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Psychomotor Skill Measurement of Video Game Players

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PSYCHOMOTOR SKILL MEASUREMENT OF VIDEO GAME PLAYERS

by

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ABSTRACT

Psychomotor skills are a combination of innate abilities as well as skills developed because of repeated actions. Researchers have dedicated many studies to understand the extent to which past videogame play contributes to psychomotor skills and fine motor control dexterity. However, not all gamers are created equal. With today's proliferation of platforms, many people are gamers who never pick up a controller. Grouping all gamers together forms dangerous confounds when trying to generalize across a population as diverse as today's gamers.

The current study aims to study a population comprised only of gamers to see if there are significant differences in their psychomotor skills. A psychomotor skills test has been developed, which is designed to simulate proven physical tests, with the express purpose of exposing differences between gamers. After filling out an extensive survey of gaming habits, participants completed the psychomotor skills test.

Participants were then grouped by measured psychomotor ability and a selection of high and low performing gamers completed four tutorial exercises on the dV-Trainer by Mimic Technologies, a validated robotic laparoscopic training device.

The study shows that the number of hours reported per week using analog controllers is correlated with the psychomotor score as measured by the newly developed simulation. In particular, the Purdue Pegboard and Finger Tapping simulation software is the best discriminator among members of the gamer population.

I dedicate this dissertation to my family, students, and committee. Although it's taken me over twelve years to complete this journey, you've all been there to talk me out of giving up. Good going, you win. I did it!

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When I was first introduced to UCF in 2005 as a game programmer looking for something more inspiring to spend my life doing, I met a couple young dudes at UCF named Mike Moshell and Charlie Hughes.

I was so impressed with them I decided to leave the only life I knew and strike out in a different direction. It's only fitting that my advisor, mentor and friend Charlie is still by my side, helping me grow as an academically-minded researcher and leader. I've had my share of ups and downs with committee members, but the one rock that has been there from the beginning continues to be my biggest inspiration, and I thank him very much for that.

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Roger Smith gave some students and me a tour of the Nicholson Center, and during that visit, he showed me the dV-Trainer and gave me the idea that was the inspiration for this work. I wouldn't have made this journey without that visit, and I'm deeply indebted to him for sharing his passion.

Although I've known Peter Smith a long time, he recently was so helpful to me regarding the whole process to becoming a PhD, I invited him to join my committee. I very much appreciate his input, which made the last part of this journey less stressful than the rest of it and look forward to continuing our collaboration in the future.

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CHAPTER ONE: INTRODUCTION

Psychomotor Skill Measurement

In 1796, Astronomer Royal Neville Maskelyne noticed that he and his assistant would make different readings when observing the same physical phenomenon and promptly fired his assistant because of the errors. In 1820, Friedrich Wilhelm Bessel set up an experiment to attempt to quantify the difference between two different observers timing and recording the same event. The result was the notion of a Personal Equation, which quantifies the notion that each observer has different fundamental reaction times, thought to be guided by their own internal connection between their neurological and motor systems (Mollon & Perkins, 1996). Once this connection was made, researchers have endeavored to better understand psychomotor skills, which define the connection between our cognitive functions and our physical movements.

We use psychomotor skills when attempting to move our body precisely guided by our cognitive senses. In a gross sense, actions like walking a straight line, throwing a ball or driving a car are examples of using psychomotor skills. The level of psychomotor skill plays a major part in one’s ability to execute motor movements in extremely precise situations, such as expertly playing a difficult piece of music, hitting a home run off a 100mph fastball, or performing a surgery. Not surprisingly, psychomotor skill attainment by an individual is thought to be a combination of innate abilities as well as repeated practice performing the actions in question (Schmidt & Lee, 2013).

In the late 19th century, researchers started studying motor skills in different ways. They continued to develop various motor skill and dexterity tests in hopes of understanding how the brain and motor control work together. Some tests utilize simple pen and paper methods, having the subjects write on paper with researchers later analyzing their work and drawing conclusions about various neural operations (MacQuarrie, 1927; Porteus, 1919) . Other researchers worked to create physical instruments meant to measure psychomotor skills, both with gross motor movements as well as finer motor controls and fingertip dexterity. Both styles of tests have been used to measure a subject's suitability for pursuing careers that demand certain types of motor skills.

Psychomotor Skills and Surgical Training

Excellent psychomotor skills are a prerequisite for performing a wide variety of tasks. For example, professional athletes and musicians possess very high psychomotor skills in order to perform successfully. Similarly, surgical techniques commonly require surgeons to perform very fine movements. While many of these skills require thousands of hours of practice, a certain amount of innate psychomotor skill must be possessed as a starting point.

Laparoscopic surgery, or minimally invasive surgery, is growing in popularity because patients' bodies are impacted less than with traditional open surgeries, resulting in reduced recovery times, less pain, and less scarring. The patient receives only a few small incisions where the camera and instruments are inserted, as opposed to open surgery where a large incision allows the surgeon access to the area to work. In traditional laparoscopic surgeries, the surgeon manipulates the instruments and the camera directly.

Robotically-assisted laparoscopic surgery involves a computer-controlled mechanical device that manipulates the laparoscopic instruments. In contrast to traditional laparoscopic surgery, the surgeon controls the robot, but the robot manipulates the instruments. This is advantageous because the articulation possible with a mechanical robot far exceeds that of a human surgeon, resulting in more accurate and finer control of movements.

Performing laparoscopic surgery requires different psychomotor skills than traditional open surgery. Because of the growing popularity of laparoscopic surgery, surgeons educated and experienced in open surgery are training to become capable laparoscopic surgeons as well.

The dv-Trainer from Mimic is a full featured simulator employed by doctors and hospitals to train surgeons to successfully use Intuitive Surgical's DaVinci® robot for robotically-assisted laparoscopic surgery.

Figure 1 A doctor trains in laparoscopic surgery using the dV-Trainer

The dv-Trainer® utilizes the Mantis Duo, a two-handed haptic system with seven degrees of freedom. Mimic has designed a robust software solution that integrates with the hardware, which together form the dv-Trainer®. Fortunately, Mimic provides developers with the Mantis SDK, authored in C/C++, allowing standalone third-party applications to be authored utilizing the same unique hardware platform as the dV-Trainer®.

Video Games and Psychomotor Skills Measurement

Players of modern video games develop enhanced psychomotor skills as a result of repeated experience playing videogames (Rosser et al., 2007). Over time, players develop an ability to be more precise with their movements, resulting in better ability to perform in the game. In contrast, skilled surgeons frequently possess excellent innate psychomotor skills, but training is necessary to enhance their capabilities to the point where delicate surgical techniques can be completed successfully.

Precise movements, taxing the psychomotor skills of surgeons, are also needed for using Intuitive Surgical's DaVinci® robot, the most popular robotically-assisted laparoscopic surgical device. Surgeons train on devices such as Mimic Technology's dV-Trainer® to learn to use the DaVinci® robot, initially learning the basic controls before advancing to more complex tasks such as knot tying, suturing, and even simulated surgeries.

Hand Positioning

Looking further at why a game player might possess psychomotor skills readily adaptable to robotic laparoscopic surgery, we first consider the interfaces.

Figure 2 Typical game controller with double analog and trigger controls

Figure 3 Typical controls presented to a laparoscopic surgeon

The position of the hand is in a similar position using a game controller as it is when doing laparoscopic surgery, leading to the hypothesis that experienced gamers might have psychomotor skills readily transferable to that of laparoscopic surgery. In particular, the thumb and index fingers of each hand are often used by the participant to control their interactions in both interface paradigms. A greater amount of dexterity in movements of these particular digits gained as a result of gaming could translate into increased initial ability to successfully employ the robotically controlled laparoscopic interface. Assuming that part of learning to perform robotically controlled laparoscopic surgery typically involves initially adapting to the psychomotor skills needed to use the interface, a shorter learning curve for people with experience using game controllers is a reasonable expectation.

Video Game Genres and Psychomotor Skills

Everyone is familiar with how we categorize content of our favorite forms of entertainment, whether the medium is books, movies, TV shows or video games. Even in the extremely different domains of Sci-Fi, comedy or horror, the content of the material is what drives the genre in which the item is categorized.

With interactive games, researching how players interface to the game becomes extremely important when trying to understand the physical attributes a player may acquire by playing. It's not good enough to categorize someone as a player of a certain genre of game, such as a first-person shooter or action-adventure game. Instead, how the player is interacting with the game is paramount, and researchers must dig deeper than simple traditional genres when studying a gamer's psychomotor skills.

By focusing on how the player is interacting with the games they play, this research sets out to correlate a player's experience in a particular genre of interactivity with the psychomotor skills that have been developed. For example, take two gamers that both play first-person shooters the same number of hours each week. One of the gamers is a "mouse/keyboard" gamers, meaning they play the game with a mouse and keyboard as input. Typically, the mouse movement is used for aiming, the mouse button is used for firing a weapon, while the keyboard is used for movement around the game world. The other gamer uses a game controller to control the game, using the left analog stick to move around the game world, the right analog stick to aim the camera, and a trigger button to fire a weapon. The fundamental question this research asks is whether these two players of first-person shooter games develop psychomotor skills differently due to the difference in input mode.

Confounds in Existing Research

Past research assessing psychomotor skills of gamers often categorizes participants as gamers by asking them how much they play games. In today's day and age, so many types of videogames exist, on so many different platforms, that what each person considers a game is debatable. For example, one person might consider playing a casual game on their phone or other mobile device gaming, while others may have a much stricter definition, be it on a game console, on a PC, or using a controller. By simply asking someone how many hours a week they game, inaccurate answers should be the norm. Additionally, trying to remember how many hours you play a day, week or month is more problematic as the varying types of interactions with some form of gaming increase.

Other research measures player performance in a particular game. For example, Rosser used games such as Super Monkey Ball 2 and Silent Scope to measure "Demonstrated Video Game Skill," which he then correlated with laparoscopic skill and suturing scores (Rosser et al., 2007). When playing off-the-shelf games for the measurement, participants' scores can be affected by many things in addition to raw psychomotor ability, such as player feedback, audio, special effects, achievements and many other game-related confounds. Additionally, if a subject has played that game or a similar one beforehand, they may be better about utilizing winning strategies based on that experience. They may outperform other subjects who are still climbing the learning curve of that particular game.

New Approach

By creating a standalone application for a subject to interact with, this research will measure psychomotor skills in a controlled environment specifically designed to collect the appropriate data. User attention will not be diverted by normal game elements such as user interfaces, flash graphics or audio, or alerting the user as achievements are earned. Instead, primitive graphics will indicate to the player those steps necessary to complete the exercises. The subject would use a game controller to complete the exercises, while we measure psychomotor skill acquired by virtue of playing games. The only question: What exercises to simulate?

Dimitrios Stefanidis and his colleagues have shown that raw psychomotor skill ability predicts the rate at which new surgeons pick up laparoscopic skills (Stefanidis et al., 2006). In their research, the following traditional means for measuring psychomotor skills were used:

1. Tremor – the steadiness with which a subject could hold their hand
2. Reaction Time – the time a subject would take to respond to a stimulus
3. Finger Tapping – the speed a subject could press a button
4. Purdue Pegboard – standardized manual dexterity measurement
5. Grooved Pegboard – more complex version of Purdue Pegboard

Eight years later, another team reviewed 86 articles that evaluated dexterity measurements used for evaluation of health professionals (Causby, Reed, McDonnell, & Hillier, 2014). Based on that review, the study recommends the use of the Purdue Pegboard, the Grooved Purdue Pegboard and a Finger Tapping Test for evaluation of dexterity.

By designing an application to mimic the test Stefanidis used in the research (see (Carbone, McDaniel, & Hughes, 2016) for a detailed overview), subjects would perform similar classic psychomotor skill tests, only instead of with their hands, they would use the controller.

Research Questions

This research will attempt to answer some fundamental questions:

1. Can physical psychomotor test be simulated with digital gaming technology using a controller as input?

2. Can performance on such a test discriminate between users with various experience levels in videogames?

3. How does a gamer's experience-dominant genre of interactivity impact their ability in the digital simulation of the five psychomotor skills tests? For example, do gamers who play with dual-analog game controllers in precision-based videogames develop better hand steadiness skill using the controller than players who do not?

4. Do psychomotor skills with a dual-analog game controller transfer to the robotically-assisted laparoscopic interface? Do subjects who do well on the controller-based tests also do well on the Mimic simulator interface?

5. How well does self-assessment of video game experience correlate with

performance in a game-controller based psychomotor skills test? Are the players who indicated the most experience with dual-analog game controllers the ones who demonstrate the top psychomotor skills using the dual-analog game controller outside of the game environment?

Thesis Organization

The remaining dissertation is comprised of four chapters and six appendices. Chapter 2 presents a review of relevant prior research and the tools employed by such research projects. This chapter also notes some of the limitations of the prior work that are addressed in this dissertation. Chapter 3 describes the experiment, which consists of a survey of gaming habits, completion of an exercise measuring psychomotor skills, and a final study for some participants on the dV-Trainer. Chapter 4 describes the participant pool and details the results of all of the psychomotor skills tests, while Chapter 5 discusses conclusions from the results and future work ideas related to the work presented here. Appendix A contains a copy of the survey questions and answers, while the rest of the appendices contain graphical representations of the raw data collected in each of the psychomotor tests.

CHAPTER TWO: REVIEW OF LITERATURE

Historical psychomotor skill measurement techniques

Mechanical Tests

In the early 1900s, simple mechanical tests were developed to measure psychomotor skills such as tapping speed of hand steadiness. In 1892, Clark University Doctoral candidate Fletcher Dresslar looked at measuring rapid motor movements and what sorts of factors affect them (Dresslar, 1892). He used a telegraph like apparatus to record movements. In addition to finding that subjects could tap at about 8.5 times per second, he also noticed that the tapping speed increased if done immediately after a vigorous mental exercise. For the first time, the connection between motor movement and the brain was demonstrated. In 1908, psychologists used telegraph machines to measure speed of tapping, thinking about things like how handedness, practice and fatigue effect results(Carpenter, 1909; F. L. Wells, 1908). In the same labs around the same time, reaction time measurement devices were being developed, and experiments were designed to help understand the connection between the auditory and visual senses, brain processing and muscle movement (G. R. Wells, 1913).

Forty years later, the Purdue Pegboard (Tiffin & Asher, 1948) test was created as a reliable way of assessing mechanical dexterity of potential workers in areas requiring exacting physical movements such as manufacturing assembly lines where workers were required to operate certain machinery. The test, shown in Figure 4, consists of a board with 2 parallel rows of 25 holes each and small metal pegs that fit into the holes.

By asking the subject to move pegs from the dishes to appropriate holes in the board, subjects use gross motor skills as well as finer fingertip type movements.

Figure 4 The Purdue Pegboard (Left) and the Grooved Pegboard (Right)

After warming up, subjects would complete the timed test with each hand separately, and then together, and times would be collected as well as other information, such as number of pegs dropped. A variation of the Purdue Pegboard, called the Grooved Pegboard, asks the user to rotate the pegs as they are inserted into the holes, thus increasing the amount of dexterity required to complete the test.

Figure 5 The Minnesota Manual Dexterity Test

Many other similar dexterity tests have been developed as alternatives to the Purdue Pegboard. Tests such as the Crawford Small Parts Dexterity Test (Crawford & Crawford, 1949; Travis & Sanders, 1956), the O'Connor Finger Dexterity Test (Corlett, Salvendy, & Seymour, 1971), the O'Connor Tweezer Dexterity Test (Fleishman, 1954) and the Minnesota Manual Dexterity Test (Paterson, Elliott, Anderson, Toops, & Heidbreder, 1930) have been shown to successfully predict performance for a wide range of motions requiring psychomotor abilities. Tests are developed for specific motions that most closely mimic motions the subjects would be exposed to in the particular field which the tests are being used.

Pen and Paper Tests

In 1916, French psychologists Alfred Binet and Theodore Simon developed an intelligence test, designed to detect brain development abnormalities in children (Binet & Simon, 1916). Lewis Terman, a psychologist at Stanford University, adapted the test for American children and renamed the test to the Stanford-Binet Intelligence scale. Stanley Porteus created the Porteus Maze Test (Porteus, 1919), a set of mazes designed to supplement the Stanford-Binet test and provide a more robust way to distinguish between uneducated children and children with developmental impairments. The Porteus Maze Test was shown to be a discriminator for children with developmental problems and social difficulties (Poull & Montgomery, 1929). Mazes are thought to abstractly test concepts such as planning, selection, and trial and error, providing a more meaningful measure of neural development than specific knowledge possibly missed as a child ages, depending on surroundings. Following the research success of the Porteus Maze Test and later experiments showing the predictive nature of the test, psychologist Tony Gibson developed a psychomotor test called the Gibson Spiral Maze (Gibson, 1964), which removed the timed nature of the test.

At the same time researchers were studying connections between the ability to complete mazes and cognitive development, scientists began to notice not everyone had the same dexterity when it came to completing the tests. To study the psychomotor ability of a subject, removing the maze and forcing the subject to simply draw and write carefully and with precision became the subject of The Macquarrie Test for Mechanical Ability (MacQuarrie, 1927), which was developed in 1926 as a simple way to test psychomotor skills. These skills were commonly used as discriminators for potential skill in certain occupational tasks as well indicators of general intelligence.

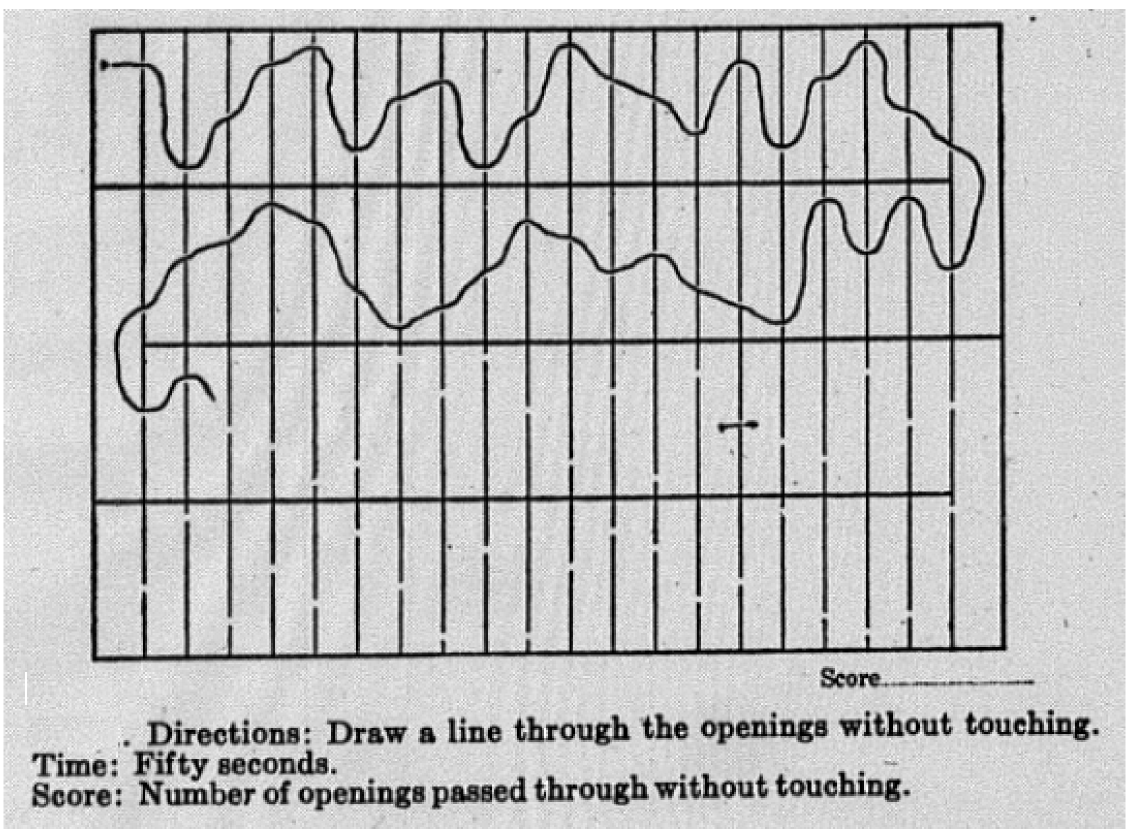


Figure 6 Sample from the Macquarrie Test for Mechanical Ability

Figure 6 shows a sample test element, where the subjects are asked to draw a line through as many of the holes in the lines as they can in 50 seconds. Figure 7 shows a test where students were asked to place dots in circles for 30 seconds.

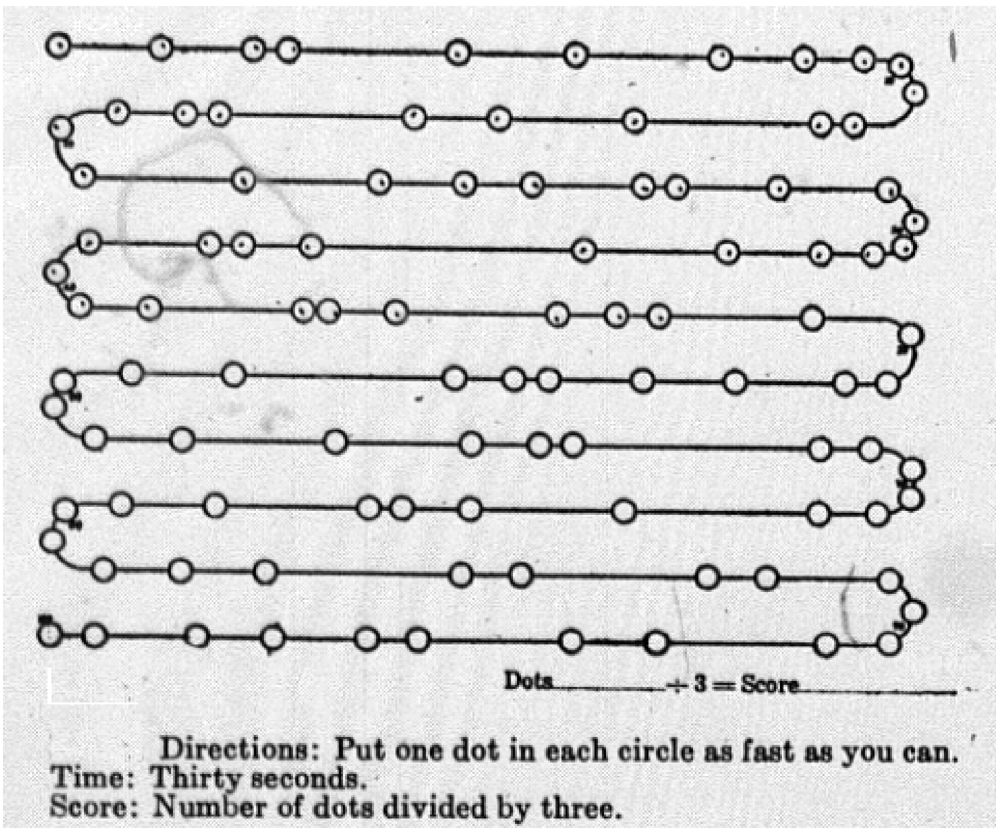


Figure 7 Sample from the Macquarrie Test for Mechanical Ability

For example, Mary Burr (Burr, 1934) showed that the Macquarrie Test for Mechanical Ability could be used to determine which students from a population would not be able to develop the mechanical skills necessary to be successful in nursing school. 241 incoming nursing students completed the Macquarrie test, and the results showed a strong correlation with student grades and nursing efficiency measured during a 6-month period of the second year of nursing school, meaning the Macquarrie test successfully predicted which students would excel in the nursing program.

Research and Videogame Genres

Traditionally, videogames are classified by genre in a different way than classical genre bounds found in books and movies because of the interactive nature of the medium (Kent, 2010). Games are broken up by players and marketers alike into categories such as "First Person Shooter" (FPS), "Real Time Strategy" (RTS), and "Massively Multiplayer Online Role Playing Game" (MMORPG), as well as many others. These genres inform the potential player of the type of game they may be playing. For example, an FPS player expects to be moving around a 3-d environment, where the player takes the perspective of the main protagonist of the game, with the game being rendered as the character would see the surroundings. At first glance, the traditional genre categories may seem useful when analyzing how videogames may build psychomotor skills, since certain genres require consistent types of interactions. Earnest Adams describes many of the traditional game genres along with their design techniques (Adams, 2009), revealing that many classic game genres share common controller manipulations such as character control with the left analog stick, or interface manipulations with the d-pad and right face buttons. This analysis leads to the conclusion that, while useful for players looking to purchase new games similar to those they already play, these traditional genres are not useful for understanding psychomotor skills of players, since many different genres involve very similar controller manipulations.

Studies commonly use traditional sounding genre boundaries to delineate games and their effects, which can lead to confusion in conclusions or studies. How current research treats genres, as well as defining gamers and gamers in the genres, varies greatly. There are many examples of researchers using players of certain videogame genres as subjects of experiments to draw conclusions about their effect on players.

For example, action games, a loosely defined genre, has been shown to have some noticeable effects on regular players. Green and Bavelier, for example, conclude in a study that playing “action” games modifies a player’s visual attention (C. S. Green & Bavelier, 2003). But what exactly they mean by “action” game is somewhat subjective. In their list of “action” games are Crazy Taxi and Super Mario Cart, which are universally considered driving games; Marvel vs Capcom, a bestselling fighting game; and Halo, one of the best-selling titles in the FPS genre. Many other studies since then have explored potential cognitive impacts of action games on decision making (C. S. Green, Pouget, & Bavelier, 2010), multitasking (Chiappe, Conger, Liao, Caldwell, & Vu, 2013; Strobach, Frensch, & Schubert, 2012), improved visual sensitivity (Appelbaum, Cain, Darling, & Mitroff, 2013), processing speed (Dye, Green, & Bavelier, 2009; C. S. Green & Bavelier, 2003), ability to track multiple objects (Dye & Bavelier, 2010; C. S. Green & Bavelier, 2006; Trick, Jaspers-Fayer, & Sethi, 2005), working memory

(Colzato, Van Leeuwen, Van, & Hommel, 2010) and recalling visually presented information (Blacker & Curby, 2013; Sungur & Boduroglu, 2012).

Gackenbach contends there is no “right” way to come up with a list of genres, and used mainstream gaming websites when identifying genres to come up with a list comprised of Action, Adventure, Driving, Miscellaneous (Casual), Role Playing, and Sports (Gackenbach & Bown, 2011). Clearwater takes a closer look at what aspects of a game should contribute to the genre classification, but fails to reach a one-size fits all solution for researchers to reference (Clearwater, 2011). Green and Bavelier called for replacing the genre-based approach to understanding behavioral enhancements that they pioneered a decade earlier with a structure that looks at certain characteristics of games across traditional genre boundaries (C. Shawn Green & Bavelier, 2015). Instead of simply trying to connect playing traditional genres of games with outcomes, researchers are looking deeper into the actual mechanisms with the games that may be responsible for the change. These mechanisms being identified are genre-agnostic and examples can often be found in several genres. For example, a study on cognitive flexibility did not attach significance to a gamer’s genre, but rather found games that are situated in 3-d environments and require frequent switching between multiple tasks led to improved cognitive flexibility (Colzato et al., 2010). In their study, they used Call of Duty, a classic member of the FPS genre, alongside Grand Theft Auto, an action adventure game. Schlickum compared subjects playing Chessmaster with subjects playing Half-Life (a popular FPS) and concluded that a “more visual-spatial loaded game” was the reason the subjects playing Half-Life improved their performance in the

MIST-VR laparoscopic trainer (Schlickum, Hedman, Enochsson, Kjellin, & Fellander-Tsai, 2009).

Alternative to Traditional Genre Classification

Mark J.P. Wolf does an extensive job of analyzing the notion of genres as they are currently used in the game industry (Wolf, 2001). He points out that the well-established film industry's idea of genres helps inform how videogames could and should be categorized and breaks games up into 42 proposed interactivity-base genres. Thomas Apperley takes it one step further and introduces other variables, such as input mode and platform to further distinguish as "Genres of Interactivity" (Apperley, 2006). Apperley argues that traditional genres boundaries, based on visual and narrative style, make it difficult to study their underlying similarities. He notes that by moving towards breaking up games by interaction style, we may more successfully research gaming topics. In studying addition of video games, some researchers found it difficult to use the standard genres as game groupings and proposed a new taxonomy which takes into account different aspects of games (King, Delfabbro, & Griffiths, 2010). One of the categories in the taxonomy he recommends is called "Manipulation and Control Features," which mirrors my research interest in organizing a gamer's habits by input.

For the purposes of this research, a robust set of traditional genres were surveyed, but more importantly, a genre of interaction is also recorded. It stands to reason that the enhancement in psychomotor skills is a function not only of how much gaming someone does, but how they choose to control their games.

What makes a gamer?

No consistent methods to determine what makes a gamer has emerged from the research. Researchers will usually ask players about their gaming habits via a survey, but the details of the questions are anything but standardized. Sometimes, studies will not only ask participants to analyze their own play habits, styles, or expertise, but they'll have them play a game and observe their performance before grouping them for the purposes of their experiment.

Self-Assessments

Most studies use some form of self-assessment as a starting point, and often as the only information, when distinguishing gamers from non-gamers. Most of the assessments ask how much time per day a participant plays and ask the subject to consider times in their recent history as well as longer time periods in the past.

For example, researchers from Duke University measuring multisensory temporal processing abilities of video game players decide "non-video game players" would be defined as those participants who had 0 hours per week of first-person shooter experience in the past 6 months, as well as having less than 1.5 hours per week within the past 6 months of real-time strategy and sports games. On the other hand, video game players were defined as having at least 2 hours per week of first-person shooter experience in the past 6 months, as well as playing any type of action game (including first-person shooter, real-time strategy, and sports games) for a minimum of 4.5 hours per week within the past 6 months (Donohue, Woldorff, & Mitroff, 2010). On the other hand, researchers studying cognitive flexibility distinguished gamers as the subjects that played gamers at least four times a week for the last six months. Subjects who played mainly "web-based puzzle games" were considered non-gamers (Colzato et al., 2010). Another study referred to "avid" gamers as those that played more than 6 hours per week over the last 6 months (Clark, Fleck, & Mitroff, 2011).

Sometimes players are simply asked to rate themselves, as in the visual sensitivity study mentioned earlier (Appelbaum et al., 2013). Participants were asked to rate their own expertise on a 7-point Likert Scale, with 6 being the highest score, in a selection of 8 different video game genres. Those who rated themselves as a 5 or higher on "action/platforming" or "first person shooter" games were considered "action video game players," while those who rated themselves 0 on both genres were categorized as "non-video game players."

Game-based assessments

Researchers will sometimes supplement a self-survey with a more objective performance-based metric for evaluating video game performance. Off-the-shelf games designed for entertainment purposes have been used in psychomotor and other psychological research since they reached the mainstream.

In studying whether video games can improve spatial representational skills, researchers chose to use The Empire Strikes Back arcade video game “for its graphic representation of three-dimensional space on a two-dimensional screen”(Greenfield, Brannon, & Lohr, 1994). Players were asked to play the game and their scores were recorded. Players were then divided into groups based on their scores, with those scoring over 100,000 points going into the “skillful” gamers group. The study showed that the skillful gamers were better at answering questions on a mental 3-dimensional paper-folding test (Shepard & Feng, 1972), which is an indication of cognitive skills. Although the game and especially the graphics are primitive by today’s standards, even in the early days of games, studies have been using them as a tool to understand the impacts of playing them from a psychological and physiological perspective.

Eight years later, researchers were still using the off-the-shelf games of the day. Miskry showed that performance in the racing game Diddy Donkey Kong Racing on the Nintendo64 game console was strongly correlated with performance in completing timed trials in a laparoscopic skill station (Miskry, Magos, & Magos, 2002). They chose this game because it “required the operator to negotiate a vehicle through a three-dimensional environment, incorporating obstacles, with optimal route being rewarded with quicker lap times.”

When the XBOX game system was released, a study showed that a gamer’s skill in Project Gotham Racing 2, Amped 2, and Top Spin Tennis was a strong predictor of laparoscopic surgery skill in novice surgeons (Rosenberg, Landsittel, & Averch, 2005).

The researchers had the subjects play 30 minutes of each game, measuring their performance objectively (scores, crashes, etc.) and subjectively, by having an observer rate the player's overall hand-eye coordination on a scale of 1-5. After playing the games, the subjects performed laparoscopic tasks on two pigs. Again, their performance was measure both objectively (time to complete) as well as subjectively, with hand-eye coordination measurement. The study found performance in the games strongly correlated with laparoscopic skills.

In his landmark study, James Rosser asked surgical residents and attending physicians about their gaming background, and followed that up with having each of them play an off-the-shelf video game (Rosser et al., 2007). In the study, Super Monkey Ball 2, Star Wars Racer Revenge and Silent Scope were chosen because of the similarity between the mechanics in the game and the actual laparoscopic procedures, such as fine minor control and eye-hand coordination. In addition, characteristics of the scoring in the game lent itself to the nature of the experiment, so it was a straightforward process for researchers to measure performance by simply looking at the player's score at the end of their play session. No players in the study had ever played any of the games they chose, although it's unclear whether they filtered out potential participants based on that criteria.

Video Games and Laparoscopic Training

Many researchers have devoted time to studying the acquisition of specialized psychomotor skills by video game players and whether those skills lead to faster learning on robotic laparoscopic trainers. It is clear from the body of literature since 2007 that the psychomotor skills gamers develop as part of playing games are related to those needing to be developed as part of training for laparoscopic surgery.

Rosser, in his study that has inspired many ancillary and supplemental studies, showed that surgical residents and attending physicians with past video game play experience made 37% fewer errors and completed training 27% faster than those categorized as non-gamers (Rosser et al., 2007). In a follow up study, surgeons who played video games for 6 minutes immediately before performing a laparoscopic drill were significantly better in their suturing scores. Many of the previously mentioned studies also conclude that previous game experience increases the laparoscopic performance.

However, there have been a few studies which did not agree with the majority. For example, Harper found that video game experience was inversely related to suturing skills. However, it is important to note that this study was based strictly on self-reported gaming habits, and no skills-based psychomotor test was done. In addition, although Rosenberg's team found that practicing with the XBOX games in their study described above did not improve scores, practicing with actual laparoscopic instruments did improve the scores noticeably.

Potential confounds in assessments

Prominent researchers have openly pointed out the inconsistency and many possible confounds present when relying so heavily on subjective data gathered from the user (Boot, Blakely, & Simons, 2011; Latham, Patston, & Tippett, 2013). Off-the-shelf games are designed for entertainment, and as such contain many elements extraneous to the scientific measurement of psychomotor performance. Rosser mentioned the likelihood that the specific game being chosen is likely to be a major contributor to the results of the study, because not all games require the same sorts of input (Rosser et al., 2007). These methodological shortcomings are not easy to work around, given the lack of objective ways of gathering the data.

Because the goal is to develop an application that tests psychomotor ability, we need a standardized set of exercises to test. However, no such controller-based procedures exist. Stefanidis analyzed the most common innate psychomotor testing used by the research community in designing the experiment to test psychomotor skills among medical residents doing laparoscopic training (Stefanidis et al., 2006). Five motor skill tests were chosen: a tremor test to test hand steadiness; a reaction time test to test response speed to a stimulus; finger tapping, to test the speed of tapping the index finger; Purdue Pegboard; and the Grooved Purdue Pegboard, described previously in the introduction. In their study, they found that the finger tapping test and the Grooved Purdue Pegboard test were both significantly correlated with high performance in the laparoscopic training.

The idea of this experiment is to simulate the motor skill measurements that Stefanidis chose. In this modified version, the input comes from a game controller to try to adapt the concept of the physical psychomotor test to the virtual world.

dV-Trainer in research

To determine if the subject with the highest psychomotor skills measured in the software shows similar aptitude with laparoscopic training as participants in Rosser's landmark study, a laparoscopic training simulator would need to be selected. Many studies have concluded that the dV-Trainer is a valid laparoscopic training device (Finnegan, Meraney, Staff, & Shichman, 2012; Kenney, Wszolek, Gould, Libertino, & Moinzadeh, 2009; Korets et al., ; Lerner, Ayalew, Peine, & Sundaram, 2010; Perrenot et al., 2012; Sethi, Peine, Mohammadi, & Sundaram, 2009).

When deciding which exercises to use to verify performance on the trainer, Perrenot's study consulted with robotic experts to choose Pick and Place, Ring and Rail, Match Board and Camera Targeting (Perrenot et al., 2012). They also used the Peg Board exercise, but this was removed from this study for brevity.

Key Takeaways

Several key takeaways from the literature influenced this research.

Even though many researchers use genres played and hours of play as a way to group gamers, the genre of interactivity, or how you interact with the game, is likely to matter more when looking at psychomotor skills. Because of this, the survey includes a section that allows participants to be grouped by how much they've played with controllers.

Research varies widely on how to handle time of play as an indication of whether a participant is a gamer and whether they are an "avid" gamer, as some experiments refer to experienced gamers. For this research, all participants consider themselves gamers, and the survey collects the number of hours per week of play, as well as whether a participant has practiced gaming, also found to be a strong indicator of substantial play.

Some studies measure gaming acumen by having participants play a game, with scores being collected and used as a ranking mechanism. In contrast, this research makes the argument that psychomotor skills are best measured in a standalone tool specifically designed for that purpose. The designed software mimics the physical psychomotor tests performed by Stefanidis and his team.

Finally, studies linking gaming and performance in laparoscopic training are summarized, which indicate a strong correlation between video game experience and performance in laparoscopic trainers. The final step in the experiment tests to see if the highest and lowest performing participants show the same correlation that Rosser found in his study from 2007

CHAPTER THREE: METHODOLOGY

The fundamental hypothesis of this research is that increased psychomotor skills gained by playing video games translates into better performance when doing laparoscopic surgery. By asking a player for a self-assessment of their video game abilities, natural confounds exist in different subjects' ability to accurately recall and assess their experience. By testing a player's gaming ability using an off-the-shelf videogame, unintended confounds exist as well. Since off-the-shelf games are designed to maximize enjoyment and not research purposes, a person's ability in a particular game may be influenced by a wide variety of factors other than psychomotor skills. For example, games using sound FX, graphical effect, scoring and other factors provide motivation for players to do well and have fun. These factors can affect performance, and therefore a player's perceived psychomotor ability, since so many studies base groupings and conclusions on score. In addition, the extent to which a player has played similar games to the one being used as part of an experiment can be a major factor in overall performance.

The goal of this experimental design is to remove these confounds and isolate the extent to which psychomotor skills developed using a videogame controller transfer to the same skills when using the dV-Trainer®. An application has been developed to test psychomotor skills, with participants performing precise movements with the same type of game controllers traditionally used in games.

The participant pool consists of gamers of all types. No requirement was placed on participation, other than the fact that the participant considered themselves a gamer, and played at least 1 hour per week of video games at the time of the study. A diverse group of 100 gamers participated in the study, with varied experience gaming across all the mainstream platforms.

After completing the psychomotor skills tests, a selection of the highest and lowest performing of the participants go through tutorials on the dV-Trainer®, which automatically records their performance. This performance will be analyzed and compared to actual psychomotor ability to see if a correlation exists.

All participants in the experiment have experience playing video games, and consider themselves gamers when surveyed.

Experiment Steps

1. Participants fill out an extensive survey, addressing their detailed gaming habits, including the amount of time they spend playing games as well as the traditional genres they play most often and importantly, the type of controller they use when they game.
2. Participants use a PC-based application specifically developed for this experiment with a standard off-the-shelf game controller with dual analog

sticks as input. The application will have only basic graphics components and does not resemble a game in any meaningful way.

3. Psychomotor performance measurement for all participants are gathered and analyzed. Top psychomotor skill performers are identified.
4. Select participants from the groups of best and worst psychomotor skills groups use off-the-shelf tutorial and training exercises on the dV-Trainer®, and their performance is automatically recorded by the software. Each participant completes the same tutorials and training exercises.

The Survey

To begin the experiment, participants must complete a survey, a copy of which can be found in Appendix A.   If any participant answers “No” to the question “Do you consider yourself a gamer?”, they are immediately thanked for completing the survey and will no longer be used in the rest of the experiment.

One of the key confounds when using gamers as research subjects stems from the ubiquity of various types of gaming. When trying to draw conclusions regarding the effects of video game playing, it is often inadequate to simply ask someone if they are a gamer without exploring the subject’s gaming habits more thoroughly.

Participants who self-identified as a gamer will complete the rest of the self-assessment survey, with the goal of understanding what type of gamer they are. Like in many previous studies which hope to assess gaming habits, the survey asks participants to estimate the number of hours they have spent gaming in the last month, 6 months, 3 years and 10 years. Instead of stopping there, this experiment digs much deeper on game habits, specific game genres played, and importantly, what sort of control input they use when playing.

Subjects are asked if they've ever practiced a video game or competed in any way to try to understand their mentality as a gamer. Latham pointed out that "deliberate practice" could be a great way to distinguish high performing gamers in his work, so by collecting that data, we can compare gamers who practice with those that don't when assessing psychomotor skills acquired (Latham et al., 2013).

The survey contains all of the common game genres in a list and asks participants to nominate their top three most common genres that they play, and then asks them to further refine their answer by estimating the amount of time they play each of the genres on a percentage basis. Participants are also asked about the type of controller they use when they game. If they use a mix of mouse/keyboard and game controllers, they are asked to estimate the percentage of each.

The software

For this research, specific software designed to measure game-controller psychomotor ability of the player was developed (Carbone et al., 2016). Players are not subjected to the normal elements of games, such as level design, special effects, sound effects, background music and the like. Rather, a very basic display is used to narrow down the test to simply a subject's raw ability to manipulate the game controller in a game-like way, focusing on the psychomotor skills of the thumb and index finger.

Custom metrics gathering software was developed as part of each test to automate data collection for individual users. Each test includes a brief tutorial section at the beginning to acclimate the user to the expected movements for the test. The user has to correctly perform the action at least once before the testing begins in order to ensure the user knows what is expected of them during the process.

The measurements from the Stefanidis experiment (Stefanidis et al., 2006) were adapted for use with a game controller to test game-controller specific psychomotor skills as described in the following sections. Where the Stefanidis tests use physical means of measuring psychomotor skills, this experiment has the constraint of using an off-the-shelf game controller to simulate the tests traditionally performed by specialized equipment, as in the Stefanidis experiment.

Tremor Testing

Steadiness testing has been going on since the early twentieth century, with various types of contraptions meant to measure how steadily a subject could hold their hand or finger (Dunlap, 1921). In traditional non-controller based experiments, subjects hold an item and a machine is connected to the item which records small oscillations in physical position. In the Stefanidis test, subjects used a laparoscopic grasper to grasp a needle attached to a movement recorder for 20 seconds. Although the analog game controller is most definitely not an ultra-sensitive movement recorder suitable for careful measurement of steadiness, this test measures how accurately a subject can follow along with a slowly moving target.

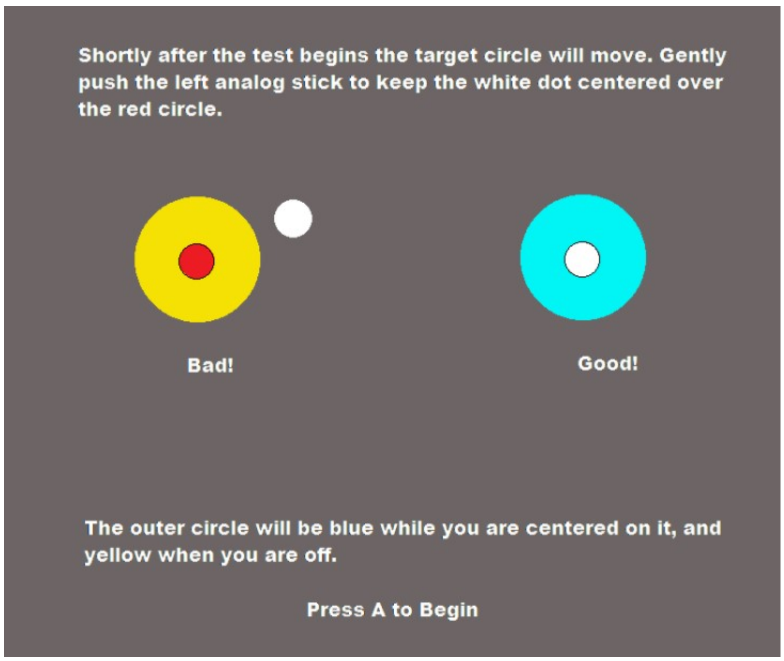


Figure 8 Tremor Test Introduction Screen

For this experiment, the user is presented with a circle with a smaller circle inside. The user is asked to move both analog sticks off center and hold a cursor as close to the center of the small circle as they can.

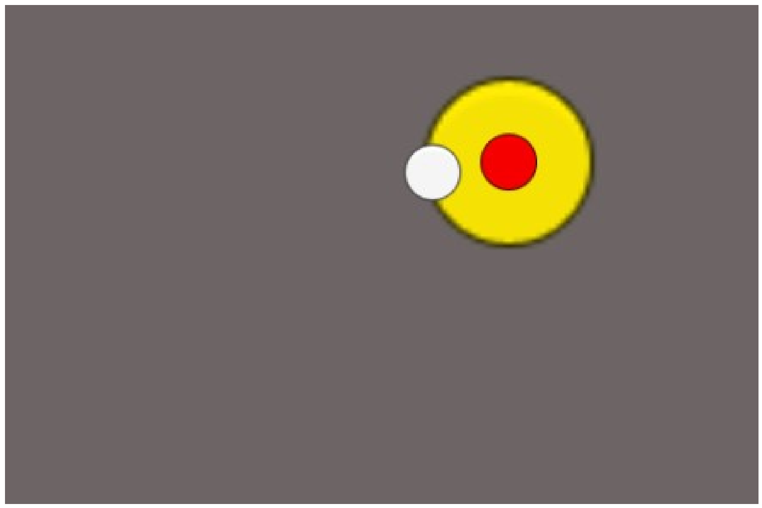


Figure 9 The user is outside the desired circle as the color indicates

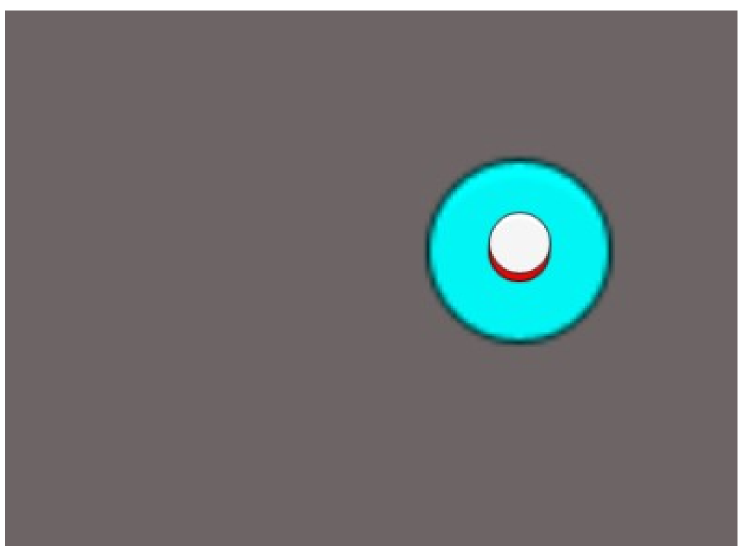


Figure 10 The color change indicates the user is inside the circle

Once the user is in the center for a set time, another off-center circle is presented and the user needs to navigate to the next circle and stay in the center again. Total time outside of the desired circle is accumulated for a total time, with the best scores being the lowest times.

Reaction Time

At the same time scientists began studying steadiness, reaction times were being studied. Audio and visual stimuli are used and the subject is asked to react as quickly as possible by pressing a button or something similar. Reaction time is the sum of the time it takes to receive the event, the time for the brain to process the event, and the time to send the signal to the muscle to press the button (Schmidt & Lee, 2013).

In the Stefanidis experiment, subjects held a button in the pressed state while waiting for one of three different lights to illuminate. When one of the lights activated, subjects released the button they were holding and pressed the lit button. The time to release, as well as the time to press the lit button, were recorded.

In adapting for use by the controller, subjects are asked to hold a button on the controller, which I'll refer to as the "base button." The application presents graphical representations of each of the controller buttons.

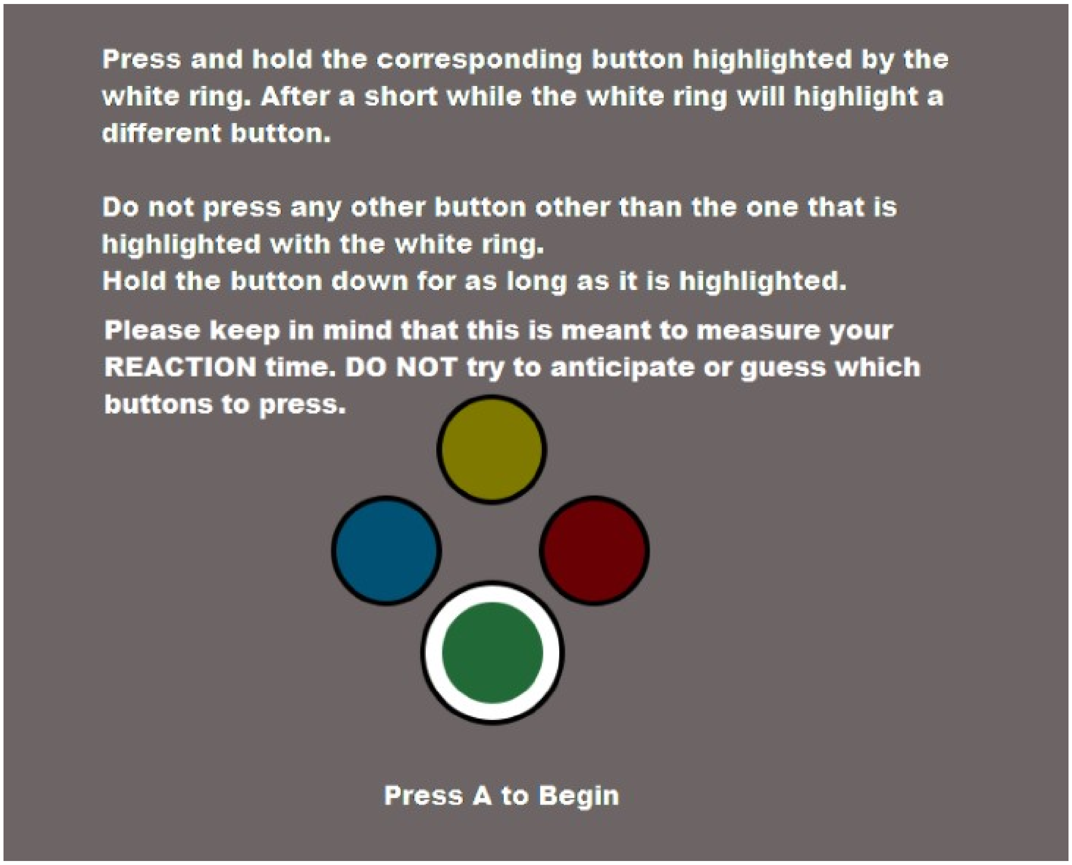


Figure 11 Reaction Test Instructions

Every 4-5 seconds, one of the three buttons lights up on screen, and the subject presses the appropriate button on the controller. When the application senses the new button is pressed, the graphic changes back and highlights the base button. The time from graphic presentation to base button release and time from base button release to alternate button press are recorded and used as a measurement of the user's reaction time.

Finger Tapping

Finger tapping has been a standard measurement of psychomotor skills since the turn of the 20th century. Although researchers no longer use the telegraph machine as they did in 1892, the measuring devices are still relatively simple. Stefanidis used a simple physical switch for a subject to press. Stefanidis tested the left index finger and the right index finger separately.

Stefanidis' simple finger tapping test was adapted to use a game controller. Because of the way the controller is naturally held, clicking of the thumbs is measured using the appropriate analog stick.

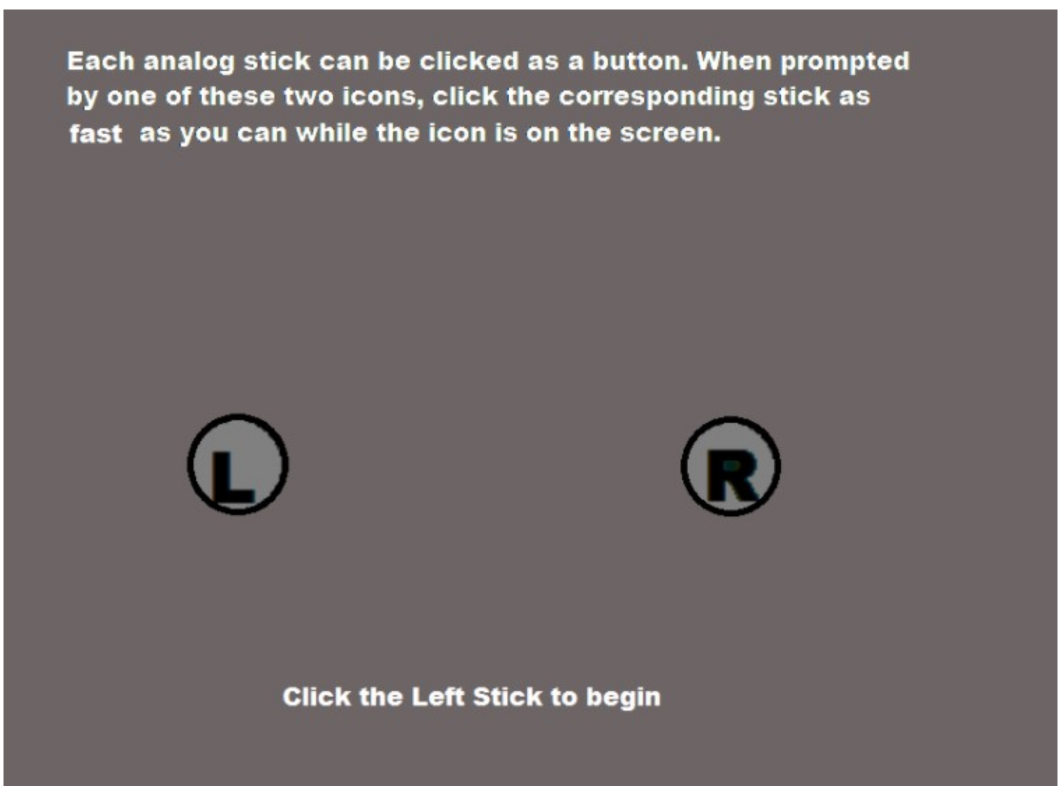


Figure 12 Instruction screen for the Finger Tapping Test

In the Stefanidis experiment, subjects were asked to tap for 10 seconds, a total of 5 times with each of their index fingers.

In this experiment, the subject is asked to click as fast as they can on the analog sticks of the controller. They click each stick independently through 5 rounds, each lasting 10 seconds.

Purdue Pegboard Test

The Purdue Pegboard test is a popular dexterity test designed by Joseph Tiffin in 1948, which Stefanidis used as part of his experiment this research is simulating. In the Purdue Pegboard test, subjects complete a series of tests involving inserting pegs into appropriate holes, placing small collars and washers over the pegs, with both left and right hands.

Adapting this test to a game controller was not as straightforward as the other test Stefanidis used, since it is more complicated and involves gross motor skills by moving hands and arms as well as fine motor skills, in the form of picking up placing the actual pins in the holes.

The simulation developed for this experiment has the user moving white circles with the controller analog stick, simulating moving their hands to pick up the pins out of their dishes and placing pins into holes. Picking up the pins and placing the pins was simulated with clicks of the analog controller.

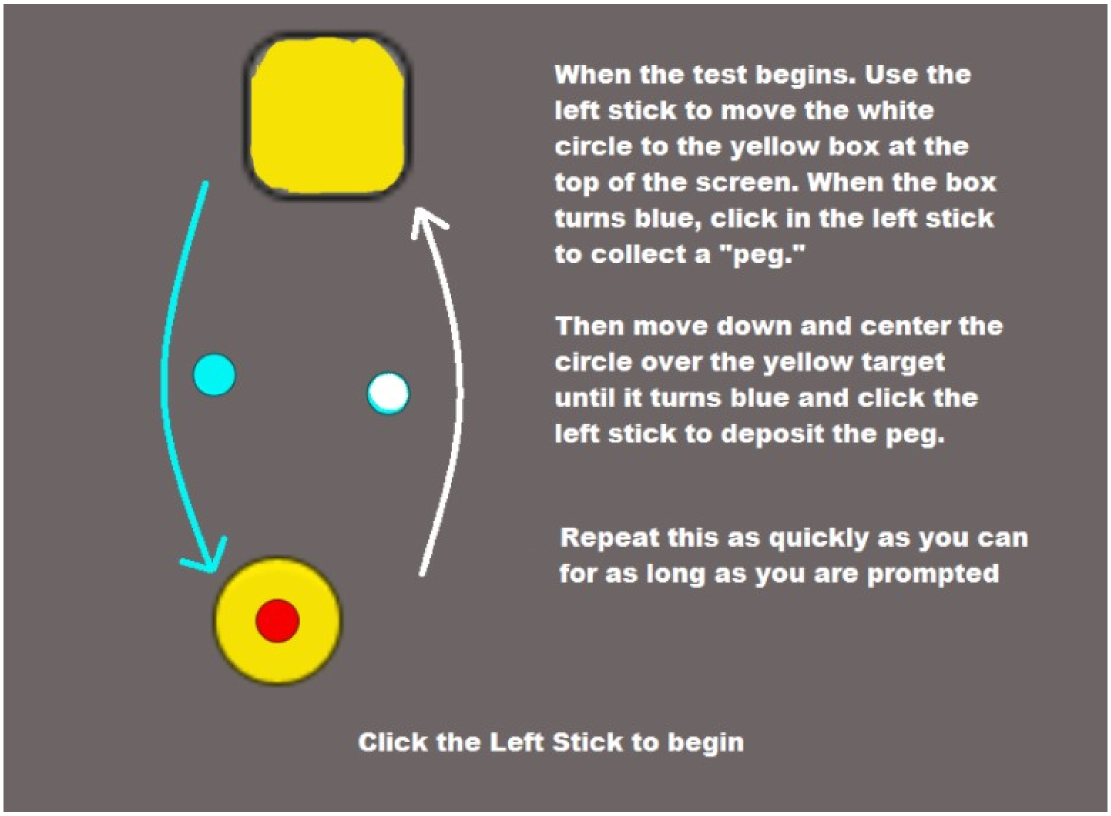


Figure 13 Purdue Pegboard Instruction Screen

When the simulation starts, the subject moves the circle via the analog stick of the game controller to the yellow box, which simulates the dish of pegs. Once the white circle is inside the box, the box turns blue, indicating the user is ready to pick up a peg.

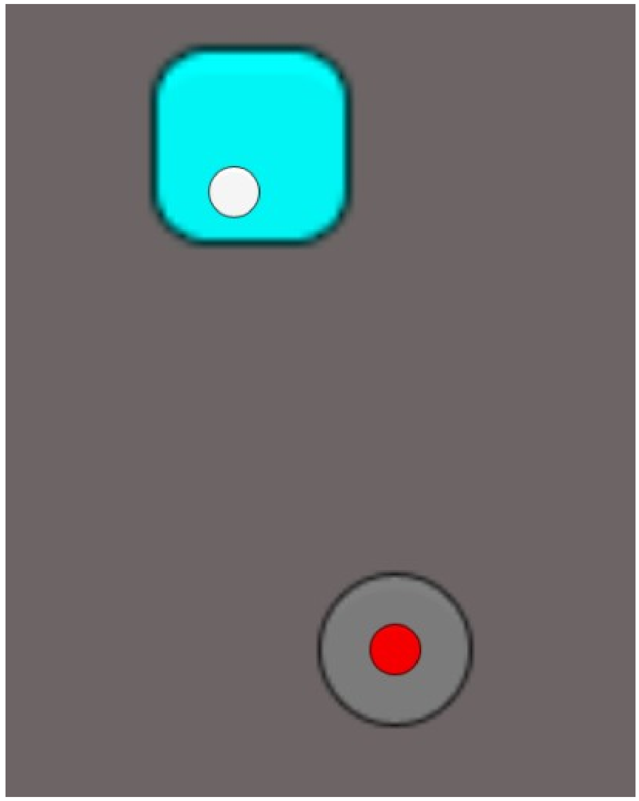


Figure 14 Simulated peg grabbing

The user then picks up the peg in the dish by clicking on the analog stick, which turns the white circle blue, indicating the user has possession of the peg. The peg is now moved to the center of a small circle, and when properly positioned, a color change indicates the user can click to place the peg in the simulated hole. Once the subject places 5 pegs into holes, the exercise is complete.

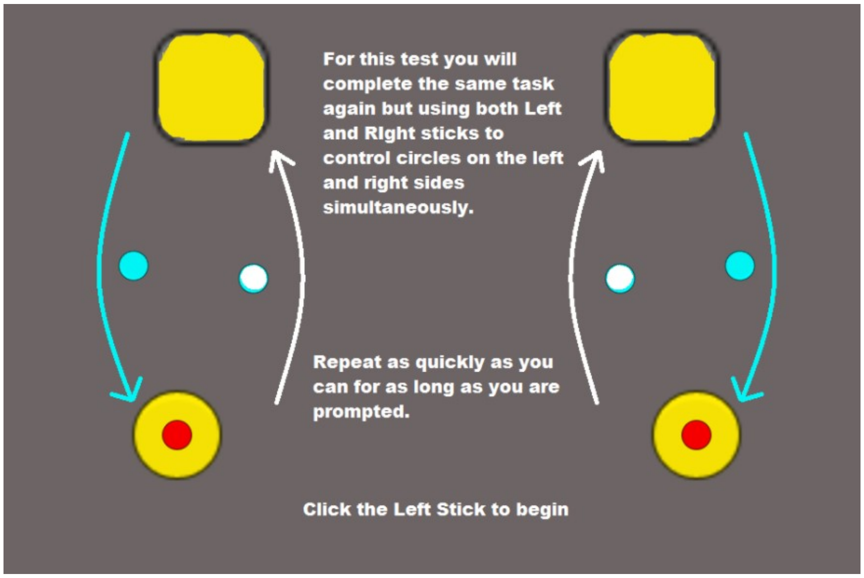


Figure 15 Instruction screen for the both-hand test

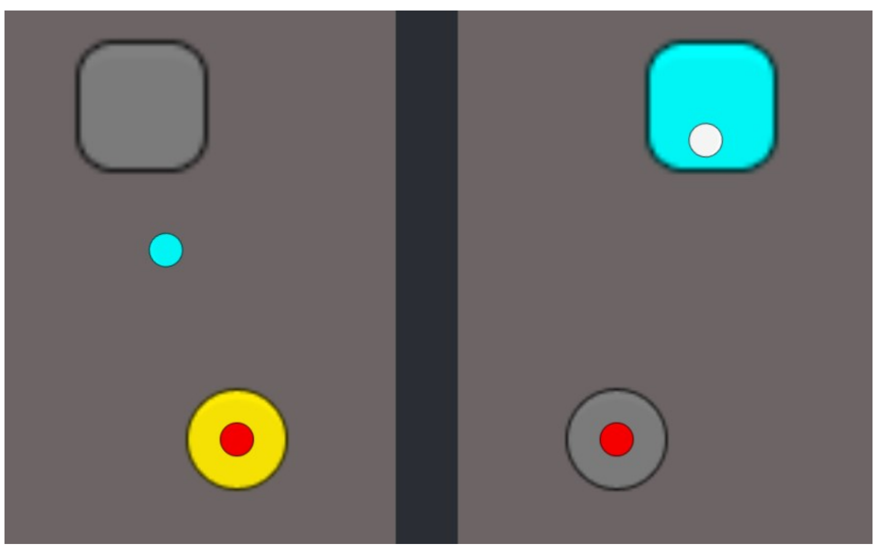


Figure 16 Gameplay screen for both-hand test

Just as the Purdue Pegboard test requires, each participant will complete the test first with the right hand, followed by the left hand, and finally the test will be accomplished with both hands simultaneously. The user can choose whether to actually do the test simultaneously with both hands, or do one side followed by the other.

Grooved Pegboard Test

The Grooved Pegboard test is identical to the Purdue Pegboard test, except that it requires the subject to rotate the peg when putting it into the hole.

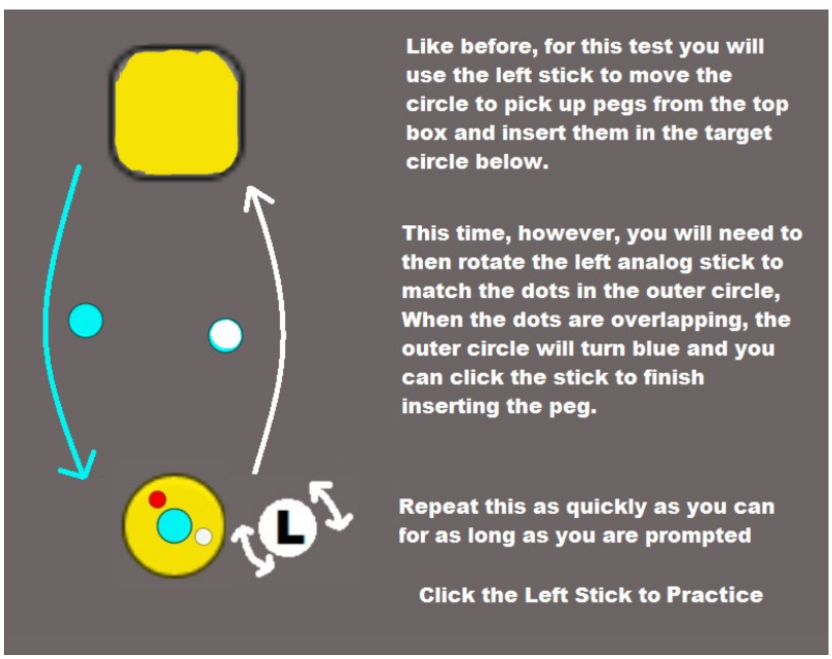


Figure 17 Grooved Purdue Pegboard Instruction Screen

For the controller adaptation, the Purdue simulation described in the previous section is modified slightly. Instead of the user simply clicking to place the peg into the board, the circle will lock into place when the analog stick is clicked, and the user will then be asked to rotate the analog stick to simulate turning the peg into the hole. A small white and red circle appear and the user must rotate the white hole on top of the red hole before clicking the analog stick again, locking the peg into place.

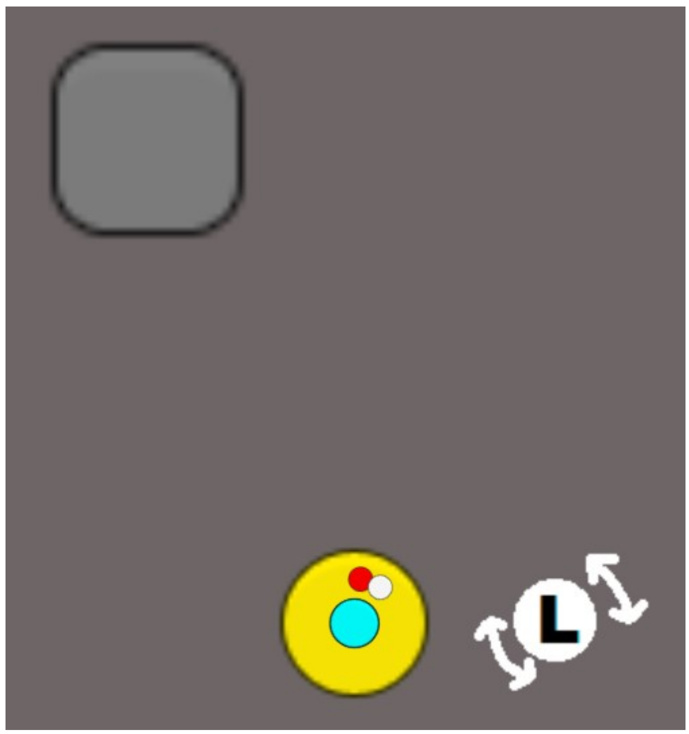


Figure 18 User rotating small white dot to red dot

Psychomotor Skills Grouping

After all of the participants had completed the survey, and the gamers had completed the psychomotor skills, the results were analyzed. After analysis, the gamers were grouped by psychomotor abilities, based on results of the psychomotor testing described earlier in this section.

To accomplish the grouping, first the tests that showed significant differences between gamers of different experience with analog controllers were isolated. As you'll see in the results section later in the document, the tests which had significant differences included the left tapping test, the right tapping test, and all three of the Purdue tests (right, left and both). These 5 scores were used when computing the total psychomotor score of each participant.

Participants scores in these tests were computed by dividing their score by the average score of all 100 participants. For example, a participant who scored a time in the Purdue Right test of 8.863 seconds, which had an average score of 11.86 seconds across all 100 participants, would have a skill score of 1/(8.86/11.86) = 1.34. The reason for the inversion is because a lower score is better for the Purdue test. Similarly, the score for the left tapping test (average across all 100 participants of 49.21) for the same participant, if they had scored an average of 57.2 taps across the 5 samples, would be (57.2/49.2102) = 1.162. No inversion is performed, since the higher tap values are better. Total score was computed by simply adding up the scores of each individual test. Total score for the participants ranged from 6.2839 down to a low of 3.5851.

Five users from the top group of 10 participants, and five users from the bottom group of 10 participants were chosen to participate in further testing using the laparoscopic training, as a way to test if the psychomotor abilities identified by the test translated to significant differences in performance on the laparoscopic trainer.

Laparoscopic Training

The laparoscopic portion of the experiment utilized the dV-Trainer from Mimic. None of the subjects in the experiment had ever used the dV-Trainer or done any other kind of laparoscopic training.

Research personnel explained the basic operation of the dV-Trainer to each participant, which included a preamble to describe how the machine worked along with an explanation of each of the input controls needed for the experiment.

Once the basic explanations were out of the way, participants familiarized themselves with the physical setup of the dV-Trainer and got the machine adjusted so they were comfortable manipulating the controls in an unguided setting. The tutorials used for this experiment were the Camera Targeting, Pick and Place, Match Board, and Rings and Rails. Each participant completed each of the tutorials and all results were stored using the dV-Trainer software for later analysis.

CHAPTER FOUR: RESULTS

Participant Pool

All participants were “gamers” by the common definition of “one who plays videogames,” but this research is designed to find differences between gamers by looking at their gaming habits. The survey was designed to provide, through some mathematical manipulation, a total amount of time per week that a subject spends with an analog controller playing games.

The survey asks participants to estimate the amount of total gaming time in hours per week they’ve spent in the last month, six months, three years and 10 years. For the purposes of this research, the gaming time for a subject is the maximum of the answers from the last month and last 6 months. Subjects are then asked to estimate the percentage of their total gaming time they spend on the PC, console, and mobile gaming. Participants who indicate PC gaming are asked which controller they use on a percentage basis. Using this data, a total number of gaming hours on analog game controllers per week is computed, assuming 100% of their console game is done with traditional game controllers.

A total of 100 participants filled out the survey and performed the psychomotor skills test, consisting of 83 males and 17 females, ranging in age from 19 to 43, with an average age of 26.58 years and a standard deviation of 3.90 years. During the last month, the participants reported playing with analog controllers an average of 8.23 hours per week, play on PC an average of 8.39 hours per week, play on console an average of 5.62 hours per week, and play on mobile platforms an average of 2.58 hours per week. Half of the participants played with analog controller 6 hours per week or more. Summaries of results for each test are as follows. Note that all calculations use the very conservative two-tailed test for significance, even though it's very unlikely prior use of an analog controller could possibly hurt the performance on these tests.

Tremor Test

The tremor test is very dependent on hardware being very sensitive to subtle movements on the fingertips. The experiment depends on very fine control of the analog stick with the thumb.

The measurement for the tremor test involved a simple counter, which began the test at 0. Every frame the circle was inside of the collision zone in the center of the target circle, the counter would be incremented. The score was summed for the whole test and one number was recorded. The higher the score, the more time the circle spent inside the target circle area and the better the participant performed. For statistical analysis of the results of the tremor test, the null hypothesis claim is that the amount of time a participant uses the analog controller for gaming purposes is unrelated to their performance on the tremor test. The P-value should be $<.05$ for statistical significance, which would indicate the two populations are likely to be different.

Table 1 Tremor Test Results as a function of analog controller usage

Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3 hrs	<3 hrs
Mean	2455.96	2340.36	2427.72	2386.09	2425.95	2323.04
SD	296.18	340.08	321.83	324.22	305.77	358.44
Count	50	50	29	71	73	27
Variance	63.777		71.078		77.713	
T-Score	1.813		0.586		1.324	
P-Value	0.0730		0.5594		0.1885	

The data show that the participants who have more experience with the analog controller tend to score higher on the tremor test, which indicates they spend more time in the center of the circle as it moves. When testing if the result is significant enough to generalize the finding, the data show the group with 6 hours or more of analog controller play per week exceeds 90% significance but falls short of the 95% significance threshold.

Grouping the participants in certain categories leads to more statistical analysis possibilities. The null hypothesis claims the player type for each of the types shown has no bearing on performance in the tremor test.

Table 2 Tremor Test Result as a function of player type

Player Type	FPS player	Non-FPS Player	Practicer	Non-Practicer	Competitor	Non-Competitor
Mean	2424.15	2366.4	2434.1	2314.3	2447.02	2330.69
SD	314.32	332.88	325.23	305.35	334.86	295.59
Count	55	45	70	30	58	42
Variance	65.259		67.963		63.353	
T-Score	0.885		1.763		1.836	
P-Value	0.3784		0.0811		0.694	

The data also show that subjects who play first-person shooters, which are known for a high-degree of aiming accuracy, tended to score better than non-first-person shooter players, but not nearly enough to generalize. On the other hand, participants who have practiced video games scored noticeably better than those who have not, and those who have competed in video games scored much better than those who have not, and both groups are right on the edge of indicating a significant finding.

Reaction Test

The reaction test is broken apart into two times. First, once the new button is highlighted, the time to release the currently held button is measured. This is referred to as the “release time.” Next, the time from releasing the button to pressing the highlighted button is measured. This time is referred to as the “press time”. The measured values are all shown in seconds. For statistical analysis of the results of the reaction test, the null hypothesis claim is that the amount of time a participant uses the analog controller for gaming purposes is unrelated to their performance on the reaction test. The P-value should be $<.05$ for statistical significance, which would mean the two populations are likely to be different.

Table 3 Release time as a function of controller usage

Release Time						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	0.34	0.34	0.33	0.34	0.34	0.35
SD	0.04	0.05	0.04	0.05	0.04	0.05
Count	50	50	29	71	73	27
Variance between two groups	0.009		0.010		0.011	
T-Score	0.000		1.052		0.934	
P-Value	1.0000		0.2955		0.3523	

Very little evidence was found to support the alternative hypothesis that more controller usage improves reaction release times. Mean times to release were so close as to be indistinguishable, meaning your experience with analog controllers appears to have no bearing on the time you take to release a button when given a cue to do so.

Table 4 Press time as a function of controller usage

Press Time						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	0.09	0.09	0.08	0.09	0.09	0.09
SD	0.04	0.03	0.04	0.03	0.04	0.03
Count	50	50	29	71	73	27
Variance between two groups	0.007		0.008		0.007	
T-Score	0.000		1.214		0.000	
P-Value	1.0000		0.2277		1.0000	

Very little evidence was found to support the alternative hypothesis that more controller usage improves reaction press times. Mean times to press were so close as to be indistinguishable, meaning your experience with analog controllers appears to have no bearing on the time you take to press a button when given a cue to do so.

Again, grouping the participants in certain categories leads to more statistical analysis possibilities. The null hypothesis claims the player type for each of the types shown has no bearing on performance in the reaction tests.

Table 5 Release time as a function of Player Type

Release Time						
	Non-Fighting Game Player	Fighting Game player	Practicer	Non-Practicer	Competitor	Non-Competitor
Mean	0.34	0.34	0.33	0.35	0.34	0.35
SD	0.05	0.05	0.04	0.05	0.05	0.04
Count	79	21	70	30	58	42
Variance between two groups	0.012		0.010		0.009	
T-Score	0.000		1.941		1.110	
P-Value	1.0000		0.0552		0.2698	

Subjects who admitted to practicing a video game did perform noticeably better than those who didn't in the release time part of the reaction test, coming very close to statistical significance. Fighting game players, notorious for their quick reactions to attacks in gameplay, fared no better than non-fighting game players.

Table 6 Press time as a function of player type

Press Time						
	Non-Fighting Game Player	Fighting Game player	Practicer	Non-Practicer	Competitor	Non-Competitor
Mean	0.09	0.08	0.08	0.1	.08	.1
SD	0.04	0.03	0.03	0.04	.03	.04
Count	79	21	70	30	58	42
Variance between two groups	0.008		0.008		.007	
T-Score	1.259		2.458		2.731	
P-Value	0.2111		0.0157		.0075	

Subjects who practiced or competed in a video game performed significantly better than those who didn't in the press time part of the reaction test. Fighting game players, notorious for their quick reactions to attacks in gameplay, fared only slightly better than their non-fighting game counterparts.

Tapping Test

The tapping test measures how many times the subject can click the analog stick in 10 seconds. The test ran 5 times, and the score is the average of the 5 trials. The test is run on both the right and left analog sticks, independently, so the user is only ever clicking one stick during a trial.

For statistical analysis of the results of the tapping test, the null hypothesis claim is that the amount of time a participant uses the analog controller for gaming purposes is unrelated to their performance on the tapping test. The P-value should be <.05 for statistical significance, which would mean the two populations are likely to be different.

Table 7 Right tapping count as a function of controller usage

Right Tapping						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	56.67	55.1	57.53	55.18	56.35	54.53
SD	7.08	8.72	6.73	8.34	8.38	6.6
Count	50	50	29	71	73	27
Variance between two groups	1.588		1.594		1.605	
T-Score	0.988		1.474		1.134	
P-Value	0.3254		0.1437		0.2595	

Table 8 Left tapping count as a function of controller usage

Left Tapping						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	50.51	47.73	50.37	48.61	49.58	47.88
SD	5.9	6.68	5.26	6.82	6.3	6.69
Count	50	50	29	71	73	27
Variance between two groups	1.260		1.269		1.484	
T-Score	2.206		1.387		1.146	
P-Value	0.0297		0.1685		0.2547	

The trend was very clear that experienced analog controller gamers clicked more times than gamers who don't play as much on the analog controller. Players with 6 or more hours per week of play in the last month performed significantly better than players with less than 6 hours per week of play in the left tapping test.

Again, grouping the participants in certain categories leads to more statistical analysis possibilities. The null hypothesis claims the player type for each of the types shown has no bearing on performance in the reaction tests.

Table 9 Right tapping count as a function of player type

Right Tapping						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	57.07	54.18	56.64	54.05	55.91	50.96
SD	8.5	6.86	8.35	6.72	7.71	4.96
Count	21	42	70	30	91	5
Variance between two groups	2.136		1.582		2.361	
T-Score	1.353		1.638		2.097	
P-Value	0.1791		0.1047		0.0387	

Table 10 Left tapping count as a function of player type

Left Tapping						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	50.54	47.16	49.5	48.23	48.83	51.2
SD	6.8	5.37	6.37	6.57	6.5	5.88
Count	58	42	70	30	91	5
Variance between two groups	1.218		1.421		2.716	
T-Score	2.775		0.894		0.872	
P-Value	0.0066		0.3736		0.3852	

Competitors scored better than non-competitors, and significantly better on the left tapping test. Participants who practice scored better than non-practicing participants, but not significantly. Right handed participants scored significantly better than left handed participants on the right tapping test, while left handed participants sored marginally better than right handers on the left tapping test.

Grouping the participants in game genres leads to more statistical analysis possibilities. The null hypothesis claims the game genres a player plays for each of the types shown has no bearing on performance in the tapping test.

Table 11 Right tapping count as a function of game genres played

Right Tapping						
	Fighting	Non-Fighting	FPS	Non-FPS	Rhythm	Non-Rhythm
Mean	59.46	54.9	56.35	55.26	62.1	55.6
SD	5.11	8.33	8.41	7.38	11.22	7.71
Count	21	79	55	45	4	96
Variance between two groups	1.457		1.580		5.665	
T-Score	3.131		0.690		1.147	
P-Value	0.0023		0.4919		0.2540	

Table 12 Left tapping count as a function of game genres played

Left Tapping						
	Fighting	Non-Fighting	FPS	Non-FPS	Rhythm	Non-Rhythm
Mean	52.01	48.35	49.31	48.89	53.95	48.92
SD	5.47	6.48	6.53	6.36	3.56	6.47
Count	21	79	55	30	4	96
Variance between two groups	1.399		1.457		1.899	
T-Score	2.617		0.288		2.649	
P-Value	0.0103		0.7738		0.0094	

Two genres that frequently ask players to repeatedly press buttons as part of normal gameplay are fighting games and rhythm games. In fighting games, such as Killer Instinct or Street Fighter, players control a character that repeatedly press buttons to deliver attack to their opponents. Fighting game players performed significantly better than non-fighting game players in both the left and right tapping tests.

Rhythm game like Guitar Hero and Amplitude challenge players to press buttons at a particular cadence that matches music, graphics and effects. Lower difficulty involves slower pressing, but as players advance, faster and faster pressing is required. Because of these interactions, it may be instructive to look at players that designated fighting games or rhythm games as one of their favorite genres Rhythm game players performed better than non-rhythm game players in both tapping tests, significantly so in the left tapping test. Unfortunately, since rhythm games are not as popular as fighting games, the number of participants that played rhythm games was a limiting factor.

On the other hand, first-person shooter players normally navigate through environments with the left analog stick, shooting occasionally with trigger buttons, and move the camera with the right analog stick. When compared to fighting and rhythm games, first-person shooters generally don’t ask players to press the same button repeatedly as part of the normal course of gameplay. FPS players performed very similarly to non-FPS players in both left and right tapping tests.

Purdue Test

The result of the Purdue test is the total time in seconds that it took the participant to complete the test, which included picking up and placing 5 pegs. The test is run on the left hand only, then the right hand only, followed by both hands simultaneously, referred to as “Left Purdue”, “Right Purdue” and “Both Purdue” respectively.

Overall, the Purdue tests represent a very strong result of significant differences between players experienced with analog controllers versus those with less experience. This test is, by far, the strongest indicator of psychomotor skills potentially picked up from analog controllers of the 5 implemented as part of this experiment.

For statistical analysis of the results of the Purdue test, the null hypothesis claim is that the amount of time a participant uses the analog controller for gaming purposes is unrelated to their performance on the Purdue test. The P-value should be $<.05$ for statistical significance, which would mean the two populations are likely to be different.

Table 13 Purdue Right test results as a function of analog controller usage

Right Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	11.45	12.22	11.2	12.1	11.8	11.93
SD	1.52	1.88	0.95	1.93	1.7	1.89
Count	50	50	29	71	73	27
Variance between two groups	0.342		0.289		0.415	
T-Score	2.252		3.113		0.314	
P-Value	0.0265		0.0024		0.7545	

Table 14 Purdue left test results as a function of analog controller usage

Left Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	10.75	11.71	11.01	11.32	11	11.86
SD	1.19	2.3	1.27	2.09	1.48	2.61
Count	50	50	29	71	73	27
Variance between two groups	0.366		0.342		0.531	
T-Score	2.621		0.906		1.619	
P-Value	0.0102		0.3673		0.1087	

Table 15 Purdue left test results as a function of analog controller usage

Both Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	15.33	17.01	14.77	16.74	15.87	16.98
SD	2.06	3.66	1.6	3.36	2.87	3.49
Count	50	50	29	71	73	27
Variance between two groups	0.594		0.497		0.751	
T-Score	2.828		3.962		1.478	
P-Value	0.0057		0.0001		0.1426	

The results from the Purdue Pegboard test provided very strong evidence of a difference between players with analog controller experience. The difference in times for the Purdue Pegboard test was very noticeable when comparing users with more experience on the analog controller. Players with six or more hours per week of play performed significantly better than players with less than six hours per week of play in the all three tests. Even a bigger difference was seen when considering players with ten or more hours of play on both the right handed test as well as the both hand test. The players with three hours of analog controller play per week, however, did not show as big of a difference, and although they did perform better, it was not a statistically significant difference.

Again, grouping the participants in certain categories leads to more statistical analysis possibilities. The null hypothesis claims the player type for each of the types shown has no bearing on performance in the Purdue tests.

Table 16 Purdue Right test results as a function of player type

Right Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	11.49	12.32	11.78	11.96	11.87	12.03
SD	1.33	2.11	1.77	1.7	1.78	1.67
Count	58	42	70	30	91	5
Variance between two groups	0.369		0.376		0.770	
T-Score	2.247		0.479		0.208	
P-Value	0.0269		0.6329		0.8358	

Table 17 Purdue Left test results as a function of player type

Left Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	10.93	11.64	15.91	16.78	11.27	10.87
SD	1.45	2.32	2.99	3.55	1.95	0.93
Count	58	42	70	30	91	5
Variance between two groups	0.405		0.740		0.463	
T-Score	1.751		1.175		0.863	
P-Value	0.0831		0.2427		0.3903	

Table 18 Purdue Both test results as a function of player type

Both Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	15.45	17.16	15.91	16.78	16.07	19.51
SD	2.08	3.88	2.99	3.55	2.81	5.48
Count	58	42	70	30	91	5
Variance between two groups	0.658		0.740		2.468	
T-Score	2.599		1.175		1.394	
P-Value	0.0108		0.2427		0.1667	

Although the results are not as striking as the direct comparison of analog controller usage, we see participants who have competed before in a video game competition performing noticeably better in all three tests, and statistically significantly better in both the Right Purdue test and the Both Purdue test.

Grouping the participants in game genres leads to more statistical analysis possibilities. The null hypothesis claims the game genres a player plays for each of the types shown has no bearing on performance in the Purdue tests.

Table 19 Right Purdue test as a function of game genres played

Right Purdue						
	Fighting	Non-Fighting	FPS	Non-FPS	Rhythm	Non-Rhythm
Mean	11.35	11.96	11.39	12.38	11.43	11.85
SD	1.34	1.83	1.44	1.94	1.07	1.77
Count	21	79	55	45	4	96
Variance between two groups	0.358		0.348		0.565	
T-Score	1.706		2.842		0.744	
P-Value	0.0912		0.0055		0.4588	

Table 20 Left Purdue test as a function of game genres played

Left Purdue						
	Fighting	Non-Fighting	FPS	Non-FPS	Rhythm	Non-Rhythm
Mean	10.26	11.49	10.85	11.69	10.4	11.26
SD	1.27	1.95	1.43	2.26	0.56	1.92
Count	21	79	55	45	4	96
Variance between two groups	0.353		0.388		0.342	
T-Score	3.480		2.164		2.516	
P-Value	0.0008		0.0329		0.0135	

Table 21 Both Purdue test as a function of game genres played

Both Purdue						
	Fighting	Non-Fighting	FPS	Non-FPS	Rhythm	Non-Rhythm
Mean	15.27	16.41	15.24	17.31	15.13	16.21
SD	2.32	3.22	2.2	3.59	0.82	3.14
Count	21	79	55	45	4	96
Variance between two groups	0.623		0.612		0.520	
T-Score	1.831		3.383		2.075	
P-Value	0.0701		0.0010		0.0406	

Players of fighting, FPS and rhythm games performed significantly better than their respective non-genre players for the Purdue test. Strong statistical significance was found in all three tests for FPS players. Rhythm game players performed significantly better than non-Rhythm game players in the Left Purdue test as well as the Both Purdue test, while fighting game players scored significantly better than non-fighting game players in only the Left Purdue test.

Grooved Purdue

The result of the Grooved Purdue test is the total time in seconds that it took the participant to complete the test, which included picking up and placing 5 pegs, and rotating them into place. The test is run on the left hand only, then the right hand only, followed by both hands simultaneously, referred to as “Left Grooved Purdue,” “Right Grooved Purdue” and “Both Grooved Purdue” respectively.

Table 22 Purdue Right Grooved results as a function of analog controller usage

Right Grooved Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	15.99	17.15	16.41	16.64	16.46	16.88
SD	2.01	3.68	2.1	3.32	2.72	3.7
Count	50	50	29	71	73	27
Variance between two groups	0.593		0.554		0.780	
T-Score	1.956		0.415		0.538	
P-Value	0.0533		0.6791		0.5915	

Table 23 Purdue Left Grooved results as a function of analog controller usage

Left Grooved Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	16.74	17.99	16.97	17.52	17.32	17.48
SD	2.69	4.24	2.97	3.82	3.38	4.16
Count	50	50	29	71	73	27
Variance between two groups	0.710		0.714		0.893	
T-Score	1.760		0.770		0.179	
P-Value	0.0815		0.4429		0.8582	

Table 24 Purdue Both Grooved results as a function of analog controller usage

Both Grooved Purdue						
Analog Controller Usage per week	>=6 hrs	<6 hrs	>=10 hrs	<10 hrs	>=3hrs	<3hrs
Mean	23.86	25.46	23.83	25	24.57	24.9
SD	3.47	5.25	3.2	4.92	3.95	5.78
Count	50	50	29	71	73	27
Variance between two groups	0.890		0.833		1.205	
T-Score	1.798		1.404		0.274	
P-Value	0.0753		0.1634		0.7847	

The grooved pegboard results are not nearly as insightful as the non-grooved version of the same test. While participants with significant analog controller experience performed slightly better than those with very little experience, the difference was not significant, in sharp contrast to the standard Purdue Pegboard test described in the previous section.

Again, grouping the participants in certain categories leads to more statistical analysis possibilities. The null hypothesis claims the player type for each of the types shown has no bearing on performance in the Grooved Purdue tests.

Table 25 Purdue Right Grooved results as a function of player type

Right Grooved Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	16.28	16.98	16.14	17.56	16.43	18.15
SD	2.98	3.03	2.77	3.34	2.75	5.15
Count	58	42	70	30	91	5
Variance between two groups	0.610		0.694		2.321	
T-Score	1.148		2.046		0.741	
P-Value	0.2537		0.0434		0.4605	

Table 26 Purdue Left Grooved results as a function of player type

Left Grooved Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	16.93	17.96	16.69	18.93	17.21	19.06
SD	3.76	3.29	3.48	3.4	3.17	4.56
Count	58	42	70	30	91	5
Variance between two groups	0.708		0.747		2.066	
T-Score	1.455		2.998		0.895	
P-Value	0.1490		0.0034		0.3729	

Table 27 Purdue Both Grooved results as a function of player type

Both Grooved Purdue						
	Competitors	Non-Competitors	Practicer	Non-Practicer	Right Handed	Left Handed
Mean	24.33	25.12	24.01	26.17	24.59	23.76
SD	4.37	4.67	3.98	5.28	4.33	2.72
Count	58	42	70	30	91	5
Variance between two groups	0.921		1.075		1.298	
T-Score	0.858		2.009		0.639	
P-Value	0.3932		0.0473		0.5242	

The only group where statistical significance was noticed in the Grooved Purdue pegboard test was the participants who have practiced at videogames. This group, like in other tests, did perform significantly better, adding support to the research from Latham that practice is an indicator of a subject who likely has picked up some enhanced psychomotor skills through game play.

<u>Psychomotor Skills Grouping</u>

The most significant differences in analog control experience were shown in the Purdue Pegboard tests as well as the Tapping tests. Note that these tests were specifically the ones shown by research to be the tests most commonly used as discriminators for dexterity in health professionals, as discussed in the literature review. Using these 5 categories (Purdue Left, Purdue Right, Purdue Both, Left Tapping, Right Tapping) as input to the scoring algorithm provided the following distribution of scores. Note that a score of 5.0 would mean an average of 1.0 per category.

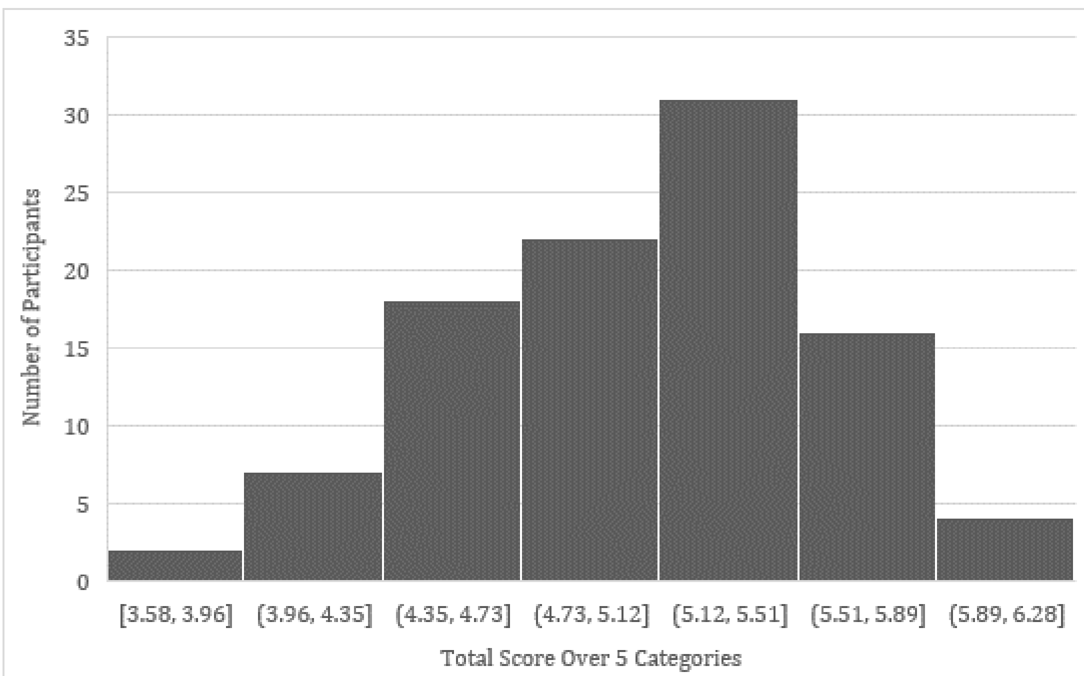


Figure 19 Total Psychomotor Score distribution over the population

Analyzing the number of hours of analog controller usage per week as a function of psychomotor score shows that there is very noticeable difference between the top 15 and bottom 15 scorers, revealing a convincing picture of the difference in the population of all gamers.

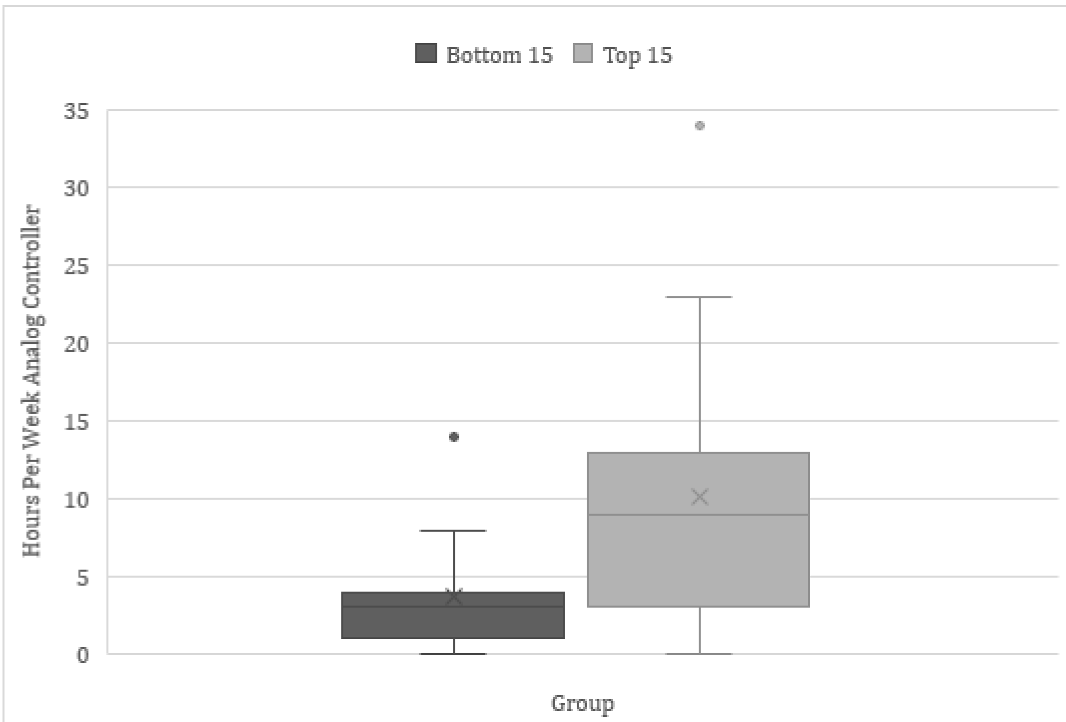


Figure 20 Analog Controller Hours by grouping

Laparoscopic Test Results

Once the results were analyzed and the psychomotor sills computed, five of the top ten participants, and five of the bottom ten participants were randomly chosen to complete the laparoscopic training. The goal was to see if trends could be identified which indicated that the results would transfer if all subjects had participated in the follow-on study. Each exercise was performed three times, and the final score was chosen as the score for the participant.

Camera Targeting

Figure 21 Camera Targeting exercise

In the Camera Targeting exercise, the user moves the camera around and focuses in on different areas of the pelvic cavity. The goal is to find the blue spheres and get them properly aligned in the circle on the display by manipulating the camera.

Table 28 Camera Targeting Scores

	Camera Targeting	
	Top	Bottom
Mean	531.8	313.24
SD	137.43	128.22
Count	5	5
Variance	84.06	
Degrees of Freedom	8	
T-Score	2.60	
P-Value	0.032	

The group of 5 chosen from the top 10 performers scored significantly better than group chosen from the bottom 10 performers in the camera targeting exercise.

Pick and Place

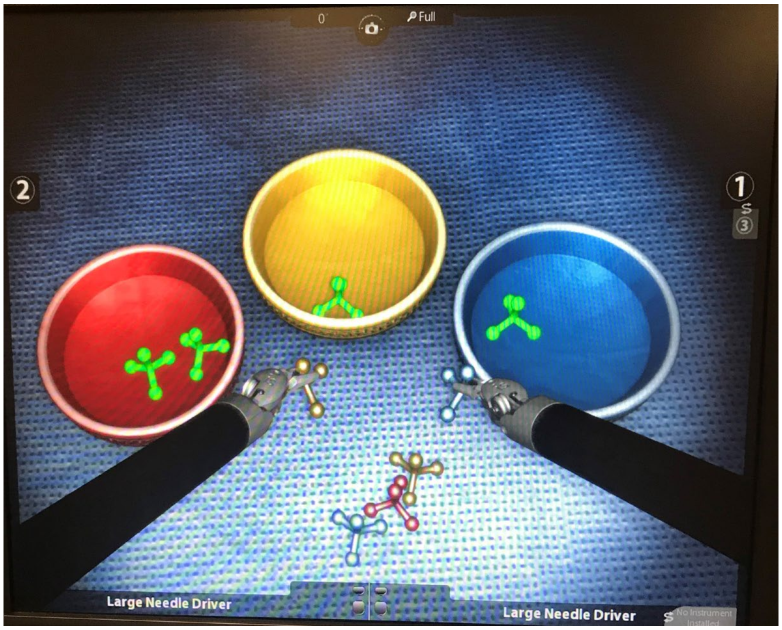


Figure 22 Pick and Place exercise

In the Pick and Place exercise, the user places the colored jacks into the appropriately colored dish.

Table 29 Pick and Place scores

	Pick and Place	
	Top	Bottom
Mean	672.58	508.39
SD	179.07	126.20
Count	5	5
Variance	97.97	
Degrees of Freedom	8	
T-Score	1.68	
P-Value	0.13	

The group of 5 chosen from the top 10 performers scored better than group chosen from the bottom 10 performers in the Pick and Place exercise, but there were not a sufficient number participants to call the findings statistically significant.

Match Board

Figure 23 Match Board exercise

In the Match Board exercise, participants must place numbers and letters scattered around the play space into their proper positions on a wooden board.

Table 30 Match Board Scores

	Match Board	
	Top	Bottom
Mean	605.97	558.4
SD	207.26	140.12
Count	5	5
Variance	111.89	
Degrees of Freedom	8	
T-Score	0.43	
P-Value	0.68	

The group of 5 chosen from the top 10 performers scored better than group chosen from the bottom 10 performers in the Match Board exercise, but there were not a sufficient number of participants to call the findings statistically significant.

Ring and Rail

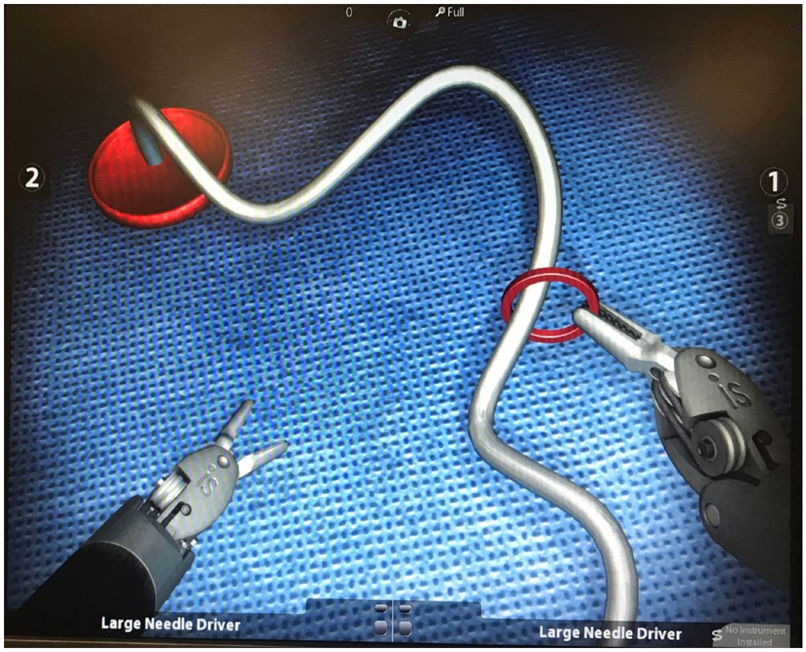


Figure 24 Ring and Rail exercise

In the Ring and Rail exercise, participants must move a ring along a twisted path all the way to the end of the rail.

Table 31 Ring and Rail Scores

	Ring and Rail	
	Top	Bottom
Mean	561.20	490.40
SD	65.95	83.86
Count	5	5
Variance	47.71	
Degrees of Freedom	8	
T-Score	1.48	
P-Value	0.18	

The group of 5 chosen from the top 10 performers scored better than group chosen from the bottom 10 performers in the Ring and Rail exercise, but there were not a sufficient number of participants to call the findings statistically significant.

Summary

The data shows that the tests vary in their ability to detect differences in the gamer population. The test designed after the Purdue Pegboard does the best job of distinguishing between the population of gamers. There is a clear distinction between gamers that play with analog controllers regularly and those that do not. The important finding here is that although much of today's research would put a gamer with 20 hours per week of gaming into the "avid" gamer group for purposes of analyzing acquired psychomotor skills, the gamers that have played more on the controllers do much better in the tests. Researchers should inquire about gaming habits, and specifically genre of interactivity, to insure that the gaming population they seek has the proper experience they are looking for, because not all gamers are picking up psychomotor skills by merely playing games.

CHAPTER FIVE: CONCLUSIONS AND FUTURE WORK

Conclusions

The experiment performed shows a great deal of difference in psychomotor skills developed between gamers who primarily play with traditional gaming controllers and those that play on PC using the Keyboard/Mouse as gaming input. In terms of overall psychomotor skill, the top 15 players average 10.13 hours per week on analog controllers, compared to only 3.67 hours for the bottom 15. However, the bottom 15 players play 10.58 hours per week on PC, compared to only 9.53 hours per week for the top 15. It’s apparent that console gamers playing on controllers are picking up psychomotor skills that PC gamers are not.

Because of these differences, researchers hoping to understand gamers, and specifically psychomotor skills acquired during play, should understand the types of input the gamers in their studies have experience with.

Individual Psychomotor tests

Just as in the Stefanidis (Stefanidis et al., 2006) experiment, the controller-based version psychomotor skills tests developed for this experiment showed a variable amount of ability to detect differences between gamers of varying amounts of gaming experience.

Tremor Test

The lack of sensitivity of the analog controller's analog sticks makes the challenge of designing a tremor test very difficult. All the players performed similarly on the tremor test as designed, and experience with the controller did not benefit those players at all. This test just didn't translate all that well to the digital form.

Reaction Test

The reaction test was also not a good discriminator in general for players with experience using the analog controller. Seeing the practicing players perform better, the general "competitive" mindset of those players may have been enough to tip the scales in a test as simple as pressing buttons fast.

Tapping Test

The population was dominated by right-handed gamers, and this showed in the test, where left clicks were about 10% lower than right clicks in general. However, it was clear that experienced analog players left-clicked faster than inexperienced analog players. This lends credibility to the notion that gamers found the left click action not as natural, meaning practice over time leads to improved scores on the left side. Fighting games are notorious for rewarding fast action button pressing, so it's not surprising to see fighting game players performing better in this test.

Purdue Test

Of all the tests, the Purdue Pegboard stood out as a very strong discriminator between gamers experienced with analog controllers and those who are not that experienced with them. The biggest difference in all the tests performed was in the Purdue Pegboard test that involved both hands, which is the most taxing on the player of all the tests (in both digital and physical forms).

Grooved Purdue

The rotation portion of the grooved tests proved problematic for players in general, and led to an increase in times from the Purdue Test, with no real discrimination happening with the rotation action. In contrast with the Tremor Test, a redesign of the grooved test may improve the results.

Distinguishing Gamers, Non Gamers, and Avid Gamers

The results of the experiment show that analog controller use is significantly correlated with psychomotor skills developed by gamers, which indicates that gameplay repetition with analog controllers builds psychomotor skills more than the same gaming hours on a mouse/keyboard input. Commonly, researchers ask participants about their gaming habits, and specifically about frequency and duration of their gaming. Based on their answers, they group them, sometimes as “gamers vs. non-gamers” or “non-gamers vs. gamers vs. avid gamers,” or similar groupings. This research shows that all gaming is most definitely not equivalent, and that gamers who primarily play on keyboard and mouse do not develop the same sort of psychomotor skills as those that play on the controller. Many of the gamers in this study would qualify as “avid gamers” under other studies, even though they do not play with a game controller, and showed poor psychomotor skills as a result. Other researchers should go further to include the “genre of interactivity” when trying to distinguish between gamers and non-gamers for psychomotor purposes.

Using off-the-shelf games in research

Another key result of the experiment shows that some of the skills tests developed as part of this experiment were successful predictors of experience on game controllers. In particular, the simulation meant to model the Purdue Pegboard, as well as the simulation meant to model the finger tapping test, showed strong correlation with analog controller usage. By not using an off-the-shelf game as a measure of psychomotor skills, this research avoids confounds where user performance maybe be affected by previous play with the game, or other non-psychomotor impacts.

Future Work

Existing Research

The survey and data collected as part of this experiment contains a wealth of information that has not been fully analyzed as part of this research. Although significant correlation was found for certain criteria such as recent controller gaming and specific genres of fighting games and first-person shooters, other subject attributes collected may also contain valuable statistical information. One example is whether gamers of certain genres perform better in any of the psychomotor tests performed. This research looked specifically at fighting games and FPS games, but other interesting correlations may exist. In addition, although handedness data was collected, it was not analyzed as part of this research, since of the 98 subjects, only 6 were left-handed. Assessing how handedness plays a part in psychomotor skills developed by gamers could assist game UX designers by allowing players to specify handedness in games.

The tremor test as designed for this research was not a useful discriminator for analog controller usage. However, the analog stick may not have the sensitivity needed to assess steadiness. It's possible that using the internal tilt sensors of the controller may be a more useful way of measuring tremor, depending on the sensitivity of those sensors.

The grooved Purdue Pegboard simulation proved to be awkward because of the software implementation of the peg turn. A redesign to make the peg turn easier for users to manipulate would likely improve the results of that portion of the experiment.

Future Related Work

Inspired by the 1892 work of Fletcher Dresslar (Dresslar, 1892), understanding the limits and variation of human abilities on a game controller would be very enlightening for game designers seeking to design challenging yet approachable interfaces. Just as Dresslar studied the capabilities of rapid finger tapping on a telegraph machine, understanding how rapidly and accurately humans can manipulate the various buttons on a game controller would help game designers understand the limits of various types of players. More than just measuring tapping or clicking speed, each button input on the controller has the potential for different characteristics based on how the controller is held. The shoulder buttons, for example, have different properties than the D-pad directional buttons.

In addition to measuring maximum speeds, fatigue can play a factor as well, when a game designer decides how long to expect players to perform certain repetitive actions. Understanding how different button rates are affected by fatigue, and which types of players show fatigue characteristics would help a designer understand what to expect from a gamer playing through certain types of challenges.

A simulation that measures raw input properties to the tools been developed in this research would be a great first step in measuring the limits on the psychomotor skills of gamers. Taking it one step further, is it possible to design software in a way to coax more performance out of a player? When you ask for a player to simply perform at their best, is it really their best? Is there a better way to motivate? Here are a few ideas that I feel would be informative and I am personally planning to study:

1. Does providing feedback on speed have an effect on maximum tapping speed possible?
2. Does giving a specific challenge to reach have an effect on maximum tapping speed possible?
3. Does playing with a friend co-operatively have an effect on maximum tapping speeds possible?
4. Does playing with a friend competitively have an effect on maximum tapping speed possible?

If motivating a player in some way increases psychomotor performance, researchers would benefit from a more complete understanding of how putting context into the performance measurements might yield more accurate results in future studies.

APPENDIX A: THE SURVEY

Video Game Usage

Start of Block: Ask if gamer

Q1 Do you consider yourself a gamer?

- ○ Yes (1)
- ○ No (2)

End of Block: Ask if gamer

Start of Block: Yes they are gamer

Q2 Are you Right-Handed or Left-Handed?

- ○ Right-Handed (1)
- ○ Left-Handed (2)
- ○ Ambidextrous (3)

Q63 What is your gender?

○ Male (1)

○ Female (2)

○ Prefer not to answer (3)

Q3 What is your age?

____

Q64 What is your race?

- American Indian or Alaska Native (1)
- Asian (2)
- Black or African American (3)
- Native Hawaiian or Pacific Islander (4)
- White (5)
- Other (6)
- Prefer not to answer (7)

Page Break

Q4 What is your research ID? ${m://ExternalDataReference}?

____

Q5 On average, approximately how many hours per week have you spent gaming in the time periods given. Include all platforms including PC, Console and Mobile.

(! 1 1 2 2 3 3 4 4 5
0 5 0 5 0 5 0 5 0

Last month ()	
Last 6 months ()	
Last 3 years ()	
Last 10 years ()	

Q67 Have you ever practiced a video game?

- ◯ Yes, I drill specific strategies and situations repeatedly to get better for competitions. (1)
- ◯ Yes, I play games over and over to improve my performance. (2)
- ◯ No, I just play for entertainment. (3)

Q66 When is the last time you've played an online game with the intention of moving up the leaderboards or achieving a high ranking?

○ Last month (1)

○ Last 6 months (2)

○ Last 3 years (3)

○ Last 10 years (4)

○ I have never played a game with the intention of moving up the leaderboards or achieving a high ranking. (5)

Q65 When is the last time you played in a local in-person competition or competitive league?

○ Last month (1)

○ Last 6 months (2)

○ Last 3 years (3)

○ Last 10 years (4)

○ I have never played in a competition or competitive league. (5)

Q6 Estimate the percentage of your overall gaming time (total should be 100%) spent on the following platforms:

PC Gaming : _______ (1)
Console Gaming : _______ (2)
Tablet/Handheld Gaming : _______ (3)
Total : ________

Display This Question:

If Estimate the percentage of your overall gaming time (total should be 100%) spent on the following... [PC Gaming] > 0

Q7 When playing PC games, do you play with Mouse/Keyboard, Game Controllers, or a mix?

- ◯ Mouse/Keyboard (1)
- ◯ Game Controllers (2)
- ◯ Mix (3)

Display This Question:
If When playing PC games, do you play with Mouse/Keyboard, Game Controllers, or a mix? = Mix

Q8 When playing PC games, what percent of the time do you use dual analog controllers similar to these?

	0	10	20	30	40	50	60	70	80	90	100
% PC Gaming with Dual Analog ()											

Q9 Which genres have you played the most in the last 3 months? Include all platforms including PC, Console and Mobile. Drag and Drop your answer into the box, **YOU MUST HAVE ONLY HAVE ONE UNIQUE GENRE PER BOX, EVEN IF YOU'VE ONLY PLAYED ONE GENRE EXCLUSIVELY**

Most Played	Second Most Played	Third Most Played
______ First Person Shooter (Call of Duty, Halo, Overwatch) (1)	______ First Person Shooter (Call of Duty, Halo, Overwatch) (1)	______ First Person Shooter (Call of Duty, Halo, Overwatch) (1)
______ MOBA (DOTA2, League of Legends, Heroes of the Storm) (2)	______ MOBA (DOTA2, League of Legends, Heroes of the Storm) (2)	______ MOBA (DOTA2, League of Legends, Heroes of the Storm) (2)

______ Turn based RPG (Final Fantasy, Baldur's Gate) (3)

______ Action RPG (Diablo, Fallout, Skyrim, Mass Effect) (5)

______ Fighting (Street Fighter, Killer Instinct, Super Smash Bros) (6)

______ Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) (7)

______ Racing (Need for Speed, Forza, Mario Kart) (8)

______ Open World Sandbox (GTA V, Minecraft) (9)

______ Sports(Madden, FIFA, NBA 2k) (10)

______ Real-Time Strategy (Starcraft, Civilization, AOE) (11)

______ Casual (Candy Crush, Solitaire) (12)

______ 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) (14)

______ Rhythm Game (Rock Band, Guitar Hero) (15)

______ Puzzle (Tetris, Braid, Limbo) (16)

______ Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) (17)

______ Turn based RPG (Final Fantasy, Baldur's Gate) (3)

______ Action RPG (Diablo, Fallout, Skyrim, Mass Effect) (5)

______ Fighting (Street Fighter, Killer Instinct, Super Smash Bros) (6)

______ Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) (7)

______ Racing (Need for Speed, Forza, Mario Kart) (8)

______ Open World Sandbox (GTA V, Minecraft) (9)

______ Sports(Madden, FIFA, NBA 2k) (10)

______ Real-Time Strategy (Starcraft, Civilization, AOE) (11)

______ Casual (Candy Crush, Solitaire) (12)

______ 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) (14)

______ Rhythm Game (Rock Band, Guitar Hero) (15)

______ Puzzle (Tetris, Braid, Limbo) (16)

______ Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) (17)

______ Turn based RPG (Final Fantasy, Baldur's Gate) (3)

______ Action RPG (Diablo, Fallout, Skyrim, Mass Effect) (5)

______ Fighting (Street Fighter, Killer Instinct, Super Smash Bros) (6)

______ Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) (7)

______ Racing (Need for Speed, Forza, Mario Kart) (8)

______ Open World Sandbox (GTA V, Minecraft) (9)

______ Sports(Madden, FIFA, NBA 2k) (10)

______ Real-Time Strategy (Starcraft, Civilization, AOE) (11)

______ Casual (Candy Crush, Solitaire) (12)

______ 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) (14)

______ Rhythm Game (Rock Band, Guitar Hero) (15)

______ Puzzle (Tetris, Braid, Limbo) (16)

______ Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) (17)

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = First Person Shooter (Call of Duty, Halo, Overwatch) [Most Played]

Q10 Approximately what % of your overall gaming time do you dedicate to First Person Shooters? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
First Person Shooter % ()											

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = MOBA (DOTA2, League of Legends, Heroes of the Storm) [Most Played]

Q11 Approximately what % of your overall gaming time do you dedicate to MOBAs? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
MOBA % ()											

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Turn based RPG (Final Fantasy, Baldur's Gate) [Most Played]

Q12 Approximately what % of your overall gaming time do you dedicate to Turn Based RPGs? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Turn Based RPG % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action RPG (Diablo, Fallout, Skyrim, Mass Effect) [Most Played]

Q13 Approximately what % of your overall gaming time do you dedicate to Action RPGs? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Action RPGs % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Fighting (Street Fighter, Killer Instinct, Super Smash Bros) [Most Played]

Q14 Approximately what % of your overall gaming time do you dedicate to Fighting Games? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Fighting Games % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) [Most Played]

Q15 Approximately what % of your overall gaming time do you dedicate to Action Adventure games? (Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Action Adventure % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Racing (Need for Speed, Forza, Mario Kart) [Most Played]

Q16 Approximately what % of your overall gaming time do you dedicate to Racing games? (Most Played)

0	10	20	30	40	50	60	70	80	90	100

Racing % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Open World Sandbox (GTA V, Minecraft) [Most Played]

Q17 Approximately what % of your overall gaming time do you dedicate to Open World Sandbox games? (Most Played)

0	10	20	30	40	50	60	70	80	90	100

Open World Sandbox % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Sports(Madden, FIFA, NBA 2k) [Most Played]

Q18 Approximately what % of your overall gaming time do you dedicate to sports games? (Most Played)

0	10	20	30	40	50	60	70	80	90	100

Sports Games % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Real-Time Strategy (Starcraft, Civilization, AOE) [Most Played]

Q19 Approximately what % of your overall gaming time do you dedicate to Real Time Strategy games? (Most Played)

0	10	20	30	40	50	60	70	80	90	100

Real Time Strategy% ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Casual (Candy Crush, Solitaire) [Most Played]

Q20 Approximately what % of your overall gaming time do you dedicate to Casual games? (Most Played)

(	10	20	30	40	50	60	70	80	90	100

Casual % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) [Most Played]

Q21 Approximately what % of your overall gaming time do you dedicate to 3-D platformer games? (Most Played)

(	10	20	30	40	50	60	70	80	90	100

3-D platformer % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Rhythm Game (Rock Band, Guitar Hero) [Most Played]

Q22 Approximately what % of your overall gaming time do you dedicate to Rhythm games? (Most Played)

(	10	20	30	40	50	60	70	80	90	100

Rhythm % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Puzzle (Tetris, Braid, Limbo) [Most Played]

Q23 Approximately what % of your overall gaming time do you dedicate to Puzzle games? (Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Puzzle % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) [Most Played]

Q24 Approximately what % of your overall gaming time do you dedicate to Endless Runner games? (Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Endless Runner % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = First Person Shooter (Call of Duty, Halo, Overwatch) [Second Most Played]

Q25 Approximately what % of your overall gaming time do you dedicate to First Person Shooters? (Second Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

First Person Shooter % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = MOBA (DOTA2, League of Legends, Heroes of the Storm) [Second Most Played]

Q26 Approximately what % of your overall gaming time do you dedicate to MOBAs? (Second Most Played)

	0	10	20	30	40	50	60	70	80	90	100
MOBA % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Turn based RPG (Final Fantasy, Baldur's Gate) [Second Most Played]

Q27 Approximately what % of your overall gaming time do you dedicate to Turn Based RPGs? (Second Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Turn Based RPG % ()											

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action RPG (Diablo, Fallout, Skyrim, Mass Effect) [Second Most Played]

Q28 Approximately what % of your overall gaming time do you dedicate to Action RPGs? (Second Most Played)

	0	10	20	30	40	50	60	70	80	90	100
Action RPGs % ()											

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Fighting (Street Fighter, Killer Instinct, Super Smash Bros) [Second Most Played]

Q29 Approximately what % of your overall gaming time do you dedicate to Fighting Games? (Second Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Fighting Games % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) [Second Most Played]

Q30 Approximately what % of your overall gaming time do you dedicate to Action Adventure games? (Second Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Action Adventure % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Racing (Need for Speed, Forza, Mario Kart) [Second Most Played]

Q31 Approximately what % of your overall gaming time do you dedicate to Racing games? (Second Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Racing % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Open World Sandbox (GTA V, Minecraft) [Second Most Played]

Q32 Approximately what % of your overall gaming time do you dedicate to Open World Sandbox games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Open World Sandbox % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Sports(Madden, FIFA, NBA 2k) [Second Most Played]

Q33 Approximately what % of your overall gaming time do you dedicate to sports games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Sports Games % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Real-Time Strategy (Starcraft, Civilization, AOE) [Second Most Played]

Q34 Approximately what % of your overall gaming time do you dedicate to Real Time Strategy games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Real Time Strategy% ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Casual (Candy Crush, Solitaire) [Second Most Played]

Q35 Approximately what % of your overall gaming time do you dedicate to Casual games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Casual % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) [Second Most Played]

Q36 Approximately what % of your overall gaming time do you dedicate to 3-D platformer games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

3-D platformer % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Rhythm Game (Rock Band, Guitar Hero) [Second Most Played]

Q37 Approximately what % of your overall gaming time do you dedicate to Rhythm games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Rhythm % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Puzzle (Tetris, Braid, Limbo) [Second Most Played]

Q38 Approximately what % of your overall gaming time do you dedicate to Puzzle games? (Second Most Played)

0 10 20 30 40 50 60 70 80 90 100

Puzzle % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) [Second Most Played]

Q39 Approximately what % of your overall gaming time do you dedicate to Endless Runner games? (Second Most Played)

0	10	20	30	40	50	60	70	80	90	100

Endless Runner % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = First Person Shooter (Call of Duty, Halo, Overwatch) [Third Most Played]

Q40 Approximately what % of your overall gaming time do you dedicate to First Person Shooters? (Third Most Played)

0	10	20	30	40	50	60	70	80	90	100

First Person Shooter % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = MOBA (DOTA2, League of Legends, Heroes of the Storm) [Third Most Played]

Q41 Approximately what % of your overall gaming time do you dedicate to MOBAs? (Third Most Played)

0	10	20	30	40	50	60	70	80	90	100

MOBA % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Turn based RPG (Final Fantasy, Baldur's Gate) [Third Most Played]

Q42 Approximately what % of your overall gaming time do you dedicate to Turn Based RPGs? (Third Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Turn Based RPG % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action RPG (Diablo, Fallout, Skyrim, Mass Effect) [Third Most Played]

Q43 Approximately what % of your overall gaming time do you dedicate to Action RPGs? (Third Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Action RPGs % ()	

Display This Question:

If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Fighting (Street Fighter, Killer Instinct, Super Smash Bros) [Third Most Played]

Q44 Approximately what % of your overall gaming time do you dedicate to Fighting Games? (Third Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Fighting Games % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Action Adventure (Uncharted, Tomb Raider, Bayonetta, Last of Us) [Third Most Played]

Q45 Approximately what % of your overall gaming time do you dedicate to Action Adventure games? (Third Most Played)

(	10	20	30	40	50	60	70	80	90	100

Action Adventure % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Racing (Need for Speed, Forza, Mario Kart) [Third Most Played]

Q46 Approximately what % of your overall gaming time do you dedicate to Racing games? (Third Most Played)

(	10	20	30	40	50	60	70	80	90	100

Racing % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Open World Sandbox (GTA V, Minecraft) [Third Most Played]

Q47 Approximately what % of your overall gaming time do you dedicate to Open World Sandbox games? (Third Most Played)

(	10	20	30	40	50	60	70	80	90	100

Open World Sandbox % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Sports(Madden, FIFA, NBA 2k) [Third Most Played]

Q48 Approximately what % of your overall gaming time do you dedicate to sports games? (Third Most Played)

(	1	2	3	4	5	6	7	8	9	1
0	0	0	0	0	0	0	0	0	00	

Sports Games % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Real-Time Strategy (Starcraft, Civilization, AOE) [Third Most Played]

Q49 Approximately what % of your overall gaming time do you dedicate to Real Time Strategy games? (Third Most Played)

(	1	2	3	4	5	6	7	8	9	1
0	0	0	0	0	0	0	0	0	00	

Real Time Strategy% ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Casual (Candy Crush, Solitaire) [Third Most Played]

Q50 Approximately what % of your overall gaming time do you dedicate to Casual games? (Third Most Played)

(	1	2	3	4	5	6	7	8	9	1
0	0	0	0	0	0	0	0	0	00	

Casual % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = 3-D plaformer (Portal, Mario 64, Crash Bandicoot, Jak and Daxter, Banjo-Kazooie) [Third Most Played]

Q51 Approximately what % of your overall gaming time do you dedicate to 3-D platformer games? (Third Most Played)

(	1	2	3	4	5	6	7	8	9	1
0	0	0	0	0	0	0	0	0	00	

3-D platformer % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Rhythm Game (Rock Band, Guitar Hero) [Third Most Played]

Q52 Approximately what % of your overall gaming time do you dedicate to Rhythm games? (Third Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Rhythm % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Puzzle (Tetris, Braid, Limbo) [Third Most Played]

Q53 Approximately what % of your overall gaming time do you dedicate to Puzzle games? (Third Most Played)

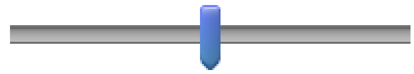
(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Puzzle % ()	

Display This Question:
If Which genres have you played the most in the last 3 months? Include all platforms including PC, C... = Endless Runner (Jetpack Joyride, Canabalt, Bit.Trip Runner, Subway Surfers) [Third Most Played]

Q54 Approximately what % of your overall gaming time do you dedicate to Endless Runner games? (Third Most Played)

(1 2 3 4 5 6 7 8 9 1
0 0 0 0 0 0 0 0 0 00

Endless Runner % ()	

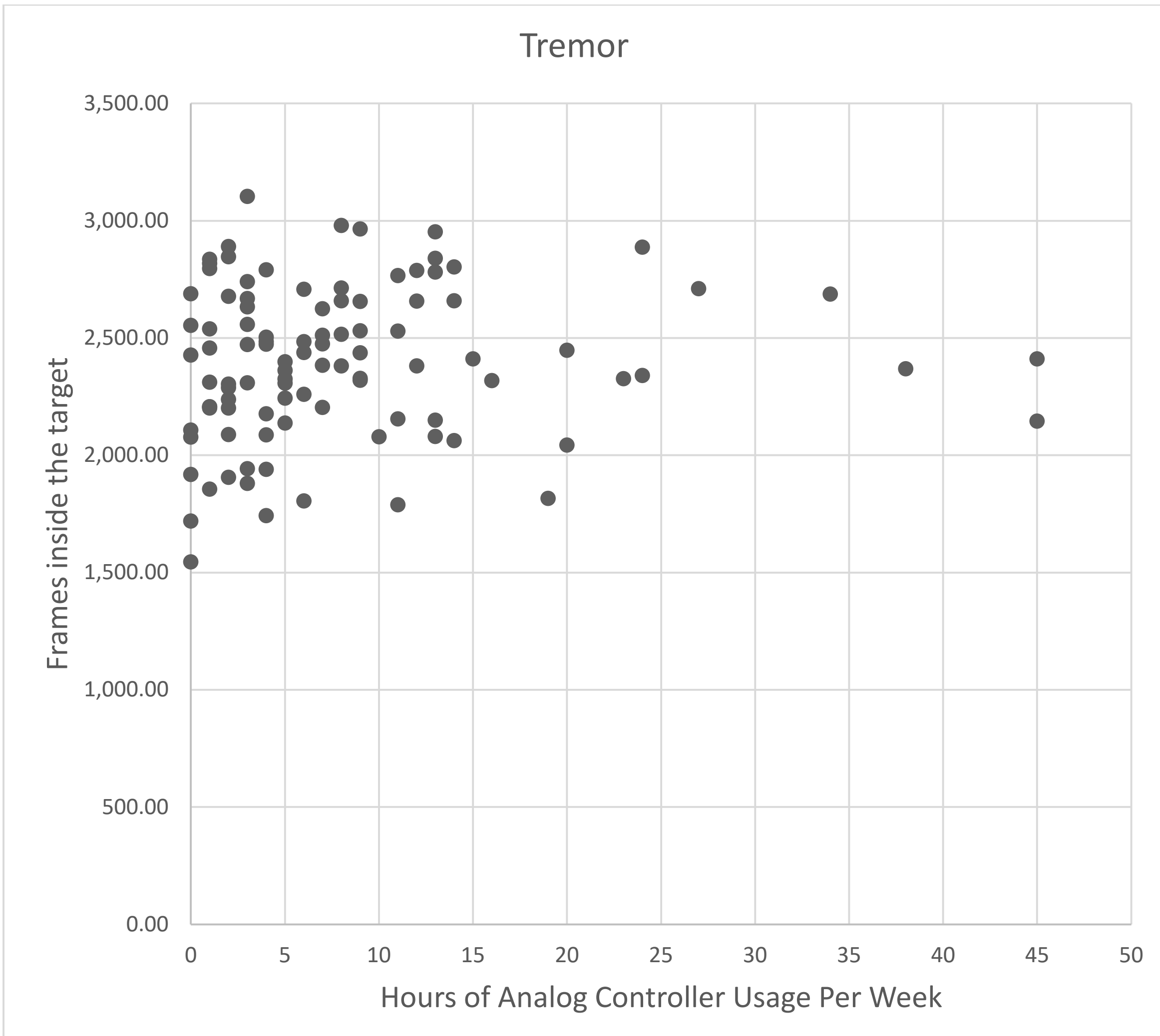
End of Block: Yes they are gamer

Start of Block: No they are not gamer

Q68 Thank you for participating. No controller test required.

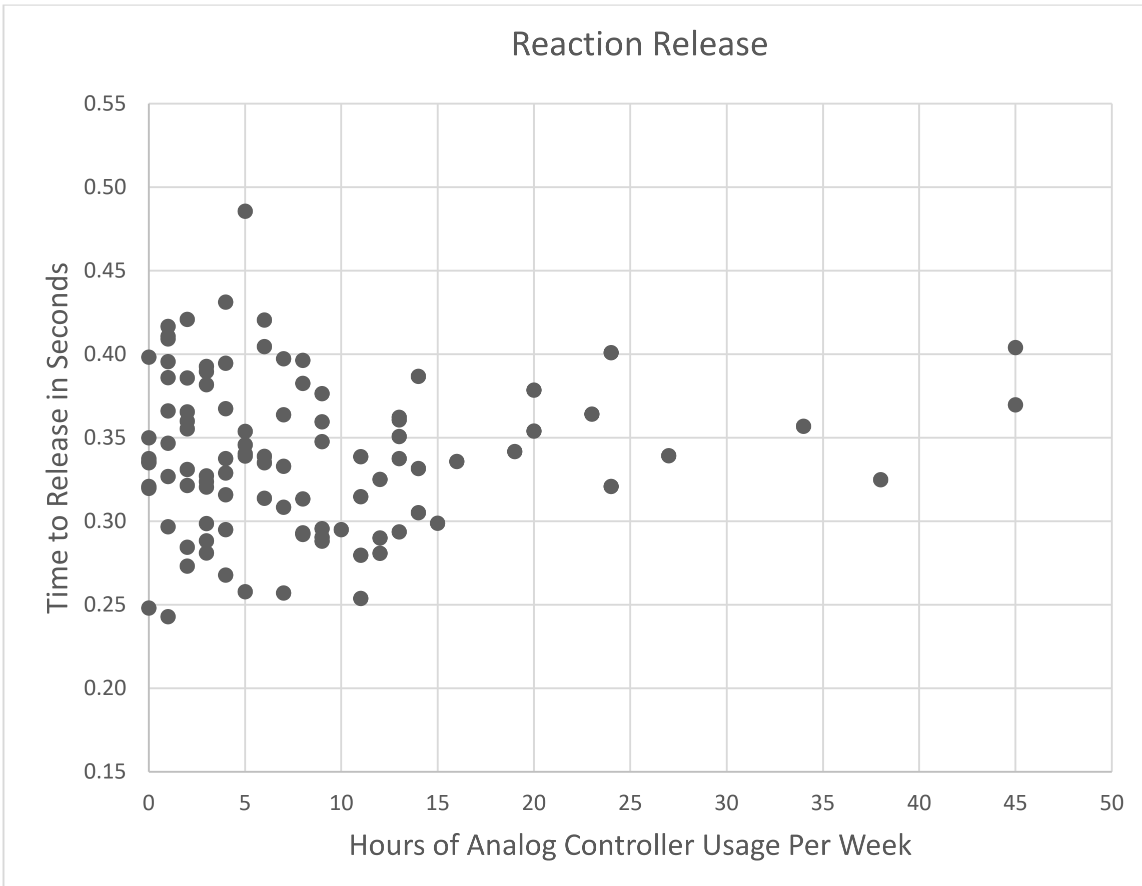
End of Block: No they are not gamer

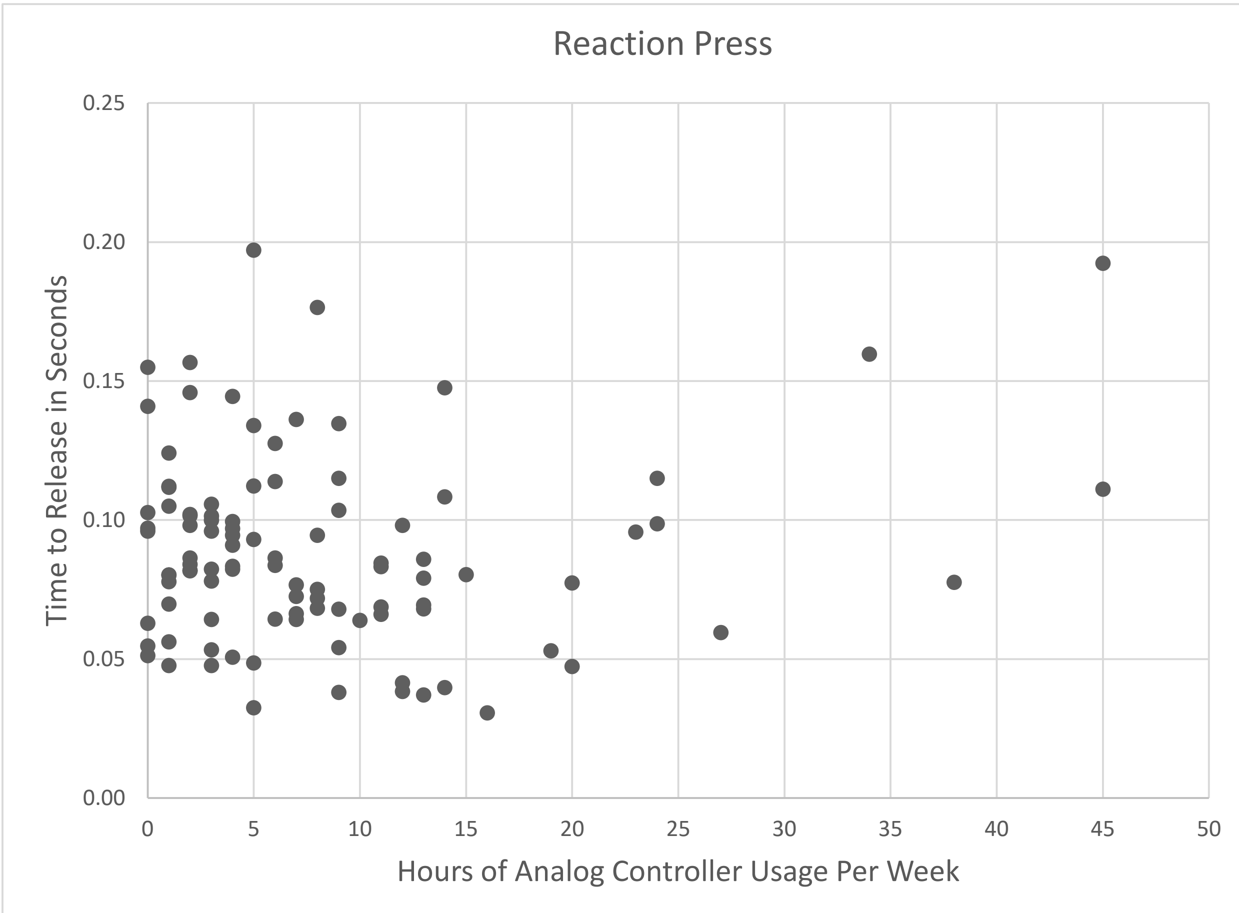
APPENDIX B: RAW DATA TREMOR



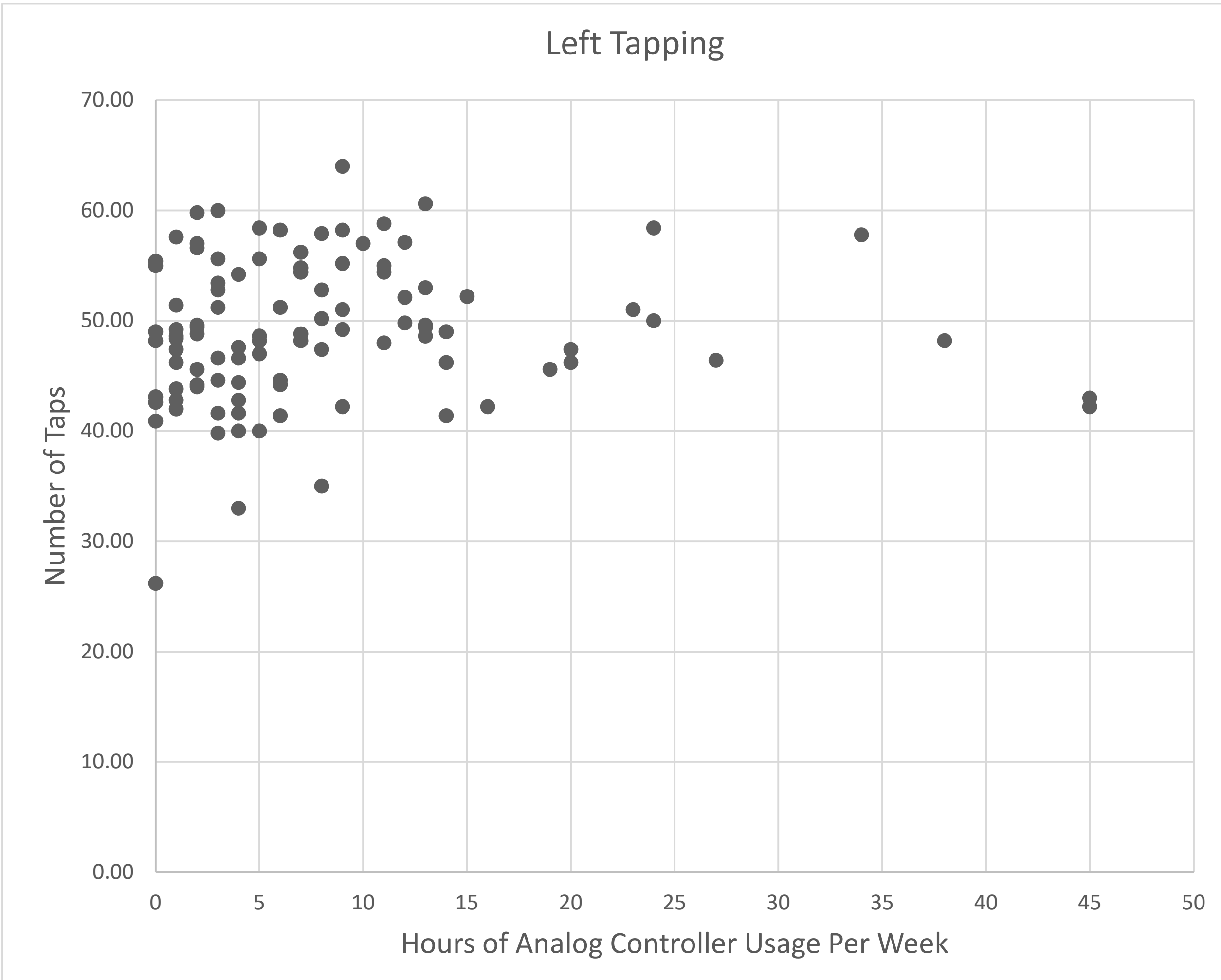
Tremor
3,500.00
3,000.00
2,500.00
2,000.00
1,500.00
1,000.00
500.00
0.00
Frames inside the target
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week

APPENDIX C: RAW DATA REACTION

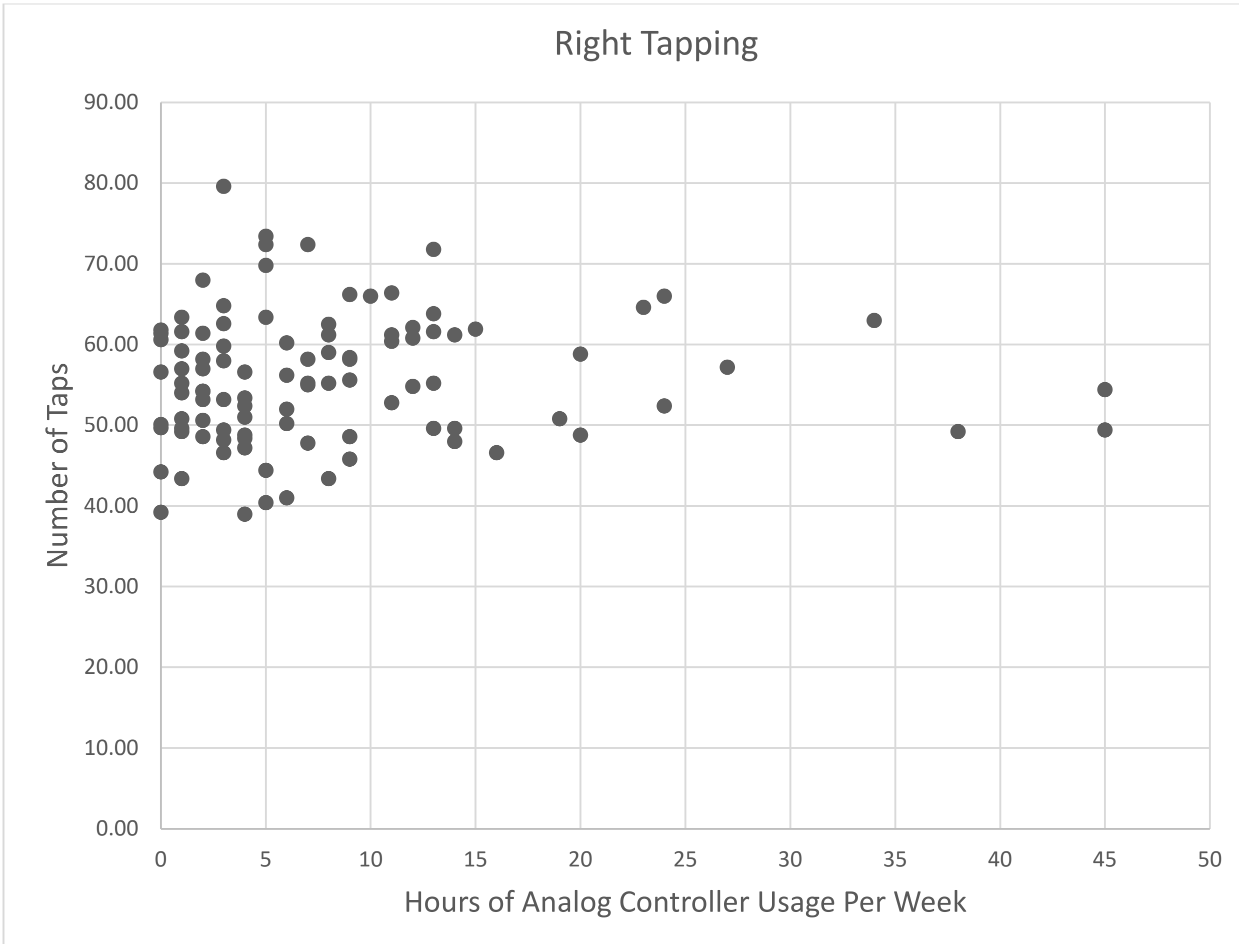

Reaction Release
Time to Release in Seconds
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week


Reaction Press
0.25
0.20
0.15
0.10
0.05
0.00
Time to Release in Seconds
0 5 10 15 20 25 30 35 40 45 50
Hours of Analog Controller Usage Per Week

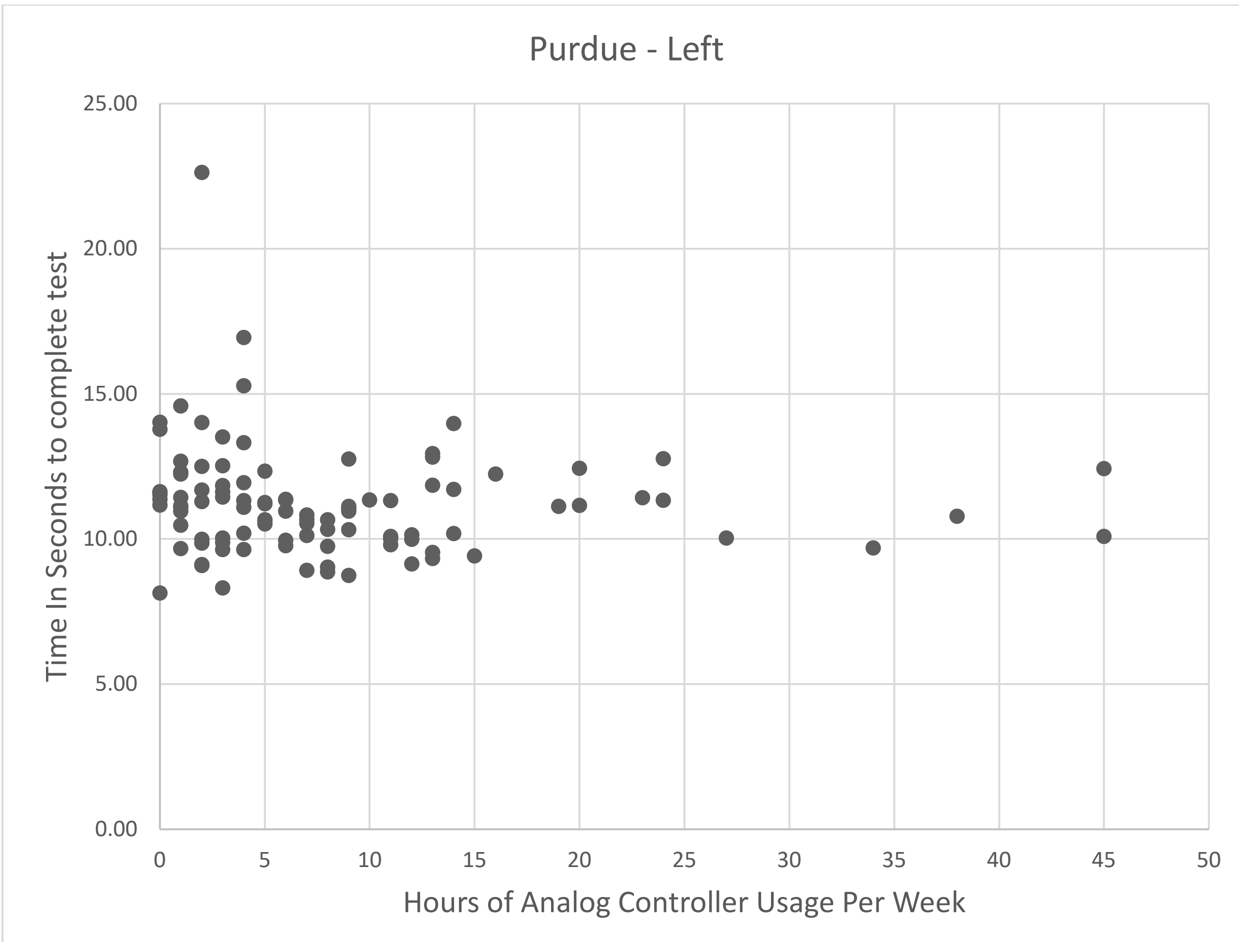
APPENDIX D: RAW DATA TAPPING



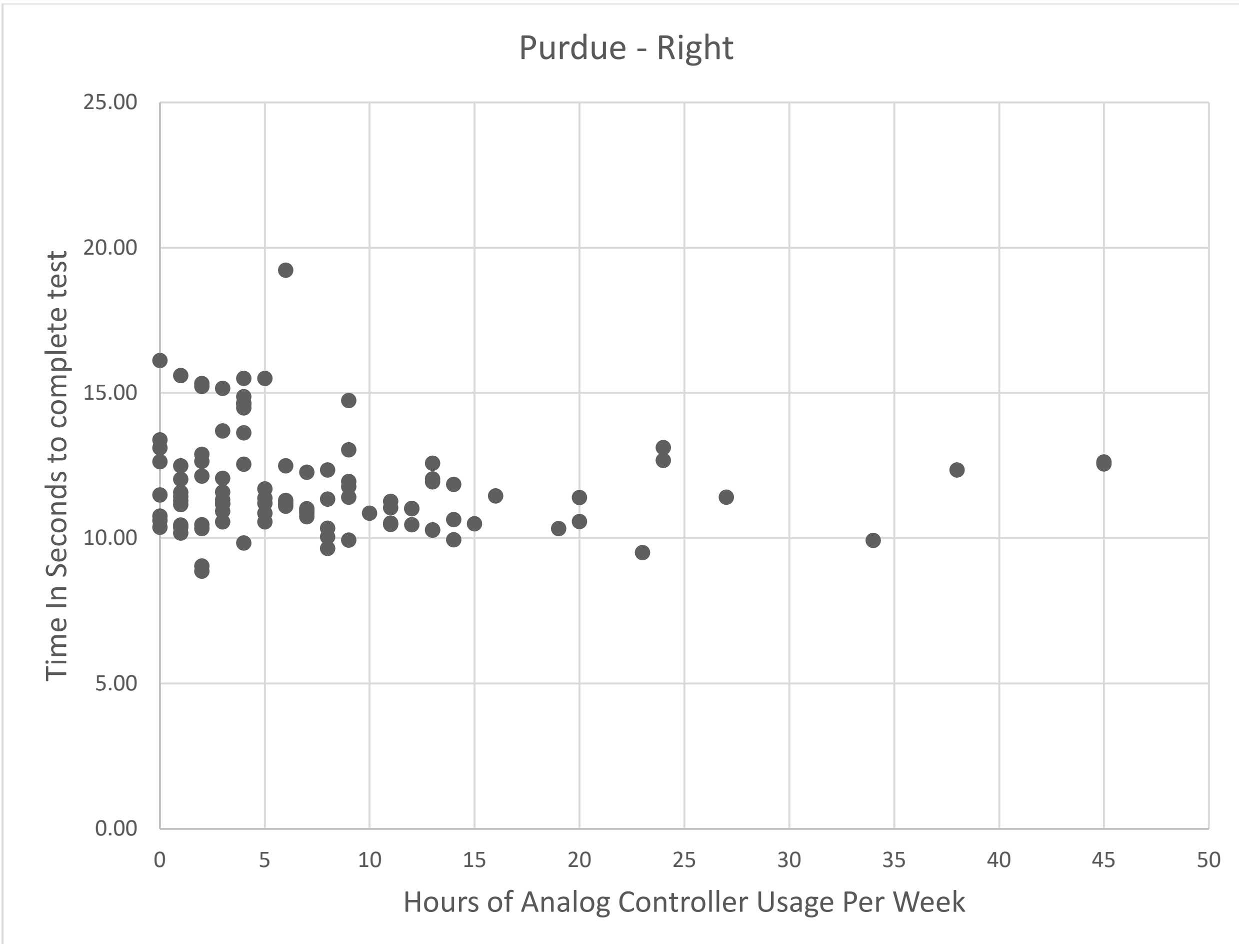
Left Tapping
Number of Taps
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week

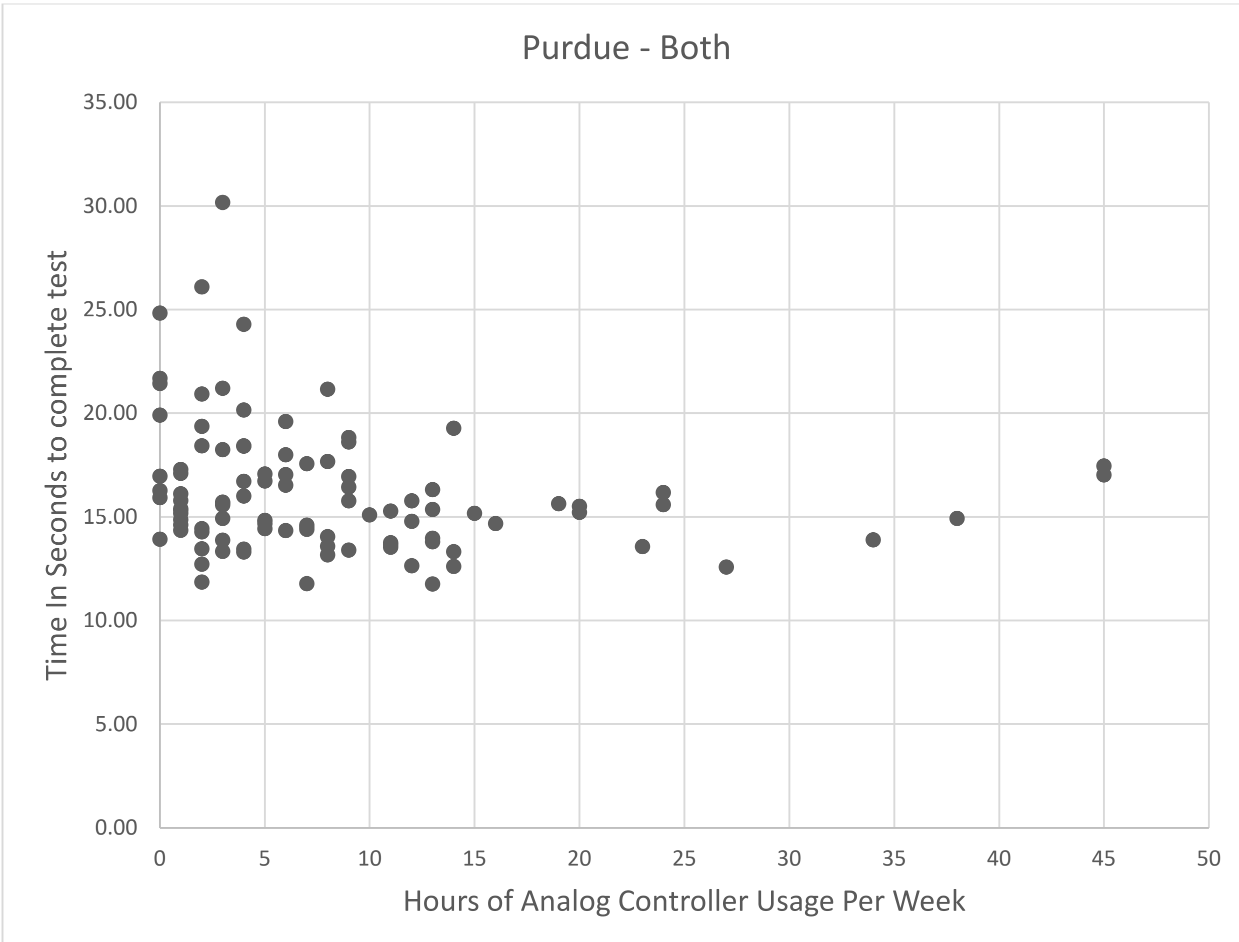

Right Tapping
Number of Taps
Hours of Analog Controller Usage Per Week
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
0
5
10
15
20
25
30
35
40
45
50

APPENDIX E: RAW DATA PURDUE PEGBOARD



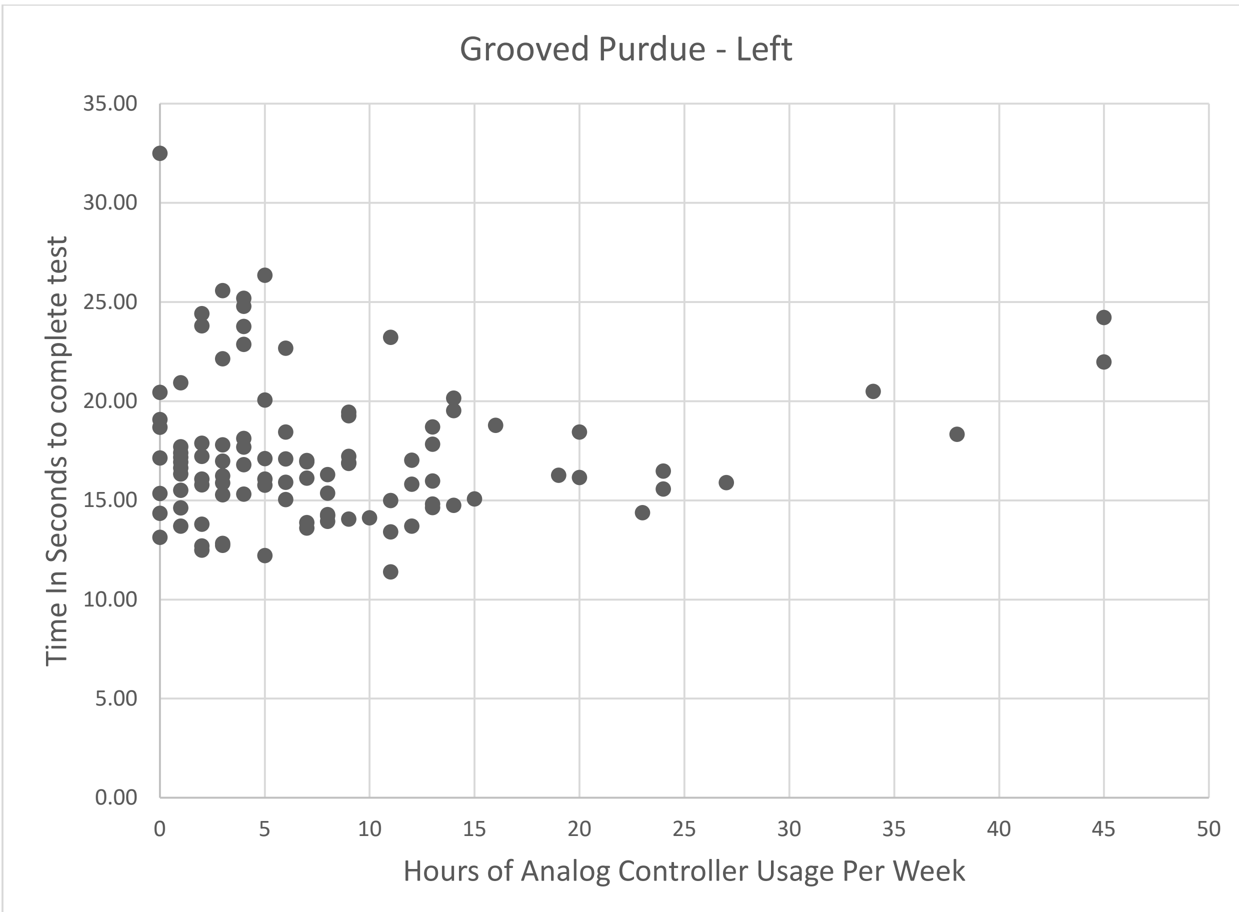
Purdue - Left
25.00
20.00
15.00
10.00
5.00
0.00
Time In Seconds to complete test
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week


Purdue - Right
Time In Seconds to complete test
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week

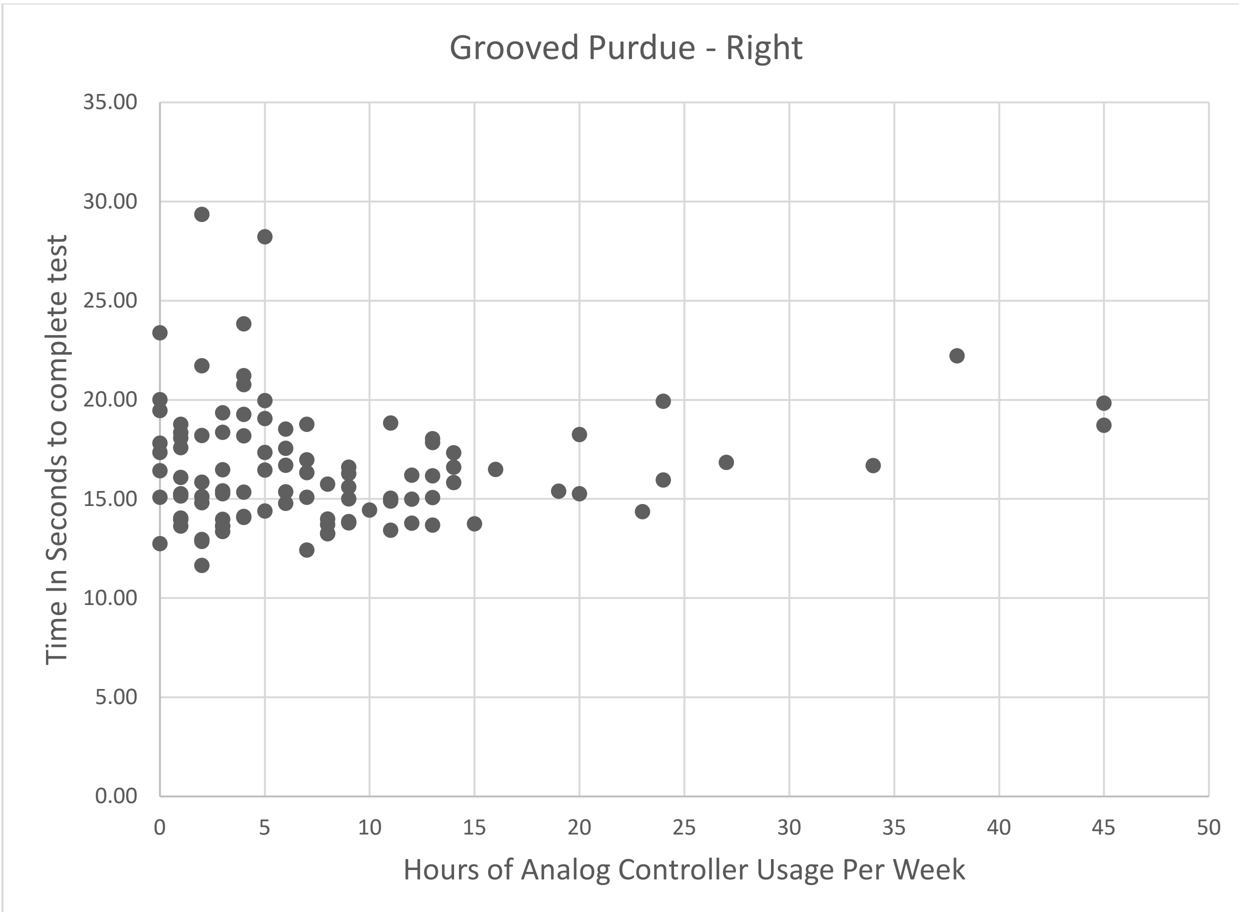


Purdue - Both
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Time In Seconds to complete test
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week

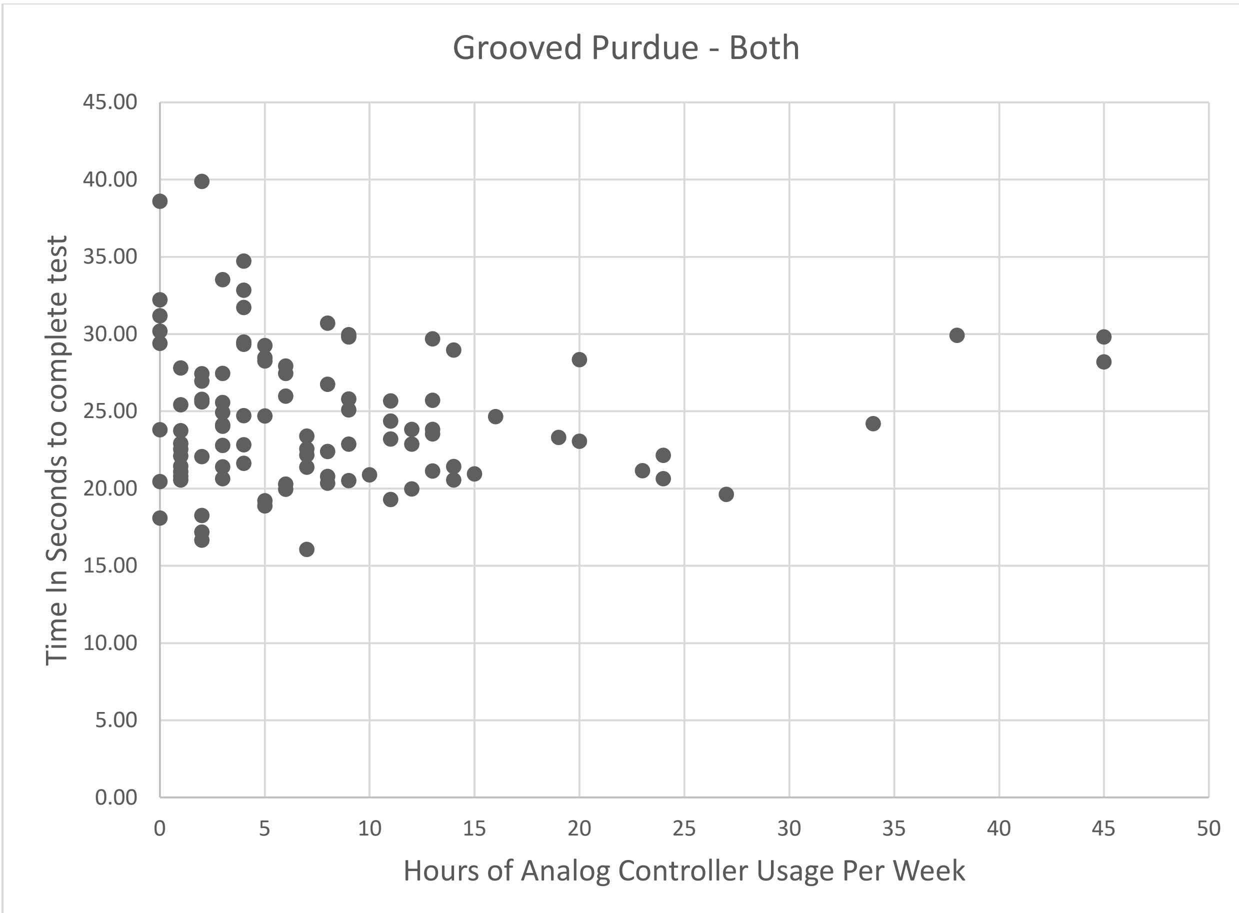
APPENDIX F: RAW DATA GROOVED PURDUE PEGBOARD



Grooved Purdue - Left
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
35
40
45
50
Time In Seconds to complete test
Hours of Analog Controller Usage Per Week



Grooved Purdue - Right
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Time In Seconds to complete test
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week


Grooved Purdue - Both
Time In Seconds to complete test
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
35
40
45
50
Hours of Analog Controller Usage Per Week

APPENDIX G: UCF IRB OUTCOME LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Thomas F. Carbone**

Date: **June 01, 2017**

Dear Researcher:

On 06/01/2017 the IRB approved the following minor modifications to human participant research until 01/25/2018 inclusive:

Type of Review:	IRB Addendum and Modification Request Form Expedited Review
Modification Type:	Charles Hughes was added as a Faculty Advisor and Olivia Carbone was added as a Research Assistant.
Project Title:	Psychomotor Skills Measurement for Surgery Training using Game-based Methods
Investigator:	Thomas F. Carbone
IRB Number:	SBE-16-12571
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 01/25/2018, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

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