University of Alberta

The Exploration of Video Games as a Tool for Problem Solving and Cognitive Skills Development

by

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Abstract

Video games have changed the way we view, think about, and participate in recreation, entertainment, and play. However, with over 25 years of research, there is still little empirical evidence of the long-term effects of video games on problem solving and cognitive skills development. Sixty-five students from the University of Alberta, 34 Gamers and 31 Non-gamers, were tested using the Canadian Test of Cognitive Skills. The results showed that Gamers scored significantly higher in the areas of sequencing, non-verbal, and overall cognitive skills. The PARI cognitive task analysis was used to compare eight Gamers and eight Non-gamers problem solving strategies in a video game environment. Although no significant difference was found, both groups showed the ability to adapt their cognitive strategies as they progressed in the game. The results of the study suggest that video games are an effective tool for problem solving and cognitive skills development.

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CHAPTER ONE

Introduction and Statement of the Problem

Video games have changed the way we view, think about, and participate in recreation, entertainment, and play. Introduced to the public as a mainstream medium of child's play in the early 1980's, video games have evolved into a multifaceted medium that encompasses many aspects of social, economic, and cultural values. Designed as digital environments where users test both their mental and physical abilities to reach a particular goal, video games have changed society's idea of gaming and play. Evolving from the simple shapes of *Pong* (Atari, 1972) to the massive multiplayer game of *World of Warcraft* (Blizzard, 2004), the medium has moved beyond the confines of simple gaming and play. This cultural phenomenon is as important and significant as other media in their development such as radio, television, and movies that have changed the way we view the world and communicate. Just as these other media were once viewed with skepticism for their impact on education, psychology, and sociology, we have since seen their movement into mainstream acceptance. Educational audio programs, videos, and movies, now make up a large segment of supplemental education resources. Video games, as another powerful medium of influence, offer the education and research community another medium for educational exploration.

The Cultural Impact and Significance of Video Games

Video games, in their short 25 years of global mainstream acceptance, are one of the main mediums of entertainment and play worldwide (ESA, 2005). With worldwide console, portable, and PC game sales reaching 31 billion dollars in 2003 (Gaudiosi, 2003), and 11.2 billion dollars in sales in the U.S. alone (NPDFunworld, 2004); and with a user group in the hundreds of millions (ESA/IDSA, 2003), video games are one of the most powerful mediums of communication, art, and entertainment.

A cultural phenomenon that affects both young and old globally, video games are a major influence on popular culture. From being adapted to television and movies, such as *Lara Croft Tomb Raider* (Core Design, 1996), *Final Fantasy* (Square Enix, 1990), and *Resident Evil* (Capcom, 1996), to crossing over into music and fashion, for example music from *Final Fantasy VIII* (Square Enix, 1997) reached number one on Japanese music charts, to being able to buy the bikinis featured in Tecmo's *Dead or Alive: Xtreme Beach Volleyball* (Team Ninja, 2003), video games are a major force in mass media. The breath of video games influence in media domains, other than gaming, have other industries taking notice that video games are an important medium for commercial exploitation.

Since television viewership among men aged 18 to 34 declined by approximately 12 percent in 2003, while the same group spent 20 percent more time playing video games (Wong, 2004a), every industry that has a stake in meeting this demographics' commercial, social, and entertainment needs are taking notice. The film, television, and advertising industries are beginning to view video games as an integral part of their development and production process. This is no more evident than in the intertwining of plots between movies and video games like in the *Matrix* (Shiny, 2003) and *Star Wars* (Bioware, 2003) franchises. With video game development budgets in excess of $20 million dollars, an extra hour of filmed scenes with the original actors from the films, as well as additional storyline elements, the *Matrix* and *Star Wars* franchises have shown the crossover power of video games' commercial influence (Herold, 2003). Movie, sports, and music stars have also taken notice of video games as a medium of self-promotion. While video game characters such as Pac Man and the Mario Brothers have become cultural icons as important as leading actors and actresses (GameInfowire, 2005), many media personalities are lending their image and talents to the video game industry. Britney Spears' *Dance Beat* (Metro Graphics, 2002), Michael Jackson's *Moonwalker* (Sega, 1990), Tony Hawk's *Pro Skate* (Neversoft, 1999), and John Madden's *NFL* franchise (EA Sports, 2005) have demonstrated the huge potential for cross-media advertising and promotion to become big business. Fictional landscapes in video games are now accented with product placements and billboards, pitching everything from shoes and movies, to new cars (Wong, 2004b). Generating nearly $79 million dollars in advertising revenues in 2003, of which $10 million came from in-game advertising (Janik, 2005), marketers have found a new medium to captivate the attention of the 18-34 year old demographic. Since the average age of gamers is 30 years old, and 92 percent of all games are purchased by adults over the age of 18 (ESA, 2005), game companies are pushing the envelope to meet the needs of the mature gamer.

Although the vast majority of games sold are still rated "E" for everyone (83% in 2004), the video game industry is now finding that it is not only children's game characters that have mass appeal (ESA, 2005). In the October 2004 issue of Playboy magazine, a number of leading female game characters posed in the nude. From a hyper realistic half-vampire half-human character from the game *BloodRayne* (Terminal Reality, 2003) to the vixens from *Leisure Suite Larry* (High Voltage Software, 2004), we see that games have moved beyond the confines of childhood fantasy (CBS, 2004).

Just as we see that video games have influenced culture and industry, we can also observe the influence of shifting cultural values in gaming. Video game makers are now testing the limits of questionable content with the adoption of the Electronic Software Rating Board's rating system. Depictions of gay marriage in *The Temple of Elemental Evil* (Troika, 2003), lesbian flirting of female Jedi in *Star Wars: Knights of the Old Republic* (Bioware, 2003), fully simulated sex in *Singles: Flirt Up your Life* (Rotobee, 2004), and realistic killing in the *Grand Theft Auto* franchise (Rockstar North, 2004; Thompson, 2004), illustrate that the video game industry is exploring the boundaries of culture, illusion, and entertainment. This influence, however, has not only affected the leisure markets of entertainment and mass media, but has influenced a generation's idea of engagement.

No longer impressed by sitting idly in front of a television, many in the 18-29 year old age demographic prefer video games as their number one source of leisure, recreational, and social activity (Anderson and Bushman 2001; Dewitt, 1993; ESA/IDSA, 2003; Gentile, et al., 2004). With this growth and influence, has come wide speculation about video games' impact on children and society. As video games have also taken a dominant position in children's recreation and leisure activities, both the media and researchers are condemning video games as a medium that promotes serious mental, physical, and psychological risk (Anderson & Bushman, 2001; Funk, 1993; Griffiths, 1997, 1999).

The Perceived Negative Influence of Video Games

Since the earliest days of videos games, many government and lobbyist organizations have taken an avid interest in condemning games for their influence on

North American children. Coined as the "common video game controversy" (Brainyencyclopedia, 2004) many politicians, parental groups, and lobbyists are critical of video games for their potential to both cause and promote harm. A large number of these attacks, in the media and in research, focus on the violent nature and content of video games, and their potential to transfer into violent acts by the individuals who use them. Building on the research of the long-term effects of media violence in movies and television (Hearold, 1986; Wood, Wong, & Chachere, 1991; Paik & Comstock, 1994; Bushman & Anderson, 2001; ESA/IDSA, 2001; Johnson et al., 2002) researchers are now turning their focus to the consequences of playing violent video games.

Anderson (2004), in a meta analysis of 44 empirical reports of violent video game effects, looks at the consequences of exposure to violent video games have on the outcome variables: aggressive behavior, aggressive cognition, aggressive affect, helping behavior, and physiological arousal. Anderson finds in this meta-analysis that general exposure to violent video games in both experimental and correlation studies found increases in 4 out of 5 outcome variables; helping behavior is the only one that decreased. This finding, however, is in stark contrast to many other reports of video games' effects on youth violence. The most notable is the report by the U.S. Surgeon General on the incidence, causes, and prevention of youth violence in 2001 (U.S. Surgeon General, 2001). The report, commissioned after the shootings at Columbine High School in April 1999, stated that in relation to video games and youth violence "the overall effect size for both randomized and correlation studies was small for physical aggression and moderate for aggressive thinking…[and that]…the impact of video games on violent behavior remains to be determined" (ESA/IDSA, 2001, p. 7). What these conflicting reports show is, if taken in context of measurable social change, a number of studies concerning video games and youth violence are diverse in their correlations, and questionable in their conclusions (Durkin & Barber, 2002). With nearly every study plagued with unclear definitions, ambiguous measurements, and overgeneralizations of the data (Goldstein, 2000), there is obvious questions concerning their validity. This point is validated by the fact that youth violence, as reported by the U.S Department of Justice, Office of Juvenile Justice and Delinquency, showed a decrease of 21% for the 25-29 age group, 19% for the 18-24 age group, and 39% in the 15-17 age group, between 1994-1999 (ESA/IDSA, 2001), while the game industry continued to grow significantly in the same period (ESA, 2005). It is recognized that video games, along with violent movies and television, may give form to aggressive behavior such as play fighting, wrestling, and play acting, however, there is no strong evidence to suggest that video games motivate individuals to commit aggressive acts if they are not already inclined to do so (Goldstein, 2000). The phenomena of deindividuation, social identity/deindividuation (SIDE), social modeling, moral disengagement, and group conformity, are models in which the observation of aggressive behaviour and play of individuals who play video games can be framed (Zimbardo, 1997; Reicher et al. 1995; Bandura, 1990). The intense sensory stimulation of games and the flow in which players lose their identity to agents of the game, can lead to less attention to self-regulation and more to the acts and identities in which the player are immersed (Coleman et. al., 1999). However, no studies could be found on this hypothesis as they relate to children, violence, and video games.

As research continues to frame the issue, it is evident that these studies on video game violence merely highlight society's apprehension to look at parental, family, and societal culpabilities (Moore, 2002), rather than the true nature of video games as a medium influence. Just as researchers have focused upon video games as a medium that significantly influences negative social change, so too should the positive influence of video games as a medium of change garner the same attention (Walsh et al., 2004). The larger question of the effects of this medium and its influence on positive change has yet to be answered. Television, film, and videos were once attacked for their cultural worth and then later reassessed as important media for instruction and educational supplementation (Squire, 2002). Likewise, the application of video games as an educational medium will come to fruition.

Education, Learning, Games and Simulation

> Games are thus the most ancient and time-honored vehicle for education. They are the original educational technology, the natural one, having received the seal of approval of natural selection. We don't see mother lions lecturing cubs at a chalkboard; we don't see senior lions writing their memoirs for posterity. In light of this, the question, "Can games have educational value?" becomes absurd. (Crawford, 1982, p. 16)

The potential of video games to influence and promote educational objectives have been theorized since their inception. Seen as an effective medium of "edutainment" (Wikipedia, 2005), their potential is discussed, debated, and speculated upon in many educational contexts. From complex combat simulations to children's literacy, video games have the potential to change the way we approach education and learning.

Since the video game industry has proven its influence on popular culture, educational gaming has seen an influx in attention and focus. With educational gaming research groups such as the MIT *Games-to-Teach*, the *Electronic Games for Education in Math and Science (EGEMS)* group at the University of British Columbia, and the *Simulation and Advanced Gaming Environments (SAGE)* group at Simon Fraser University taking the lead, the educational value of games, and their ability to influence educational outcomes are a serious area of research. Focusing mainly on the obvious aspects of games, such as their ability to promote motivation (Becta, 2002; Bisson and Luckner 1996; Prensky, 2002), student engagement (Kafai, 2001; Klawe and Phillips 1995), and information retrieval and retention (Brownfield and Vik, 1983; Ricci, 1994; Squire, 2003), many researchers are looking at video games as the potential "Philosophers Stone" to solve teaching ills.

A large number of projects and studies have looked at video games as possible vehicles for content acquisition. Learning domains such as mathematics, science, language arts (Randel et al, 1992), geography (Jayakanthan, 2002), history (Squire, in press), body awareness (Bosworth, 1994), and safe sex (Thomas et al., 1997) are a few that have been explored. In many of these studies, it is the positive attributes of games, as a motivational space of learning that are hypothesized to promote content acquisition. The results of these studies, in relation to observable gains in objective tests, however, are mixed.

Other educational benefits that have been noted in the marriage between games and education, are games' abilities to teach information retrieval (Halttunen and Sormunen, 2000), to cater to different learning styles (Kirriemuir 2002), to promote computer literacy (Natale 2002), and to encourage creativity, experimentation, and thought (Gee, 2003). Positive social effects of games in education have also been widely explored in a number of studies. Games offer many attributes that make teaching and learning easier and more enjoyable by encouraging collaboration (Klawe and Philips, 1995; Kusunoki et al., 2000), promoting learning (Din and Calao, 2001), promoting and encouraging discovery learning (Leutner, 1993), and cooperative learning (Graves & Klawe, 1997). Also, beyond the obvious content knowledge and skill acquisition, video games have the ability to serve as a mediator of computer and media literacy (Greenfeild et al., 1994), shape students values and attitudes towards ICT (Fromme, 2003), and be used to influence children's performances on computer tasks that relate closely to similar gaming contexts (Pillay, 2003). The benefits of using games for student exploration in simulated environments are also recognized. Many teachers and students can now explore and interact with previously unimaginable domains that may be too dangerous, difficult or impractical to implement in a classroom (Berson, 1996 cited in Squire, 2002). These wide-ranging applications of games in teaching and learning have brought gaming to the attention of many educators, parents, and the media.

Books such as Marc Prensky's *Digital Game-Based Learning* (2001), James Paul Gee's *What Video Games Have to Teach Us About Learning and Literacy* (2004), and Clark Aldrich's *Learning by Doing: A Comprehensive Guide to Simulations, Computer Games, and Pedagogy in e-learning and Other Educational Experience* (2005), are making research accessible to the general public and educators. This growth in interest and research, however, has primarily concentrated on the application of games as another practical adjunct to traditional teaching, rather than as a new tool for educational exploration. Few studies are found that consider the relationship between video games and academic performance (Mitchell & Savill-Smith, 2004). Although there are a growing number of proponents and research studies regarding the use of educational gaming as a teaching tool, critical analyses of these works are anecdotal, descriptive, and/or judgmental (cf. Randel et al, 1992; Dempsey et al. 1994; Emes, 1997; Harris, 2001). In as much any serious survey of educational research in games reveals that beyond the obvious social and motivational aspects of playing video games, finding empirical evidence of the academic benefits of gaming is difficult, if not impossible (Kafai, 2001). In the many studies that look at the causal link between academic performance and game play, researchers have found no clear relationship (Emes, 1997; Harris, 2001; Dempsey et al. 1996).

Educational game design is one of the main factors that contribute to the poor performance of games as an educational tool. In a public lecture regarding the effective design and use of educational computer games, Maria Klawe, a founder and director of the University of British Columbia EGEMS project, stated that in relation to educational game design, the "most common problem with educational software is that students don't pay attention to or learn the way designers intended" (Klawe 2000, cited in De Castrell and Jenson, 2003). The disconnect between gamers and designers has contributed to the lack of development of exemplary educational games that could substantiate the investment in the development of an educational gaming industry. A recent summit on Educational Games by the Federation of American Scientists on October 25, 2005, identified that one of the two main causes impeding the development and commercialization of games for learning is "the absence of exemplar products that can demonstrate the kinds of benefits that would encourage change on the part of educational institutions" (Kelly, 2005, p. 5). Even with 20 plus years of speculation and trial-and-error, this realization has failed to produce designs that meet both the academic and commercial needs of students. In many cases, educational objectives are implemented mainly as assessments in a gaming context; for this reason, a majority of educational gaming titles are for young children rather than teenagers or adults who will react to the novelty of the gaming environment more than respond to the game as a powerful medium of education. The inability of designers to meet both the educational and entertainment needs of adults and youth leads many to believe that the majority of educational gaming titles for these cohorts lack any obvious cognitive value, and are neither fun nor engaging (Hogle, 1996).

Despite 25 years of thought, debate, and speculation, "so far, the marriage of education and video-game like entertainment has produced some not-very-educational games and some not-very-entertaining learning activities" (Brody, 1993, p. 2). There are, however, many informal educational aspects of video games that are not obvious in their content. Most notable are video games' ability to help players develop problem solving, cognitive, creative, and critical thinking skills through their use.

Purpose of this Study

The purpose of this study was to explore the long-term effects of video game play on students' cognitive skills development in the areas of sequencing, analogies, memory, verbal reasoning, non-verbal, and overall cognitive skills, using the *Canadian Test of Cognitive Skills, level 5* (CTC, 1992a), by measuring if there is a difference between those who play video games and those who do not. The differences in video game players and non-players problem solving abilities were also assessed using the *Precursor, Action, Interpretation, Results (PARI)* cognitive task analysis (Hall, Gott, & Pokorny, 1995) while playing the puzzle game *The Incredible Machine: Even More Contraptions* (Sierra, 2001).

Research Questions

This study attempts to address the following questions:

1) Is there a difference in cognitive skills between students who play video games and those who do not?
2) Is there a difference in problem solving abilities, in a situated problem solving video game environment, between students who play video games and those who do not?

Significance of the Study

This study is significant because it contributes to an area of research that is still ill-defined and ill-established. The results of this study will allow educational psychologists and educators to identify the specific cognitive processes engaged in during game play, and their possible implications and applications. The results will also identify video games' function as a tool in the area of cognitive skills development, and their consequential use in cognitive psychology and rehabilitation science. Empirical evidence suggesting that video games' influences and possible transferability in the area of cognitive skills, will also further our understanding of transfer, a well-debated topic of educational and psychological research. In addition, the long-term cognitive effects of individuals interacting in a complex environment, like those of video games, are currently unknown. Research on the use of video games as a cognitive tool will ultimately lead to new theories, philosophies, and practices.

Definition of Terms

The following definitions are applied to terms in this study for their identification and clarification.

Video Games. Video games are an activity or contest of physical and/or mental skills and strengths, which require the participant(s) to follow a specific set of rules in order to attain a goal in a digital environment (Hogle, 1996). These games are played in digital environments including, but not limited to, computers, laptops, Palm systems, cellular telephones, dedicated video game consoles, hand-held gaming systems, and video arcade equipment. They are served and supplied via DVD, DVDROM, CDROM, memory stick, ROM chip, cartridge, Intranet, The Web, or as hybrids of two or more of these technologies.

Cognitive Tools. A cognitive tool is a tool that engages and facilitates cognitive processes (Kommers, Jonassen, & Mayes, 1992 cited in Jonassen, 1994). Cognitive tools are instruments that facilitate and extend users' cognitive abilities and are therefore used in the development and articulation of cognitive skills.

Problem Solving and Cognitive Strategies. Problem solving and cognitive strategies are the thinking tasks used to solve a particular problem. They are categorized as cognitive processes that are goal directed and require effort and concentration of attention (Van Someren et al., 1994). The strategies that are used to solve problems are observed either through verbal protocols or through the observation of the sequence of steps that an individual takes to solve a particular problem. Specific identifiable problem solving strategies include: heuristics, means/ends analysis, hill climbing, sub-goaling, working backward, analogies, difference reduction, induction, deduction, and trial-and-error.

Cognitive Skills. Cognitive skills are concerned with the processes of analysis, interpretation, and decision-making that are required to carrying out a procedural task (Patel et al. 2002). These skills are both conscious and subconscious procedures which include verbal, non-verbal, and memory skills. Specific identifiable cognitive skills include visual spatial skills, verbal reasoning, iconic reasoning, problem solving, memory skills, drawing analogies, and pattern recognition.

Limitations of the Study

Some of the limitations of this study include external validity, generalizability, and limited ability to support causality. Sixty-five university-educated individuals, who may not represent the general gaming and non-gaming populations, participated in this study. In addition, this study is limited in its ability to draw clear and direct correlations between the predictor and criterion variables in both the test of cognitive skills and the cognitive task analysis. Using a causal-comparative ex-post-facto design, the results of the study are more descriptive than prescriptive, since the causal relationship between gaming and cognitive skills and cognitive strategy development cannot be concluded with the test results.

Threats to internal and external validity of this study are found in the extraneous subject characteristics that influence who participated in the study, and in the participants' abilities to affectively supply relevant and accurate information during the PARI interview process. The study is also limited in its ability to examine students' problem solving abilities using verbal protocols. Although the PARI cognitive task analysis lays a framework to administer and sequence the verbal task analysis which has been supported in research as a valid protocol (Chi & Van Lehn, 1991), it does not, however, address student differences, and verbal abilities to describe the problem solving event.

Thesis Organization

Chapter One provides a background to the study of video games as a cultural phenomenon. Their impact on popular culture and education are reviewed and examined. Chapter Two introduces the relevant literature and research about video games, problem solving, and cognitive skills. Models for cognitive learning and transfer are examined as they relate to video games and the research questions. Chapter Three describes the research methodology, tools, instruments, data collection, and data analysis, used to test and evaluate the research hypothesis. Chapter Four presents the results and analysis of data collected from the study. Chapter Five discusses the analysis and results of the study in reference to established research, in order to articulate the findings of the study and to draw relevant conclusions. Chapter Five also presents recommendations for future research.

CHAPTER TWO

Review of the Literature

> If you want to teach people a new way of thinking, don't bother trying to teach them. Instead, give them a tool, the use of which will lead to new kinds of thinking. (Buckminster Fuller, n.d.)

Games have been the staple of problem solving research since its inception. By offering researchers a broad base of potential problem sets, problem solving domains, and strategies for problem solving exploration, they are the quintessential example of problem solving in practice. In classic problem solving research, researchers used games such as the *Tower of Hanoi* (Simon and Hayes, 1976 cited in Robertson, 2001), *Chess* (Telegina, 1975 cited in Robertson, 2001), and the *Hobbits and Orcs* problem (Thomas, 1974 cited in Robertson, 2001), to measure a player's ability to logically reason their way through the beginning, intermediate, and final phases of a problem. Although games, and the technology that runs them, have changed a great deal since their inception, the fundamental nature of games has not changed (Subrahmanyam et al., 2001a). Just as the important creative, critical thinking, and cognitive skills that are developed and utilized during the play of "traditional" games, such as Chess, Mastermind, and Go are accepted in research, so too should research recognize video games as complex problem solving environments.

Looking at the characteristics of problem solving as defined by Mayer (1992), it is obvious that video games can be clearly identified as a domain of problem solving. First, video games are cognitive. They are played using the problem solver's cognitive skills and strategies that can be inferred indirectly from the video game player's behaviors during play. Second, video game play is a process. It involves representing and manipulating knowledge and skills in the player's cognitive system. Third, video games are directed. They represent both ill-defined and well-defined problem solving situations where the player(s) are motivated to win the game by achieving a goal. Finally, video game play is personal. This point is recognized in both the intellectual and affective domains. For example, the ease or difficulty of any game is based on the player's knowledge and skills in which the game is to be played. Furthermore, game players recognize themselves emotionally in video games as they do in traditional games. This is no more evident than when players, who use avatars like Lara Croft, Mario, or Pac Man, situate themselves in the game, and consider their actions as personal feats or defeats. This is evident in their verbal assertions like, "I died" or "oh did you see me jump across that bridge?" which are similar declarations made when playing traditional games. This relationship and realization give a strong basis in which to frame and define video games as a medium of problem solving.

Henderson (2005), using a verbal protocol for the examination of thinking skills and strategies of five teenagers playing the action adventure *Final Fantasy* (Square Enix, 1990), found evidence of cognitive skills such as metacognition, deduction, and induction strategies during play. Henderson concludes that these types of skills support informal educational objectives and that video games should be included in schools for this reason.

Saldana (2004) found that the video game version of the popular game *MasterMind* was an adequate medium to study metacognitive processes. Looking at video games as a medium to study the difference in metacognition among lowfunctioning and average-intelligence students, Saldana found a significant difference between each group on both dynamic and static measurements. Saldana also concludes that video games provide a valid and reliable measure for metacognition.

Hong and Liu (2003), investigating the difference in strategic thinking between experts and novices in the computer game *Klotski*, found that expert players used more analogical thinking, while novices tended to use trial-and-error. These findings are consistent with other studies that look at the relationship between problem solving in expert and novice groups (Robertson, 2001).

Ko (2002), while looking at children's inferential thinking and game performance between the computer and board version of the game *Find the Flamingo*, found that the type of medium has no effect on the development of inferential thinking skills, but did find different play patterns, choices in the game play, between good problem solvers and random guessers. Ko also established that the children in the study differed based on their age and development; with older children using more advanced inferential thinking skills. The children's inferential problem solving capabilities also improved over many practice games.

Doolittle (1995), exploring video games as a possible medium for creative thinking, suggests that video games encourage cognitive flexibility. Deemed as a more important trait to creative problem solving than problem solving fluency, the ability to generate more solutions regardless of type, Doolittle suggests that video games facilitate creativity in generating alternative hypothesis for problem solutions. This facilitation of creativity, he suggests, also helps combat functional fixedness, which hinders students from seeing alternative solutions in a problem domain. Although this study offers sound logic concerning why video games may be used as a cognitive tool, no empirical evidence was presented to offer an objective test of the hypothesis.

Ward and Carroll (1998), using the puzzle game *The Incredible Machine* (Sierra, 1992), look at the use of video games as a means of improving practical mechanical reasoning skills and abilities. Although no significant difference was found between the experimental and control group, differences in mechanical reasoning were noted based on gender. Ward and Carroll also found improved abstract reasoning skills in the players who played the game versus those who did not.

As the research has shown, video games as a medium of problem solving exploration have gone widely unnoticed and unaddressed. Although, theoretically recognized as a powerful medium that promotes the development of problem solving abilities and strategic thinking, there are few research studies to support these claims (Squire, 2002). Through it is recognized that problem solving heuristics are not specific to video games, it can be concluded that the breadth and complexity of problem solving in video games makes them a unique environment in which to study and explore human problem solving and cognition.

Evaluating Problem Solving and Cognitive Strategies in a Video Game Environment

Verbal protocols, such as the PARI (Hall, Gott, & Pokorny, 1995) and ACT-R methodologies (Anderson, 1987), serve as the basis of human problem solving and cognitive task analysis research. Using "think aloud" methods, researchers have been able to probe experts for both the knowledge and the reasons behind particular problem solving steps and strategies. In this way, the cognitive and metacognitive processes that are responsible for knowledge deployment are made apparent (Pillay, 2003). From these verbal protocols, researchers have been able to infer particular cognitive maneuvers associated with a task, such as mean-ends analysis, sub-goaling, inductive and deductive reasoning, visual search, inferences, analogical reasoning, heuristics, and trial-and-error. Although verbal protocols are used in many problem solving contexts, from the design of expert systems to solving simple word problems, video games offer a unique challenge in using such protocols to infer cognitive strategies. As video games introduce new variables into the problem solving environment, such as time and complexity, it is observed that video games and the conditions, in which players interact, can be categorized as either traditional or complex problem solving environments.

Complex problem solving environments differ from traditional problem solving environments in that they introduce the variables of dynamism, time, and complexity (Quesada, Kintsch and Gomez, 2001), while traditional problem solving environments do not. The realization that video games are complex problem solving environments is argued with three points. First, video games are dynamic, because early actions determine the environment in which subsequent decisions are made, and features of the task environment may change independently of the solver's actions. Second, video games are time-dependent, since decisions must be made at the correct moment in relation to environmental demands. Finally, video games are complex, in that most variables are not related to one another in a one-to-one manner (Quesada, Kintsch and Gomez, 2001). As many gamers' actions and reactions are virtually instantaneous in reference to the games dynamics and variables in the environment, the use of verbal protocols, and the ability of the users to both act and report their actions and interpretation of the actions, becomes impossible. Action games, head-to-head fighting games, and racing games, are a few examples of game types where verbal protocols may be deemed inappropriate as they would undoubtibly interfere with the game play. In addition, although it would be desirable to research video games as complex problem solving environments, the methodologies and analytical tools available for this type of research are scant or non-existent nor is there agreement in the research community on how to proceed with respect to this type of research philosophy (Funke, 1995).

The games where "twitch speed" (Prensky, 2001) is not necessary, and where verbal protocols are used to probe gamers' cognitive strategies, represent traditional problem solving spaces. Games where players have time to make decisions in the gaming environment, and both see and reflect on the consequences of those actions with few related variables, like time dependence, dynamics, and environmental complexity, also represent traditional problem solving spaces. Examples of traditional problem solving spaces where verbal protocols can be used include role-playing games (RPG's), strategy, simulation, and puzzle adventures.

The fact that most games are too fast paced for verbal protocols have contributed to the lack of research in this area. Even though there are many who speculate about the complex problem solving and cognitive strategies that are employed during video game play (Doolittle, 1995; Prensky, 2001), only four studies (Blumberg and Sokol, 2004; Hong and Liu, 2003; Pillay et al, 1999; Pillay, 2003) are found that utilize verbal protocols and offer some qualitative evidence concerning the existence of problem solving and cognitive strategies employed during video game play.

Utilizing the PARI (precursor, action, result, interpretation) cognitive task analysis methodology, Pillay et al. (1999), in an exploratory study looking at the cognitive processes students engaged in while playing the simple flight simulation game *Pilotwings* (Paradigm, 1996), found that gamers use a multitude of complex cognitive processes during play. Reading and encoding explicit and implicit information, using inductive and deductive reasoning, making inferences from visual information across screens, reasoning metacognitively, and general problem solving, are a few of the inferences made. In a follow-up study (Pillay, 2003) examined the influence of two video games on children's performance on computer-based instructional tasks. Using both the PARI cognitive task analysis, to identify the cognitive maneuvers employed during video game play, and a measure of the time and number of correct solutions in a common set of educational tasks in a third piece of educational software, Pillay finds that playing computer games influence performance on subsequent computer-based educational tasks (Pillay, 2003). The results however, suggest that the transfer of such skills is based on the similarity between the design and functionality of the video game and educational tasks.

Hong and Liu (2003), investigating differences in strategic thinking between experts and novice computer game players, found a significant difference in thinking types employed depending on the gamers' experience. Hong and Liu found that expert players used more analogical thinking – they were able to identify reasons for their actions – while novice players tended to use trial-and-error. The findings suggest that expert game players use metacognitive problem solving skills.

Blumberg and Sokol (2004), in a study looking at the gender differences in cognitive strategies used when learning how to play a new game, *Sonic the Hedgehog 2* (Sonic Team, 1992), found that more frequent players and older children used internal strategies, like reading the manual and trial-and-error, rather than external strategies, such as asking for help, when learning to play a new game. Blumberg and Sokol also found no significant gender difference in the use of these strategies.

With few studies concentrating on the area of video games and problem solving, the domain and methodologies for the research of problem solving and conscious cognitive strategy, in reference to video game play, is still in its infancy. It is for this reason that more studies are needed to explore the methods and tools, as well as the results of video games' relevance as a medium for problem solving.

Video Games as a Cognitive Tool

Video game play consists of a myriad of complex cognitive tasks. From physical skills, such as hand-eye coordination, to cognitive skills, like spatial reasoning and memory, video games are simulated complex environments that challenge the user to extend and perfect skills in many cognitive domains. Requiring concentration, memory, coordination, two and three-dimensional spatial recognition, symbol recognition, complex hand-eye coordination, solution analysis, strategic planning, fine motor skills, short-term memory, and reaction time, video games are unique in their demand that players utilize these skills simultaneously. Although a plethora of cognitive skills are engaged during game play, most studies have only concentrated on visual skills such as spatial intelligence, iconic representation, and divided attention.

McClurg & Chaille (1987) looked at whether video games would increase the scores of fifth, seventh, and ninth graders on a spatial ability measure tests. They found that all three groups had improved mental rotation skills as a result of playing two different games, *The Factory* (Micro Power, 1984) and *Stellar 7* (Penguin Software, 1983). Similarly, Subrahmanyam and Greenfield (1994) found that students who played the spatially rich game, *Marble Madness* (Rare Ltd, 1989), improved their spatial performance, compared to those students who played a non-spatial computer-based word game. Okagaki and Frensch (1994) found improvements in males' spatial skills as a result of playing the game *Tetris* (Tengen, 1989). Similarly, Sims and Mayer (2002) found that skilled *Tetris* players outperformed non-*Tetris* players on the mental rotation of similar *Tetris* shapes. Sims and Mayer also noted no significant difference of spatial ability between *Tetris* players who received twelve hours of *Tetris* playing experience and a matched control group, who did not play the game. Blumberg (1998) looking at the differences in children's selective attention and performance in video games, found that older and more frequent players showed better attention performance. Although the results of these studies are mixed, there is enough evidence to suggest that video game play can lead to the development of complex cognitive skills and that they can be defined as, and applied, as a cognitive tool.

A cognitive tool, as defined by Hogle (1996) "aids a student in performing conceptual operations otherwise beyond their availability" (p. 6). If research shows that playing video games lead to the development of complex cognitive skills, they can be defined as a cognitive tool. Salomon (as cited in Hogle, 1996) lists the four attributes of a cognitive tool as (a) an implement or device, such as a symbol system, mental strategy or computer program (b) which entails the purpose for which it is designed to serve, (c) serves functions beyond itself, and (d) is distinguished from machines by its need for skillful operation throughout its function. It is this definition that allows us to frame video games as a cognitive tool and to define and theorize about their extended application in cognitive science and education. It is also this definition that allows the use of standardized tests of cognitive skills to evaluate gaming as a cognitive tool. Although there are many studies that have looked at spatial (Sims and Mayer, 2002), iconic (Greenfeild, 1993), and divided attention skills (Greenfield et al., 1994), no studies are found that utilize a standardized test of cognitive skills such as the Test of Cognitive Skills, Second Edition (CTB/McGraw, 1982) or The Canadian Test of Cognitive Skills (CTC, 1992a), in the measurement of the effects of video games on memory, non-verbal, and verbal skills. It is recognized, however, that video games use the same skills that are tested in cognitive skills and intelligence tests, as in the Test of Cognitive Skills (CBT/McGraw, 1992), the Wechsler (Harcourt, 2003), and the Stanford-Binet (Thomson Nelson, 2003).

With many of these studies looking for transfer in a matter of hours (Blumberg and Sokol, 2004), over a few sessions (Sims and Mayer, 2002), or over a few days (Ricci, 1994) researchers have ignored the fact that cognition is a process of development and not a reactionary skill. The understanding that players must not only be exposed to the condition of video game play, but also undergo a process of learning and development, is necessary to see any lasting cognitive transfer effect. This process of development, from experience, reflection, abstraction, and testing in a gaming environment, ultimately leads to the learning and development of cognitive skills and strategies

Cognitive Learning in Games

Cognitive learning, in a video game context, is best be described by Kolb's Experiential Learning theory (Kolb, 1984). Learning cycles (see Figure 1), as they relate to gaming, is the natural cycle in which gamers experience, learn, and adapt. Its relevance to cognitive gaming is that it combines experience, perception, cognition, and behavior into one learning theory (Zull, 2002); which sets a base in which to discuss, debate, and explore video games as a cognitive tool.

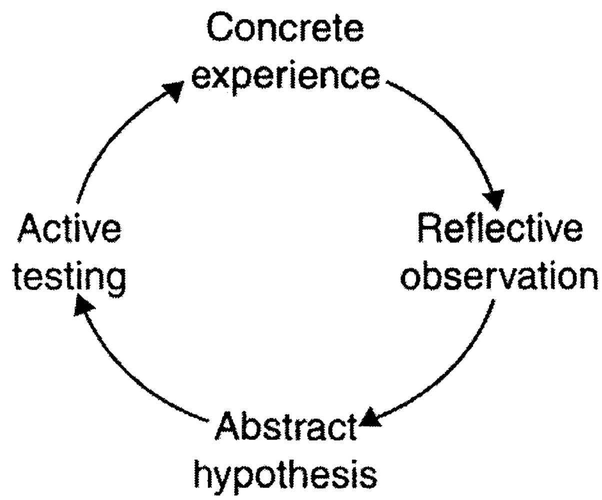

Figure 1. Kolb's learning cycle (Zull, 2002, p.17)

The sequence of experience, reflection, abstraction, and active testing, ultimately lead to a gamer's comprehension of the cognitive skills and cognitive strategies that are needed to be successful. While this is a somewhat simplified model of game learning, it is witnessed through the casual observation of game players. In any Wal-Mart, Best Buy, or Radio Shack that has a game system on display, children as young as four are witnessed to be readily developing skills and testing hypothesis (Forbes, 1999). As they approach unknown games, with little more than general domain knowledge and general skills, these children are able to play these games within minutes. Through active testing, experimenting, and hypothesizing, gamers change their gaming strategy and ultimately their gaming behavior (Garris et al., 2002), as they adapt their game play to meet the particular gaming environment. This allows gamers to refine their skills and knowledge of the particular gaming domain as they play. It is the relationship between the functions of learning and cognitive skill development that frame the constructs and theories that surround how one move from novice to expert in a gaming environment.

Novice and Expert Gamers

Game players can be classified as novice or expert based on their declarative, procedural, and strategic knowledge and skills in a gaming context (Robertson, 2001). When comparing novices and experts, specific differences in the groups are apparent. Expert gamers have many articulated domain specific skills and abilities that allow them to be successful in their field of practice. This enables the categorization and analysis of players and their abilities.

It is discerned that experts and novices are different in that (a) experts have better analysis and judgment abilities, (b) experts have extensive knowledge concepts, (c) experts can solve problems faster, (d) experts know what is needed, and how to solve a problem, (e) experts realize their own mistakes quickly while solving problems, (f) experts have resilient methods for specific problems, (g) experts infer a question forwards from known fact, but novices work backwards from the outcomes, (h) experts tend to employ pattern recognition, and (i) experts deal with knowledge in chunks and take more time to identify target questions (Stubbart and Ramaprasad, 1990 cited in Hong and Liu, 2003). These observations, however, do not explain why, how, and under what conditions expertise in gaming develops.

Experience is at the core of any game player's expertise. In playing video games, users gain general declarative knowledge of the play environment. Focusing first on the 2D and 3D representations of objects, sounds, and events and how they are related, gamers explore the gaming world though direct observation before they actually develop any procedural skills. The acquisition of knowledge, in many cases, is based on direct observation of other players or through direct trial-and-error. Experts knowledge and experience of the facts, concepts, processes, procedures, and principles, or artifacts of content (Clark & Chopeta, 2004), are the building blocks of their expertise. It is this vast knowledge base and understanding that allows a gamer to develop an understanding of the relationship of the facts and in turn develop propositions of the relationship of the artifacts in general gaming environments. Glaser and Chi (1988 cited in Feltovich, Prietula, & Ericsson, 2005) identified this relationship of the elements as "experts see and represent a problem in their domain at a deeper (more principled) level than novices; novices tent to represent a problem in a superficial level" (p13).

While exercising their abilities to use general domain knowledge and cognitive skills, expert game players readily produce and recognize gaming schemas (Ermi and Mayra, 2005). The highly articulated cognitive schemata that are developed enable gamers to combine and categorize their knowledge into larger concept units (Claser and Chi, 1998). These units, or "chunks" (Chase and Simon, 1973), allow expert game players to fuse and chunk elementary declarative, procedural, and strategic knowledge into larger groups. It is the fusing of smaller chunks of perceptual skills and knowledge into larger chunks that lend itself for memory management (Loftus, 1983). Experts are able to access these chunks in long term memory, which is supported in research using traditional games such as Chess and Go (Charness, 1976; Engle and Bulstel, 1978), to solve game based problems readily. No studies with video games can be found on memory regulation, however, it can be inferred that the mechanisms of cognitive control in traditional games are similar, if not more articulated. It is inferred that the cognitive control of memory of video gamers, where twitch speed, sound, and graphics are all an accelerated pace, may be more involved that in traditional games.

It is also recognized that there are significant differences in play patterns between expert game players and random guessers (Ko, 2002). Expert game players can also be seen to engage in insight or covert reasoning. Expert game players have the ability to try out various solutions in their minds, without the need for overt trial-and error-methods. The trial-and-error process is done covertly; trying all the responses mentally until one that works is found (Robertson, 2001). Since this form of trial-and-error process cannot be seen, the solution therefore appears to be achieved suddenly, as by a flash of insight (Mayer, 1992). This appearance of insight, however, is a highly articulated cognitive skill. Also, expert behaviors such as self-monitoring, pattern recognition, problem recognition, deep problem solving, principled decision making, qualitative thinking, and superior short term and long term memory (VanDeventer and White 2002), are attributes of expert gamers. These attributes, although seen as general cognitive skills, are supported by research to be domain specific; these general cognitive skills do not transfer (Ericsson and Lehmann, 1996; Glaser and Chi, 1988).

The Issue of Transfer

The issue of cognitive skills and problem solving transfer is a well-debated topic in educational psychology. Defined as “the ability of a person’s prior experience and knowledge…[to]…affect learning or problem solving in new situations” (Mayer & Wittrock, 1996, p. 49), transfer has been at the forefront of educational and cognitive theory in learning. As one of the primary goals of education is to prepare students to solve new problems that they have not previously encountered (Mayer & Wittrock, 1996), educational psychologists have been trying to outline the constructs and frameworks in which transfer occurs.

Beginning in the early twentieth century with the “doctrine of formal discipline”, school subjects like Latin were believed to improve a student’s ability to learn mathematics, sciences, as well as other languages (Robertson, 2001). The logical structure of Latin was believed to improve students’ abilities to think, reason, and cope in other contexts. This reasoning is also presented in recent research in computer languages such as Logo (Papert, 1980), where the progression of logic is thought to influence processes needed to solve new problems in new domains (NRC, 2000). And although, as humans, we all believe that acquiring knowledge and skills in one setting should save time and effort and perhaps increase effectiveness for future learning (Larkin, 1989), research has shown us that this is not exactly accurate (Haskell, 2001). The scope and theory of transfer, however, is still being debated and discussed.

With the abundance of both skills-based and knowledge-based research as well as theoretical investigations in transfer, four different theoretical views are used to look at transfer in a gaming context: general transfer of general skills, specific transfer of specific behaviors, specific transfer of general skills, and metacognitive control of general and specific strategies (Mayer & Wittrock, 1996). These four views frame problem solving and skill-based transfer in games.

General transfer of general skills follows the doctrine of formal discipline. Based on the idea that subject domains such as Latin, science, chess, and video games, serve to improve the mind in general, much of this view is established on the idea that general training of mental functions would have general effects that would transfer across domains (Mayer, 1992). In this case, a subject who plays a video game like *Tetris* (Tengen, 1989) or *Dr. Mario* (Nintendo, 1991) that utilizes spatial ability should show improvement of subsequent spatial performance, regardless of the similarity to the game or domain in which it is used (Sims and Mayer, 2002). Although it is believed that we have the ability to generalize, classify, and stereotype procedural skills and knowledge, research shows us that this is not always the case (Chi et al., 1988; Gagnon, 1985; Thorndike and Woodwarth 1901 cited in NRC 2000; Sims and Mayer 2002). With few people able to use domain specific skills and knowledge in new contexts, analogical transfer is limited to our recognition of surface features and surface skills. Unless it is explicitly shown that a problem has deeper structural similarities, like transferring mathematical reasoning into baking, we do not transfer general skills into new domains.

In the specific transfer of specific behaviors view, specific component skills, like shooting and aiming skills in *Ghost Squad Deluxe* (Sega, 2005), that are learned in a particular video game would transfer as the same skills in different games or different domains. For example, the component skill of learning to aim and shoot in *Doom 3* (id software, 2004) would transfer to aiming and shooting in other first person shooter games like *Call of Duty 2* (Infinity Ward, 2003), *Halo* (Gearbox Software, 2003), and *Half Life 2* (Valve Software, 2005) or, in the case with arcade shooters such as *Target: Terror Gold* (Raw Thrills, 2005), *Vampire Night* (Namco, 2005), or *Virtual Cop Deluxe* (Sega, 2005), the aiming and shooting skills would transfer to the use of a real gun. Named the "theory of identical elements", by Thorndike and his colleagues (Robertson, 2001), this view is largely supported in the use of simulations for the training of military and law enforcement officers. In this respect, the officers' preparatory training, which involves everything from shooting a gun to flying an F-18 fighter jet, have enough surface similarities with the real experience to transfer.

The view of specific transfer of general skills follows the idea that certain skills have a broad domain of application that extends beyond specific behaviors (Mayer and Wittrock, 1996). According to this view, learning to solve one type of problem can help students solve new problems even when there are no identical components in the two tasks. Acquired general skills such as hand-eye coordination in a game context, for example, transfer to new domains. In this case, a general skill, such as learning the controls and combat strategy in a game like *Warcraft* (Blizzard, 1994), will transfer to playing a non-strategy game like *NHL Hockey* (EA Sports, 2005), even though they use different controls and different strategy. However, the general skills of game play transfer across all game domains. This view is supported by casual observation of game players who can move from one game genre to another with little need for control or game orientation. This view of video games as a tool for the development of transferable skills is receiving support in the research. Rosser et al. (2004), in a causal comparative study looking at the transfer of video game skills to surgery, found that doctors that played video games for at least three hours a week made 37 percent fewer mistakes in laparoscopic surgery and performed the tasks 27 percent faster than other doctors who did not play video games. The general declarative and procedural skills, such as hand-eye coordination that were developed in playing video games, transferred to new contexts.

The last view of transfer is the metacognitive control of general and specific strategies. This view follows that transfer occurs through the awareness and monitoring of one's own cognitive processes. Transfer, then, occurs when the game player is able to recognize the requirements of the new problem, select previously-learned specific and general skills, apply them to a new problem, and monitor their application in solving the new problem. This idea is best exemplified in puzzle and puzzle-adventure games, such as *Myst* (Cyan Worlds, 1995), *The Incredible Machine* (Sierra, 2001), and *Pandora's Box* (MS Games Studios, 1999), where in order to use the game's tools effectively, players must evaluate their own thinking to successfully solve the game's puzzles. In these games players utilize their ability to problem solve to move from one game to another. This view is also evident in players' abilities to evaluate a particular enemy in games like *Dungeons and Dragons: Dragonshard* (Liquid Entertainment, 2005), or *EverQuest* (Sony Online Entertainment, 1999) where the player must evaluate and manage their prior knowledge of their weapons, and the strengths of and weaknesses of particular enemies, to be successful. This also includes the evaluation of strategy in live team player on-line games such as *Warcraft (Blizzard,* 1994), *Halo* (Gearbox Software, 2003), and *Counter Strike* (Counter Strike Team, 2000), where players, in these games, play head-to-head in simulated combat. In these situations the players must consciously evaluate not only their goals, but the skills needed in collaboration, and in team strategy. The metacognitive knowledge, skills, and strategies of each play space can then be transferred and used in new domains. From the ability of a player to use gaming strategy during a business meeting, to transferring on-line team building skills to coaching a sports team, to using environmental strategies for business negotiation, metacognitive transfer all relates to one's ability to metacognitively evaluate their knowledge, skills, and strategies and to monitor, control, and regulate their cognition and learning in new environments (Pintrich, 2002). This point is supported in research. Brand, Reimer, & Opwis (2003) found that subjects who were stimulated with metacognitive thinking performed better on both structurally similar and dissimilar transfer tasks, than those who were not metacognitivly stimulated, in solving several *Tower of Hanoi* problems.

Using the four views of problem solving transfer, as proposed by Mayer and Wittrock (1996), transfer in the context of both the utilization and development of transferable cognitive skills and cognitive strategies are explored. Although Thorndike's research has helped put the doctrine of formal discipline to rest, the contemporary theories of thinking are still haunted by what Singley and Anderson (1989) call the "ghost of transfer" (cited in Mayer, 1992). Despite recent progress in studies of transfer, there are still a number of scholars that question its existence, while others try to understand under what conditions it does or does not occur (Mayer and Wittrock, 1996). These points, however, are speculative given that the global phenomena of video games are changing the cognitive environment in which children develop.

Even with the recognition of video games as simulated complex environments, researchers still have no idea what the long-term effects of mass-media exposure and interaction on cognitive development and transfer are. Although there is much research in cognitive neuroscience and neurobiology to suggest that complex simulated environments influence both biological and cognitive development in animals (Black et al., 1997; Diamond, 1988; Rosenzweig and Bennett, 1978 cited in NRC, 2000), very little is known about these effects on humans (Atherton et al., 2003). It is for this reason that research on the long-term effects of video games as simulated complex environments, cognitive development, and transfer must continue.

Conclusion: Implications and Applications of Video Games as a Cognitive Tool

It is in the convergence and understanding of the relationship between learning, problem solving, and cognition that leads to a more complete picture of how cognitive development occurs (NRC, 2000). As research into cognitive tools that support and facilitate development in the cognitive domain progresses, we will find that tools like video games become accepted media in the progressive pursuit of cognitive development (NRC, 2000). Though many researchers recognize the benefits of educational gaming as a tool for instruction (cf. Hostetter, 2002; Squire, 2003; Jenkins and Squire, 2003), the power of the gaming medium is in its ability to develop skills that are not readily taught. Since video games are a commercially viable tool for the development of problem solving, critical thinking, memory, and cognition, educators and researchers can begin looking beyond the obvious content knowledge base of games, and into the applications of 'cognitive gaming'.

CHAPTER THREE

Methodology

This study employed an ex-post-facto or causal-comparative research design to compare Gamers and Non-gamers in the areas of cognitive skills and general problem solving. Participants were asked to volunteer based on their ability to fit the demographic requirements of Gamer or Non-gamer. Based on this self-report, subjects were non-randomly assigned to either the Gamer or Non-gamer research groups.

Pre-test questionnaires (Appendix B, C) were distributed to both groups before completing the CTCS (CTS, 1999a). The data in the questionnaire were compiled in order to gather general characteristics and demographics for both groups.

Participants were asked to complete all four multiple choice subtests of the CTCS, level 5. Following their completion, the tests were sent to Psychometrics for machine scoring. Independent *t* tests were used to determine if there were significant differences between the means of the scaled scores for the two groups on the four subtests (sequencing, analogies, memory, and verbal reasoning), the combined non-verbal, and total score.

The PARI cognitive task analysis methodology (Hall, Gott, & Pokorny, 1995) was used to determine the problem solving strategies of the participants while they played the video game *The Incredible Machine: Even More Contraptions* (Sierra, 2001). Participants were solicited for their problem solving strategies using a think aloud process. Audio and video were recorded using screen capture software to capture both the participant verbal explanations of strategy as well as the gaming interface. The qualitative information obtained from the interviews was coded and analyzed for general and specific problem solving strategies using HyperRESEARCH (HyperREASERCH, 2005), a qualitative data analysis software package. General and specific problem solving strategies were compared to establish if there were any trends or general differences in problem solving strategies between the groups as they progressed in the game. The use of the PARI cognitive task analysis for soliciting cognitive strategies in a video game environment was partially based on research by Pillay (1999, 2001).

Hypotheses

Canadian Test of Cognitive Skills (CTCS) Hypotheses

Hypothesis I. There will be no significant difference between Gamers and Non-gamers scores in the area of sequencing (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Hypothesis II. There will be no significant difference between Gamers and Non-gamers scores in the area of analogies (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Hypothesis III. There will be no significant difference between Gamers and Non-gamers scores in the area of memory (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Hypothesis IV. There will be no significant difference between Gamers and Non-gamers scores in the area of verbal reasoning (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Hypothesis V. There will be no significant difference between Gamers and Non-gamers scores on the combined non-verbal tests (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Hypothesis VI. There will be no significant difference between Gamers and Non-gamers scores in overall cognitive skills (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$).

Precursor, Action, Results, Interpretation (PARI) Hypothesis

Hypothesis I. There will be no significant difference in problem solving or cognitive strategy between Gamers and Non-gamers in a situated problem solving video game.

Predictor Variables

The predictor variables for this study are the categorization of the participants based on their self-report of game play. Participants were asked to characterize themselves as a Gamer or Non-gamer based on their experience with video games.

Criterion Variables

Canadian Test of Cognitive Skills (CTCS) Criterion Variables

There are six criterion variables for the CTCS. These variables are as follows:

1) The sequencing scaled test score on the CTCS.

2) The analogies scaled test score on the CTCS.

3) The memory scaled test score on the CTCS.

4) The verbal reasoning scaled test score on the CTCS.

5) The combined non-verbal scaled score on the CTCS.

6) The overall cognitive skills scaled score on the CTCS.

Precursor, Action, Results, Interpretation (PARI) Criterion Variables

There were seven criterion variables used to code the data of the PARI. The strategy used most was the participants' dominant cognitive strategy. The variables, and their categorization, were based on the two studies using the PARI and video games by Pillay (1999, 2001). The variables are as follows:

1) General search.

2) Goal-directed search.

3) Anticipatory search.

4) Working backward.

5) Stepwise.

6) Data gathering.

7) Making inferences.

Variables and their Operationalization

Gamer and Non-gamer. The type of game player is the predictor variable for both the CTCS and the PARI cognitive task analysis. Respondents were asked to participate in the study based on self-reports of being a Gamer or Non-gamer. A Gamer was defined as an individual who uses video games as one of their primary recreational, leisure, or social activities. Anyone who does not fit into this definition was defined as a Non-gamer.

Cognitive Skills. Cognitive skills test scores are the criterion variable for the CTCS. A multitude of cognitive skills tests have been devised to measure these skills using paper and pencil assessments. These tests do not measure cognitive skills directly, but are inferred by assessing behaviors that reflect those abilities (CTC, 1992b). The CTCS, level 5, was used to measure the group's verbal, non-verbal, and memory skills. Four pencil and paper subtests in the area of sequencing, analogies, memory, and verbal reasoning, were used to measure these cognitive skills. The CTCS produces scaled scores for each subtest, as well as the combined non-verbal, and overall test.

Problem Solving and Cognitive Strategies. Problem solving and cognitive strategies are the criterion variable for the PARI cognitive task analysis. Various cognitive task analyses and verbal protocols have been effectively used in the elicitation, recording, and research of these strategies. The PARI cognitive task analysis was used to elicit, record, and identify the cognitive strategies that are employed while playing. The particular cognitive strategies that were coded in the PARI include general search, goal-directed search, anticipatory search, working backwards, stepwise, data gathering, and making inferences.

Participants

Students from the general University of Alberta population were asked to participate in this study via posters posted around the University of Alberta campus (Appendix D). This particular population was chosen for the study for three reasons (a) they are a convenient sample population, (b) they encompass a wide range of both Gamers and Non-gamers from a variety of backgrounds and interests, and (c) they represent a large group of both Gamers and Non-gamers.

The Game

The Incredible Machines: Even More Contraptions (Sierra, 2001) was the game used in the study. The puzzle game, the fourth edition in the series, poses a problem that the user has to solve by using component parts to build a simple machine. Utilizing a situated problem solving environment, users have to employ declarative knowledge, procedural skills, and strategic thinking to solve the puzzles and to complete the contraptions. Users also have to exercise general mechanical reasoning skills and induction to be successful, as the users' abilities to understand simple mechanics and physics contributes to their success. The first three puzzles on the Easy level were chosen to administer the PARI cognitive task analysis.

Instrumentation

The Canadian Test of Cognitive Skills, level 5

The Canadian Test of Cognitive Skills (CTCS) (CTS, 1999) is a cognitive skills test composed of four mental ability measures in the areas of verbal, non-verbal, and memory skills. The CTCS is divided into five levels from grade one through adult, with each level consisting of four subtests. The four subtests of the CTCS are sequencing, analogies, memory, and verbal reasoning. An adaptation of the CTB Macmillan/McGraw-Hill Test of Cognitive Skills, Second Edition (1992), the CTSC was developed over 10 years. Taking into account the unique nature of Canadian students resulted in improved measurement accuracy and content focus. The CTCS is also designed to reduce the possibility of subject characteristics becoming a confounding variable by taking into account ethnic, regional, socioeconomic, and gender in its design. The four subtests of the CTCS are:

- *Test 1, Sequences*: Measures a student's ability to comprehend a rule or principle implicit in a pattern of figures, letters or numbers.
- *Test 2, Analogies*: Measures a student's ability to discern various literal and symbolic relationships.
- *Test 3, Memory*: Measures the ability to recall paired pictures or nonsense words.
- *Test 4, Verbal Reasoning*: Measures the ability to reason deductively, analyze category attributes and discern verbal relationships and patterns.

Tests can be either hand-scored or machine-scored. With the hand-scored method, raw numerical scores are converted to scaled scores using number-correct scoring conversion tables. With machine-scored tests, the computer applies an iterative procedure directly to the item responses to obtain a scaled score, which is the base score of the CTCS. Overall, the CTCS is a sound cognitive skills test that measures developed abilities and skills that are acquired through years of training and practice (Anastasi, 1984).

The Precursor, Action, Results, Interpretation (PARI) Cognitive Task Analysis

PARI cognitive task analysis (Hall, Gott, & Pokorny, 1995) is a verbal protocol methodology for the exploration of cognitive strategies in situated problem solving environments. Developed by the United States military at the Brooks Air Force Base, the methodology employs in-depth probing interviews which focus on gaining information about cognitive strategies used to accomplish a particular task (Hall, Gott, & Pokorny, 1995). Situation assessment strategies, identification and interpretation of critical cues, metacognitive strategies, perceptual distinctions, and search heuristics are some of the strategies that are recognized in the PARI task analysis (Militello and Hutton, 1998). Utilizing the "think aloud" protocol, the PARI provides researchers with the ability and a means to detect how people solve problems (Ericsson & Simon, 1993).

The PARI is a structured verbal protocol that uses both a situated problem solving session and a rehash session for cognitive strategy elicitation. The structure of the problem solving session and rehash can be seen in Figure 2 and Figure 3.

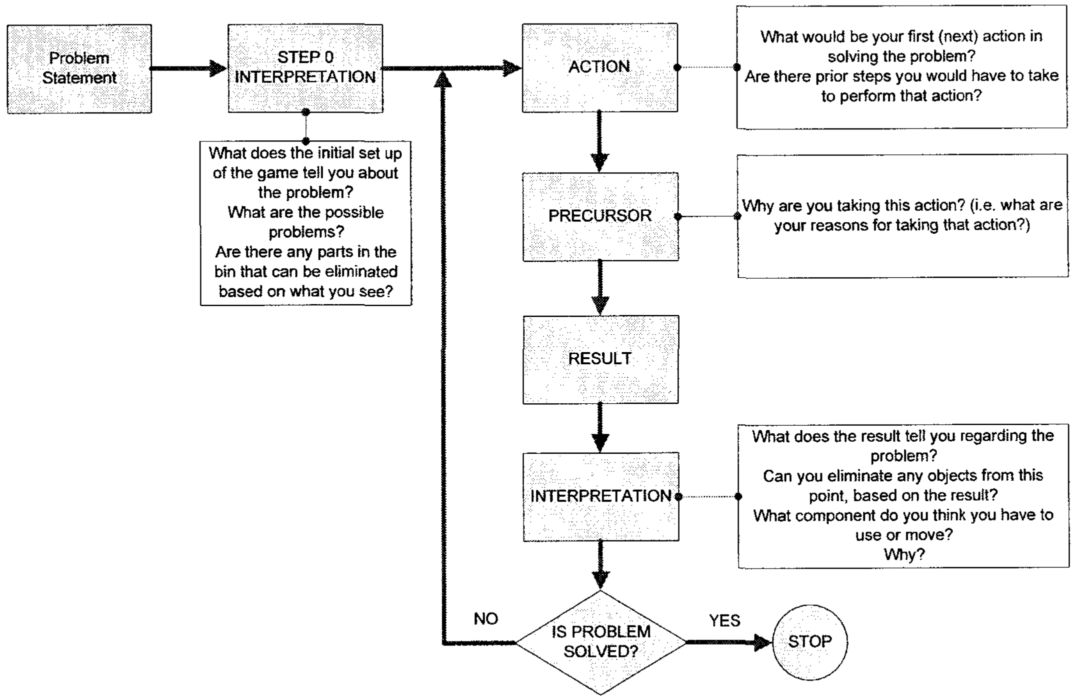

Figure 2. The PARI problem solving session.

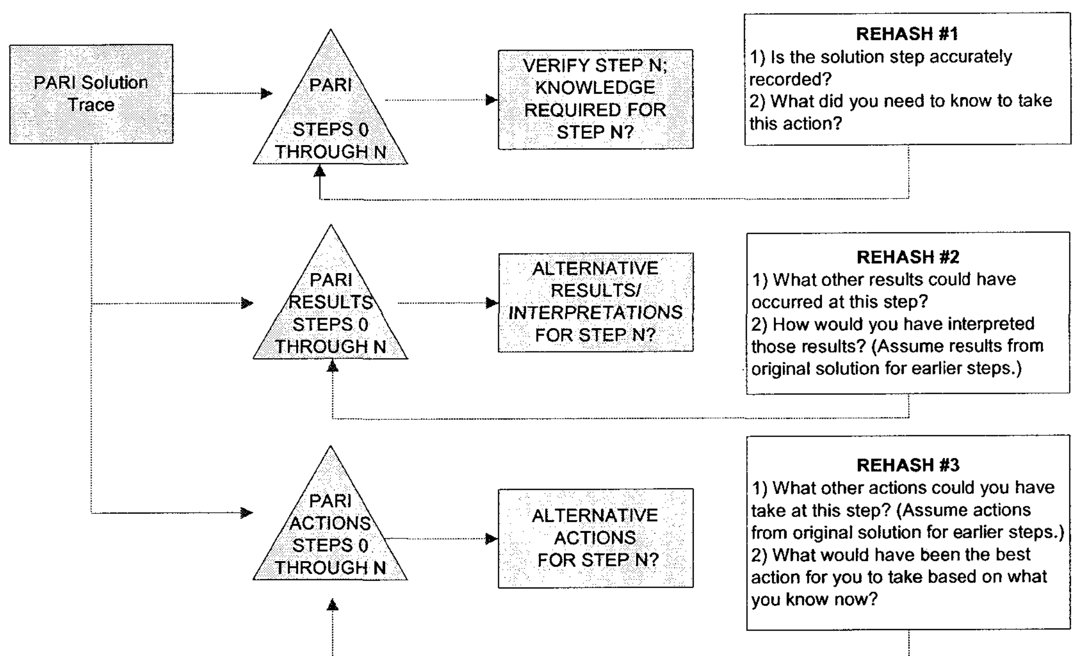

Figure 3. The adapted PARI rehash session.

The PARI methodology was adapted for this research to ensure the most logical use and progression in the elicitation of problem solving strategies' in a gaming environment. Two adaptations were made to the methodology to best suit this research study. The stage 3 illustrated diagrams of the technical faults in the system as outlined in the PARI methodology (Hall, Gott, & Pokorny, 1995) was omitted, due to its lack of relevance in the task analysis. Also excluded were rehash sessions four and five in the task analysis. In rehash session 4, users are to evaluate alternative precursors, once all equipment targets are stated. In this study, there are no preferred set or sequence of parts used to solve the problem. In rehash session 5, users are to group actions for a given solution. Users are given a list of all possible actions, and asked to arrange them in perceived similar groups (Hall, Gott, & Pokorny, 1995). This action, again, is not necessary as all problems and machines developed in *The Incredible Machine: Even More Contraptions* (Sirerra, 2001) are relatively simple and have very few possible actions.

Procedure

A classroom in the Education Building at the University of Alberta was used for the administration of the CTCS and the PARI cognitive task analysis. Scrap paper and pencils were supplied by the researcher, as well as all computer equipment and software. Volunteers were asked to sign-up via an online web form; on the form participants were able to choose the study they wanted to participate in, as well as the time and date for test administration. An email was automatically generated telling both the researcher and the participant the date and time they signed up for, along with the research room number.

Volunteer Informed Consent

Prior to the CTCS and PARI, participants were given the Informed Consent letter (see Appendix A). Participants were asked to sign two copies; returning one to the researcher, and keeping the other for their own records. Any questions in regards to the study were answered before the study began.

Participant Compensation

Participants were compensated for their time in both the CTCS and the PARI. A payment of $10 cash was given to the volunteers' for 1 to 1.5 hours of their time. Participants were allowed and encouraged to participate in both tests in the research study. If participants volunteered for both tests, they were compensated to a maximum of $20 for approximately 3 hours of their time. Participants were asked to print and sign their names on a research records sheet when handing in their CTCS, finishing the PARI interviews, or opting out of the study. At that time participants were given $10 cash.

Survey of Previous Game Experience

An initial survey of computer game use was administered to the participants using a paper and pencil survey prior to the instruction and commencement of the cognitive skills test. Survey administration time was approximately 5 minutes. Questions relating to general computer use and user experience with video games was addressed in the survey. Respondents were asked about their general recreation and entertainment activities as they relate to video games and gaming. The Gamer and Non-gamer surveys can be found in Appendix B and Appendix C. Once the surveys were completed the volunteers were asked to place the survey back into the supplied envelope.

The Canadian Test of Cognitive Skills Administration Procedure

The guidelines supplied by the Canadian Test Centre for the administration of the CTCS were strictly followed. The researcher followed the recommended examiners script and suggestions as laid out in the CTCS Examiner's Manual (CTC, 1992b).

Participants were given an envelope with the test, a designation as Gamer or Non-gamer, and a non-random number. The numbers were used to ensure confidentiality and anonymity of the test results. The numbers were also employed to differentiate between the two groups – Gamers and Non-gamers. The marking sheets were filled out by the researcher prior to the study with the designation of GM and number to represent Gamer and NGM and number to signify Non-gamer.

The CTCS began with the administration of the memory definitions following the examiners script. After the memory definitions, the participants in both groups were asked to complete the first test of the CTCS. Each subtest was timed and the recommended time limits were strictly adhered to in order to ensure validity. A stopwatch and clock were used to keep time. A visible clock with digital seconds and minutes was available for the students to see the time. A total test duration of 55 minutes was allotted, as recommended by the CTCS instruction booklet. The test breakdown and times are shown in Table 1.

Once the participants were finished, they were asked to check over their score sheet to make sure it was complete, and that all Scantron circles were filled in completely. Participants were then asked to place the tests into their designated envelopes.

The tests were then sent to the Psychometrics testing center for computer scoring.

Table 1

CTCS test time breakdown

Test Unit	Number of Items	Approximate Instruction Time	Working Time	Approximate Total Time
Memory learning definitions	--	--	--	10 min
Test 1: Sequences	20	2 min	13 min	15 min
Test 2: Analogies	20	2 min	7 min	9 min
Test 3: Memory	20	1 min	5 min	6 min
Test 4: Verbal reasoning	20	3 min	12 min	15 min
Total test time	--	--	--	55 min

The Precursor, Action, Results, Interpretation (PARI) Cognitive Task Analysis Procedure

Participants were given a brief five minute tutorial on how to play the game once they arrived. This tutorial was situated as a part of the game. The researcher, in this regard, was an observer. Once the participant completed the tutorial, participants were asked to play the video game and to verbally describe what they were doing at each decision point of play. The script for the PARI was followed to ensure consistency in the test questioning. Screen capture software and a microphone were used to capture both the screen of the computer and the participants' verbal explanation during the test. Once the player finished playing for 60 minutes they were given an optional five minute break before beginning the rehash session. The PARI research structure and timing are shown in Table 2.

Table 2

The PARI interview research time and structure.

Test Unit	Approximate Total Time
Instruction	5 min
Game Play	60 min
Optional Break	5 min
Rehash Session	25 min
Total test time	95 min

Precursor, Action, Results, Interpretation (PARI) Interview Procedure

The PARI problem solving session began with the step-by-step elicitation of the PARI elements (see Figure 2). Questions following the PARI procedure were continued for each puzzle until the problem was solved. At no time did the researcher offer any suggestions, comments, or help during the tests other than that they could use the 'hint' button if they were stuck and could not continue. This action was also regarded and recorded as a problem solving strategy.

Participants were asked to describe the first move they were going to make and why: precursor. They were then asked to make that move: action. They were then asked to describe the results of that action: result. They were also asked to evaluate their move: interpretation. During these verbal sessions the researcher asked probing questions as to the "what" and "why" of each move to elicit thought patterns.

Precursor, Action, Results, Interpretation (PARI) Rehash Procedure

Once the three puzzles were complete and the PARI session recorded, the researcher and the volunteer conducted a rehash session (see Figure 3). Through the viewing of the recorded session the results of the PARI were verified and elaborated on by the participant.

In rehash session 1, the participants were asked to verify and elaborate on their explanations. Any ambiguities and unclear explanations were clarified. In rehash session 2, the problem solvers were asked to state other possible outcomes of the action taken at that step and to interpret the outcome. In rehash session 3, participants were asked for alternative actions they could have taken and to interpret what the best action would have been based on the outcome of their action. All three rehash sessions were completed sequentially in the 25 minute rehash session. The rehash sessions were audio recorded and notes were written to reflect the participants' answers.

Data Collection

Participant Survey

The participant survey was distributed prior to the administration of the CTCS to collect general subject characteristics and demographics. The participants filled in the survey with a pencil and the survey was returned to the researcher.

The Canadian Test of Cognitive Skills (CTCS)

Participants were asked to identify themselves as Gamer or Non-gamer prior to the administration of the CTCS. Based on their self-categorization, a Scantron marking sheet was handed out with a prerecorded name and number identifying them as a Gamer or Non-gamer and a number. The CTCS test was administered and the filled in Scantron answer sheets were returned to the researcher for scoring. The answer sheets were sent to Psychometrics for machine scoring.

The Precursor, Action, Results, Interpretation (PARI) Cognitive Task Analysis

The player's actions and verbal explanations were recorded in video format using Camtasia (TechSmith, 2005) screen capture software. Following the experimental session, the players were asked to view the screen captured video and to elaborate and further explain their actions in the game. The follow up rehash sessions were audio recorded and added to the data.

Data Analysis

Participant Survey Data Analysis

The results of the participant survey were coded and entered into SPSS to gain baseline demographic information about each group. This quantitative information was used to categorize the groups and to examine the groups' relation to the general gaming community. Descriptive statistic analysis including frequencies and charts were generated to describe the results.

The Canadian Test of Cognitive Skills, level 5, Data Analysis

All results of the four subtests for the two groups (sequencing, analogies, memory, and verbal reasoning), the non-verbal scaled score, and overall score on the CTCS were entered into SPSS for analysis. The scaled score means of each subtest for each group were calculated and independent *t* tests were performed to see if there were significant differences between the two groups on each of the four subtests, the non-verbal, and the total test scaled score. Other measures performed include the Grubb's test for outliers, the Levene's test for equality of variances, boxplot, and confidence interval graphs.

The Precursor, Action, Results, Interpretation, (PARI) Data Analysis

The discourse between the players and researcher during the recorded PARI sessions were coded using the HyperRESEARCH software package (ResearchWare, 2005). The videos were reviewed and coded for each time a particular cognitive strategy was used. The data was grouped into PARI categories to investigate the cognitive maneuvers and problem solving strategies that are employed by Gamers and Non-gamers during game play. As players used a variety of different combinations and search processes to solve the goal of the game, the one approach that was most used was recorded as their cognitive strategy. This way the patterns were allowed to emerge from the data rather than imposing predetermined patterns (Pillay, 1999).

CHAPTER FOUR

Results

This chapter presents the findings of the study. First, subject characteristics and demographics are presented to establish the general preferences and information in regards to the subjects who participated in the study. The results of CTCS, level 5, are then presented with relevant tests. Independent samples *t* tests, the Levene's test of equality of variances, boxplot, and 95% confidence interval graphs are presented for each subtest, the combined non-verbal tests, and the test as a whole. An alpha level of .05 (α = .05) is used for all independent *t* tests. The PARI cognitive task analysis results are then presented. Qualitative results from the verbal protocol are presented in both quantitative tables as well as qualitative transcripts. Grouped qualitative results are also presented in quantitative tables to represent the problem solving strategy that was most used by the participant through out the cognitive task analysis. A Chi-square test of independence is used to determine the significance in the cognitive strategies used by each group for the puzzles in the PARI cognitive task analysis.

General Subject Demographics

All subjects for the study were drawn from the general University of Alberta student population. General subject characteristics and demographics were collected with a brief subject survey prior to the administration of the CTCS.

A total of 110 participants, 41% (N = 46) Gamers and 58.2% (N = 64) Non-gamers, signed up to participate in the study via an online web form. Of those who signed up for a specified time and day, 53.1% (N = 34) of the Gamers group and 67.4% (N = 31) of the Non-gamers subject group came to the research room at the specified time to participate in the study. Forty-five of those subjects, who signed up for the study at a specified time and date, did not show up at the research room at anytime during the study.

Combined Group Demographics

Table 3 provides the demographics for the subject groups that participated in the study. A total of 34 Gamers and 31 Non-gamers participated. The average age of the Non-gamers was slightly older than the Gamers group. There were many more males who participated in the Gamers group than the Non-gamers group and many more females in the Non-gamers group than the Gamers group. All of the Gamers owned personal computers and a majority of the Non-gamers owned personal computers. In ranking their computer proficiency from *not proficient* to *expert*, both groups reported very similar computer proficiency. The results of the groups' report of computer proficiency are displayed in Figure 4. In ranking the reasons that they use their personal computers, school work was reported as the main reason for both groups, with other reasons such as social reasons, play, work, and information in a lower proportion. The results of the groups' report of computer use are displayed in Figure 5.

Table 3

General subject demographics of the participants for the CTCS.

Survey question	Answer choices	Gamers (n = 34)	Non-gamers (n = 31)
1. Average age (years)		20.42	22.57
2. Gender	Male	30 (88.2%)	14 (45.2%)
	Female	4 (11.8%)	17 (54.8%)
3. Computer ownership		34 (100%)	26 (83.9%)
4. Computer proficiency	Somewhat proficient	6 (17.6%)	6 (19.4%)
	Proficient	7 (20.6%)	7 (22.6%)
	Very proficient	16 (47.1%)	18 (58.0%)
	Experts	5 (14.7%)	
5. Computer use	School	13 (38.2%)	19 (61.3%)
	Play	7 (20.6%)	1 (3.2%)
	Social	9 (26.5%)	5 (16.1%)
	Information	2 (5.9%)	2 (6.5%)
	Work	3 (8.8%)	4 (12.9%)

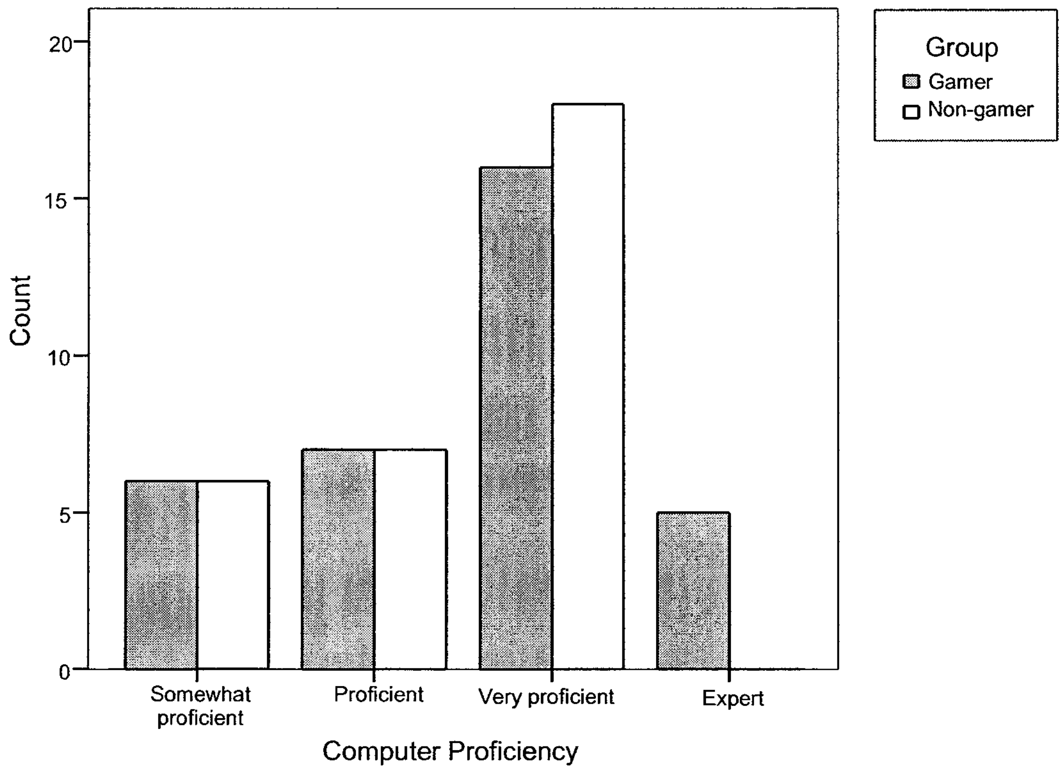

Figure 4. The reported computer proficiency of Gamers and Non-gamers.

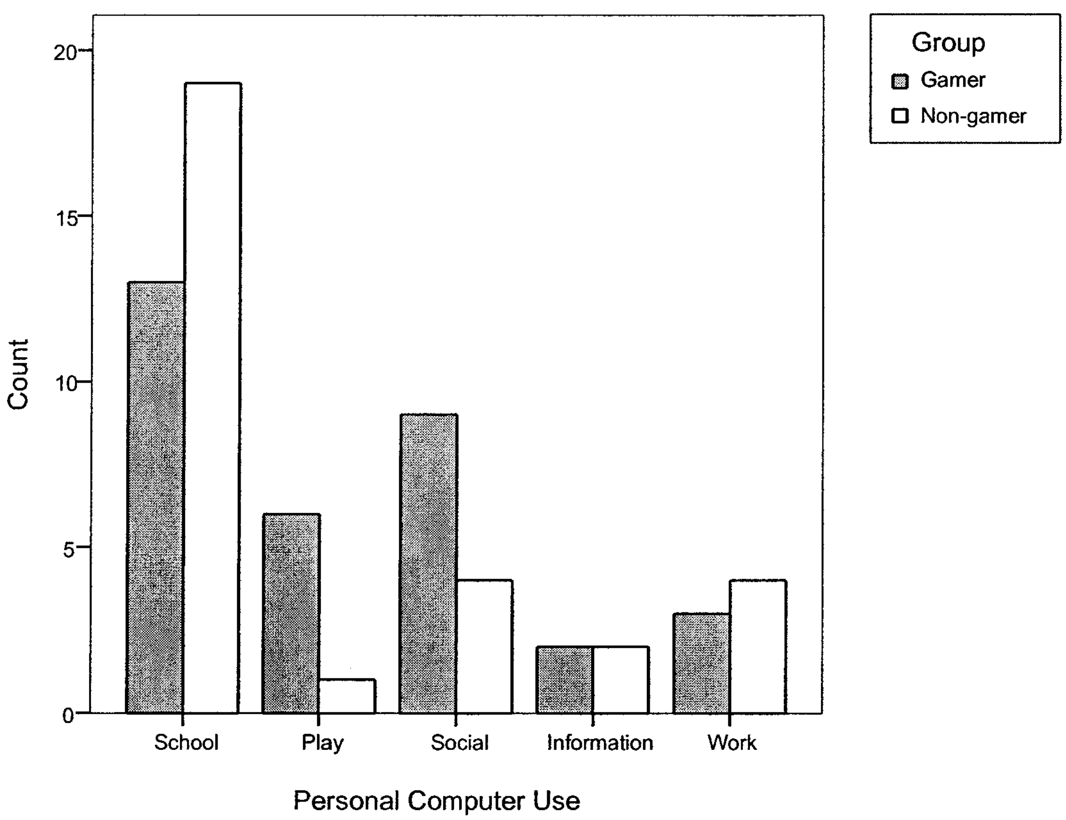

Figure 5. The combined personal computer use of Gamers and Non-gamers.

Gamer Group Demographics

Table 4 provides the demographics for the Gamer subject group. When asked how many years they have been playing video games in a range between 1 and 20 years, a majority answered 10-15 years. The number of years Gamers have been playing are shown in Figure 6. Gamers were also asked to report the approximate number of the hours they play video games in an average week, with ranges from 2 to over 25 hours, a majority answered 2 to 5 hours. Gamers also reported that the main reasons they play video games are for fun (see Figure 7). Other reasons Gamers reported for playing video games included to pass the time and for the competition. The gaming systems that Gamers reported owning and using for play included a majority using their personal computer, and in few instances, dedicated gaming consoles such as using the Sony Playstation 2, Sony Playstation 1, Nintendo, or Gameboy Advanced. A majority of Gamers reported owning more than one gaming system at home. Gamers were also asked if they plan to buy a new gaming system when one is released; approximately half answered yes and half answered no. The average amount of money that Gamers spend on video games and game related equipment a year, in the range from 0 to $2000.00, was between $100 and $250 dollars.

Table 4

Gamer subject demographics for the CTCS.

Survey question	Answer choices	Gamers answer (n = 34)
1. Years playing games	2-5	2 (5.9%)
	5-10	7 (20.6%)
	10-15	15 (44.1%)
	15-20	9 (26.5%)
	20+	1 (2.9%)
2. Average hours playing (per week)	2-5	13 (38.2%)
	5-10	9 (26.5%)
	10-15	5 (14.7%)
	15-20	2 (5.9%)
	20-25	1 (2.9%)
	25+	4 (11.8%)
3. Main reasons for playing	Fun	31 (91.2%)
	Time	1 (2.9%)
	Competition	2 (5.9%)
4. Game systems owned	PC	33 (97.1%)
	PS 2	13 (38.2%)
	PS 1	4 (11.8%)
	Xbox	12 (35.3%)
	Gameboy Advanced	8 (23.5%)
	Nintendo	11 (32.4%)
6. Multiple systems owned	Yes	28 (82.4%)
	No	6 (17.6%)
5. Planning on buying new system	Yes	19 (55.9%)
	No	15 (44.1%)
7. Amount of money spent on games and equipment (per year)	0 - $100	7 (20.6%)
	$100 - $250	14 (41.2%)
	$250 - $500	7 (20.6%)
	$500 - $1000	4 (11.8%)
	$1500 - $2000	2 (5.9%)

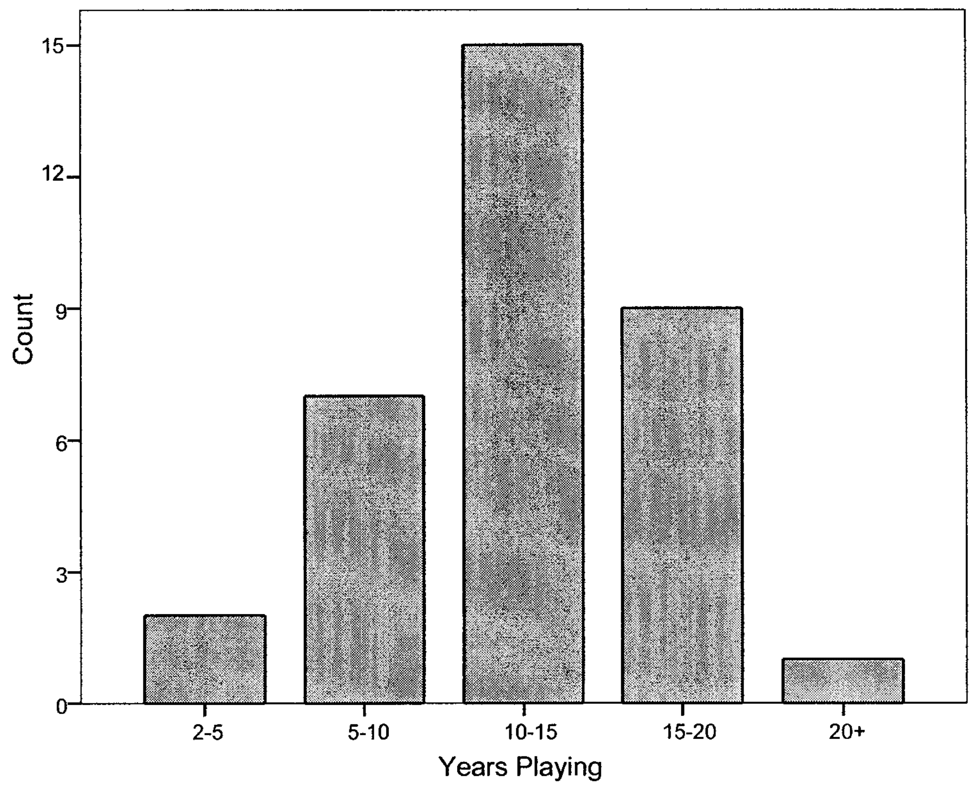

Figure 6. The numbers of years Gamers have been playing video games.

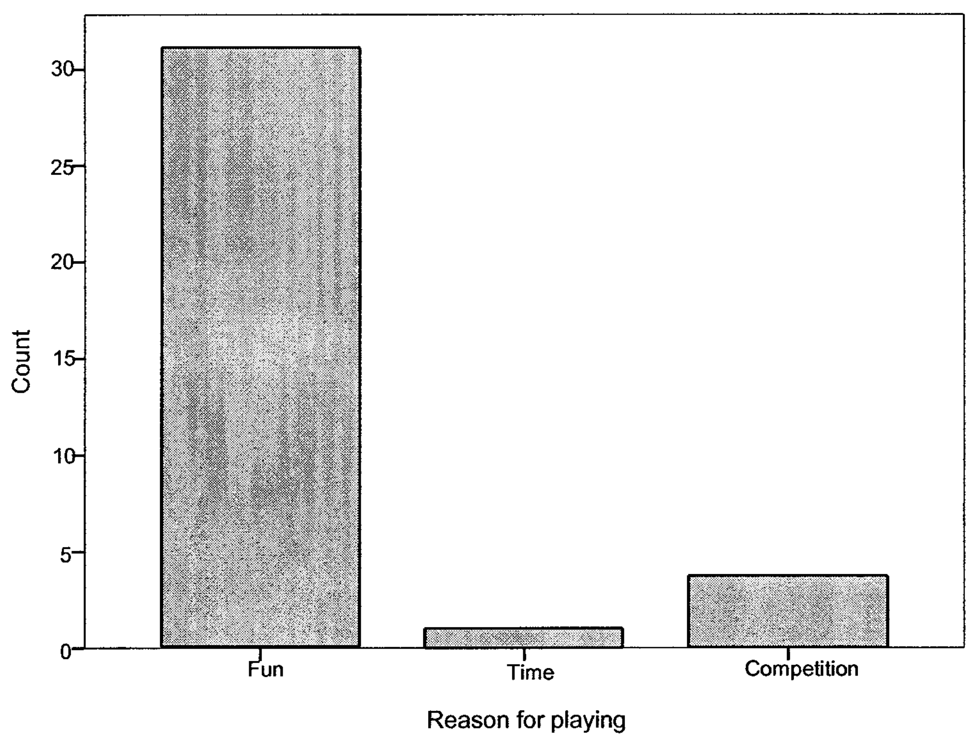

Figure 7. The main reasons Gamers play video games.

Non-gamer Demographics

Table 5 provides the demographics for the Non-gamer subject group. When asked if they have ever tried playing video games in the past, almost all of the Non-gamers reported that they have. The systems that Non-gamers reported using when they did try video games included a majority using PC or Mac based games. Over half of Non-gamers also reported using a Sony Playstation 1 or 2 or arcade-type machine. Other machines used for gaming include the Xbox, various versions of the NES system including NES64, SuperNES, NES8, the Coleco Vision, Sega Genesis, and the Atari 2600. When asked to rank the reasons why they do not play video games (see Figure 8) a majority reported that they do not play because of lack of time. Other reasons they do not play video games included that they do not think video games are fun, games are a waste of time, they don't like the competition in games, would rather spend their time in other social activities, and that they do not like the challenge of games.

Non-gamers were also asked if they would play video games if they had more time or money; approximately half said they would, and half said they would not.

Table 5

Non-gamer subject demographics for the CTCS.

Survey question	Answer choices	Non-gamers answer (n = 31)
1. Played video games in the past	Yes	30 (96.8%)
	No	1 (3.2%)
2. Systems used when playing games	PC	27 (87.1%)
	PS 1 or PS 2	16 (51.6%)
	Xbox	11 (35.5%)
	Nintendo system	9 (29.0%)
	Arcade	17 (54.8%)
3. Why they do not play games	Time	14 (45.2%)
	Waste of time	5 (16.1%)
	Don't like competition	4 (12.9%)
	Social reasons	4 (12.9%)
	Don't like the challenge	1 (3.2%)
	Not fun	3 (9.7%)
4. Would play if more money and time	Yes	16 (51.6%)
	No	15 (48.4%)

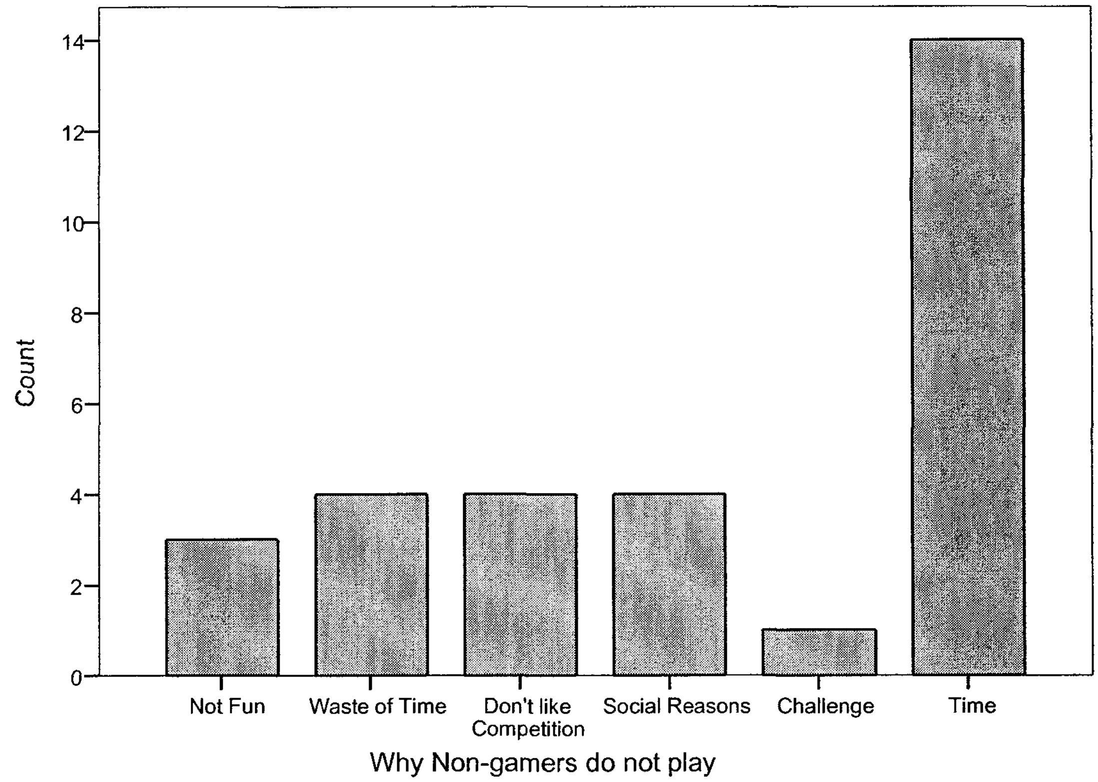

Figure 8. The reasons Non-gamers do not play video games.

The Canadian Test of Cognitive Skills (CTCS), level 5

The CTCS, level 5 results were analyzed using independent samples *t* tests with an alpha level of .05 ($\alpha = .05$). The critical *t* value was determined to be 1.999 with 63 degrees of freedom ($df = 63$). Levene's test of equality of variances, boxplot, and 95% confidence interval graphs are presented for each subtest as well as with the combined non-verbal and total test scaled scores.

Hypothesis I: CTCS sequencing subtest

Hypothesis one stated that there will be no significant difference between the groups on the CTCS sequencing subtest (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The Grubbs test for outliners was performed to determine if one of the extreme values in the Non-gamers group data set on the CTCS sequencing subtest was an outlier prior to data analysis (see Figure 9). The Grubbs test with a two-sided significance level of 0.05 (α = .05) and a Critical value of z = 2.92 determined that the z value of the outlying data (N = 892.00) was not an outlier (z = 2.60) and therefore should be included in the data.

The mean scores of the subtest for both groups are presented in Table 6. Table 6 shows that the Gamers group scored significantly higher (M = 743.79, SD = 83.07) than did the Non-Gamer group (M = 703.45, SD = 72.48) on the sequencing subtest.

Based on Levene's test for Equality of Variances with values of F =.171 and p = .680, there is no reason to doubt that the group variances are not equal, so the t value for equal variances can be used to test the null hypothesis.

An independent groups t test found a significant difference in the mean scaled scores between the Gamers and Non-gamer groups on the sequencing subtest, $t(63)$ = 2.077, p = 0.042. The calculated independent t test values are shown in Table 7. The distribution of the scaled scores for the CTCS sequencing subtest are shown in a boxplot graph in Figure 9. Figure 10 shows the 95% confidence interval for the means on the CTCS sequencing subtest.

Table 6

Mean scaled scores of Gamers and Non-gamers on the CTCS, level 5 sequencing subtest.

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	743.79	83.08	14.25
Non-gamer	31	703.45	72.48	13.02

Table 7

Independent samples t test of the CTCS sequencing subtest.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	2.077	63	.042	40.34	19.42	1.53	79.15

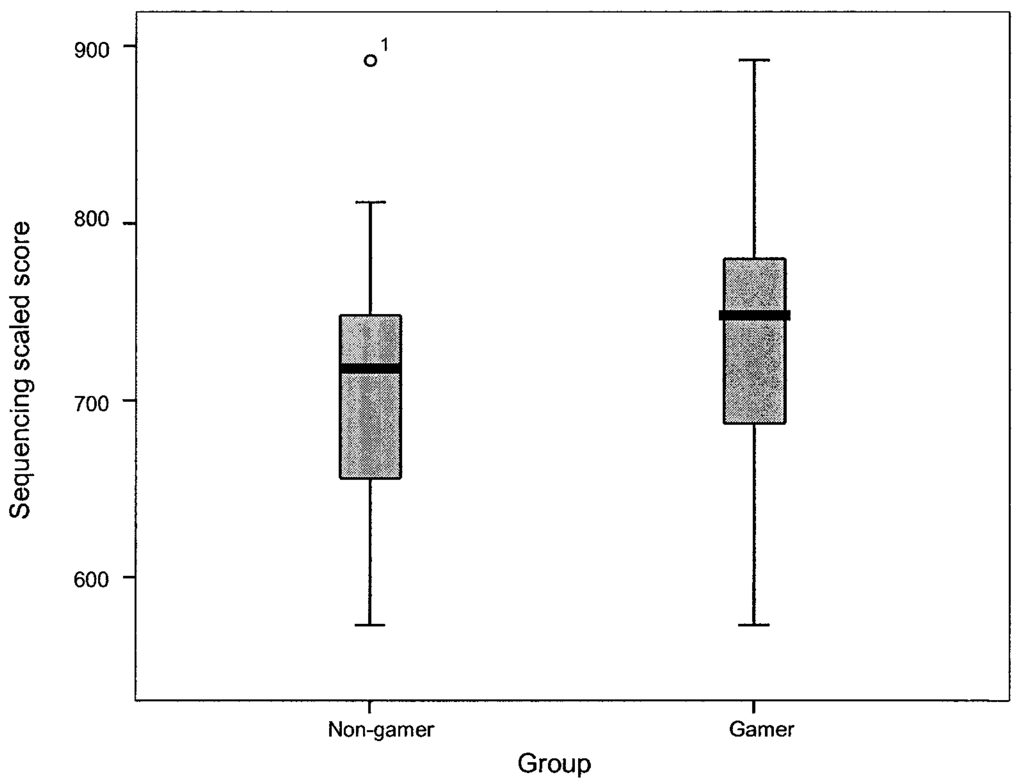

Figure 9. The boxplots of the CTCS sequencing subtest scores by test group.

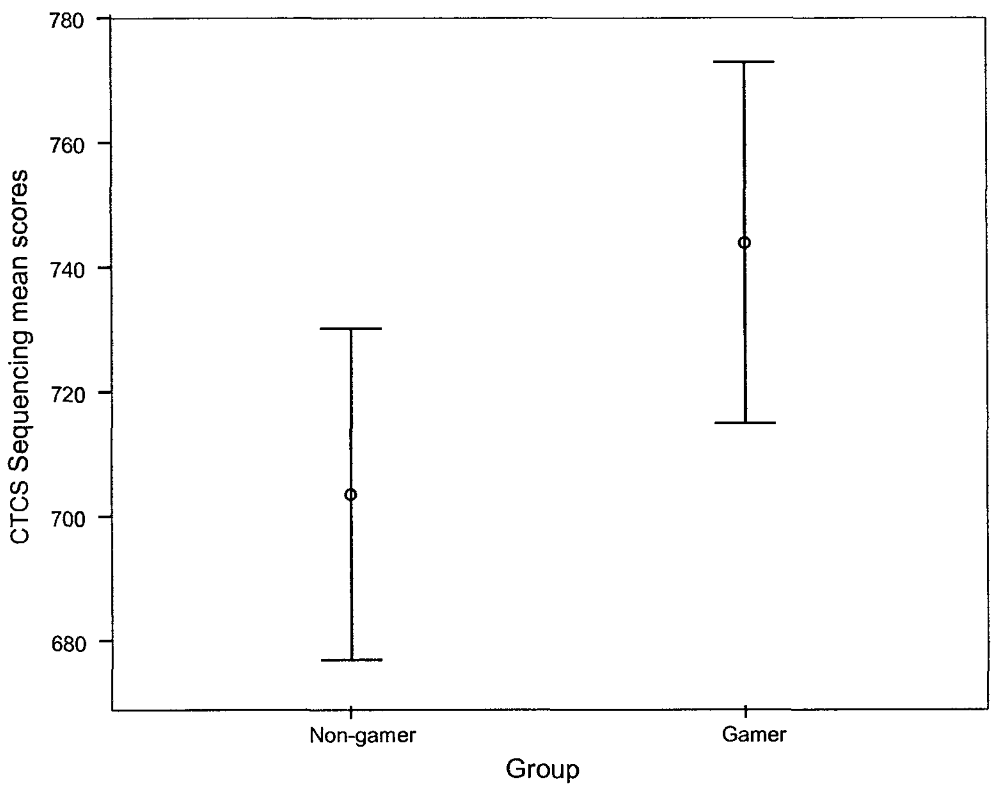

Figure 10. The 95% confidence interval for the means on the CTCS sequencing subtest by test group.

Hypothesis II: CTCS analogies subtest

Hypothesis two stated that there will be no significant difference between the groups on the CTCS analogies subtest (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The mean scaled scores of the subtest for both groups are presented in Table 8. Table 8 shows that the Gamers group scored higher (M = 771.47, SD = 86.63), although not significantly higher, than the Non-gamer group (M = 730.74, SD = 96.55) on the analogies subtest.

Based on Levene's Test for Equality of Variances with values of $F = .560$ and $p = .457$, there is no reason to doubt that the group variances are not equal, so the t value for equal variances can be used to test the null hypothesis.

An independent groups t test found no significant difference in the mean scaled scores between the Gamer and Non-gamer groups on the analogies subtest, $t(63) = 1.793$, p = 0.078. The calculated independent *t* test values are presented in Table 9 and the distribution of the scaled scores for the CTCS analogies subtest is represented Figure 11. The 95% confidence intervals, for the mean scores on the CTCS analogies subtest, are shown in Figure 12.

Table 8

Mean scaled scores of Gamers and Non-gamers on the CTCS analogies subtest.

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	771.47	86.63	14.86
Non-gamer	31	730.74	96.55	17.34

Table 9

Independent samples t test of the CTCS analogies subtest.

						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.793	63	.078	40.73	22.72	-4.67	86.13

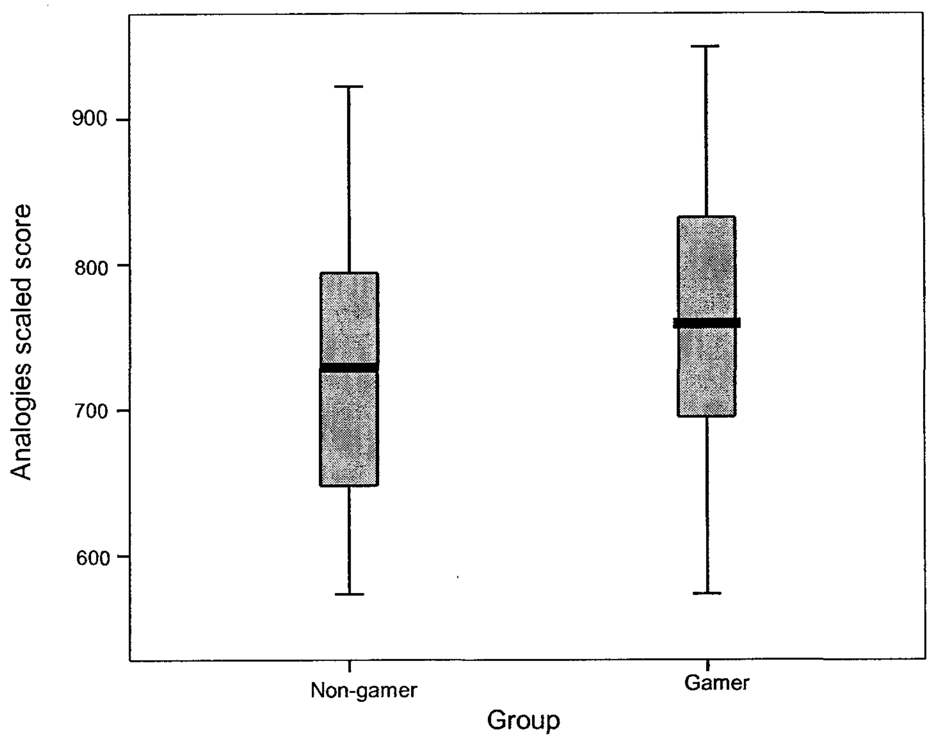

Figure 11. The boxplots of CTCS analogies subtest scores by test group.

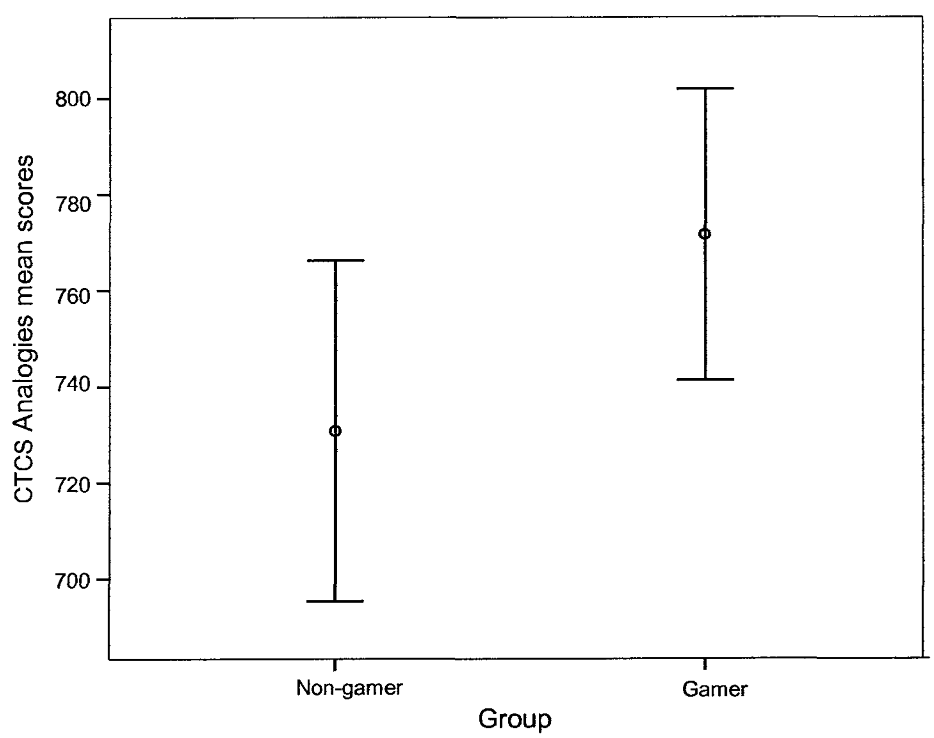

Figure 12. The 95% confidence intervals for the means of the CTCS analogies subtest by test group.

Hypothesis III: CTCS combined non-verbal subtests

Hypothesis three stated that there will be no significant difference between the groups on the CTCS, combined non-verbal subtests (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The mean scores of the combined non-verbal subtests for both groups are presented in Table 10. Table 10 shows that the Gamers group scored significantly higher (M =757.88, SD = 63.68) than the Non-gamer group (M = 717.32, SD = 73.01) on the combined non-verbal subtests

Based on Levene's Test for Equality of Variances with values of $F = 2.138$ and P = .149, there is no reason to doubt that the group variances are not equal, so the t value for equal variances can be used to test the null hypothesis.

An independent groups t test found a significant difference in the mean scaled scores between the Gamer and Non-gamer groups on the combined non-verbal subtest, $t(63) = 2.392$, p = 0.020. The calculated independent t test values are presented in Table 11, while the distribution of the scaled scores for the CTCS, combined non-verbal subtest are shown in Figure 13. The 95% confidence intervals, for the mean scores on the CTCS combined non-verbal subtest, are shown in Figure 14.

Table 10

The mean scaled scores of Gamers and Non-gamers on the CTCS combined non-verbal score.

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	757.88	63.68	10.92
Non-gamer	31	717.32	73.01	13.11

Table 11

Independent samples t test of the CTCS combined non-verbal scores.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Equal variances assumed	2.392	63	.020	40.56	16.96	6.67	74.5

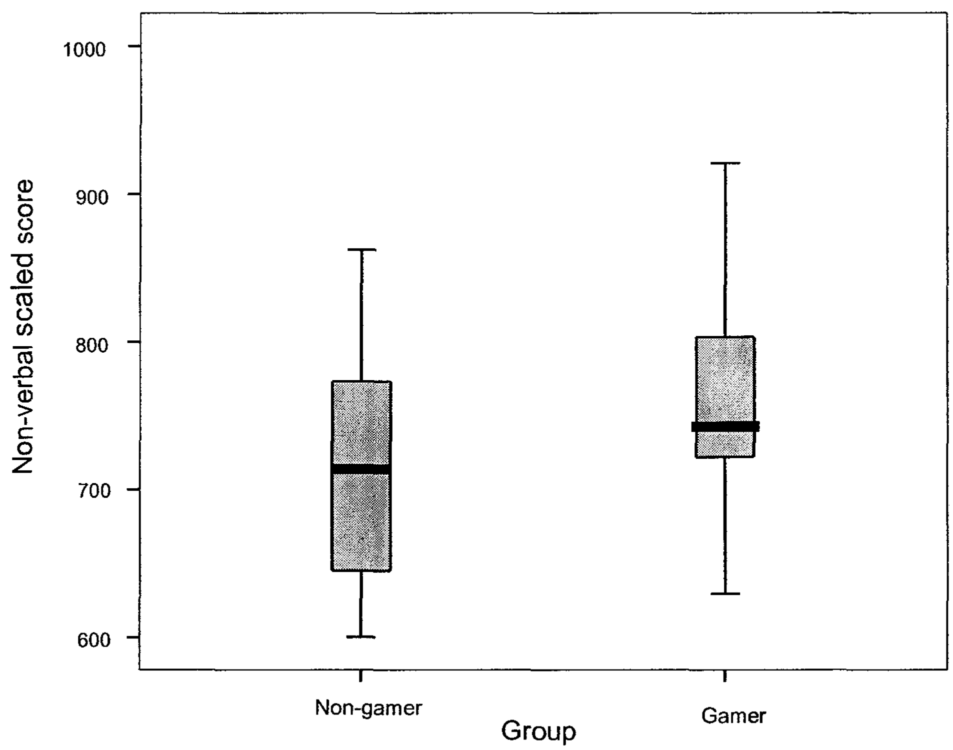

Figure 13. The boxplots of the CTCS combined non-verbal subtest scores by test by group.

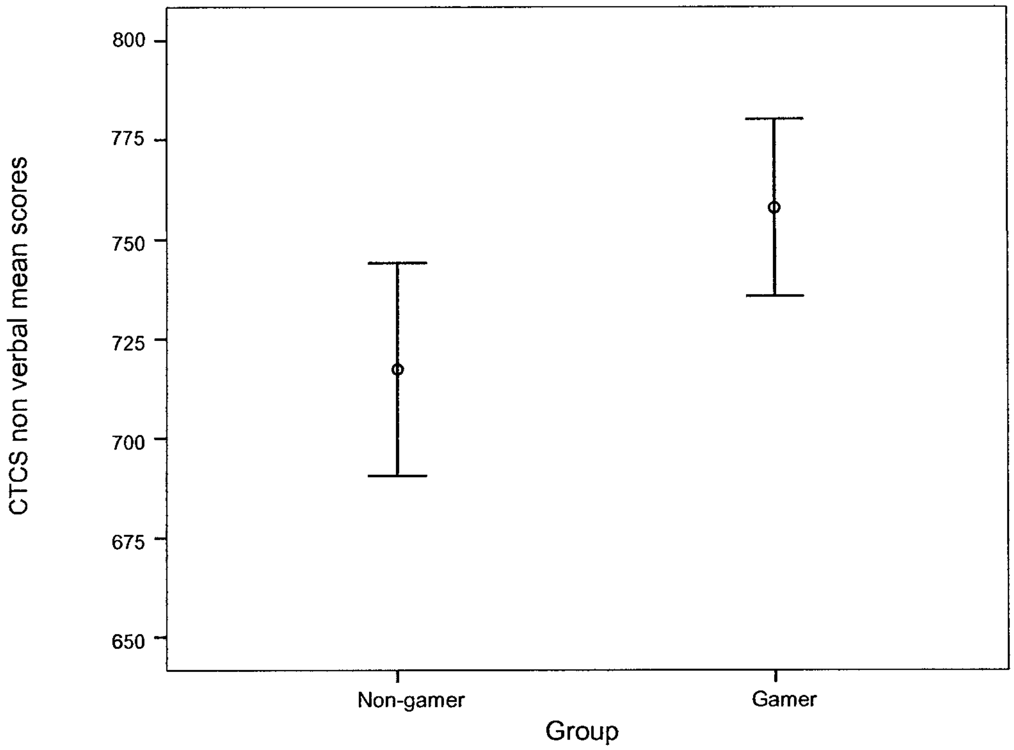

Figure 14. The 95% confidence intervals for the means of the CTCS combined non-verbal scores by test group.

Hypothesis IV: CTCS memory subtest

Hypothesis four stated that there will be no significant difference between the groups on the CTCS, memory subtest (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The Grubbs test for outliers was performed to determine if one of the extreme values in the Gamers group data set (see Figure 15) on the CTCS memory subtest was an outlier prior to data analysis. The Grubbs test with a two-sided significance level of 0.05 and a Critical value of z = 2.965 determined that the *z* value of the outlying data (N = 425) was not an outlier (z = 2.73) and therefore, should be included in the data set.

The mean scores of the memory subtest for both groups are presented in Table 12. Table 12 shows that the Non-Gamers group scored higher (M = 652.56, SD = 83.25), although not significantly higher, than did the Gamers group (M = 617.97, SD = 114.58) on the memory subtest.

Based on Levene's Test for Equality of Variances with values of *F* = 3.681 and p = .060, there is no reason to doubt that the group variances are not equal, so the *t* value for equal variances can be used to test the null hypothesis.

An independent groups *t* test found no significant difference in the mean scores between the Gamers and Non-Gamer groups on the memory subtest, *t*(63) = 1.401, p = 0.166. The calculated independent *t* test values are presented in Table 13. The distributions of the scores for the CTCS, memory subtest are presented in Figure 15. The 95% confidence intervals, for the mean scores on the CTCS combined non-verbal subtest, are shown in Figure 16.

Table 12

Mean scaled scores of Gamers and Non-gamers on the CTCS memory subtest.

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	617.97	114.58	20.58
Non-Gamer	31	652.56	83.25	14.28

Table 13

Independent samples t test of CTCS memory subtest.

						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.401	63	.166	34.59	24.69	14.74	83.92

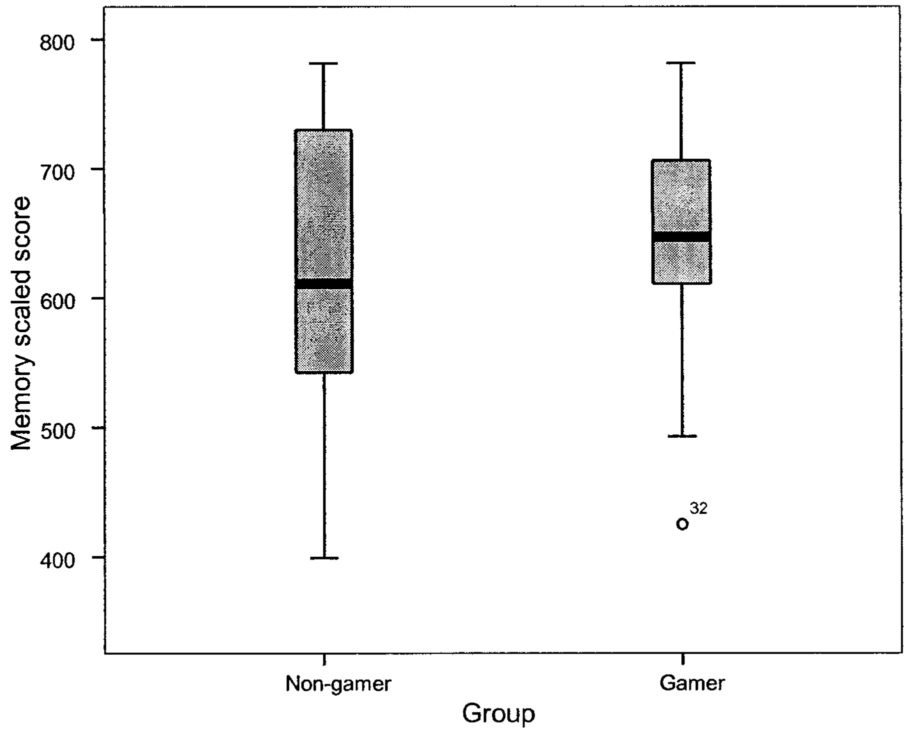

Figure 15. The boxplots of CTCS memory subtest scores by test group.

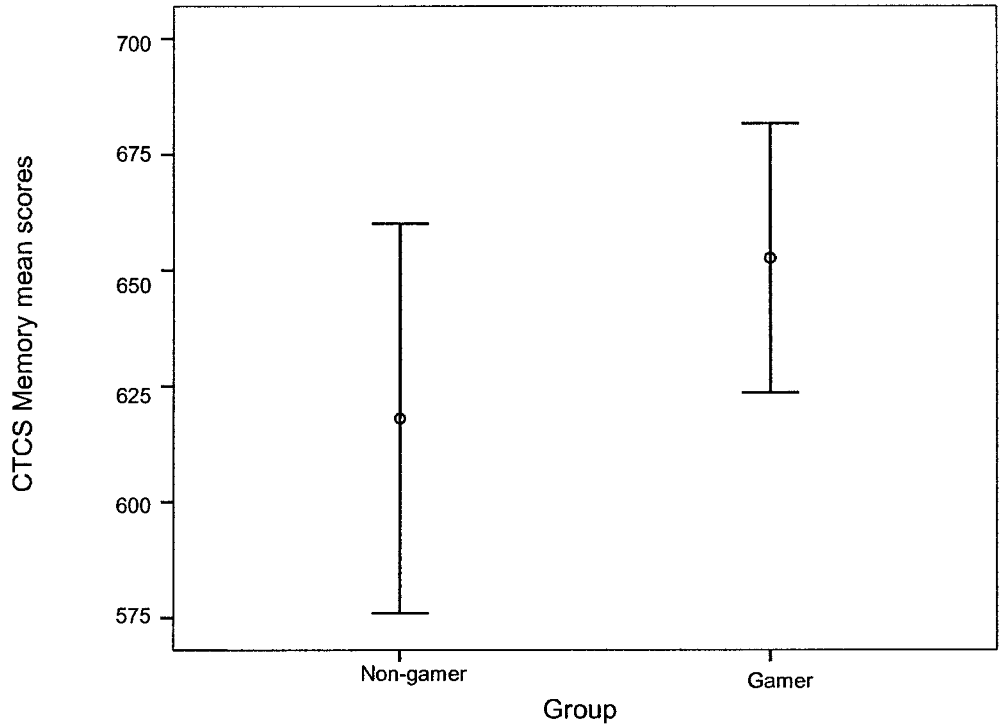

Figure 16. The 95% confidence intervals for the means of the CTCS memory subtest by test group.

Hypothesis V: CTCS verbal reasoning subtest

Hypothesis five stated that there will be no significant difference between the groups on the CTCS verbal reasoning subtest (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The mean scaled scores of the subtest for both groups are presented in Table 14. Table 14 shows that the Gamers group scored higher (M = 823.68, SD = 105.03) although not significant, than did the Non-gamer group (M = 785.71, SD = 99.68) on the verbal reasoning subtest.

Based on Levene's test for Equality of Variances with values of $F = .0.40$ and p = .842, there is no reason to doubt that the group variances are not equal, so the *t* value for equal variances can be used to test the null hypothesis.

An independent groups *t* test found no significant difference in the mean scaled scores between the Gamer and Non-gamer groups on the verbal reasoning subtest, t(63) = 1.491, p = 0.141. The calculated independent *t* test values are presented in Table 15. The distributions of the scaled scores for the CTCS verbal reasoning subtest are shown in Figure 17. The 95% confidence intervals, for the mean scores on the CTCS verbal reasoning subtest, are shown in Figure 18.

Table 14

Mean scaled scores of Gamers and Non-gamers on the CTCS verbal reasoning subtest.

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	823.68	105.029	18.01
Non-Gamer	31	785.71	99.68	17.90

Table 15

Independent samples t test of the CTCS verbal reasoning subtest.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	1.491	63	.141	37.97	25.46	-12.91	88.84

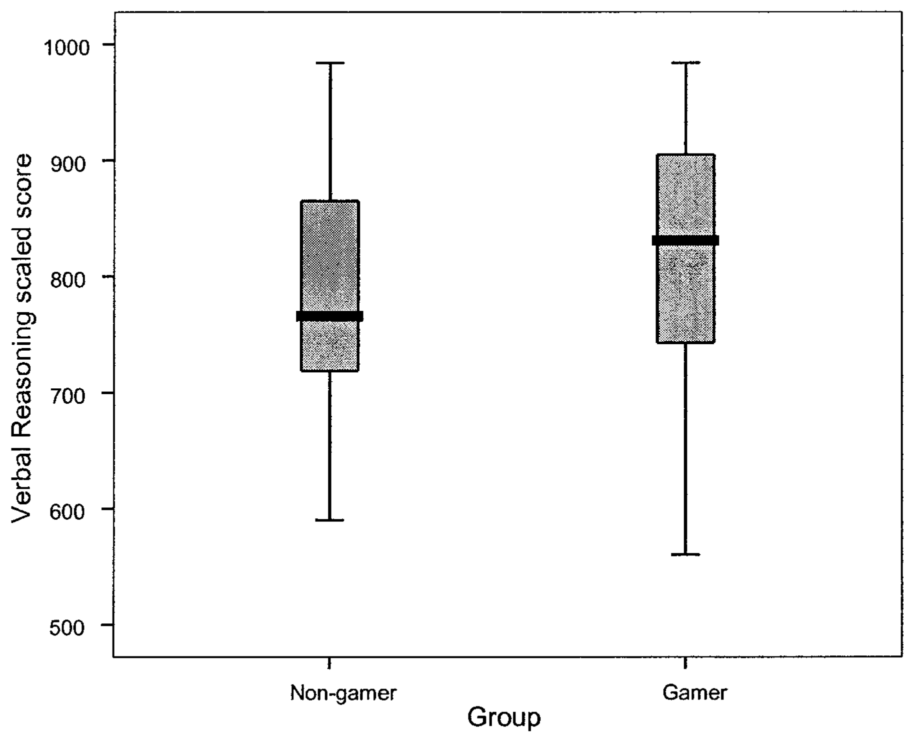

Figure 17. The boxplots of CTCS verbal reasoning subtest scores by test group.

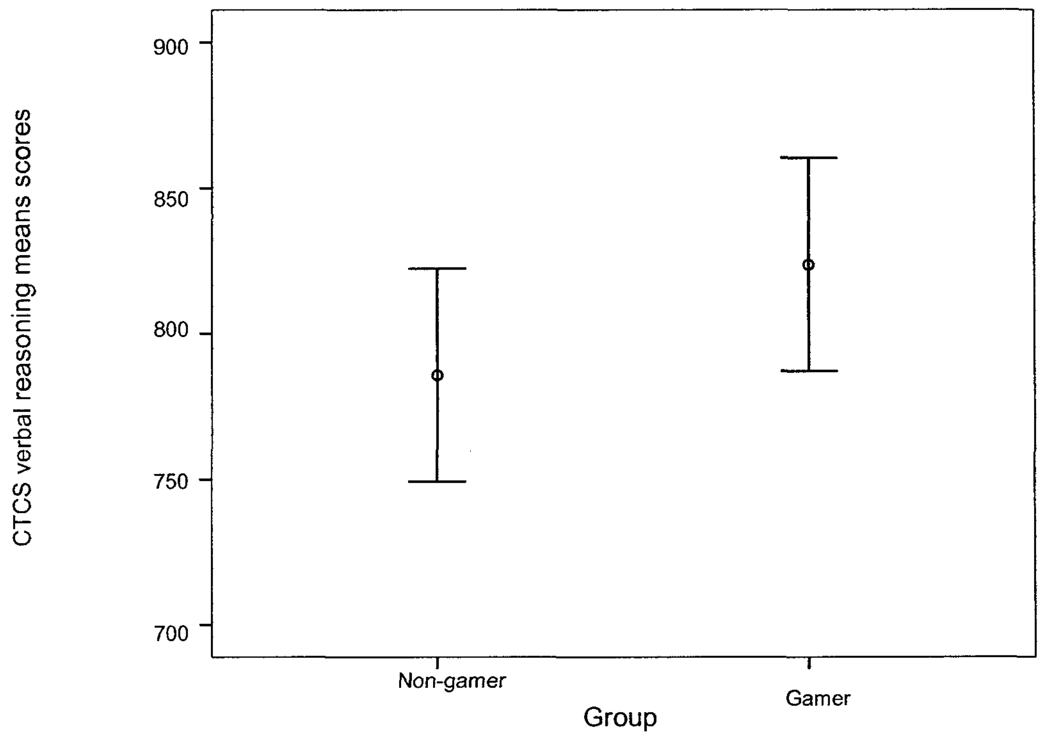

Figure 18. The 95% confidence intervals for the means of the CTCS verbal reasoning subtest by test group.

Hypothesis VI: CTCS overall combined cognitive skills

Hypothesis six stated that there will be no significant difference between the groups on the CTCS overall cognitive skills score (H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$; $\alpha = .05$). The mean scaled scores of the total test for both groups are presented in Table 16. Table 16 shows that the Gamers group scored significantly higher (M = 747.94, SD = 60.86) than the Non-gamers group (M = 709.61, SD = 67.83) on the combined cognitive skills test. Based on Levene's Test for Equality of Variances with values of $F = .416$ and $p = .521$, there is no reason to doubt that the group variances are not equal, so the *t* value for equal variances can be used to test the null hypothesis.

An independent groups *t* test found a significant difference in the mean scaled scores between the Gamer and Non-gamer groups on the total test combined scores, $t(63) = 2.401$, $p = 0.019$. The calculated independent *t* test values are shown in Table 17. The distribution of the scaled scores for the CTCS overall cognitive skills are displayed in Figure 19. The 95% confidence intervals, for the mean scores on the CTCS total test, are shown in Figure 20.

Figure 21 presents the mean scores of the groups on the CTCS by subtest. It is shown that the Gamer group scored higher on five of the six tests, with only significant differences on the sequencing, non-verbal, and overall cognitive test scores. The Non-gamer group scored higher than the Gamers on the memory subtest, although the difference is not significant.

Table 16

Mean scaled scores of Gamers and Non-Gamers on the CTCS overall score

Group	N	Mean	Std. Deviation	Std. Error Mean
Gamer	34	747.94	60.86	10.44
Non-gamer	31	709.61	67.83	13.02

Table 17

Independent samples t test of the Canadian Test of Cognitive Skills total test.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	2.401	63	.019	38.33	15.96	6.43	70.22

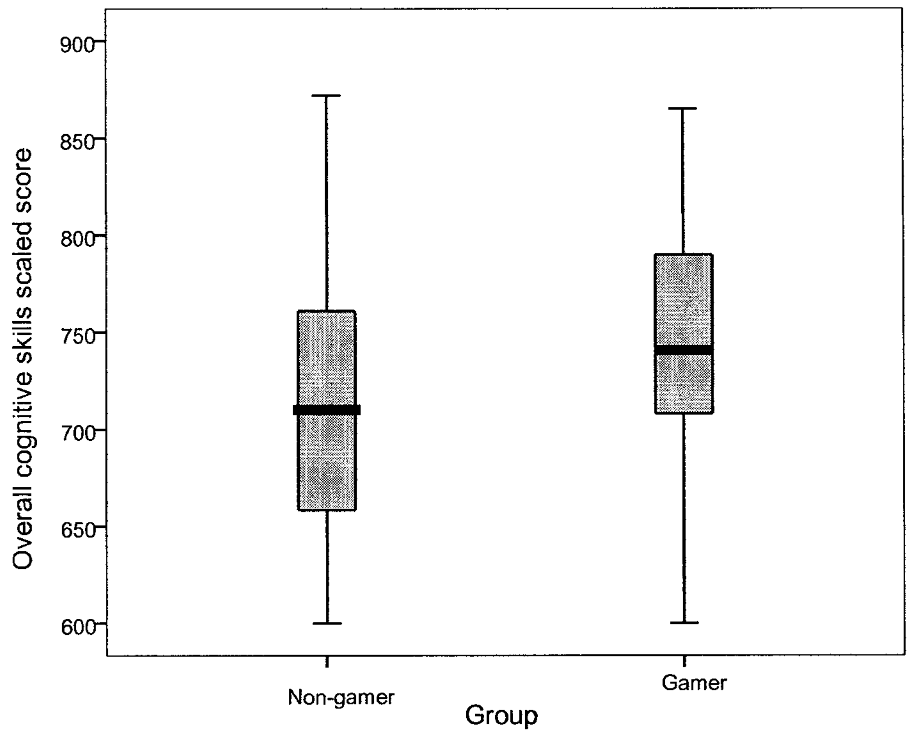

Figure 19. The boxplots of the CTCS overall cognitive skills scores by test group.

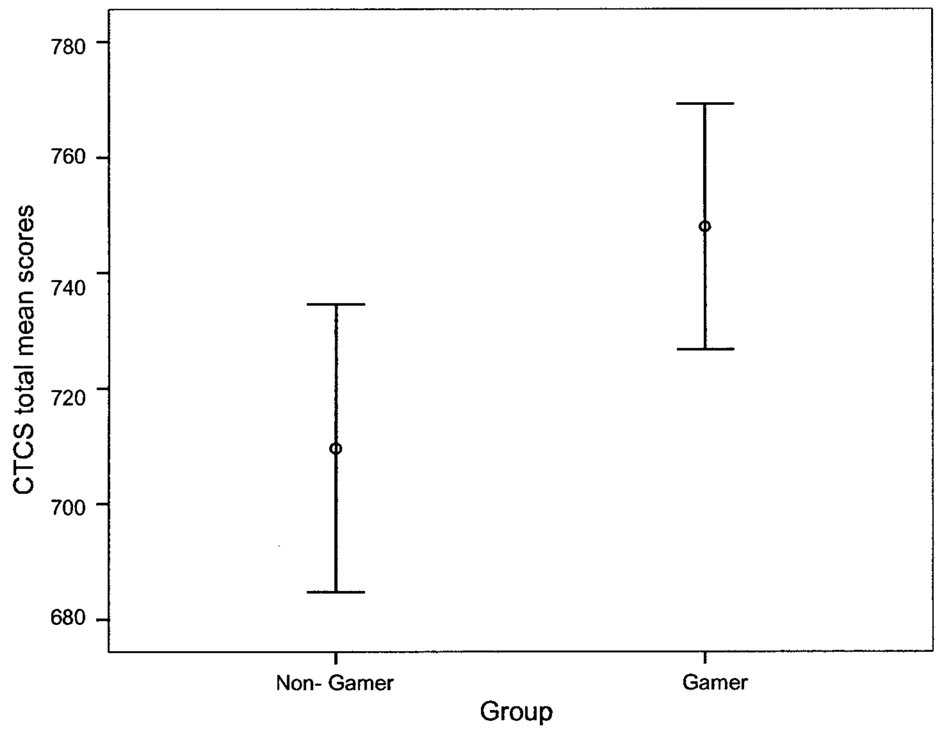

Figure 20. The 95% confidence intervals for the means of the total score on the CTCS by test group.

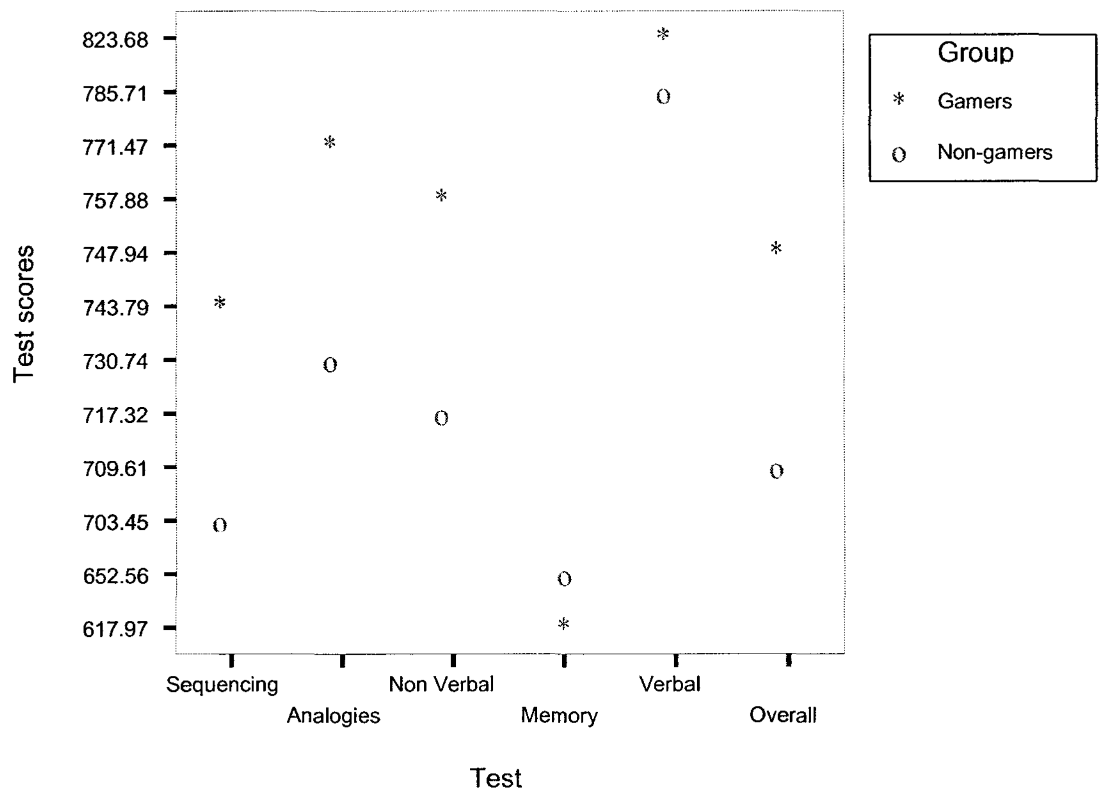

Figure 21. A scatter plot of the test scores on the CTCS by test group

The Precursor Action Results Interpretation (PARI) Analysis

Eight Gamers and eight Non-gamers participated in PARI cognitive task analysis. The participants had no idea of the game they would be playing prior to the task analysis, and only one (n = 1) of the sixteen participants identifying that they had previously played the chosen game. When asked if they liked the game chosen for the study, and whether they would consider playing it in their recreational time 25% (n = 2) of the Gamers said they would, and 0% (n = 0) of the Non-gamers said they would. Of these subjects, 37.5% (n = 6) were female and 62.5% (n = 10) were male.

Cognitive Strategies during Play

The cognitive strategies were classified based on the work by Pillay (2001). The strategies, their description, and an example from the task analysis are presented in Table 18.

Table 18

Cognitive strategies employed by game playing during the PARI cognitive task analysis.

Cognitive Strategy	Description	Example from video
General Search	Game players do not use any particular strategy for game play and engage in a trial-and-error process to explore game features.	"I don't know what's going to happen. I'm just trying things out."
Goal-directed search	Game players make a move that is goal-directed toward a particular goal or sub-goal that moves them closer to achieving a solution. Previous game experiences can often trigger this strategy.	"I know from the previous game that I need a flame to make the canon go. So I will use the flint to make the flame to make the rocket go."
Anticipatory thinking	Game players anticipate future game situations and thus base their game play on these anticipated results. Players try to extend their thinking beyond the given information.	"I tried earlier on knowing that the mouse would go for the cheese. So either the mouse goes for the cheese, and the cheese is down there, so the mouse may jump off the ledge, and hit the cheese, and the mouse may be an object that will hit the cutters and that will cut the rope."

Table 18 continued

Working backward	Game players identify sub-goals from the goal and move backwards to solve the problem. This means-ends analysis strategy works well in the absence of sufficient domain knowledge (Pillay, 2001).	"If I need to blow up the blimps, I'll need to first use this rocket, then with the flint I can attach the rope to the pulleys and then to the teeter-totter and it should work."
Stepwise	Game players adopt a systematic or linear/sequential path to solving the problem.	"Ok, so first I got him off the ledge, now I'm going to have to somehow get him over the hole."
Data gathering	Game players use hints and game features to gather more information as the basis of game choices.	"I have no clue. I'm going to click on the hints to see if there is something I'm missing."
Making inferences	Game players make general conclusions of game feature and situations that are not directly implied or stated.	"In classic cartoon physics usually mice like cheese, so I'm assuming that in this game that the mouse will be attracted to the cheese."

The frequencies of the cognitive strategies for the combined three puzzles are shown in Table 19. The most used cognitive strategy for the combined three puzzles for both Gamers and Non-gamers was goal-directed search. General search and anticipatory search follow close as the second most used cognitive strategy. Table 19 shows the frequency of each strategy as well as the overall strategies used are very similar for both groups. In averaging the cognitive strategies over the three puzzles, Gamers averaged 34.2 strategies, while Non-Gamers averaged 38.8 strategies during play of the three puzzles. The strategies are further extracted for each group per puzzle in Table 20.

Table 19

The frequency of cognitive strategies used by each group

Cognitive strategy	Gamers	Non-gamers
General Search	83	79
Goal-directed search	96	95
Anticipatory search	62	76
Working backward	0	2
Stepwise	1	2
Data gathering	38	40
Making inferences	18	27
Total	298	321

For puzzle one, both groups used general search, goal-directed search, and anticipatory search as their three main cognitive strategies. There was also a considerable use of data gathering in the first puzzle as a cognitive strategy by both groups.

In puzzle two, both groups used less maneuvers to solve the puzzle and therefore had less documented strategies. Table 20 shows that both groups used general search, goal-directed search, and anticipatory search as their three main cognitive strategies.

In puzzle three, the results are similar to the first two puzzles with general search, goal-directed search, and anticipatory search as both groups' three main cognitive strategies.

Table 20

The frequency of cognitive strategies used by each group per puzzle

	Puzzle 1		Puzzle 2		Puzzle 3	
Cognitive Strategy	Gamers	Non-gamers	Gamers	Non-gamers	Gamers	Non-gamers
General Search	43	41	14	24	26	14
Goal-directed search	48	46	9	11	39	38
Anticipatory search	39	39	12	15	10	22
Working backward	0	1	0	1	0	0
Stepwise	1	0	0	0	0	2
Data gathering	24	27	8	5	6	8
Making inferences	8	13	5	8	5	6

The dominant cognitive strategy used the most by each participant per puzzle is shown in Table 21. The strategy used most frequently by the participants throughout the cognitive task analysis, per puzzle, is deemed to be the participants' dominant strategy.

In puzzle one, both groups are very similar in their application of cognitive strategies with general search, goal-directed search and anticipatory search as their three main cognitive strategies.

In puzzle two, there is a slight shift in the main cognitive strategies that are used by both the Gamer and Non-gamer groups. Gamers still used the general search, goal-directed search, and anticipatory search as a cognitive strategy, but there was a marked shift to also using data gathering, and making inferences. Non-gamers still used goal-directed search and anticipatory search as cognitive strategies, but there was a shift toward general search as the dominant cognitive strategy.

For puzzle three, both groups used goal-directed search as their main cognitive strategy. General search was also used, as well as anticipatory search.

Table 21

The dominant cognitive strategy used by Gamers and Non-gamers per puzzle.

	Puzzle 1		Puzzle 2		Puzzle 3	
Cognitive Strategy	Gamers	Non-gamers	Gamers	Non-gamers	Gamers	Non-gamers
General Search	3	3	2	5	3	1
Goal-directed search	2	3	1	2	4	6
Anticipatory search	3	2	2	1	1	1
Working backward						
Stepwise						
Data gathering			2			
Making inferences			1			

Analysis of Dominate Cognitive Strategies during the PARI

Chi-square tests of independence were done for each puzzle to determine if there were significant differences in the cognitive strategies used by each group on the PARI. The Pearson Chi-square test of independence was not significant for puzzle 1 (Chi^2= .400, df = 2, p = .819). The Pearson Chi-square test of independence was not significant for puzzle 2 (Chi^2 = 4.952, df = 4, p = .292). The Pearson Chi-square test of independence was not significant for puzzle 3 (Chi^2= 1.400, df = 2, p = .497).

Summary of the Results

The results of the study support that video games are an effective environment for the study of cognitive skills and problem solving. The results of the CTCS, shows that there is a significant difference between the Gamer and Non-gamer groups in the areas of sequencing, non-verbal, and overall test score on the CTCS. The PARI results support that there is no significant difference between the groups in cognitive strategy used in the three puzzles of the task analysis.

CHAPTER FIVE

Discussion

This chapter discusses the results of the study and presents the studies' outcomes and findings. The subject demographics, Canadian Test of Cognitive Skills (CTCS), and Precursor, Action, Results, Interpretation (PARI) cognitive task analysis discussion follow the structure of the results as presented in the previous chapter. The implications of results as well as recommendations for further research are also presented.

General Subject Demographics

The video game player demographic has grown in both size and diversity in the past 20 years. As video game players have matured, from children playing 25 cent arcade classics like *Pooyan* (Konami, 1982), to purchasing the latest games and gaming systems like *Call of Duty 2* (Infinity Ward, 2005) for the *Xbox 360* (Microsoft, 2005), players have evolved with the games they play. With 35% of gamers being 18 years and younger, 19% over 50, and 43% aged 18-49 years [*sic*], the age demographic chosen for this study (20.42 years for Gamers and 22.57 years for Non-gamers) falls within the largest demographic of those who play video games (ESA, 2005). The average age of the Gamers (22.42) and Non-Gamers (22.57) used in this research study, however, falls below the average age of gamers (30 years) (ESA, 2005). This was due to the participant demographic that was chosen for the study. Since over 20% of Canadians have university undergraduate or graduate degrees and, conversely, over 40% of Canadians have some vocational education (OECD, 2004), it is highly probable that the participant groups for this study are more educated than those who represent the general gaming demographic. As no studies or reports on the general educational level of the gamer and non-gamer demographics are found, the groups' fit is inferred based on the information available. It is surmised, due to the education and age of those who participated in the study, that although this group does represent a subgroup within the gaming population, they are not representative of the general gaming demographic. The results, however, do draw some important results in regards to those who chose to participate in the study.

Of a total of 110 participants who signed up for the study 59.1% (n = 65) came to the research room at the specified time and date. This is a high turn out for a research study, and is likely due to the attendance options given to the research subjects for their participation. The ability to choose a date and time, the ease in which to sign up for the study (via a web form), and the minor compensation that was afforded for their time ($10 for 1.5 hours) may be factors that contributed to the high participation. It is also interesting that, out of the total population who enrolled in the study, that there were more Non-gamers (67.4%), than Gamers (53.1%), who actually participated. Although few conclusions are drawn from this, it would have been assumed that more Gamers would participate due to their interest in video games. Arnold (1997) in an exploration for the motives for video game use found that there are four dimensions of player motivation: verisimilitude, problem solving, control, and competition. Even with the Gamers not knowing the game of choice or the research instrument used, inferences that Gamers would be more motivated to participate in the study than Non-gamers based on one or more of these factors, is proposed. This, however, was not the case in this study.

Since computers and dedicated game consoles are a large part of gaming, the question of each group's computer proficiency is significant. Although, computer proficiency may be hypothesized to be a factor in gaming, no published studies are found that examined this hypothesis; in as much, it was almost identical for both groups (see Figure 4). This supports that Non-gamers are as active with computers as Gamers, but rather, they choose to use their computers for other means; their comfort level using computers playing little part in their choice to play games or not. The question, then, is not if Gamers and Non-gamers use computers, but rather, if Gamers and Non-gamers are both computer proficient, what is each group using its computers for?

Both groups computer use is consistent, with school work (38.24% for Gamers; 61.29% for Non-gamers) and social reasons (26.47% for Gamers; 16.13% for Non-gamers), as the two main uses of their personal computer. This finding likely occurred because all of the participants in the study were university students who must use their computer for schoolwork. The Gamers group used their personal computer for play (20.59%) far more than the Non-gamer group (3.23%), which is an expected finding. In looking at the computer use for each group (see Figure 5), the Non-gamers' group utilized their personal computers for school work (61.29%), far more than the combined time the Gamers use their personal computers for schoolwork (38.24%) and play (20.59%). This suggests that playtime on the computer may be displacing school work. No studies are found concerning the displacement of activities such as schoolwork or studying due to gaming, however, some studies are found where video games displace television viewing (Subrahmanyam et al., 2001). The research supports, however, that video games serve to fill "free time" and that children who own a video game system do not greatly alter their daily activities (Creasey and Myers, 1986; Media Analysis Lab, 1998). The Entertainment and Software Association also report that beyond game play, gamers devote more than triple the amount of time spent playing games each week to exercising or playing sports, volunteering in the community, religious activities, creative endeavors, cultural activities, and reading (ESA 2005). The results of this study support the claim that video games are a means to fill free time, even when the most hardcore Gamers choose schoolwork and social computer use over gaming.

Gamer Group Demographics

Gamers make up as much as 50% of the adult population (ESA, 2005). It is this fact that provides a great deal of information about this groups' preferences, patterns, and demographics. In this study, Gamers reported playing video games on average 10-15 years; this falls within the average of 12 years in the general gamer demographic (ESA, 2005). Gamers also report that they play video games 2 to 5 hours a week on average, and that the main reason for playing is for fun (91.2%). This is far below the average of 9 hours a week (13 hours for boys) found in the general gamer demographic (ESA, 2005). Although this group defines itself as Gamers, the majority of hardcore gamers play games far more often, and for longer periods of time, than the Gamers group in this study. This finding may be because the participants were university students who are busier with other activities, like schoolwork and studies, compared to the general gaming population.

A vast majority of the Gamers owned more than one gaming system (82.4%), though most used their PCs as their primary gaming system (97.1%). This is in direct contrast to the fact that, for most Gamers, the primary use of their PCs is for school and social reasons (see Figure 5). It also shows that Gamers use many different gaming appliances for their main recreational activity. With only about half of the Gamers planning to buy a new system (55.9%), the hype of new gaming systems, such as the *Sony Playstation 3* and *Xbox 360*, have little effect on their purchase decisions.

The amount of money that Gamers spent on video games, 41.2% spending $100-250 per year, shows that Gamers are not spending a considerable amount of money on gaming, their main recreational, leisure, or entertainment activity. This is below the average, where British Columbian hardcore gamers spend $500 a year on gaming, while light gamers spend $410 (Media Analysis Lab, 1998). This is likely due to the fact that the participants are university students, who in many instances, do not have the money to spend on video games.

Non-gamers Group Demographics

The majority of Non-gamers in the study are actually "wannabe" gamers. Since a majority of Non-gamers report played games in the past (96.8%), and with over half reporting that they would play games if they had more time and money (51.6%), it is argued that a majority of Non-gamers are in fact future gamers. When playing these games, Non-gamers reported that they used different gaming systems and types of games throughout the years (Atari 2600 to the Sony Playstation 2). However, they are not drawn into playing regularly enough to classify themselves as Gamers. Further investigation into the reasons non-gamers choose to not to play games needs to be addressed. Although it is identified that there are gender issues concerning why females do or do not play video games (Lucas and Sherry, 2004; Media Scope Press, 1999), there are no studies of why the general population of non-gamers choose to stay away from video game play.

Non-gamers reported that the main reason they do not play games is due to not having enough time (45.2%), with over half (51.6%) saying they would play games if they had more time or money. This is expected, as all of the participants in the study are university students who also have class work and studies to attend to. It is interesting that the majority of the Non-games group reported that they would play if they had more time or money (51.6%). Although this may be one of the major factors that contribute to non-gaming, it does draw some relationships between the groups that participated.

Summary of Participant Demographics

The demographics collected in the study show that the participant groups are not representative of the general gaming population. The gamers that were used in the study are found to be younger, and played less hours per week, than the general gaming community. The groups, however, are somewhat homogenous in other demographics. With all students being well-educated, similarly aged, and with the consideration that a majority of the Non-gamers reported to be "wannabe" gamers, the main difference between the groups is how they choose to spend their recreational time; whether they play video games or not.

The Canadian Test of Cognitive Skills (CTCS), level 5

The recognition that humans are "highly resourceful at exploiting their environment to extend their cognitive capabilities and they do this with a variety of strategies, tools, and representations" (Scaife and Rogers, 2005, p. 182) allows us to better frame video games as complex cognitive environments. The results of this study support that as higher demands are placed on a person's cognitive processing abilities (Mayer, 2005), they can adapt and enhance those abilities in time. Since the Gamers group was subjected to various cognitive tasks through their video games play over many years, there is a possibility that they have developed or enhanced particular cognitive skills.

The results of the CTCS indicates that Gamers have significantly better articulated cognitive skills in the area of sequencing, non-verbal, and overall cognitive skills than Non-gamers. The null hypothesis for all of the tests, including sequencing, analogies, verbal reasoning, memory, non-verbal, and overall cognitive skills was that there would be no significant difference between Gamers and Non-gamers on these measures. These results, however, show that three out of the six hypothesis – analogies, verbal reasoning and memory – support the null hypothesis (H_0: $\mu_1 = \mu_2$), and three, sequencing, non-verbal, and overall cognitive skills reject the null hypothesis (H_1: $\mu_1 \neq \mu_2$). Gamers scored significantly higher on the sequencing, non-verbal, and overall cognitive skills tests. The results support that there is a difference in cognitive skills between video game players and non-players and that video games may be an effective cognitive tool.

The Gamers' ability to "to comprehend a rule or principle implicit in a pattern of figures, letters, or numbers" (CTCS, 1992b, p. 2) is the conclusion found from sequencing subtest. The test supports that Gamers can better "learn from processes, by repeating a procedure or method until it becomes familiar" (CTCS, 1992b, p. 2). This is expected since the comprehension of patterns, and the repetition of procedures and methods, are traits needed by effective gamers. If these skills are not developed during play, these gamer would soon be frustrated at repeating both on-screen movement patterns, physical game control patterns, and recognizing iconic patterns in the game (what is "good" and what is "bad") in order to be a successful gamer. Gamers' perpetual playing and replaying of video games in order to explore and gain declarative, procedural, and strategic knowledge support this finding. It is while replaying that

Gamers are able to not only develop and articulate these skills, and gain expertise, but also enables them to use of these skills intern to become more effective gamers. The role of self-regulated learning, metacognition, and emotional control, are all used in the development of an effective gamer, although, these theories of learning are not being attributed to learning in video games.

Encoding, inferring, mapping, justifying, and responding (Sternberg, 1997 cited in CTCS, 1992b) are processes that are tested in the analogies subtest. These skills are used in abstract reasoning, and are therefore very attractive in the fields of science and engineering. Finding no significant difference in the groups was surprising, considering that to be successful in most games, gamers must have the "ability to see concrete and abstract relationships and to classify object or concepts according to common attributes" (CTCS, 1992b, p. 8). The ability to discern the "good guys" and the "bad guys", along with the related elements of play, is a specific skill of game play that uses the skills tested by the analogies subtest. Research suggests that video games develop and promote complex iconic and symbolic reasoning skills (Prensky, 2001; Greenfield, 1993), however, these assertions are not supported with this study's findings.

Memory skills are also important for Gamers in their ability to both play and develop as effective gamers. Although no significant difference is found between the Gamer and Non-gamer groups on this measure, the type of memory that was tested maybe a factor in the outcome. The records of memory (Anderson 1995), that are exercised and attributed to gaming are more likely to be procedural than declarative. As tested in this study, declarative memory, the knowing that one nonsense word equates to an item, is a different memory skill than storing procedural knowledge, the knowing of how to do a particular task, which is developed in gaming.

It is also be suggested that Gamers develop episodic knowledge (Byrnes, 2001), the knowing of when and where, that may lead to gaming success. With 25 minutes and two tests taken between the learning of the word pair definitions and the test, there may be a negative correlation between the strength of the cue and what gamers develop during gaming. Dual coding theory (Paivio, 1971) gives a good basis in which Gamers and Non-gamers would encode this information, however, it does not exploit the specific type of memory that is developed in a gaming environment. Since games exploit working memory, not permanent memory, the test may lead to decay, interference, and loss of retrieval (Byrnes, 2001) as these skills are not readily developed in video games.

Hypothetical-deductive reasoning with words and sentences is not a trait used in many modern video games. The finding that there is no significant difference between Gamers and Non-gamers for the verbal reasoning test, is not surprising, given that most information in video games is iconic, pictorial, and symbolic. In most games, the reasoning comes in the form of actions within a spatial environment. An example of this would be a war game that focuses on the maneuvering of units which utilize strategic and spatial skills. The verbal cues for command and control, logistics, and deductive reasoning have been removed from the design (Crawford, 1993) and, in this case, they are all visual spatial. It is assumed that research that suggests that video games develop deductive and logical reasoning skills (Prensky, 2001; Hostetter, 2002) are not intended for the domain of verbal reasoning, although both deductive and logical reasoning skills are needed in this regard.

The non-verbal test was the combined scaled score on the sequencing and analogies subtest. The null hypothesis was rejected as there is a significant difference in non-verbal skills between Gamers and Non-gamers. Gamers on both the sequencing (M = 743.79, SD = 83.07), and the analogies (M = 771.47, SD = 86.63) subtests scored higher than the Non-gamer group (M = 730.74, SD = 96.55 and M = 703.45, SD = 72.48). Although there is no significant difference for the analogies subtest, the combined test showed significant results. This supports that Gamers do have highly articulated non-verbal skills in the area of pattern recognition and abstract reasoning.

Gamers also scored higher in overall cognitive skills, which is a combination of all four subtests. This finding, that Gamers had better overall cognitive skills, carries that video games can be an effective cognitive tool used to develop and articulate particular skills. This finding is exciting in that it suggests that video games may be one of the factors that contribute to the successful development of skills that are related to academic learning (CTCS, 1992b).

Increasing one's thinking and reasoning skills is an important basis for both academic learning and for success in the workforce. While there is no single systematic approach to the instruction of cognitive skills (CTCS, 1992b), like those tested in the CTCS, the development of these skills are vital to the success of those who possess them. Cognitive tools, like video games, are ideal in the application of environments that promote cognitive growth and enhancement that are both fun and stimulating.

In conclusion, the results of the CTCS support two preliminary conclusions. First, the results support that there are significant differences between the groups that choose to play video games and those who do not. Second, video games may serve as an effective cognitive tool for development in the areas of sequencing, non-verbal, and overall cognitive skills. With cognitive factors such as sequencing, non-verbal, and overall cognitive skills serving as factors for the predisposition for success in video game play, people who have these traits are more likely to become gamers. Although the results cannot address causality for video games developing cognitive skills, they do give a strong basis for continued studies on gamers and non-gamers, and the effects of video games on cognitive development. Investigations into the causality of video games influence on cognitive skills development should be pursued in order to better understand if those who play video games improve cognitive skills through there use.

The Precursor, Action, Results, Interpretation (PARI) Cognitive Task Analysis

The results of this study suggest that *Grand Theft Auto III* (Rockstar North, 2005) is as likely an environment for the study of problem solving as the *Tower of Hanoi*. The fundamental nature of problem solving, as proposed by Mayer (1992), is recognized in the current first person shooters (FPS), role-playing (RPG), and puzzle adventure games. The way in which we study problem solving in video games, however, is still in its infancy.

The PARI cognitive task analysis served as an exploratory study of the difference in problem solving skills used by Gamers and Non-gamers in a situated game-based problem solving environment. The null hypothesis for the study stated that there would be no significant difference in the cognitive strategies that are used between Gamers and Non-gamers; the results of the study support this hypothesis.

Stubbart and Ramaprasad's (1990) assertions that (a) experts know what is needed to and how to solve problems, (b) that experts realize their own mistakes very soon while solving problems (c) experts have resilient methods for specific problems, and that (d) experts infer a question forwards from known fact, but novices work backwards, were not supported in this study. In both the overall cognitive strategies along with the dominate strategies, there was little difference in the problem solving maneuvers that were used by Gamers and Non-gamers.

The number of cognitive strategies used, while engaged in during the three puzzles played in this study, were very similar for both Gamers (n = 298) and Non-gamers (n = 321), with the breakdown of the cognitive strategies followed by each group, per puzzle, following the same trend (see Table 19). Both groups used a very similar frequency of general search, goal-directed search, and anticipatory search, as cognitive strategies of play. This is in contrast to the findings by Hong and Liu (2003) who found that expert players used more analogical thinking while novice players used trial-and-error in their game-play strategies.

Since neither group was knowledgeable of the particular game played in this study, with only one gamer reporting have played the game before, both groups approached the game as novices. Gamers may have had a slight advantage with their procedural skills using the game controls, however, both groups lacked the declarative and strategic knowledge of the game. This allowed the Non-gamers to play beside Gamers on an even plain, and as such allowed their strategies of play to be the main factor in how they moved from novice to game player. Both groups, in this case, had similar declarative knowledge of the puzzle game domain. The facts, concepts, processes, and principles of the game (Clark and Chopeta, 2004), were unknown to both groups, and therefore had to be learned in order to build a context-base of knowledge.

It was also shown that the Gamer and Non-gamer groups used very similar cognitive strategies to build and adapt their declarative and strategic strategies of play (see Table 20). The ability of Gamers to recognize and adapt cognitive schemas did not help them to solve the puzzles in the game. Gaming schemas, in this case, since they had not developed appropriate schemas for this particular domain of game play. When recognizing that most Gamers play first-person shooters (FPS), or role-playing games (RPG) (ESA, 2005), the previous cognitive schemas that were developed in video game play, served little advantage.

In puzzle one (see Table 21), both groups utilized general search, goal-directed search, and anticipatory search as their dominant cognitive strategies at nearly identical frequencies. The assumptions that the Gamers' group are experts, and therefore able to better analyze and judge the game environment, know what is needed to solve the problem, and infer from known facts (Stubbart and Ramaprasad, 1990 cited in Hong and Liu, 2003), is not support in this observation. Both groups approached the game in a very similar fashion, and used very similar cognitive strategies. Thus without possessing previous declarative knowledge, strategic knowledge, and cognitive schema, Gamers do not have a problem solving advantage when approaching a new genera of game.

In puzzle two, there was a slight shift in the strategy that was used by the Gamers group. The ability to gather data and make inferences shows that the Gamers group has the ability to use built-in game information as a strategy of play. Players like this may be adept to using the in-game tutorials or game books when they do not understand all of the games' features. The Non-gamers in this study reverted to using general search, instead of gathering more information or making inferences. This trail-and-error approach is a reversion back, in terms of complexity of problem solving, to other strategies that were used in puzzle one, such as goal-directed search and anticipatory search.

In puzzle three, both groups used goal-directed search as their dominant cognitive strategy. The qualitative and quantitative data support that, as both groups gained both declarative and strategic knowledge through the solving of the two previous puzzles, they were better able to recognize gaming symbols, controls, and strategies of play. Two examples of this recognition are shown below:

Gamer Puzzle Three: Using a Cannon to blow-up a suspended fish tank.

Ex: "What does the initial set-up of the game tell you about the problem and what are some possible problems?"

Gamer Six: "I have my teeter-totter, which judging from the parts available, I can attached to the match lighter, which will fire the cannon for me. I have an accelerator going down. I can probably use that and the tube to get the basketball to hit my teeter-totter. Now I just need to put these in their place."

Non-gamer Puzzle Three: Using a Cannon to blow-up a suspended fish tank.

Ex: "What does the initial set-up of the game tell you about the problem and what are some possible problems?"

Non-gamer Six: "Well, there is more to put on the playing field this time. I just noticed that I have to somehow position the cannon to blow-up the fish tank…there is the flint I will use to light the cannon…and could possibly attach this to the teeter-totter; I'm not to sure how to use these last two items yet."

It is declarative and strategic knowledge from previous games that allowed both groups to use goal-directed strategy in their placement of these items, and in the subsequent solving of the puzzle. This acknowledgement of using one's previous thinking supports Henderson's (2005) evidence of metacognitive strategy during video game play.

Overall, the results of the cognitive task analysis support the null hypothesis that there would be no significant difference in cognitive strategy between Gamers and Non-gamers. The results suggest that since both groups were new to the puzzle genera of game play, they both had to gain the declarative, procedural, and strategic knowledge in order to be successful. The assertion that expert gamers have superior cognitive flexibility and problem solving fluency (Doolittle, 1995), and use analogical thinking more than non-gamers (Hong and Liu, 2003), is not supported in these findings. The play patterns that are mentioned in Ko (2002), between expert game players and random guessers, did not surface since both used similar strategies. The research does support that as both Gamers and Non-gamers progress in games, they have the ability to develop and adapt their cognitive strategies and skills. It is these skills, such as analogical, metacognitive, and goal-directed search that can be used to support informal educational objectives (Henderson, 2005).

It is posited that the difference in findings from Ko (2002), Hong and Liu (2003), and this study, may be due to the demographic of subjects that were used in the study and the type of game played. Ko used children aged 7 to 10 years old playing a spatial flip card game utilizing inferential thinking. Hong and Liu also used elementary aged schoolchildren and a spatially rich problem solving game. This study, in contrast, used university age students who played a mechanical reasoning puzzle game. Due to the diversity and difference in these studies, in both the participants and games, it is questionable if there is any relationship to their findings and the findings of this study. The lack of research in the area of video games and problem solving, however, offer few alternatives for comparing similar research.

Implications of Study Results

The Serious Games Movement and *The Education Arcade* are two examples of how video games have moved outside the realm of simple play. The fact that the Federation of American Scientists, whose Board is populated by Nobel Prize winners, is developing video games, shows that video games have enormous potential to be used as tools in both teaching and learning, which goes beyond their original purpose (ESA, 2005b). The hypothesis that video games change the mind, however, has yet to be supported.

The results of this study support the inference that the people who choose to play video games have highly articulated cognitive skills that are more developed than those who do not. As the research suggests, there may be a correlation between game play and cognitive skills development. These findings, in turn, legitimize video games as an environment that promotes serious mental effort. Games require the people who play them to use complex cognitive skills, and the development of such skills, progress long after the gamer has left the gaming environment. The implications for having more articulated cognitive skills, such as sequencing, non-verbal, and overall cognitive skills, and their implications on schooling and the workforce is not known. What is known is that the findings of this research support that there is a difference between those who choose to play video games and those who do not, that the use of video games as a tool for research in cognitive psychology should garner serious consideration, and that more directed research on the long-term affects of video games as a tool for cognitive development are needed.

Recommendations for Further Research

The results of this study, and the current lack of empirical research papers or data in the area of video games, problem solving, and cognition raise many questions as to the direction of, and areas for, further research. Based on the findings of this study, there are five recommendations for research.

First, more studies on the long-term effects of video game play on cognitive skill development, in both causal-comparative and experimental research, must be conducted to explore their relationship. Experimental studies with pre-test/post test results using a standardized test like the Canadian Test of Cognitive Skills, where Non-gamers are subjected to game play over a considerable period of time, and a control group who are not, would better address the question of causality. An experimental study of this nature, would lend stronger support for video games as effective tools for cognitive development, than supporting the predisposition theory; that gamers cognitive skills make them predisposed to playing games. In order to evaluate the difference in the groups who chose to play video games, a repeat test comparing Gamers and Non-gamer in the Canadian Test of Cognitive skills on all levels, from grade one to adult, would also serve to evaluate if there is a difference in the cognitive skills that affect the choice of whether someone becomes a gamer or non-gamer. Further tests using verbal protocols, such as the PARI cognitive task analysis, will also contribute to our understanding of the problem solving strategies that are used in such environments, as well as evaluate if there is any merit to the assertion that video games develop problem solving skills (Doolittle, 1995; Squire 2002; Prensky, 2001).

Second, research into the design of problem-based complex environments would also help in the design and development of video games that specifically target the development of explicit cognitive skills. Complex cognitive tasks, such as iconic reasoning, sequencing, and memory, could be implemented as cognitive tools both inside and outside the classroom. These tools could also be used in education and rehabilitation medicine for individuals with cognitive impairment or brain injury.

Third, the study of video games use as a cognitive tool for self-regulated learning, metacognitive regulation, and executive control will also help in our understanding of how students regulate their learning experiences in a gaming environment. Research supports that video games may serve as an ideal environment for learning, however, there are no studies concerning video games and self-regulated learning. Our understanding of video games as a space for self-regulated learning, metacognition, and executive control would ultimately serve to better educational game design.

Fourth, cognitive neuroscience has paved the way for more testing of the physiological brain, cognition, and the effects of video games as simulated complex environments. Functions of the brain, and the differences between gamers and non-gamers, must be conducted to correlate the findings of cognitive psychology. Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography PET, electroencephalograms (EEG), event-related potentials (ERP), biofeedback, and eye tracking are a few of the new tools that can be used to study the differences in neurological development of those who have been subjected complex simulated environments such as video games.

Fifth, new tools for the exploration of complex simulation environments, such of video games, must also be developed. Current tests and tools, including verbal protocols and paper and pencil tests, do not fully accommodate the depth and complexity of these environments; as such, we can only evaluate a slice of a much larger picture. Current video games, which are too fast paced for verbal protocols, make up a majority of the most popular games that are played; however, there are no sufficient tools for their study. Cognitive systems that not only capture user eye movement, button use, biofeedback, along with artificial intelligence systems that draws relationships between these variables, must be developed to study these phenomena. As video games can are framed as complex problem solving environments, tools for the study of actions and reactions in these environments can lead to a greater understanding of real-life problem solving techniques.

Conclusion

Steven Johnson, in his book, *Everything Bad Is Good for You* (2005), asks the reader to imagine that video games were invented one hundred years ago, and that only recently had something called a book become the new fascination for children. He asks the reader to envisage what the teachers, parents, and critics would say in regards to this new medium:

> Reading books chronically underestimates the senses. Unlike the longstanding tradition of game playing—which engages the child in a vivid, three-dimensional world filled with moving images and musical sound-scapes, navigated and controlled with complex muscular

> movements—books are simply a barren string of words on the page. Only a small portion of the brain devoted to processing written language is activated during reading, while games engage the full range of the sensory and motor cortices. Books are also tragically isolating. While games have for many years engaged the young in complex social relationships with their peers, building and exploring worlds together, books force the child to sequester him or herself in a quiet space, shut off from interaction with other children. . . But perhaps the most dangerous property of these books is the fact that they follow a fixed linear path. You can't control their narratives in any fashion—you simply sit back and have the story dictated to you . . . This risks instilling a general passivity in our children, making them feel as though they're powerless to change their circumstances. Reading is not an active, participatory process; it's a submissive one. (p.19, 20)

Like music in the 1950's, television in the 1980's, and now video games, critics of gaming not only have the facts against them; they have history against them also (Economist, 2005). Rock music was seen as taboo, but is now accepted in mainstream culture; and where video games were not considered academically rigorous enough for consideration in the hallways of academia, video games are now a serious field of study and research. The study of video games as a cognitive tool, and their implications and applications in cognitive psychology, however, has yet to be fully explored. We still have no idea on what effect, if any, these complex environments have on our cognitive and physiological development. The exposure of video games on subsequent cognitive skills and behavior is noticeably lacking in research and remains speculative at best (Griffiths, 1993). The two studies of this thesis, the CTCS and the PARI cognitive task analysis, aimed to combat this current lack of evidence in research and to contribute to our understanding of video games as a cognitive tool. Although causality is not assessed in this study, the results do support that there is a difference in those who play games versus those who do not. The reasons for these differences, whether gamers are predisposed to playing games because they have these particular skills, or that development occurs as a result of playing video games, cannot be concluded.

The results of the CTCS indicate that video game players exhibit superior sequencing, non-verbal, and overall cognitive skills over non-game players. The results suggest that video games may play a part in the development and enhancement of particular cognitive skills. They also indicate that there is a significant difference in cognitive skills between those who play video games and those who do not. These findings suggest that video games may serve as an effective cognitive tool for the development of complex cognitive skills.

The PARI cognitive task analysis, though did not show a significant difference between the Gamer and Non-gamer groups in the use of cognitive strategy, it did show an evolution of cognitive strategy in both groups as they progressed in the game. From the simplistic use of general search heuristics and weak methods of problem solving in the first puzzle, to the use of goal-directed and anticipatory search in the third puzzle, both groups showed the ability to adapt and change their cognitive strategy with improved domain knowledge. The results support that video games are an important tool for the study of problem solving, metacognition, executive attention, and self-regulation.

It is in the convergence of our understanding of media, their long-term effects, and their role in cognitive development that will lead to new questions in developmental psychology. Questions concerning the applications and effects of complex environments, such as video games, on our growth and development have yet to be answered. By using video games as a possible cognitive tool, the application of these complex simulated environments will lead to exciting new possibilities for research in development, rehabilitation, and learning.

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Appendix A

Participant Informed Consent Form

Dear Participant

Thank you for your participation in this research study. Graduate research is an integral part of the University of Alberta and your participation is both important and appreciated.
The purpose of this study is (1) to identify cognitive skills that are developed by playing or by not playing video games and (2) to determine the problem solving strategies that are employed during video game play. Nicholas Zaparyniuk, B.Ed. is the primary researcher in this study and the findings of this study are to be used in thesis research in the pursuit of a Masters of Education.
The study is divided into two phases which will be completed at different times:
Phase I: participants will complete a multiple choice cognitive skills test and brief questionnaire that will take approximately 1 to 1.5 hours.
Phase II: participants will play a particular video game while discussing the choices within the game. Information from these discussions will be used to determine the problem solving strategies of the particular player. Participant's choices in the game will be video taped and discussed with the researcher after the play session. This phase will take approximately 1 to 1.5 hours.
As a participant, you are encouraged to participate in both phases of the research, but it is not mandatory. As a volunteer participant, you have the right not to participate, to withdraw from the study at any time, to opt out without penalty, and to have any collected data withdrawn from the study. As a participant, your personal identify and data will be anonymous and confidential. All research data including tests, video tapes, and notes will be kept secure by the research for a minimum of 5 years following completion of research in a bank secured safety deposit box.
All participants who complete either phase I or II of the research, or choose to opt out during the phases, will be compensated $10 dollars Canadian, upon signing a funding release.
By signing the enclosed Informed Consent Statement, you are consenting to the use of your responses in both phase I and II for individual as well as grouped data for this thesis, conference presentations, and research papers. All information gathered in the study will be anonymous and your personal information will stay confidential.
Individual scores and reports will not be available to participants, but you may request a copy of the complete research results by contacting Nicholas Zaparyniuk or Dr. T Craig Montgomerie in the Department of Educational Psychology at the University of Alberta with the contact information stated below.

Thank you again for your participation.

Name:_________________________ **Date:**____________________

Researcher (Primary Contact)	**Advisor**	**Department Chair**
Nicholas Zaparyniuk M.Ed Candidate Department of Educational Psychology 3-104 Education North University of Alberta Edmonton, AB T6G 2G5 Canada nickzap@ualberta.ca	Dr. T.C. Montgomerie Department of Educational Psychology 3-104 Education North University of Alberta Edmonton, AB T6G 2G5 Canada Craig.Montgomerie@ualberta.ca	Dr. Robert Short Department of Educational Psychology 6-102 Education North University of Alberta Edmonton, AB T6G 2G5 Canada rob.short@ualberta.ca

The plan for this study has been reviewed for its adherence to ethical guidelines and approved by the Faculties of Education and Extension Research Ethics Board (EE REB) at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Chair of the EE REB at (780) 492-3751.

Appendix B

Gamer Survey

Please take a few minutes to complete the following survey.

Personal Information

Age: _____ Gender: Male / Female

Please circle the appropriate response for the following 3 questions.

1. How many years have you been playing video games?

1-2 3-5 5-10 10-15 15-20 20+

2. How many hours each week on average do you play video games?

0-1 2-5 5-10 10-15 15-20 20-25 25+

3. How much money on average do you spend on video games and related equipment each year?

$0-100 $100-250 $250-500 $500-1000 $1000-1500 $1500-2000 $2000+

4. Please rank the following reasons you play video games from 1 to 5.
[(1) being most important (5) being least important]

______ Fun (i.e. I find video games fun)

______ Passes the time (i.e. It passes the time)

______ Competition (i.e. I like to compete)

______ Social reasons (i.e. I play them with my friends)

______ Challenge (i.e. I find them challenging)

______ Other: ____________________

5. What game system(s) do you currently own? (Check all that apply)

☐ PC/Mac ☐ PS2 ☐ PSP/PS1 ☐ XBOX ☐ Game Cube

Other: ____

6. Are you planning on buying a new gaming system when they are released?

☐ Yes ☐ No

7. Do you own a personal computer? ☐ Yes ☐ No

If yes, rank the following reasons you use your PC or Mac from 1 to 5
[(1) being most important (5) being least important]

_____School _____Play _____Social _____Information _____Work

8. How would you rank your computer proficiency?

☐ Not Proficient ☐ Somewhat Proficient ☐ Proficient ☐ Very Proficient ☐ Expert

Appendix C

Non-gamer Survey

Please take a few minutes to complete the following survey.

Personal Information
Age: _____ Gender: Male / Female

Please answer the following questions.

1. Have you ever tried to play video games? ☐ Yes ☐ No

If yes, what system did you play on: (Check all that apply)

☐ PC/Mac ☐ PS2/PS1 ☐ XBOX ☐ Game Cube ☐ Arcade

Other: ______________________________

2. Please rank the reasons why you DON'T play video games from 1 to 7.
[(1) being most likely (7) being least likely]

______ Not Fun (i.e. I don't find video games fun)

______ Waste of time (i.e. It's a waste of time)

______ Don't like competition (i.e. I don't like to compete)

______ Social reasons (i.e. I'd rather spend time with my friends/family)

______ Challenging (i.e. I don't find them challenging or find them to frustrating)

______ Money (i.e. They are too expensive)

______ Time (i.e. I don't have time)

______ Other: ______________________

3. Would you play video games if you had more time or money? ☐ Yes ☐ No

4. Do you own a personal computer? ☐ Yes ☐ No

If yes, rank the following reasons you use your PC or Mac from 1 to 5
[(1) being most important (5) being least important]

_____School _____Play _____Social _____Information _____Work

5. How would you rank your computer proficiency?

☐ Not Proficient ☐ Somewhat Proficient ☐ Proficient ☐ Very Proficient ☐ Expert

Appendix D

Research Poster

Video Game Research

Are you a Gamer?

Or

Are you someone who never plays video games?

A research study at the University of Alberta is looking at the effects of video games on problem solving and cognitive skill development and both avid gamers and non-gamers are asked to participate

Testing will take approximately 1 to 1.5 hours and all volunteers will be compensated for their participation.

For more information or to participate please contact:

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http://www.ualberta.ca/~nickzap

The plan for this study has been reviewed for its adherence to ethical guidelines and approved by the Faculties of Education and Extension Research Ethics Board (EE REB) at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Chair of the EE REB at (780) 492-3751