin to a prompt that you then fill in the blanks with.

The pervasive “silent protagonist” trope comes from proto-characters. They have an active narrative that you’re following but are mostly devoid of personality, especially since you are made to choose every sentence they say from a premade list of choices (if the protagonist chooses to talk at all). Link, the main character of *The Legend of Zelda: Breath of the Wild* (2017) and almost every other *Legend of Zelda* game was one of the first proto-characters. He’s consistently portrayed as a noble young man worthy of holding the “Triforce of Courage” (one of three pieces of a divine relic left behind by three goddesses when they created the world). Every incarnation of him fearlessly battles evil, but we never hear anything more than grunts or shouts from him even when he’s being directly addressed. He rarely has any independence from the player.

Embodiment and Presence

The type of character a game has is an important factor in the level of immersion in a game, known as presence. Similar to agency, there are several subtypes of presence. Though social presence can play a factor when playing cooperatively or against someone else over the internet, sensation mirroring mainly focuses on character and spatial presence. Character presence involves engrossment and identification with the player character. A phenomenon

known as “aesthetic doubling” takes this description to the next level. Having roots in Drama Therapy, aesthetic doubling occurs when an actor takes on two identities within their consciousness; One being the actor themselves as an observer, and the other being the consciousness of the role they are playing (Bowman, 2018). Video games aren’t typically played on a stage but aesthetic doubling can still occur while playing because the players have themselves as an audience to entertain, as stated in the Theory of Puppetry. Games with fully fleshed out characters tend to see players experience aesthetic doubling much more than any other classification, though it doesn’t particularly matter whether they’re ego or allocentric (Tu et al., 2022). From this, it’s safe to assume that players don’t typically empathize with and internalize a playable character and their goals if they have to project themselves onto it. In other words, the necessary factors for someone to feel such character presence that they embody the character they are playing as the character needs to have a clearly defined personality and arc that the player can map onto themselves as they play the game. The more the player has to fill in the blanks about their avatar, the less they identify with them on an empathetic level.

Creating an identity based on the consciousness of a character during aesthetic doubling is only part of identifying with them. It may help with enabling strong empathy while playing but that doesn’t necessarily cover the practical part of it. It’s not often that a video game does not have some sort of goal. Goals can vary wildly between video games. From paying off your debt and maintaining a small community to killing fate itself in order to save yourself from a god’s betrayal, nearly every game has some sort of objective for the player character. Players often have their own goals as well, be it a self-imposed challenge or a gameplay objective the game gives them to further the story. The medium of video games and the worlds they contain host a three-way interaction between itself, the player character, and the player (Gee, 2005). The player

and their character take on each other's goals and must work together in order to achieve anything in the virtual world. Furthermore, the player and their character don't necessarily have the same knowledge. A player character may have skills that are imperative to the world they're in, but they don't know how to make themselves move to carry out their goals. The world must convey that information so the player can overlay it on what a player character *does* know.

Lollipop Chainsaw's (2012) Juliet Starling has a vast knowledge of zombie hunting that the player isn't necessarily told, but without the player knowing what button to press to make Juliet swing her chainsaw around she would simply stand there making conversation with her magically revived boyfriend's decapitated head until she's eaten by zombies. In this way, a player and the game's central character are two halves of a whole mind, quite similar to aesthetic doubling's two identities. One directs and observes from the third person, while the other is in the thick of it, thinking and feeling in an environment.

Obviously, embodiment of a character seems to have great ties to the virtual environment. They need a place to move about in, but also an environment is necessary for controlling the game. It sets boundaries that would otherwise turn a game into a more abstract interactive experience rather than something with a goal in mind. This is why the environment is part of the final aspect of puppetry: facilitators.

Facilitators

Facilitators don't have as much to do directly with the player or player character as control or ownership. Facilitators are more about the external variables that shape the player's subjective experience with the game (Calvillo-Gómez & Cairns, 2008). Some of the factors considered are previous experience with the game and others like it, and the time spent with a

game (Figure 39). Aesthetics of a game are also a factor but “aesthetics” is only vaguely defined, which is why there are other factors that can act as facilitators in place of aesthetics.

The experience of playing a video game if it is your first time touching a controller is vastly different than when it's your hundredth. Veterans have an edge that novices don't. They've developed muscle memory of where the individual buttons and sticks are, and have acquired skills and knowledge that can be transferred between games via inference. This is even marked by a marked difference in motor neuroplasticity (Giboin et al., 2021). The phrase “practice makes perfect” is prolific in our society largely because it has some truth to it. Take a game like *Super Smash Bros. Ultimate* (2018) for example. It is a fighting game with exactly 89 fighters for players to choose from. A player who has played the game for several hundred hours amongst the five games in the *Super Smash Bros.* series will not only fare better in a fight with their fighter of choice but with any of the 89 fighters than someone who has only played a couple of rounds in *Super Smash Bros. Ultimate*. The skills are not fighter, game, or even series exclusive. Having less experience with a game means more attention is being put into learning the controls and systems than the more advanced and niche details that have been implemented into the world and its gameplay.

The meaning of “time spent with a game” is quite literal. How much time do you have to play a game right now? Not many people have the luxury of being able to sit down and play a game uninterrupted for an extended period of time. It would be very hard for a student to get immersed in a virtual world knowing they have to keep track of time, lest they be late for their class in an hour. This is symbolic of a greater facilitator, the external environment in which you're playing a game in. Playing a video game in a public area or at a social gathering is much different than playing one alone. Between the haptic feedback, large screen, and the light gun

controller shaped like the weapon used in the game (Figure 41), one would think *Luigi's Mansion Arcade* (2015) would be an experience rich in puppetry. There is one issue with this notion: *Luigi's Mansion Arcade*, as the name implies, is an arcade game. Though it has a covered extension where players can sit, this arcade cabinet is rarely found outside establishments such as Dave & Buster's, a bar-and-arcade restaurant chain. These establishments are often filled with colored LED lights and noise from adjacent attractions. Though the environmental activity of a Dave & Buster's is an extreme case, it holds all the core elements of reality that could distract a player enough to prevent full engagement. Conversely, some games are not designed to be played in an isolated setting. Some are meant to be social affairs, both in person or over the internet. Games such as the *Mario Party* franchise are designed to be a social experience as well as entertainment. If played alone it may accomplish more in making the player feel isolated from the world than in entertaining them. External environment can likely be ignored if attention is diverted towards the game enough, through what is possibly the most important facilitator of all: virtual environment.

When a puppeteer performs, the puppet must inhabit a world suited to its needs. The same goes for player characters in video games. Aesthetics is mentioned by Calvillo-Gómez & Cairns as a facilitator, but the visual design is just a part of the virtual environment, which quite literally facilitates the game. The virtual environment consists of art style, setting, sound design, and a system that determines how the player can interact with the world through their avatar. In fact, these interact heavily with the control aspect of puppetry. Usually, a player is granted high control over their avatar, allowing them to take ownership of the player character's actions. In cases such as *MGSV* though, the player's control is restricted heavily. This is where facilitators play their most vital role. When control is low, ownership can still be maintained through the

facilitators (Calvillo-Gómez & Cairns, 2008). As Venom Snake all the player can do is push forward on the analog stick to make him move, and it's the virtual environment that keeps the player engaged and embodying him. The section would not induce sensation mirroring if it weren't for the stools and railings that Venom Snake can try to lift himself up on and knock down when he fails. As this happens you can see fire and hear gunshots and footsteps. They help create a much more desperate and injured affect in the player than when they are able to move and fight back freely later on in the mission. The virtual environment doesn't only act as a facilitator when control is low, however. It's ever-present, especially since environments are often built around the capabilities of the player, the combined goals of the player and character, and the genre of game they're playing. Players are forced to confront and understand the environment if they want to play the game properly (Polito & Hitchens, 2021). The original *Metal Gear Solid* (1998) for the *PS1* is a stealth game. If the art and plot synopsis wasn't enough to inform a potential player, the tagline "Tactical Espionage Action" spells it out for them. The goal of the game is to find the best methods to sneak past enemy soldiers toward the objective. The developers designed both the island the game is set on and the controls of the main character Solid Snake to encourage this. Generally, it's an ill-fated idea to make Solid Snake barge onto the island guns blazing, as the developers purposefully focused on his sneaking skills rather than combat skills when creating him. There are scripted points where combat is unavoidable, but those scenarios often take place in areas built to accommodate combat rather than stealth. Players can embody Solid Snake better when they are not fighting against the flow of the environment he inhabits. This goes for just about any game.

Theory of Puppetry Revisited

The Theory of Puppetry, initially coined by Eduardo H. Calvillo-Gómez & Paul Cairns in 2008, views video games through the lens of a puppet show. The video game is the setting in which the show takes place, the player's avatar is the puppet, and the player steps into the role of puppeteer as they perform for an audience of themselves. As an audience member, they suspend disbelief, allowing themselves to take fiction as reality for the sake of entertainment, and to be entertained the puppeteer must pull the strings. The puppeteer doesn't merely pull the strings just to pull them, however. The puppeteer takes on a secondary identity in conjunction with their own, the identity of the puppet. It's easiest to embody this new identity when the major details of the identity are already filled in, and it's up to the puppeteer simply to act within them. The world in which the puppet moves is tailored to the story as well as whatever type of puppet is being used. When it can't seem to move at all, the environment must hold the key as to why, otherwise the person who made the puppet did a very poor job. It is through these keys that the player of a video game, Can fully embrace the world they are in and the character they represent, both as entertainer and entertaineer. That's when they begin to embrace tension in the strings as they try to move the puppet forward when it gets stuck as part of the show, even knowing that they don't have to try very hard to free it.

This is only one theory to describe the phenomenon that drives sensation mirroring. While both the original and the current versions of the Theory of Puppetry can be supported by data collected from other studies, not everyone would be partial to it. There are those who believe that self-reported data collection isn't the most reliable way to seek answers. After all, human memories are highly subject to alteration (Howe & Knott, 2015). There may be a more concrete explanation of sensation mirroring. While cognition could be the reason behind it, it

could just as easily be attributed to the ways in which our brains and bodies are built. Cognition could have nothing to do with sensation mirroring, while biology has everything to do with it.

Controls in the Body and Brain

Illusions in the body are not all about cognition. The actual processes the brain and body undergo contribute heavily to illusion induction, even when we know logically that the illusion is impossible. The infamous “Rubber Hand” illusion (Botvinick & Cohen, 1998) is the poster child for the likelihood of physiology being involved with illusion in some capacity. The initial study on the illusion (based on a phantom limb study by V.S. Ramachandran, D. Ramachandran, and S. Cobb in 1995) is a feeling of displacement in body parts. The way Botvinick & Cohen set up the illusion was as follows: Participants sat in a chair that obscured their view of their left hand but placed a detached rubber model of a left hand within their field of view. Participants’ hidden left hand was stroked with a paintbrush in sync with a brush that stroked the rubber hand. Participants then began to identify the fake rubber hand within their field of view as their own, as opposed to the real hands that have been attached to their bodies since birth. Video games could very well be a giant Rubber Hand, but this is not the only possibility.

The neuron systems of the brain are highly complex. Like the ocean or outer space, no matter how much we learn about the brain there will always be more to discover (Lam, 2016). That being said, we’ve gained extensive knowledge about the complexities of its many regions. We’ve made such great strides that we’re able to disconnect the two halves of the brain in such a way that people can largely recover (*Hemispherectomy*, 2020). We can identify specific activity, and begin to craft theories and hypotheses based off of our observations. There’s a limit to the extent we can manipulate and observe the brain’s inner workings, but there is much to discover before that limit is hit. With what we’ve learned about the functions of certain neuron systems thus far, it wouldn’t be surprising to learn that neuroactivity is one of the forces behind sensation mirroring. Neuron activity is so vital to human functioning that we wouldn’t be able to survive

without it. Of all the directions to tackle this issue from but the most prominent ones as of right now tend to fall into two categories: one that focuses more on actual physiological responses, and one that puts the responsibility on our neurons.

Human-Computer Physiology

One of the biggest experiences in sensation mirroring is the illusion of physiological alterations, especially in movement. In *MGSV*'s case, it's loss of movement. While it makes sense under the Theory of Puppetry why alterations in cognition can produce this effect, there's no immediate mechanical explanation. Logic would dictate that there's no real reason for such alterations to occur. What could be happening biologically that can defy logic? There's no single answer, as several processes are happening at once.

In Body

Sensation mirroring could be explained in part by the way the body reacts to video games, of which there are several. These reactions occur all over, both inside and out. The most notable to the average person occurs on the outermost part of the body, the skin. This reaction is known as the Galvanic Skin Response (GSR), an automatic response when faced with emotional stress. It's the alteration of natural heat and electricity patterns that pass through the skin in response to arousal ("Definition of Galvanic Skin Response," 2011).

Some overlap between physiological and cognitive explanations is unavoidable since in both cases a player is interacting with a virtual environment, and must develop a mental model with the avatar as a frame of reference similar to spatial mapping in reality. As such, GSR can potentially be used as an indication of presence to a certain extent. As a player becomes focused on a video game, event-related potentials (the pulses of electricity fired from the neurons in response to stimuli) fire more readily (Terkildsen & Makransky, 2019). But the more noticeable

changes occur via GSR and seem to indicate attention is shifted away from reality and more towards the environment in the game. The indicators for this shift are found in the number of sharp GSR inclines followed by declines, or “peaks”, per minute. It appears that the more arousing and attention-grabbing both the avatar and virtual environment are, the more GSR activity there is (marked by more peaks per minute). The physical effects of this change seem to reflect the shift in attentional reallocation too. In cases of the Rubber Hand and other body illusions, the temperature of the skin lowers (Swinkels et al., 2020). Along with this, there is a reduction in somatosensory processing. Pain sensitivity becomes lower and reaction times increase.

Despite the decrease in somatosensory processing, kinesthetics may also play a large role in how the visual information is processed resulting in sensory illusions. This is all thanks to the haptic feedback that the *N64* and original *DualShock* controllers integrated and popularized. Haptic feedback originally just vibrated the controller in a static area but it has gotten incredibly realistic in recent years, with some companies even claiming that players can tell how many ice cubes are in a virtual cup just by shaking the controller (Takahashi, 2017). The Rubber Hand illusion doesn't only work when the target object is in reality. When hand tendons were vibrated in time with virtual stimuli it was shown via questionnaire that similar illusions can be induced in VR (Fusco et al., 2021). These sensory illusions tended to increase when the real limb that was vibrating was out of view of participants in the study. Interestingly, a similar increase was observed when the virtual limb appeared disembodied rather than attached to the participants' real bodies.

All these sensory inputs in the muscle and tissue of a player and resulting bodily changes are intertwined with more internal changes in the form of neurological phenomena. Again,

overlap between physiology and cognition is unavoidable, as the Theory of Puppetry states that body and mind cannot be separated (Calvillo-Gómez & Cairns, 2008). It was initially meant in a more metaphorical sense, but it still stands true when taken literally.

In Brain

Because the mind and body are so inseparable, it would be logical to think that, much like the Galvanic Skin Response, bioelectric rhythms in the brain would be thrown out of balance. Those who follow this line of thinking would be correct! Normally brain area activity for both mental motor imagery and its physical execution have event-related potentials that increase and decrease in sync with each other (Nakayashiki et al., 2014). When in VR like the somatosensory study by Fusco and colleagues (2021) the electrical rhythm of the two areas get desynced from each other (Pfurtscheller et al., 2007). This can be seen via EEG. This is attributed to the activation of certain neurons, but those neurons likely play a greater role in sensation mirroring than merely desyncing sensorimotor rhythms with the body. There are other important neurological processes occurring that are unrelated to these neurons to focus on though. Specifically, the processes of mapping and adaptability.

At this point, it's apparent that there are a host of elements that, if removed, would make human existence extremely difficult. Joining the ranks of these elements is the brain's ability to process its surroundings relative to the body, as well as its structural adaptability. If humans weren't spatially aware they'd be bumping into things all the time after all. That's why it could be one of the factors in sensation mirroring. The brain has already demonstrated its ability to spatially remap on the fly to compensate for various factors entering the equation. This is best exemplified by how it considers something "near" or "far" (Berti & Frassinetti, 2000). The brain recognizes objects differently based on whether they are "near" or "far". Generally, an object is

considered near if it is within reach, and far if it isn't. Different visuotactile neurons fire based on this distinction. This is based on an animal model which has previously been suggested to be congruent with a human model. When monkeys were given a tool to extend their reach the neurons that recognized near objects would fire for objects that were considered far before. While there's not one definitive explanation for this change, it does support the theory that the brain has remapped the surrounding space in response to this new factor entering the equation. Viewing the controller as a tool, it may be that the brain remaps the virtual environment as something within reach knowing that it is now accessible, though how this change could happen so quickly is not immediately apparent from the work of Berti & Frassinetti (2000).

There could be a link between how the brain recognizes a virtual environment that it knows it can't reach physically as near, and the neuroplasticity of the player. The link between neuroplasticity and video games has already been studied to an extent. Veteran video game players have had changes to their synaptic pathways that allow for greater excitatory and inhibitory output (Giboin et al., 2021). This was determined by measuring the motor-evoked potentials and resting motor thresholds in the participants of their study. Motor-evoked potentials, the electrical signals that are let out after muscles move, were greater in those who were veteran gamers compared to novices, even in games neither group had ever touched before. When the participants' resting motor thresholds (the intensity of stimulation that the body minimally responds to) was tested, it was also found that the veterans reacted at a higher threshold than novices. While this may sound like their reaction times are slower, in actuality it means they have greater inhibitory responses. These features of veterans are likened to great horsepower in an engine, but also a great braking system. The brain develops these systems as a result of its choice of entertainment medium. It's unlikely that motor pathways are the only

system the brain reforms when necessary while playing video games. Being able to relate distance to the avatar within the world is vital, thus it's possible it has adapted a spatial mapping system to suit its hobby.

Sensation mirroring explained by physiological adaptation is a valid theory. The brain may adapt to video games with frequent enough experiences, and eventually recognize the controller as a tool to reach into the game. Primed for gameplay, the player's brain might react in a way that's more in line with what can "reach" the player, because the player is no longer so far removed from the world of the game. It's a start, but it's incomplete if only the motor neurons are considered. While motor neurons are important, they are not the only neuron system in the brain by a longshot.

Specific Neuron Activity

Nothing in the human body gets done without the firing of neurons. Neurons send and receive the bursts of electricity that make everything in the body happen (*Brain Basics*, 2023). They facilitate physical processes, like manipulating a video game controller, but they are also necessary for neurological processes. Not only are they proactive in telling the body how to move and where, but they are reactive as well. When we have a change in emotion they kick in to tell our bodies how to react to the change in affect. They also work in reverse. They activate to tell the brain what areas of the body have been injured, which then causes it to send out distress signals in the form of pain. Neurons are a vital system for any living creature to have. Because they are so present in everything we do, it's an obvious assumption that they play some sort of role in sensation mirroring. We cannot assume how important of a role they play. They could simply be playing messenger in response to visual, tactile, and emotional stimuli. But they could just as easily be the backbone of the whole phenomenon. After all, they are the main channel of

information and action between the external environment and our internal mechanisms. The neurons that are potentially responsible for sensation mirroring are most likely the Mirror Neurons.

History of the Mirror Neuron

Mirror Neurons were first discovered in the 1990s by a group of researchers in Italy (Winerman, 2005). They were not discovered in humans initially, but rather in Macaque monkeys. Researchers had found that certain parts of their premotor cortex would fire not only when a monkey reached for a peanut and ate it, but also when the researchers themselves reached for peanuts. After confirming their findings and giving these mystery neurons their current name, the researchers' next target was to find out if humans had Mirror Neurons as well. They faced an issue in ethics as they couldn't attach electrodes directly to a human's brain like they could with monkeys. They needed to find some alternative way to identify them. Their solution was to study motor-evoked potentials. The motor-evoked potentials that fired when a participant grabbed an object appeared to be similar in both pattern and location to the fired motor-evoked potentials when they watched researchers grab the same object. While not definitive proof, the evidence seemed to imply that humans had Mirror Neurons too. Since then most studies on Mirror Neurons have followed similar designs as the initial one after their discovery. They began to use neuroimaging to do so, with fMRIs being the most common among them. While we are aware of how they function in the motor cortex, there are other areas of the brain that react similarly in other scenarios. The aim of many current studies of Mirror Neurons is not just finding definitive proof, but understanding similar phenomena that appear in other areas of the brain.

What Are Mirror Neurons?

As previously stated, Mirror Neurons were first noticed in the motor cortex, though they were quickly discovered in the premotor cortex as well (Gallese, 2009; Winerman, 2005). Much like the other neurons in these cortices, they fire whenever the body executes an action. In large movements like walking, all the way down to the slightest muscle twitches, Mirror Neurons pulse with motor-evoked potential (Gallese, 2009). What makes Mirror Neurons so special from others related to movement is that it isn't the only time when these neurons fire. Mirror Neurons also mirror actions that are observed. While the body doesn't move when Mirror Neurons fire upon observation, motor-evoked potential occurs in corresponding areas of the observer. In an animal model, Mirror Neurons have been shown to respond even to the movement of nonbiological objects (Albertini et al., 2021). The animal model doesn't confirm this happens in humans as well, but enough parallels exist between the animals used as models and humans that it's probable.

The current theory as to what purpose Mirror Neurons serve is to allow the brain to interpret visual depictions of motor activity by firing neurons in the same or similar patterns (Gallese, 2009). It implies that this interpretation is necessary to understand what action is being observed. Mirror Neurons are highly accurate too, as they don't react exclusively to actions in full view. They have been shown to fire correctly when presented with actions that are obscured from view, and even in response to sounds associated with specific movements and actions. Simulation via Mirror Neurons doesn't stop at physical movement. It appears that they also fire in response to observing emotion. Mirror Neurons could be contributing to empathy by firing in the same patterns that would fire if the observer were feeling the emotion. Ultimately, the brain is

constantly simulating observations without actually executing them itself in order to make sense of them.

Mirrors in the Player

Because of the physiological attributes of Mirror Neurons, studies asking whether they can be used for rehabilitation have begun to pop up. It's been suggested that because of the Mirror Neurons' functions, motor pathways can be reestablished by observing actions (Lim & Ku, 2020). It's already been established that video recordings of body parts in action trigger Mirror Neurons (Lim & Ku, 2020). It's been further proven that viewing body parts move in the context of interaction with objects stimulates greater Mirror Neuron activation than watching them move on a blank background (Lim & Ku, 2020). The role of Mirror Neurons in sensation mirroring is still unknown but two games that can be controlled through neuron activation were developed for Lim & Ku's (2020) purposes. Participants with motor disabilities played the game by watching video footage of an action being performed alongside it. The footage was meant to show what would happen in the game to accomplish the goal, and when the participants observed it the controller would read the neurons firing and mimic the action in the game. The participants managed to successfully control the game through this method. The trials even hinted at some rehabilitation in the previously damaged motor pathways.

With what we know about Mirror Neurons currently, the most probable scenario is that they are working in tandem with our physiological reactions to induce sensation mirroring. This is supported by irregularities in the electrical rhythms in the motor cortex that Pfurtscheller and colleagues (2007) attributed to them. It's likely that as the player engages with the game their Mirror Neurons are firing in response to watching their avatar. With Mirror Neurons being present in both motor and emotional functions, they are firing in patterns that mimic the brain's

own for when they are (or hypothetically would be) in similar scenarios. In earlier days of video games, it may have been hard for Mirror Neurons to fire during a game in the first person, but games have become far more sophisticated since then. In modern first-person games, avatars have become very vocal (communicating in grunts if they are a silent protagonist) and their hands or weapons often come into view when performing an action. Knowing that Mirror Neurons in the motor-related cortices can mimic observations based on auditory and visually obscured stimuli, it's not a stretch to assume that the Mirror Neurons in other areas of the brain exhibit similar capabilities. Depending on how focused a player's attention is on the game it's possible that the signals from Mirror Neurons become dominant, with the signals dictating the player's mechanical control receiving the same conscious priority as walking, or even breathing.

The Full Brain/Body Experience

Body and brain are unable to be separated entirely (Calvillo-Gómez & Cairns, 2008). It's true for a cognitive approach to sensation mirroring like the Theory of Puppetry, but it's also true for human physiology. Movement wouldn't be possible without the brain directing the body, and it wouldn't matter how many thoughts the brain could think if it couldn't act on them. The cross between the mental and physical engagement with a game is bound to open up the possibilities for new phenomena previously undiscovered. After all, before video games became so big you could have either or. You could watch a video, or you could play a game. Doing both at the same time likely doesn't evoke the same response because it's two separate activities. Toggling attention between two different mediums. But since the entertainment of watching something and playing something are rolled into one, it probably creates some special effects with the overlap of the multiple stimuli.

The fact that there are several layers of stimulus input when playing video games is the crux of sensation mirroring's possible physiological causes. The brain is constantly active, receiving visuals, audio, and kinesthetics while also strategizing, directing muscle movement, and simply making sense of everything that's happening on screen. The player is constantly watching the actions and hearing the reactions of their avatar. The complex systems of neurons in our brains that allow us to receive information and translate it into something the brain recognizes, the Mirror Neuron systems, are constantly firing to replicate and interpret actions and emotions based on the smorgasbord of multisensory cues the game emits. At the same time, the brain has entirely remapped the space around it to include a whole new (physically inaccessible) area as "within reach". Excitatory and inhibitory systems constantly flaring all while the somatic attention of reality is drawn towards how the controller is shaking and rumbling in response to what the player is reaching out towards. The player's digital body takes priority over their real body. If the physical body is not at risk here it might be more beneficial, and perhaps easier, to receive and interpret all these signals not as statistics that the brain has to keep track of, but as reflections of the game mapped over the real body. No physical injuries are actually sustained, and the pain of injury is nonexistent, but tracking if the player has taken damage is important, sometimes down to the area of the digital body that's affected. This, combined with the mood the game sets for the player could lead to what's been dubbed sensation mirroring. The player feels similar sensations to their avatar because during the abundant amount of processing and information retention that is occurring, it lightens the mental load to feel rather than know.

That's Just a Theory

There are many different angles to look at sensation mirroring. The physiological and cognitive angles are not the only ones to explore this phenomenon from. They are just the two most prominent and accessible. Once again, there is extremely scarce research on the subject of sensation mirroring. So scarce that it did not even have a name. At this point in time its existence is only marked by anecdotes and self-reports. Many veteran gamers will describe it, but none have a real name for it. If the gaming community or even the general public studied sensation mirroring it could be exploited to create even more immersive gaming experiences. It could also be used in VR for other purposes, such as more accurate simulations. To study it at all though, there needs to be a place to start. Some potential explanations that testable hypotheses can be formed around. With such an unusual topic it would be hard to find that starting point if all the research that could possibly relate to it is scattered across the ends of the Earth. That is why a thorough combing of existing research was needed. With that combing now complete a theory can now be crafted based on the existing information about human-computer interactions.

What is Sensation Mirroring

There is a particular phenomenon that can occur while playing video games. It has no official name as it has not yet been studied at length by the scientific community. Its current unofficial name is very literal, as it's inspired directly by how people who've felt the phenomenon described it. It is currently known as sensation mirroring. Sensation mirroring is best described through example and testimony. What these anecdotes describe seems to suggest that under the right circumstances, a player begins to have sensory experiences that mirror what their avatar in the game is experiencing. These experiences aren't a one-to-one comparison- if the player is attacked in the game while experiencing sensation mirroring they will not sustain

parallel injuries in reality, nor will they experience any pain. The sensation the player feels is a broad generalization of what the avatar is experiencing. Sensation mirroring is often cited as occurring during gameplay moments of high intensity, whether it be due to a stress reaction to the player's current situation, or an emotional reaction to the ongoing events at that moment. Based on previous studies of cognition, acting, and neuron and motor activity, a speculative theory has been formed. Sensation mirroring as an illusion consists of several aspects of a player being altered. In the cognitive sense, it is an alteration that is similar to what occurs when an actor gets into character. The player is engaging with the Theory of Puppetry (Calvillo-Gómez & Cairns, 2008), a paradigm that compares a player of a video game to both the performer and the audience in a puppet show, with the player avatar being the puppet. The player engages in aesthetic doubling as themselves watching the game and the character they are playing as. This is maintained through their level of agency and ability to control the character to their will while following the parameters of what they can and can't do. When the player's option of control and interaction is removed, it's up to the environment to facilitate their experience as the character their avatar represents, allowing for what control the player has left to retain meaning when interacting with the environment. This Theory of Puppetry is overlapped with physiological processes that the body engages in when playing video games. The brain remaps the virtual space, going from intangible to actively accessible thanks to the controller being a tool that allows the player to reach into that world. Since the player's real limbs are not in focus, the brain remaps them to be those of their avatar's. Mirror Neurons are ablaze since the body is constantly receiving stimulus input. The Mirror Neurons are constantly simulating and interpreting the input it's receiving and the body shifts the way it's processing it in this time of high intensity as real life is blocked out and the virtual environment becomes the new (but temporary) primary reality.

All of these factors come together to allow the player to empathize with the main character, their avatars. It's a glorious storm of all the right processes to transfer the mind into a virtual body and allow it to be something other than itself.

Contradictions and Holes

The current theory on sensation mirroring and its mechanisms is solid. It's grounded in previous research on elements of the mind and body that are heavily involved in the process of playing video games. Self-representation, the firing of motor pathways, and processing of stimuli, all of these have been studied extensively, just not in the context of the current phenomenon. However, this theory also has its faults. The biggest and most dangerous fault of this theory is speculation. Many of the connections made between the different topics that are compiled are based on the assumption that there is a connection. This assumption is not a stretch by any means, but there is no solid evidence to back up every claim made in the current theory. For example, the connection between Mirror Neurons and empathy is still unknown. There are neuron firings in the prefrontal cortex that appear similar to the Mirror Neurons that fire in the motor areas, so there is cursory evidence to support this theory (Gallese, 2009). Cursory does not guarantee that it is the same, however. Additionally, no evidence suggests that Mirror Neurons have anything to do with aesthetic doubling. No evidence opposes it, but it's still simply conjecture. Even the individual sections upon which the sensation mirroring theory is built have their own holes.

The cognitive side of the theory is not as unstable as the physiological side, but it still has its issues. The current Theory of Puppetry is an amalgamation of Calvillo-Gómez & Cairns's original Theory (2008) and several other studies done on character immersion, presence in video games, and human-computer interactions. Plenty of it fits the mold of the original Theory of

Puppetry but not without a little extrapolation. There are two major weaknesses to it. The first is interpreting what each study considers to be “immersion”. There is no real operational definition because it is such a subjective experience. There are several contradictory definitions within the studies referenced. For instance, the definition of immersion used in the current Theory of Puppetry describes it as a scale of emotional and mental involvement (E. Brown & Cairns, 2004). A player doesn’t need to feel as if they are the character under this definition, just that the game’s reality is the dominant one. This conflicts with a different definition that only explains it in the context of the player feeling as if they are the character (Bowman, 2018). The operational definition within the current Theory of Puppetry is more akin to the former, but it does include character enactment within it. The second major weakness is the fact that there are currently no definitive ways to measure immersion. At the moment a 2019 study on “presence” in video games and responses in the skin is the most accurate measure there is (Terkildsen & Makransky). They measured GSR but they also administered self-report surveys after testing. Human memory is prone to error (A. D. Brown et al., 2012). Terkildsen & Makransky used the Multimodal Presence Scale (Wirth et al., 2007) as the survey, and evidence suggests it’s fairly accurate, but that does not mean questions cannot unintentionally influence answers given. Misremembrance is common among humans. The other issue with Terkildsen & Makransky’s measurement system is that they found it to be based on arousal rather than presence. There was some correlation between participant arousal and presence, but not in every category. There is a chance that a better measurement system is out there, but for now, there must be compromise.

The physiological side of the sensation mirroring theory also has its caveats. First of all, not every single game in which sensation mirroring can occur has an avatar that is even vaguely humanoid. The game *Stray* (2022) is the perfect example of this concern. In *Stray*, your avatar is

a cat. It's not even anthropomorphic. It does not speak English or any other language, nor are its facial expressions exaggerated to the point where suspension of disbelief is required. An average house cat can make the sounds, express emotions, and move in the way the cat from *Stray* does. Why then is sensation mirroring possible in this game? At this point, more research is required to be able to tell if the movements of non-primates can activate Mirror Neurons in the same way human, monkey, and ape actions do. It could be possible that we translate their actions into similar actions that the human body is capable of. It's also possible that this means that Mirror Neurons have absolutely nothing to do with sensation mirroring. It's purely speculation and conjecture at this point. The other major caveat is found in how the brain maps the space around it. To put it bluntly, there isn't any evidence to support or rebuke the idea that the brain counts the controller as a tool and remaps virtual space to include it within its reach range. Any existing literature on this is few and far between. Hypothetically, if a player considers the controller a tool to reach into the environment similar to how they may consider a stick a tool to extend their reach, then the brain may remap it. While that theory makes sense, it's mostly baseless if there's no evidence for or against it. Once again, it's a resort to speculation.

With all the extrapolation and pieces of evidence that have been reshaped to fit, it would not be inaccurate to call the entire theory speculative. Frankly, that is the truth. But that's not necessarily a bad thing. It's a theory nonetheless and gives researchers further directions to look in. Time and time again researchers have devised theories, been proven wrong, then gone back to the drawing board. There is missing evidence that requires research to fill in the gaps. If those gaps turn out to be unfillable, then it's still one step closer to solving the mystery. For now, the research just needs to get done.

Fill In The Blanks

It's been established that there is still quite a bit of hard evidence missing from the theory of what's behind sensation mirroring. It's also been established that in order to rectify this there is a mountain of research still to be done in order for this theory to be viable. There are many directions to look to when deciding how to start bridging the gaps in the theory. Almost too many. There are a few leads that are extra promising and are worth turning attention towards more than others.

Can Controllers Extend Reach?

The biggest assumption made in the sensation mirroring theory is that the controller would allow the brain to remap the virtual environment to consider it "near". This is an extrapolation made from research concluding that tools become remapped as extensions of the body and expand the perimeter which the brain considers to be within reach (Berti & Frassinetti, 2000). It's a logical assumption, but assumptions can still be wrong. A replication of the study involving a video game would likely be the best way to approach this issue, but first the hurdle of getting an animal to play a video game must be cleared. They've been able to play simple games in the past (Dolins et al., 2014) but having them play something more complex may prove difficult. Alternatively, the model animal used in the study is commonly understood to be similar enough to the human brain that results would be accurate. Knowing this, neuroimaging could be used for the animals in a direct replication and then compared to that of humans while playing a video game.

Do Humans Map onto Animals?

The issue games like *Stray* and *Ōkami* present when using Mirror Neurons in an explanation for sensation mirroring is that while those games induce it, their protagonists are

quadrupedal. Amaterasu, *Ōkami*'s protagonist is far more stylized than *Stray*'s and has access to a vast array of unrealistic abilities (including the ability to draw calligraphy over the world to alter it). However, both Amaterasu and the cat from *Stray* still retain the mannerisms of their species (dog and cat respectively) while also inducing sensation mirroring at times. Do Mirror Neurons still fire when watching them move about? What about when watching quadrupeds in real life? This is an important question to answer before moving ahead in the pursuit of knowledge.

The Difference Between Player and Actor

In theory, the “double-consciousness” effect described in Tu et al.'s study on video game character immersion (2022) and drama therapy's concept of aesthetic doubling (Bowman, 2018) are one and the same, considering their strikingly similar descriptions. Video games and stage performance are wildly different mediums for experiencing characters though. The same catharsis experienced when acting out a character physically may not be the same as doing so mentally. Bowman even points out that aesthetic doubling is also sometimes referred to as “double consciousness”, but that does not guarantee they are the same. To properly approach sensation mirroring with the Theory of Puppetry, this potential difference must be determined.

Unconsidered Research

When discussing self-representation and digital media Polito & Hitchens (2021) established several key factors that aid in the alteration of self-representation. While two of them were worked into the current Theory of Puppetry and one touched on briefly (agency, presence/immersion, and identification with the avatar), the other two were left untouched. These two factors were perceived time distortions and flow states. Time distortion is as it sounds, a player's sense of time becomes distorted while being immersed in a game, and time distortion is

a contributing factor to entering a flow state. Flow is best defined as a state where “attention is freely invested to achieve a person’s goals because there is no disorder to strengthen out or no threat for the self to defend against” (Csikszentmihalyi, 1990). Essentially, it’s tunnel vision with no need to stop and think. Every action and reaction comes naturally and there is no friction between reality and its limits. A flow state feels different than sensation mirroring, but it is also something that can occur while gaming. It’s highly likely that flow is also a contributing factor to sensation mirroring, but how it fits into the puzzle is still a mystery that needs to be examined more closely.

There is one phenomenon that’s been completely left in the dust when considering the mechanisms of sensation mirroring: Phantom Vibration Syndrome (PVS). PVS is a hallucination that those who carry smartphones in their pockets often have (Rosenberger, 2015). It’s described as feeling vibrations in the pocket someone keeps their smartphone, as though they’ve received a call or notification. When an affected person goes to check their phone, however, they will find that they’ve received neither. It can even occur without the presence of the actual smartphone in the pocket when it occurs. Much like sensation mirroring, there are several theories as to why this occurs focused on both the interaction between phones and their users, and the biological processes of the body and brain. The reason this hallucination wasn’t initially considered while researching sensation mirroring is simple: human forgetfulness. The exclusion of PVS is not an issue with earth-shattering ramifications. It’s simply an additional lead to consider when discussing retroactive research.

The Next Step

When all is said and done research on sensation mirroring must continue moving forward despite the areas that require stronger confirmation. At the very least a way to measure sensation

mirroring must be devised. How that can be created is still up in the air. The technology to do so might not even be available yet. At the present moment, the best measure available is Terkildsen & Makransky's (2019) method, which combines GSR measurements with Wirth et al.'s Multimodal Presence Scale (2007). This method will require much modification and experimentation to get close to accurately reporting sensation mirroring, but if humans can take *Tennis for Two* and turn it into *MGSV*, then refining Terkildsen & Makransky's method is miles from impossible.

Conclusion

Sensation mirroring is a mystery. It's a phenomenon that creates a one-of-a-kind experience for an entire community of people, but extremely little is known about it. What is it about video games that allow us to feel with our whole bodies just by holding a lump of plastic and wires? What is it about humans? There's still no answer. But there is an estimation. A mix of how the game allows the player to move their avatar, cognition, and complex physiology that lets humans be as sophisticated as they are. A perfect storm that, when the stars align, allows a player to feel immersion unlike any other experience. There's still much to be explored about sensation mirroring, and much about human composition if we want to confirm any of it. Not only is it a gateway for entertainment, but it's also a gateway for knowledge of our composition. But for now, while it's still just a mystery, players should strap in for the ride of their lives. It's not like they'll be everyone's biggest enemy anytime soon.

Appendix

Video Games

Animal Crossing: New Horizons (Aya Kyogoku, 20 March 2020)

BioShock (Ken Levine, 21 August 2007)

BioShock Infinite (Ken Levine, 26 March 2013)

Computer Space (Nolan Bushnell & Ted Dabney, 15 October 1971)

Crash Bandicoot (Jason Rubin, 9 September 1996)

Dance Dance Revolution (Bemani, March 1999)

Death Race (Exidy, April 1976)

Doom (Marty Stratton & Hugo Martin, 13 May 2016)

Duck Hunt (Shigeru Miyamoto, 18 October 1985)

E.T. the Extra-Terrestrial (Atari, Inc., December 1982)

Far Cry 3 (Patrick Plourde & Patrik Méthé, 29 November 2012)

Halo: Fireteam Raven (343 Industries, 10 July 2018)

Hogan's Alley (Shigeru Miyamoto, 18 October 1985)

The Last of Us (Bruce Straley & Neil Druckmann, 14 June 2013)

The Legend of Zelda: Breath of the Wild (Hidemaro Fujibayashi, 3 March 2017)

Lollipop Chainsaw (Tomo Ikeda & Goichi Suda, 12 June 2012)

Luigi's Mansion Arcade (Capcom, 2015)

Metal Gear Solid (Hideo Kojima, 3 September 1998)

Metal Gear Solid V: The Phantom Pain (Hideo Kojima, 1 September 2015)

Minecraft (Markus Persson & Jens Bergensten, 18 November 2011)

Ōkami (Hideki Kamiya, 20 April 2006)

Pokémon Shield (Shigeru Ohmori, 15 November 2019a)

Pokémon Sword (Shigeru Ohmori, 15 November 2019b)

Pong (Allan Alcorn, 29 November 1972)

Resident Evil (Shinji Mikami, 22 March 1996)

Ring Fit Adventure (Hiroshi Matsunaga, 18 October 2019)

Spacewar! (Steve Russell, April 1962)

Stray (Colas Koola & Vivien Mermet-Guyenet, 19 July 2022)

Super Mario Odyssey (Kenta Motokura, 27 October 2017)

Super Smash Bros. Ultimate (Masahiro Sakurai, 7 December 2018)

Tennis for Two (William Higinbotham, 18 October 1958)

Uncharted 4: A Thief's End (Bruce Straley & Neil Druckmann, 10 May 2016)

Wii Sports (Keizo Ohta et al., 2 December 2006)

Wii Sports Resort (Takayuki Shimamura & Yohikazu Yamashita, 26 July 2009)

Video Game Consoles

Atari 2600 (September 1977)

Atari 5200 (November 1982)

Fairchild Channel F (November 1976)

Magnavox Odyssey (September 1972)

New Nintendo 3DS (13 February 2015)

Nintendo 3DS (27 March 2011)

Nintendo 64 (26 September 1996)

Nintendo Entertainment System (18 October 1985)

Nintendo Famicom (15 July 1983)

Nintendo Switch (3 March 2017)

Phillips CD-i (1990)

PlayStation (9 September 1995)

PlayStation 2 (26 October 2000)

PlayStation 3 (17 November 2006)

PlayStation 4 (15 November 2013)

PlayStation 5 (12 November 2020)

PlayStation Vita (15 February 2012)

PlayStation VR (13 October 2016)

Sega Dreamcast (9 September 1999)

Sega Genesis (14 August 1989)

Super Nintendo Entertainment System (23 August 1991)

TurboGrafx-16 (30 October 1987)

Wii (19 November 2006)

Wii U (18 November 2012)

Xbox (15 November 2001)

Xbox 360 (22 November 2005)

Xbox One (22 November 2013)

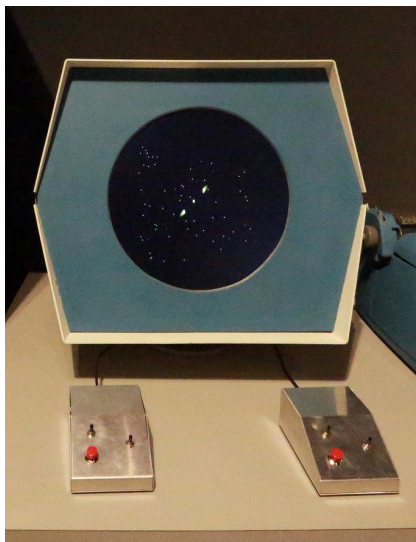
Video Game Controllers

Figure 1: *Tennis for Two*



(Resurrecting Tennis for Two, a Video Game from 1958 | Evil Mad Scientist Laboratories, 2008)

Figure 2: *Spacewar!*



(Suellentrop, 2012)

Figure 3: *Computer Space*



(RC2017/04: Personal Computer Space Transactor 2001 (E-02), n.d.)

Figure 4: *Pong*



(spablab, 2005)

Figure 5: *Magnavox Odyssey*



(“Magnavox Odyssey,” 2023)

Figure 6: *Magnavox Odyssey Light Rifle*



(*Magnavox Odyssey Light Rifle - ConsoleMods Wiki*, n.d.)

Figure 7: *Death Race*



(“*Death Race* (1976 Video Game),” 2022)

Figure 8: *Channel F Jet-Stick*



(*Video Game Controller*, n.d.)

Figure 9: Atari CX40



(“Atari CX40 Joystick,” 2022)

Figure 10: Atari 5200 Controller



(“Atari 5200,” 2023)

Figure 11: *Famicom*



(“Nintendo Entertainment System,” 2023)

Figure 12: *Nintendo Entertainment System*



(“Nintendo Entertainment System,” 2023)

Figure 13: NES Zapper



("NES Zapper," 2023)

Figure 14: TurboGrafx-16 Turbo Pad



("TurboGrafx-16," 2023)

Figure 15: *Sega Genesis*



(“Sega Genesis,” 2023)

Figure 16: *Super Nintendo Entertainment System*



(“Super Nintendo Entertainment System,” 2023)

Figure 17: *Nintendo 64*



(“Nintendo 64 Controller,” 2023)

Figure 18: *Nintendo 64 w/ Rumble Pak*



(“Rumble Pak,” 2023)

Figure 19: PlayStation



(“PlayStation (Console),” 2023)

Figure 20: Dualshock



(“PlayStation (Console),” 2023)

Figure 21: *The Duke*



(“Xbox (Console),” 2023)

Figure 22: *Xbox Controller S*



(“Xbox (Console),” 2023)

Figure 23: *DualSense*



(“PlayStation (Console),” 2023)

Figure 24: *Wii Remote and Nunchuck*



(“Wii,” 2023)

Figure 25: *Wii U Gamepad*



(Calvert, 2015)

Figure 26: *Nintendo Switch Joy-Cons*



(detached from console)



(attached to console), (“Joy-Con,” 2023)

Figure 27: *Nintendo Switch Pro Controller*



(“Nintendo Switch Pro Controller,” 2023)

Figure 28: *Time Crisis 4*



(*Time Crisis 4 Twin Arcade Shooting Game*, n.d.)

Figure 29: Halo: Fireteam Raven



*(Nashville, Tennessee, U.S.A - June 22, 2022 - The inside of the Halo Fireteam Raven Arcade
Video Game Stock Photo - Alamy, 2022)*

Figure 30: Dance Dance Revolution



(“Dance Dance Revolution SuperNOVA 2 Rental,” n.d.)

Figure 31: Ring-Con



(Ring Fit Adventure™ for Nintendo Switch™ – Official Site, n.d.)

Figure 32: Guitar Hero Controllers



(“Guitar Hero,” 2023)

Figure 33: *PlayStation VR*



(Reed, 2022)

Figure 34: *PlayStation VR 2*



(Keach, 2021)

Figure 35: *Nintendo 3DS*



("Nintendo 3DS," 2023)

Figure 36: *PlayStation Vita*



("PlayStation Vita," 2023)

Figure 37: *New Nintendo 3DS*



(“New Nintendo 3DS,” 2023)

Figure 38: *Nintendo 3DS w/ the Circle Pad Pro*



(Byford, 2011)

Figure 41: *Luigi's Mansion Arcade*



(Instant Gaming, 2021)

Glossary*Aesthetic doubling*

The presence of two simultaneous identities within a performing actor, the actor themselves as an observer, and the active consciousness of the character they are playing

Agency

The level of autonomy the player has to manipulate their avatar and their surroundings

Avatar

A digital representation of the player that can be controlled

Control (in Theory of Puppetry)

The level at which a player can influence the game both on a physical and virtual level

D-Pad

Short for “Directional Pad”. A connected set of buttons on a controller's face arranged in a cross shape representing different directions (up, down, left, and right)

Double-vision

The ability to see something as both an object and alive in its own reality

EEG (Electroencephalogram)

A method of neuroimaging that measures electrical activity in various areas of the brain

Embodiment

The measure of how much a player's current identity meshes with the player character's

Event-Related Potentials

Small electrical pulses fired by neurons in response to stimulus

Face Buttons

All the buttons and sticks that are seen on the face of the controller, the side that faces the player

Letter Buttons

Face buttons that are labeled with specific letters or symbols

Facilitators (in Theory of Puppetry)

Variables both in reality and the game that help shape a player's subjective experience

Galvanic Skin Response (GSR)

A change of heat and electricity found in the skin in response to emotional stress

Gamepad

A type of video game controller held in two hands with most of its inputs on its face

Haptic Feedback

A function of most modern controllers that vibrates the controller at various intensities in response to gameplay or cinematic sequences

Immersion

The scale at which a player is mentally and emotionally invested in a game. Also known as *Presence*

Joystick

A controller that is a stick that pivots at the bottom for directional input

Analog Stick

A shorter variation of the Joystick that's moved with just one finger rather than the whole hand found on the face of most modern controllers

Light Gun

A type of video game controller shaped like a firearm that uses light to aim

Mirror Neurons

Neurons that mimic the firing patterns of surrounding neurons when an action is either performed or observed

Motor-Evoked Potential

Electrical signals recorded from descending motor pathways and muscles that have just moved

Neuroplasticity

The brain's ability to reconnect and reorganize synapses following injury or introduction of new information

NPC

Non-player character. Any character that can be interacted with but not controlled by the player

Ownership (in Theory of Puppetry)

The level of responsibility a player feels for their avatar's actions and interactions with the environment

Peripheral

Devices that can be connected to a console to allow additional features or radically different ways to control a game

Puppetry

A state of immersion where the player feels their avatar's actions are truly their own

Resting Motor Threshold

The stimulation intensity elicits the minimal response from motor pathways

Rubber Hand Illusion

An illusion where someone begins to identify a detached rubber hand as their own

Sensation Mirroring

A term created to describe the illusory phenomenon where someone begins to feel similar sensations to what their avatar is experiencing in intense moments of gameplay

Shoulder Buttons

The two types of buttons found on the top of the controller, facing forward compared to the face of the controller. They are meant for the index or middle finger to press

Bumpers

The two shoulder buttons found on the left and right sides of the top portion of the height of the controller

Triggers

The two buttons found directly underneath the bumpers, which extend down the rest of the height of the controller

Venom Snake

The man who sold the world. The protagonist of *Metal Gear Solid V: The Phantom Pain*. Also known as “Big Boss”, the world’s greatest soldier. Placed in a 9-year coma from an ambush on his private military base in the prologue, he wakes up to a missing arm and another ambush to escape from

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[life-and-death-neuron](https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-life-and-death-neuron)

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