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Dianne Whitaker, Major Professor

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THE EFFECTS OF VIDEO GAME PLAYING ON ACADEMIC TASK PERFORMANCE AND BRAIN WAVE ACTIVITY

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Christine Vaupel

May 2002

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DEDICATION

This work is dedicated to my husband, Paul Vaupel, whose support has been unwavering and to all the people in my life who have inspired me to excel.

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ABSTRACT

The purpose of this investigation was to examine whether playing video games affected children's ability to perform certain cognitive functions. Thirty middle school students 10 to 14 years old who played video games in their leisure time participated in this controlled study. Restricted measures of math performance, memory, attention and planning, reading rate and comprehension, as well as beta and theta activity in the brain were collected as pre- and post-test measures. Participants were randomly assigned to either the experimental or control group. Participants in the experimental group played video games for one hour, while participants in the control group played card or board games for one hour. Multivariate analysis of variance (MANOVA) procedures were used to analyze pre- and post-test mean differences between groups for all variables. No significant differences were noted. When this sample of middle school aged children engaged in video game play with mildly rated (E for Everyone) recreational video games without blood, gore, and carnage for a limited time (60 minutes), brain wave activity and ability to perform certain academic tasks did not appear to be disrupted. Practical applications of the study are discussed.

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CHAPTER I

INTRODUCTION

Background

A recent study by the National Association of Secondary-School Principals (NASSP), which surveyed 1,000 students aged 13 to 17, found that 70 percent of boys and nearly 30 percent of girls spend time playing video games (1996). Students reporting on "hobbies" preferred only music, sports/fitness, and movies above video game play (Appendix A-1). Among students participating in non-school activities, twice as many on average played video games as played musical instruments (Appendix A-2).

Boys were nine times more likely to play video games than to participate in volunteer work; two times as many girls played video games as volunteered. These findings are consistent with a previous study, that showed an interest differing along gender lines (Griffiths, 1991). A 1993 study showed 90 percent of boys played video games

4.2 hours a week on average, while nearly two-thirds of girls played video games an estimated two hours a week on average (Funk, 1993).

Because children spend much of their time in school, time spent playing games must be after school, often prior to attempting homework in the evenings, or on the weekends. Researchers have investigated the possible benefits and therapeutic value of video game playing, as well as negative effects, such as aggression and addiction (Dorman, 1997; Emes, 1997; Griffiths, 1997; Funk, 1993).

Little research has been done, however, regarding the cognitive impact of video games on children and the effects of video game playing on academic task performance. Researchers have found that as school performance increased, the likelihood of video game machine ownership decreased, but this factor could be related to the fact that parents who were most concerned about their children's grades may have disallowed video game machines (Emes, 1997; Welch, 1995).

Technological advancements are moving at a rapid speed. The video game industry has kept pace with these developments, with new systems emerging almost annually offering enhanced virtual reality and more complex challenges. In the case of video games, many of the players are young students. Few have stopped to examine what effects these innovations have on the academic task performance of those who

play. Since 70 percent of boys and nearly 30 percent of girls play video games, it is important to determine the effects of electronic game play on adolescents.

Summary of Literature

There are two fundamental ways to investigate the effects of video game play: immediate, those effects noted directly after video game play; or long-term, those effects noted as cumulative effects. Currently, neither approach has a strong base of research in the literature.

A study of seventh- and eighth- graders found that 66 percent of girls played video games two hours per week, compared to 90 percent of boys who played video games 4.2 hours per week (Funk, 1993). In a self-reported survey of 2,200 third and fourth graders, 33 percent of boys indicated they played video games, and 9.7 percent of the girls responded they played video games (Harrell, Gansky, Bradley, and McMurray, 1997). Buchman and Funk (1996) found that boys who played video games generally spent twice as much time playing as girls who played. Overall, time spent playing video games was highest in the fourth grade and steadily declined through middle school.

Action, entertainment, and escape have been sited as the essential reasons for video game play (Selnow, 1984). Only two

percent of children surveyed preferred educational games (Funk, 1993). Nearly fifty percent of the students surveyed preferred video games with violent themes, followed closely by sports and general entertainment games (Funk, 1993). By middle school, girls showed favored video games with fantasy violence, while boys preferred video games with human violence (Buchman and Funk, 1996).

A meta-analysis of articles listed in MEDLINE and PSYCHINFO from 1966 to 1996 revealed inconsistent findings on the roles and effects of video games and called for long-term studies, especially pertaining to physical effects (Ermes, 1997). Dorman (1997) states that video games appear to be associated with a variety of physical effects including, seizures increased heart rate, tendinitis, pathological preoccupation with video games, and aggression.

Used as an ice breaker/rapport builder activity for therapy or in conjunction with behavior management, video games provide opportunities for behavioral observations (Gardner 1991; Spence 1988; Samoilvich, Riccitelli, Scheil, and Siedi, 1992). Video games have been found to be helpful in distracting children preoccupied with nausea during chemotherapy, chronic pain, or scar picking (Redd, Jacobsen, DieTrill, Dermatis, McEvoy, and Holland, 1987; Vasterling, Jenkins, Tope, and Burish, 1993; Pegelow, 1992; Phillips, 1991).

Increases in scanning and tracking ability in patients with attentional difficulties (Larose, Gagnon, Ferland, and Pepin, 1989) and increases in arm range of motion in traumatic brain injury patients (Siestman, Nelson, Mulder, Mervau-Scheidel, and White, 1993) have also been noted.

No direct link has been found between academic performance and video game playing. Most of the existing studies are based on the students' overall grades or teacher ratings (Lins and Lepper, 1987; Creasy and Myers, 1986; Harris and Williams, 1985; Dominick, 1984) and not on a variety of individual task performances.

Purpose

The purpose of this study was to investigate whether or not playing video games affected children's ability to perform certain cognitive functions as measured by psychometric instruments or a change in beta or theta brain wave activity. Restricted measures of math performance, memory, attention and planning, reading rate and comprehension, as well as beta and theta activity in the brain were collected and analyzed. This study examined the extent to which immediate effects occur between participants who played video games and participants who played board games.

Summary of Methodology

This controlled study examined the effects of video game playing on participant's math skills, memory, attention and planning, reading rate and comprehension, as well as beta and theta activity in the brain. Thirty middle school students ranging in age from 10 to 14 years participated in this study. All of them played video games in their leisure time. Participants were solicited from two area schools though fliers and personal contacts of the researchers. When the participant arrived at the research site, he or she was randomly assigned to either the experimental or control group. The data is archival in that it was collected prior to the approval of the dissertation proposal; however, I was directly involved in submitting the human subjects forms and in collection of all data.

A research assistant was assigned to follow the participant for the entire video game study. The term *video game study* refers to the study as a whole, beginning with the first pre-test measure and ending with the final post-test measure. Individual tests within the study are referred to by the specific test's name.

The Autogenics A-620 Assessment was used as a pre- and post-measure of beta and theta wave production for each participant. The psychoeducational test battery lasted approximately 20 minutes and

included: the Math Subtest from Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R Achievement; Woodcock and Johnson, 1989), Digit Span Forward and Backward Subtest from the Wechsler Intelligence Scale for Children—Revised Edition (WISC—R; Wechsler, 1986), Part B from Trail Making Test (TMT; Army Individual Test Battery, 1944), Random Shapes Cancellation Test (Mesulam, 1985a), and Graded Reading Passages Test (Stieglitz, 1997).

Once both the A620 Assessment and the psychoeducational battery were completed, participants in the control group played card or board games of their choice for one hour, while the participants in the experimental group played a video game(s) of their choice for one hour. The board game area for the control group was set up with minimum supervision and was intended to create a relaxed environment for the participants, similar to just "hanging out." Several research assistants remained in the room to monitor the activity and participate in the games if they were asked. The atmosphere was entertaining rather than competitive. Three or four short board or card games where usually completed within the 60-minute time frame. The participants were served refreshments and allowed to freely interact with one another.

In the video game play room, experimental group participants could chose to play either the Mario Kart 64™ or NFL Blitz™ video game, in a controlled environment. Once the hour was completed, the participants again completed the psychoeducational battery and A620 Assessment as post-tests measures. Both control and experimental group participants were given all pre- and post-assessments.

Summary of Results

Results were assessed using a general linear model (GLM) multivariant analysis of variance (MANOVA) in SPSS for windows. An analysis of the ability to perform academic tasks requiring math reasoning and calculation, memory, attention and planning, and reading comprehension in the pre- and post- experimental and control conditions were assessed for statistically significant differences. The data were broken into three categories for multivariate analysis: tests with alternate form measures for pre- and post-testing, tests with identical measures for pre- and post-testing, and beta- and theta-wave data. Each of the three categories was analyzed according to group, experimental or control, for differences between groups. No statistically significant differences were noted.

Conclusions and Recommendations

Video game play is a high interest activity for adolescents, especially boys. When middle school-aged children engage in video game play with mildly rated (E for Everyone) recreational video games without blood, gore, and carnage, such as Mario Kart 64™ or NFL Blitz™, for a limited time (60 minutes), ability to perform certain academic tasks does not appear to be disrupted.

Further research is needed to study the long- and short-term effects of video game play. Because so many students play video games, it is important to determine what, if any, effects playing has on those who participate, particularly in relation to academic task performance and brain wave activity. In order to examine long-term effects, a longitudinal study is needed to examine over time children who play video games. Short-term effects need to be studied using larger samples, evenly distributed socio-economic status groups, gender comparisons, special populations, and games rated E for Everyone versus games rated with higher ratings, such as T for Teen or M for Mature.

CHAPTER II

LITERATURE REVIEW

Investigation of the effects of video game play can be separated into two basic categories: immediate, those effects noted directly after video game play, or long-term, those effects noted as cumulative effects. Relative to an academic setting, long-term effects might include such things as changes in grades; whereas, immediate effects might include such things as temporary changes in reading or math speed or accuracy. However, this distinction is artificial because long-term effects may also be seen as an immediate effect in a different form.

Another difficulty with studying the long-term effects of video games is the complexity of ruling out other causes for the effects, such as changes in family life, motivation, and various extraneous factors. Currently, neither approach has a strong fund of research in the literature. Much of the existing literature on video games deals with long-term aspects, such as usage, preferences, and the impact of video games on violent behavior. Fewer studies have been published,

however, on video game play as it relates to children's academic performance, and all of these look at characteristics of the long-term effects of video games. In this section, an overview of video game play is presented.

Video Game Play

Evolution of the game

From the advent of video games in the 1970s, technology has continuously evolved. Since the introduction of Pong™ in 1973, improvements in video games have occurred at a tremendous speed. In the late 1980s, Nintendo revitalized the industry by offering enhanced graphics and multi-task games.

These technological improvements by video game producers, which include enhanced memory capabilities, have benefited both computer games and games for dedicated systems. Many games are now created for both computers and dedicated systems (Buchman and Funk, 1996). In the past, studies separated computer games from video games, but the literature now merges them into one category.

Types of video games

The Entertainment Software Rating Board (ESRB), an independent board of professionals established by the Interactive

Digital Software Association (IDSA), formed in September 1994. The ESRB compiled a standardized and voluntary rating system for video games to give parents and consumers a better opportunity to make informed rental and purchasing decisions. In the ESRB system, three randomly chosen, trained raters separately assess the content of each video game frame by frame and enter the data into a computer program. The program calculates the information for the review of an ESRB member, who ultimately selects the video game's final rating.

The current ESRB ratings symbols include Early Childhood (EC), Everyone (E), Teen (T), Mature (M), Adults Only (AO), and Rating Pending (RP) (Appendix B-1). Once established, the rating is displayed on the front of the video game box in the lower right or left-hand corner. Size and placement of the rating symbol are determined according to strict industry standards. The ESRB also provides content descriptors that give more detailed information regarding the violence, language, and other content (Appendix B-2). Content descriptors are located on the back of the video game box in the lower right or left-hand corner (Entertainment Software Rating Board, 1998).

Prior to the ESRB's standardized ratings, researchers had to formulate their own video game ratings. In a study published in Clinical Pediatrics (Funk, 1993), 357 middle-class middle school

students were surveyed about their video game playing preferences and asked to name two to three of their favorite video games. Based on the responses, the researcher created five categories for coding purposes: sports (SP), general entertainment (GE), educational (ED), fantasy violence (FV), and human violence (HV). Twelve students ages 8 to 17, who were not involved in the survey, then classified each of the 211 games listed in the survey into the appropriate category.

Time commitment

In a self-reported survey of 2,200 third and fourth graders (Harrell et al., 1997), 21 percent listed video games as a leisure activity, based on an average of boys and girls ratings. The activity ranked fourth behind homework (31 percent), bicycling (31 percent), and watching television (29 percent). Of the boys surveyed, 33 percent played video games, compared to 9.7 percent of the girls surveyed. In contrast, 38.9 percent of girls surveyed spent leisure time completing homework, compared to 23.3 percent of boys.

A four-year study of 900 children in the fourth through the eighth grade 52 (Buchman and Funk, 1996) was conducted to look at time commitment to video game play. Results indicated that average hours of video game play per week for boys were as follows: fourth grade, 9.44; fifth grade, 8.23; sixth grade, 6.89; seventh grade, 6.15;

eighth grade 4.97. Results for the girls indicated that average hours of video game play per week were as follows: fourth grade, 5.67; fifth grade, 3.96; sixth grade, 3.18; seventh grade, 2.25; eighth grade 2.52. For both boys and girls, time spent playing video games was the highest in the fourth grade and gradually decreased over time through middle school. When compared at the same grade level, boys who played video games almost always spent twice as much time behind the video controller as girls who played.

An earlier survey by Funk (1993) involving 357 middle-class middle school students found similar proportion; 66 percent of girls spent about two hours per week playing video games, while 90 percent of boys spent an average of 4.2 hours per week. However, because 15 percent of the described students played video games in excess of 15 hours a week, group averages may not have been a sensitive measure of actual time spent.

Reasons for play

Research has been devoted to investigating what children enjoy about video games and why they play. Games need to include challenge, fantasy, and curiosity (Malone, 1981). In 1983, video game playing was mostly a recreational activity (Lieberman, Chaffee, and

Roberts, 1988). A more recent study showed that only two percent of children surveyed preferred educational games (Funk, 1993).

Selnow found action, entertainment, and escape primary reasons for video game play (1984). In a survey of 152 high school students, the participants' reasons for play included excitement (51%), having nothing better to do (37%), being good at it (24%), having friends that play (22%), finding games cheered them up (20%), and other reasons (15%) (Harris and Williams, 1985).

Video game preferences

In Funk's (1993) study involving 357 middle-class middle school students, nearly fifty percent of the students preferred games with violent themes (31.9 percent fantasy [cartoon] violence; 17.0 percent human violence). Sports games trailed at 29.4 percent, and general entertainment at 19.7 percent, while only 2 percent preferred educational games. Strutz interviewed 500 adolescents in England and found that games with fighting were the unanimous favorites (Gill, 1996).

When Buchman and Funk (1996) looked at grade and gender differences in game preference in their four-year study of 900 children in the fourth through the eighth grade, they found violent games were preferred by 50 percent of the children across grades. By middle

school, girls showed high interest in video games with fantasy violence, while boys indicated a keen interest in video games with human violence.

Across the grades, boys indicated approximately 40 percent of their favorite games as sports games. In contrast, the younger girls indicated more interest in sports games (25 percent) than the older girls (14 percent). In the fourth grade, 14 percent of girls and six percent of boys preferred general entertainment games. These percentages increased to 30 percent of girls and 14 percent of boys in the eighth grade. Girls were much more likely to play educational games, especially in the younger grades (18 percent); however, by the eighth grade, the girls' preference for educational games dropped to six percent and boys to 0.5 percent (Buchman and Funk, 1996).

Physical effects

Data from a meta-analysis of articles listed in MEDLINE and PSYCHINFO from 1966 to 1996 shows a need for long-term studies due to inconsistent findings on the roles and effects of video games. This review of the literature also indicates that video games appear to be associated with a variety of physical effects including, but not limited to "increased metabolic and heart rate, seizures, and tendinitis" (Ermes, 1997, p. 409).

One of the earliest studies focusing on the physiological reactions to video game playing resulted in researchers finding significant increases in heart rate and blood pressure for 23 young adult males, with the highest increases in novice players (Gwinup, Haw, and Elias, 1983). Significantly increased heart rate and blood pressure measurements were found in a study involving 213 healthy Black and White children from six to eighteen years of age (Murphy, Alper, Moes, and Somes, 1986) and in diastolic blood pressure and heart rate in middle school-aged children (Matthews, Rakacky, Stoney, and Manuck, 1987). The heart rate, oxygen consumption, and blood pressure of 32 participants were measured during 30 minutes of video game play and compared to the participant's standing, inactive measurements (Segal and Dietz, 1991). Significant increases in heart rate, oxygen consumption, and blood pressure were noted. Thus there is strong evidence that video game playing tends to increase heart rate, blood pressure and oxygen consumption.

Effects of video game play have also been noted in seizures. Graf, Chatrian, Glass, and Knauss (1994) found 35 cases of video game-induced epilepsy. However, 29 percent of these patients had suffered earlier seizures unrelated to video games. Trenite (1994) estimated 50 documented cases of video game-induced seizures.

Similar to Graf's findings, 33 percent of Trenite's cases had suffered earlier seizures unrelated to video games. Recommendations for video game-induced seizures include: using 100 Hz television screens (compared to standard 50 Hz sets), increasing distance from the television screen, game abstinence, and anticonvulsant drugs (Badinand-Hubert et al., 1998; Dorman, 1997; Ermes, 1997; Graf et al., 1994; Maeda et al., 1990).

Overall, the numbers for video game-induced seizures remain relatively low. Some seizures appear to be caused by photosensitivity to flashing light (Ferrie, DeMarco, Grunenwald, Giannakodimos, and Panayiotopoulous, 1994). The generally accepted theory is that "convulsive susceptibility in striate, peristriate, infratemporal, and posterior parietal cortices to particular visual stimuli was responsible for the seizures" (Ermes, 1997, p. 410). Takahashi and colleagues report a case of nonphotosentitive video game-induced partial seizures in which the seizures were consistently elicited during play, especially in high concentration times; they postulated that " . . .seizure induction was at least in part causally related to higher brain functions and not just to visual reflex factors" (Takahashi et al., 1995, p. 840). A 1998 study of 115 epileptic French subjects found that the

nonphotosentitive group (n=40) did not present with video game-induced seizures (Badinand-Hubert et al., 1998).

Brasington (1990) reported a case of nintendinitis, acute pain within the extensor tendon of the thumb generated by repetitive pressing of a video game button; the injury self-corrected with treatment of ibuprofen and game abstinence for several days. Dorman (1997) has concurred with these effects and appended pathological preoccupation with video games and aggression to the list of potential video game effects on children.

Uses of video games

Video games are often used as an ice breaker/rapport builder activity for therapy and behavior management (Gardner, 1991; Spence, 1988). The games provide common ground and excellent opportunities for behavioral observations (Gardner, 1991). Samoilvich et al. (1992) believe video games can be useful tools for motivation and rewards as well as for behavioral observations in schizophrenic patients.

Video games have been helpful interventions in distracting children preoccupied with nausea during chemotherapy, chronic pain, or scar picking (Redd et al., 1897; Vasterling et al., 1993; Pegelow, 1992; Phillips, 1991). Among 60 participants with attentional difficulties, improved scanning and tracking was noted in the

experimental group treated with video game time (Larose et al., 1989). Game playing has been credited with significant increases in arm range of motion for 20 participants with traumatic brain injury (Siestman et al., 1993).

Academic performance

No direct link has been found between academic performance and video game playing, and video game study findings have been "limited and mixed" (Ermes, 1997, p. 413). Most of the existing studies are based on the students' overall grades or teacher ratings (Lins and Lepper, 1987; Creasy and Myers, 1986; Harris and Williams, 1985; Dominick, 1984) and not on a variety of individual task performances.

Harris and Williams (1985) surveyed 152 high school students who played video games; 74 percent said playing had no effect on grades, 21 percent said they believed grades were worse, and five percent said grades improved. Regarding their own grades, however, 90 percent of players said their grades had not changed since they started playing. However, both time and money spent on video games correlated negatively with English grades.

In looking at a sample of 234 fourth through sixth graders, a slight negative correlation between teacher's ratings of general

academic performance and math ability with arcade game use in boys was noted (Lins and Lepper, 1987). New video game ownership was not found to effect homework habits of children's or their grades in English or math (Creasy and Myers, 1986).

Brain wave activity

Beta (14-26 Hz fast wave) activity is rhythmic and occurs during mental alertness and during concentration, particularly in the presence of visual stimuli or problems; theta (4-7 Hz slow wave) activity, "considered abnormal in adults who are wake," occurs at a slower rate and is more irregular (Marieb, 1998, p. 526). One of the earliest studies (Rebert, Low, and Larsen, 1984) involved 14 participants playing the video game Pong™. Participants' brain wave activity at rest and during a reading task was compared to brain wave activity during video game play. Significant increases in theta were found during video game play.

Mann, Lubar, Zimmerman, Miller, and Muenchen (1992) found mental alertness and increased concentration was associated with beta activity, while the production of theta activity was associated with daydreaming and the inability to attend. Differences were illustrated in beta and theta waves by examining Quantitative Electroencephalograhic (QEEG) brain mapping. Their study compared

boys with ADHD to boys without ADHD. Increases in theta activity and decreases beta activity was found in boys with ADHD.

In a Japanese study involving 10 children aged 8 to 12 years, frontal midline theta was found to increase significantly both during and after video game play on the Nintendo game Super Mario 3™, while eyeblinking rate decreased significantly. Yamada (1998) concluded that theta and blinking inhibition "appear to be good indices of attention concentration" (p. 678). In a small study involving eight adult males, Koepp and colleagues (1998) found some evidence of striatal dopamine release during video game play.

Summary

Video games have both immediate and long-term effects on players, and these effects are interrelated. Improvements in technology have merged computer and video games, and the advancements generate increasingly better quality, creating a new realm of possible effects. The ESRB, an independent board that evaluates video games according to content, issues standard industry ratings for each game. Among students in the third through the eight grades, video game play ranked high on leisure activities and boys played considerable more than girls.

Most children who play video games participate for recreational or entertainment reasons, as well as an escape from routine tasks. The majority of children prefer games with violent or sport themes, with those preferring educational games in the minority. Video games have been show to affect a player's cardiovascular system, and games may be one of several factors contributing to seizures in a small number of sensitive players.

Possible uses of video games include rapport building in therapy, motivation and reward, and distraction from pain or treatment. In spite of the increased interest in video game playing, current studies look at the effect of video game playing on grades and not individual academic task performance such as reading or math skills. The few small studies that correlated beta and theta wave production and video game play found theta increased during and after video game play.

CHAPTER III

METHODS

Research Participants

Participants were 30 middle school-aged male and female children who played video games in their leisure time. Advertisements with details about the video game study were distributed in two Tennessee schools: one suburban school in Knox County and one rural school in Blount County. The researchers traveled to the school sites to explain the study and distribute fliers. A few children were referrals from personal or professional acquaintances of the researchers. No attempt was made to discriminate based on gender, ethnicity, or physical and/or mental abnormalities.

The parent or guardian of each participant self-reported on the Parent Questionnaire who the child was currently living with, family socioeconomic status (SES), and any relevant diagnoses, such as learning disabilities (Appendix C-1). Fifteen participants were assigned randomly to both the experimental and control groups.

The sample consisted of approximately two-thirds males (n=21) and one-third females (n=9) ages 10 to 14 (mean age, 12 years; standard deviation, 11 months). The participants were predominantly white as only one minority student (African-American) signed up for the study. Of the thirty participants, eight indicated a special education diagnosis. Five parents identified their child as Attention-Deficit Hyperactivity Disorder (ADHD), and three parents indicated their child had learning disabilities. See Table I for demographic information.

Other Participants

At the beginning of each academic school year the Educational Psychology Department in the College of Education at The University of Tennessee, Knoxville develops research groups comprised of faculty members and students. One research group initiated this study of the effects of video game playing on academic task performance of middle school-aged. These graduate research students and their professor partnered with graduate lab assistants from the Neuropsychology Laboratory at The University of Tennessee to collect the data.

TABLE I. Characteristics of Participants*

	EXPERIMENTAL	CONTROL
Male	11	10
Female	4	5
White	15	14
Black	0	1
ADHD	3	2
Learning Disabled	1	2
10 years of age	0	1
11 years of age	3	3
12 years of age	6	7
13 years of age	5	3
14 years of age	1	1
Household SES <$20,000	0	1
Household SES $20-$40,000	6	4
Household SES $40-$60,000	5	1
Household SES >$60,00	3	5

*Three parents from the control group, and one parent from the experimental group did not turn in a Parent Questionnaire.

This study assumed the following:

1. The participants were honest and accurate in their performance on pre- and post-tests.
2. The participant's parent or guardian responses to the parent questionnaire were honest and accurate.
3. The researchers were honest and accurate in their record and scoring of the tests.
4. The experimental equipment was sophisticated enough to identify differences in beta and theta wave patterns.

Definition of Terms

Autogenics A620: The single channel EEG equipment used in this study consisted of the Autogenics A620 hardware and software programs.

Beta: The brain's electrical activity in the range of 13 and 25 Hz.

Connection: The researcher applied conducting gel around the electrodes to establish and improve the electrode connection. An impedance meter was used to determine that minimal interference existed between the scalp and the electrode. When the impedance check was satisfactory, the connection was complete.

CZ: A placement on top of the head, using the International 10-20 system for electrode placement.

Electrode: Small circular device placed directly on the scalp and connected by wires to monitoring equipment which picks up the electrical activity generated by the brain (Grass Instruments).

Electroencephalogram (EEG): An instrument that measures potential differences in electrical activity of the brain.

Elefix®: A conductive cream (Weaver and Co.).

Hertz (Hz): A frequency unit with a cycle equaling one second.

Impedance Meter: A handheld device that examines the connection of the electrode to the scalp and allows the examiner to adjust connection to reduce interference.

Omniprep®: A clear solution that removes skin oil and allows for good sensor contact (Grass Instruments).

Theta: The brain's electrical activity in the range of 4 and 7 Hz.

Materials

The psychoeducational test battery lasted approximately 20 minutes and included: the Math Subtest from Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R Achievement; Woodcock and Johnson, 1989), Digit Span Forward and Backward Subtest from the Wechsler Intelligence Scale for Children—Revised Edition

(WISC—R; Wechsler, 1986), Part B from Trail Making Test (TMT; Army Individual Test Battery, 1944), Random Shapes Cancellation Test (Mesulam, 1985a), and Graded Reading Passages Test (Stieglitz, 1997). See Appendix D for video game research format.

The specific psychoeducational tests chosen measured a variety of areas related to schoolwork a student would normally use in the classroom or at home as homework. Specific areas chosen to test were math and reading skills, short-term auditory memory, attention and planning. The Autogenics A620 was chosen to measure beta and theta activity in the brain. Some research has indicated that theta increases during and after video game play.

The Math Subtest from Woodcock-Johnson Psycho-Educational Battery-Revised was selected to measure school math skills. The Digit Span Forward Subtest measures immediate auditory memory, while the Digit Span Backward Subtest measures immediate/representational memory. The Digit Span Subtest was from the Wechsler Intelligence Scale for Children—Revised Edition. Stieglitz's Graded Reading Passages Test was used to measure reading rate and comprehension. To avoid a "frustrational" (that is, above the student's level) reading level, prior to the reading task a word list was used to place the

participant at a reading level that would be used in the classroom for instruction.

The TMT Part B was chosen as a measure of attention and planning. Improvements are usually noted on TMT Part A and Part B when subjects are retested; group variances for Part B are generally large (Bornstein, Baker, and Douglas, 1987; Leininger, Gramling, and Farrell, 1990). Believed to be in part a measure of frontal lobe activation and concentration (Segalowitz, Unsal, and Dywan, 1992), TMT appears "to tap some aspect of perceptual-motor speed and could be designated as measuring the *focusing* aspect of attention" (Mirsky, 1989, p. 78).

Reitan's method in which the examiner points out each error to the participant so the task can be completed correctly is most commonly used scoring technique and is based on time alone (Lezak, 1995). Test norms are available are primarily available for adults (D'Elia, Boone, and Mitrushina, 1995; Heaton, Grant, and Matthews, 1991; Stuss, Stehem, and Poirier, 1987), and children ages 8 to 15 (Spreen and Stauss, 1991).

Used on diverse groups of subjects and in conjunction with other clinical measures and observations, TMT appears to be sensitive to diagnosis of mild traumatic brain injury (Leininger et al., 1990;

Stuss, Stethem, Hugenholtz, and Richard, 1989), to decline in dementia (Greenlief, Margolis, and Erker, 1985; Botwinick, Storandt, Berg, and Boland, 1988), and to prediction of outcome for moderately to severely brain injured patients (Acker and Davis, 1989). Schizophrenic and depressed patients have also been studied, although the results have been not significant.

The Mesulam's Random Shapes Cancellation Test was chosen as a measure of attention. In 1985, Mesulam published a set of four cancellation tasks, two verbal and two nonverbal. Each verbal and nonverbal task had 374 items arranged randomly and in columns and rows. The verbal tasks consist of alphabetic letters, while the nonverbal tasks consist of various shaded and open shapes. The target for the verbal tasks in the letter "A" and the target for the nonverbal tasks is an open circle with a line slanted toward the right.

Paper and pencil cancellation tasks "assess many functions, not least of which is the capacity for sustained attention. Visual scanning, and activation, and inhibition rapid responses, are also necessary" (Lezak, 1995, p. 354). Individuals without legions generally work systematically left to right, while patients having right-sided legions are inclined to start in the center or the right side of the page and then move around randomly (Mesulam, 1985b). Patients with left-sided

legions are inclined to work from left to right, rarely miss right-sided targets, but differ from intact persons by detecting shapes faster than letters (Lezak, 1995). Although the test is often used to measure right- or left-sided neglect, for the purposes of this study no attempt was made to measure neglect. More inattention errors appear when targets are placed randomly than when targets are ordered, and the shapes produce more errors than the letters (Lezak, 1995).

Alternate forms (i.e., Form A and Form B) were used to counterbalance pre- and post-test measures of the Math Subtest, Digit Span Forward and Backward Subtest, and Graded Reading Passages Test. Each participant was allocated a color-coded file folder (yellow for experimental; green for control) with organized protocols. Two pencils, several blank sheets of paper, and a stopwatch were used for the psychoeducational battery.

Two Autogenics A620 Assessment machines were employed to record beta and theta activity in the brain. The international 10-20 chart was used to locate the CZ electrode placement on top of the head. To facilitate a connection and enable the electrode to pick up the electrical activity generated by the brain, Elefix® cream was applied between the scalp and the electrode. An impedance meter was used to check the electrode connection and reduce interference.

Omniprep® solution was applied to the ear lobes to remove skin oil before a clip electrode was attached.

Two Nintendo 64 video game systems were connected to television monitors and set up in separate rooms. Two video games were used: Mario Kart 64™ or NFL Blitz™. Various games were used for the control group including: cards, checkers, chess, Sorry®, Payday®, Uno®, and Yahtzee®. Snacks were provided for all participants. Fliers announcing the study detailed information regarding where and when the study would be held, age limits for participants, and contact names and phone numbers.

Procedures

The researchers traveled to two school sites to promote the study and dispense video game fliers. Interested students then called a contact person listed on the flier, who explained the study and verified that the parent and child understood the study. The student was assigned a date, time, and place to report for the study.

Data were collected on four separate occasions. Initial data were collected at the Neuropsychology Laboratory at The University of Tennessee, Knoxville where on Monday, December 21, 1998, thirteen children were assessed and on Saturday, February 13, 1999 two children were assessed. On Friday, March 12, fifteen children were

assessed at Montvale Elementary School in Maryville, Tennessee. An equivalent number of control and experimental participants were assessed at each site.

When the participant's parent(s) brought the participant to the research site, the study was explained again to the parents and the child. The benefits of the study were described as a contribution to the understanding of how video game playing effects children's ability to perform academic tasks. The physical or psychological risks to participants were described as minimal to none. The parents and child were informed that the procedures used in the study had been used in previous studies, and posed no risk to the participants. The parents and child were advised that group or numbered data would be presented in the future.

The child was then randomly assigned to a control or experimental group. Each child was assigned a number that was the only identifier for all materials. The parents were given time to read the informed consent (Appendix E-1). Opportunities for the parents and child to ask questions ensued. After the parents had signed the informed consent form, the child's assent form was read to the child, and the child again was encouraged to ask questions (Appendix E-2).

Signatures were obtained from both the parent and the child before any testing or questionnaires were given.

Once the consent and assent forms were signed, the parent or guardian was asked to complete a ten-minute Parent Questionnaire concerning their child's video game routine and school performance (Appendix C-1). The child was asked to complete the Student Questionnaire (Appendix C-2). Once the questionnaires were complete, the parent was free to go and instructed to return in approximately four hours.

The participant was assigned a research assistant to monitor the child throughout the day, administer the psychoeducational pre- and post-tests, and ensure that all tasks were completed in an accurate and timely manner. The research assistant was aware of whether the participant was assigned to the control or experimental group; however, the participant was not aware of group membership. The primary object of the research assistant during testing conditions was to ensure that treatment validity was not compromised. This included administering the tests appropriately and recording accurate scores, keeping the participant on-task during the pre- and post-test assessment, watching the participant to verify on task behavior during the 60-minute video game play time, and/or engaging in board game

play when assigned to a control participant. Once the child was assigned a research assistant, pre-test conditions commenced.

Several instruments were used to look for a difference in pre- and post-test performance. These tests were divided into a psychoeducational test battery and the Autogentics A620 Assessment software. The psychoeducational test battery including— Trail Making Test, Digit Span Forward and Backward, Random Shapes Cancellation Test, Math Test, and Graded Reading Passages Test.

The psychoeducational test battery and A620 Assessment software were randomly assigned in the pre-test so that approximately half of the experimental group received the A620 Assessment software testing first, followed immediately by the psychoeducational test battery. The remaining half received the psychoeducational test battery first, followed immediately by the A620 Assessment software testing. Likewise, half of the control group received the A620 Assessment software testing first, followed immediately by the psychoeducational test battery.

The post-test conditions were arranged in the same manner. Because the participants were selected randomly to begin the post-test with the psychoeducational test battery or A620 Assessment software, participants who began the pre-test condition with the

psychoeducational test battery did not necessarily begin the post-test condition with psychoeducational test battery.

The A620 Assessment

The participant was seated comfortably in a chair in a quiet room for the beta and theta collection. The A620 Assessment software evaluation required two earclip electrodes be placed on each earlobe after a light cleaning with Omniprep® solution, which removes skin oil and allows for good sensor contact. Attachments were made using an electrode and Elefix® conductive cream. A third electrode was placed on top of the head at CZ (using the International 10-20 system for electrode placement). Participants were shown ways to reduce muscle tension and eye movements.

There was no significant discomfort with this procedure, either in the preparation or the wearing of the electrode during testing. Because of the time involved in attaching the electrode to the top of the head, it was secured and left in place throughout the 60-minute experimental or control condition until the post-assessment. Following the post-assessment, the electrode was removed, and the electrode gels, which are similar to hair mousse, were wiped off with a tissue or paper towel and water. All creams and gels used during this evaluation were hypoallergenic, with no known risk of irritation. The A620

Assessment instrumentation was used to record beta and theta brain wave activity during two successive phases: eyes open and reading.

The psychoeducational test battery

The psychoeducational test battery for each child included the Trail Making Test Part B, Digit Span Forward and Backward Form A or B, the Random Shapes Cancellation Test, the Math subtest Form A or B, Graded Reading Passages Test Form B or D, and Words per Minute. A reading list was used to determine reading level so that the participant would not be reading at a level that caused frustration.

In order to help control for practice effects, the psychoeducational battery included alternate forms that were equivalent, but not identical that were administered in the pre- and post-test conditions. These forms were counter-balanced so that half of the control and half of the experimental participants had the primary form in the pre-test assessment and the alternate form in the post-test assessment. The remaining half of the control and experimental participants were given the alternate form in the pre-test assessment and the primary form in the post-test assessment.

Alternate forms for the Digit Span Forward and Backward subtest, were created using the first item sequence of each number on the WISC-R Digit Span for Form A and the second item sequence of

each number for Form B. For the math achievement assessment, items 11 through 54 from the WJ-R Achievement math subtest were utilized. The existing Form A and Form B were used as alternate forms. Identical tests were given in the pre- and post-test conditions for the Part B of the Trail Making Test and Mesulam's Random Shapes Cancellation Test.

Once the research assistant and the participant were seated alone at a table in a closed room free from distractions, the psychoeducational battery testing began. The first test given was Part B of the Trail Making Test. The research assistant placed the sample item in front of the participant and explained the object of the test was to connect a number, then a letter, then a number, then a letter, and so on, in a hierarchical way (i.e., 1-A-2-B-3-C-4-D).

The participant was then asked to complete the short sample item on the paper. If the participant did not understand the instructions, the research assistant explained the task until the participant demonstrated knowledge of the directions. When the participant correctly completed the sample, the research assistant instructed the participant that when the paper was turned over the participant was to work the task as quickly as possible without making errors. The research assistant showed the participant where the

beginning and ending points were and began timing. The participant was given two minutes to complete the task. If the participant made an error, the research assistant corrected the first error, but did not correct any following errors. The participant was requested to stop the task at the conclusion of two minutes.

Formerly a subtest of the Army Individual Test Battery (1994), the Trail Making Test (TMT) now resides in the public domain. Consisting of two trials, Part A and Part B, the TMT focuses on attention, concentration, and tracking. In Part A, similar to a connect-the-dot worksheet, the participant is instructed to draw lines to connect consecutively numbered circles. In Part B, the participant is instructed to draw lines to connect consecutively numbered and lettered circles in an alternate fashion. On both trials, the participant is given a brief sample exercise before the timed exercise is begun. The participant is asked to complete the task as quickly as possible without making mistakes or lifting the pencil from the paper.

The second test in the battery was Digit Span Forward and Backward. The examiner read the directions from the WISC-R Digit Span for digits forward to the participant and then proceeded to administer either Form A or Form B of the Digit Span Forward subtest beginning with the first item. A ceiling was reached when the

participant failed two consecutive items. Next the examiner read the directions from the WISC-R Digit Span for digits backward to the participant and administered the Digit Span Backward subtest beginning with the first item. The ceiling was reached when the participant failed two consecutive items.

The third test given was Mesulam's Random Shapes Cancellation Test. The participant was shown a figure of a small circle with eight small lines surrounding it and a line through the center. The research assistant then showed the participant the Random Shapes Cancellation Test and told the participant that the goal was to cross out all of the symbols shaped like the example circle with protruding lines. The participant was encouraged to work as quickly as possible without making mistakes and given two minutes to complete the task. A time limit of two minutes was set for this test. The participant was requested to stop the task at the conclusion of two minutes.

The forth test in the battery was a portion of the WJ-R Calculation subtest. The research assistant informed the participant that five minutes would be allotted to work as many math problems as possible using only a pencil and paper. The participants were instructed to skip any problems they did not know how to do.

If in rare cases a participant finished before the five minutes had expired, the participant was encouraged to use the remaining time to check the completed problems or to attempt some of the more difficult problems. The participant was requested to stop the task at the conclusion of five minutes. The math assessment began with simple two-digit plus one-digit addition problems and became progressively more difficult, including addition of mixed fractions, algebraic equations, and logarithms.

The final test in the battery was the reading comprehension assessment. Graded Reading Passages Test (Stieglitz, 1997) was used. Reading lists were used from this material to determine the grade level of reading mastery for the participant. All materials were coded so that the participants were unaware of the grade levels presented to them. The research assistant had the participant begin two grade levels below his or her current grade. Three measures were taken from the reading passage: words per minute, free recall, and probed recall.

The participant was asked to read ten sentences on a sheet of paper. Each sentence had one word in boldface print. The research assistant kept track of the number of bold face printed words the participant missed. If the participant missed two or more bold-faced words, the research assistant administered the reading list for the

preceding grade level. If the participant missed one or fewer bold-faced words, the participant was determined to have reading mastery at that grade level.

Once reading level was established, the participant was asked to read a passage out loud at the established reading level. The Graded Reading Passages Test included alternate passages: Form B or Form D. The research assistant followed along on a separate copy of the passage and recorded the words per minute by timing the participant from the first word of the story until 60 seconds expired. The research assistant recorded the word read at the 60-second mark and did not interrupt the participant.

Once the participant completed reading the entire story, the research assistant asked the participant to tell the story using his or her own words. Five basic comprehension questions were listed on the research assistant's copy of the story. From those five main idea questions, the examiner marked the basic concepts that the participant was able to relay under the "free recall" column. The research assistant then asked any of the five basic questions that the participant had not answered. A mark was placed in the "probed recall" column for any question the participant answered correctly.

Following the pre-test condition in which the participant completed the A620 assessment and the psychoeducational test battery, the participant engaged in either playing video games or board games for 60-minutes. The experimental group was assigned to play video games, while the control group was assigned to play board games. Video games used for the experimental condition were assigned by choice of the participant, using Mario Kart 64™ or NFL Blitz™.

To make the 60-minute interval as pleasant as possible for the control group, board game activities were set up in an area with minimum supervision. Although other options, such as reading, doing nothing, or watching movies, were considered for control conditions, the board game activities were selected because they would be less likely to be perceived as punitive by the participants. The researchers created a relaxed environment for the participants, similar to just "hanging out." A variety of board and card games was used for the control condition: cards, checkers, chess, Sorry®, Payday®, Uno®, and Yahtzee®.

One to two assistants remained in the room to monitor the activity and also engage in the board games and in conversation. The atmosphere was entertaining rather than competitive. Three or four

short board or card games where usually completed within the 60-minute time frame. Often one participant would rotate out of the control room as another rotated in and took over the person's position in the game. If participants arrived early to the experiment location or stayed after the experiment was completed, they were involved in the control room activities. The participants moved about frequently, consumed refreshments, and freely interacted with one another.

Immediately following the 60-minute game session participants again completed the psychoeducational battery and A620 Assessment as post-tests measures. Both control and experimental group participants were given all pre- and post-assessments. The participants were offered opportunities to take a short break if needed before and after board or video game play.

Statistical Design

This study was designed as a controlled experiment with a single intervention (video game play). The control and experimental groups were given the same pre- and post-test measures and mean differences were compared.

Pre- and Post-Test Scoring

The Trail Making test was scored for time (TMT) in seconds and errors (TME). The correct responses to digit span forward (DSF) and backward (DSB) were added for separate sums. The Random Shapes Cancellation Test was scored for time (CTT) in seconds, omissions (CTO) or missed correct symbol errors, and commissions (CTC) or added incorrect symbol errors. The math test was scored for number of correct responses (MATH). The reading test was scored for words per minute (RWPM), free recall (RFR) correct responses, and probed recall (RPR) correct responses.

The A620 Assessment software data created eight scores for each participant: four eyes open scores and four reading scores. The four eyes open scores are theta (EOTHET), beta (EOBETA), uV theta/beta (EOUVTB), and power theta/beta (EOPWTB). The four reading scores are theta (RETHET), and reading beta (REBETA), uV theta/beta (REUVTB), and power theta/beta (REPWTB). Artifact rejection was performed to pull out data affected by tension, eye movements, or blinking.

Data Analysis

Nineteen pre- and post-test measures were broken down into three units and compared for mean differences between experimental

and control subjects. Data analysis was completed using a general linear model (GLM) multivariant analysis of variance (MANOVA) in SPSS for windows. The tests were broken up into three units of analyses: test with identical pre-and post-test measures (SET 1) tests with alternate pre- and post-test measures (SET 2), and A620 Assessment measures (SET 3). See Table II for difference score descriptors.

TABLE II. Difference Score Descriptors

SET 1	SET 2	SET 3
Cancellation Test Time	Digit Span Forward	Eyes Open Theta
Cancellation Test Omissions	Digit Span Backward	Eyes Open Beta
Cancellation Test Commissions	Calculation Test	Eyes Open Uv Theta/Beta Ratio
Trail Making Time	Reading Words Per Minute	Eyes Open Power Theta/Beta Ratio
Trail Making Errors	Reading Free Recall	Reading Theta
	Reading Probed Recall	Reading Beta
		Reading Uv Theta/Beta Ratio
		Reading Power Theta/Beta Ratio

CHAPTER IV

RESULTS

Data collected for each participant were coded for the SPSS statistical system. A general linear model (GLM) for multivariate analysis of variance (MANOVA) was used to evaluate the relationships between video game play and measures of math performance, memory, attention and planning, reading rate and comprehension, as well as beta and theta activity in the brain. This procedure was chosen because the complete test battery consisted of several short tests given one after another.

The MANOVA procedure is a sound measure for adjusting for experiment-wise error rate that results from multiple dependent variables and for correlations among dependent variables (Barker and Barker, 1984; Cooley and Lohnes, 1971; Huck, Cormier, and Bounds, 1974). Based on the Wilks' Lambda's sensitivity to equally important dependent variables, this test was chosen as the best measure of statistical significance.

The data were broken into three categories for multivariate analysis: tests with alternate form measures for pre- and post-testing, tests with identical measures for pre- and post-testing, and beta and theta data. Analyzed according to group, experimental or control, for pre- to post-test differences between groups, a separate MANOVA was run for each of the three categories: tests with identical measures, tests with alternate form measures, and beta and theta measures. The question examined in this study was the effect of differences between the participants who played video games and participants who played board games. See Appendix F for a tabular representation of pre and post-test comparisons.

Test Battery

The tests were broken up into three analyses: tests with identical pre-and post-test measures (SET 1), tests with alternate form pre- and post-test measures (SET 2), and Beta and Theta measures (SET 3). The independent variable for all analyses was group. With the use of Wilks' Lambda, the MANOVAs showed no significant group difference. See Appendix G for a graphical representation of pre- and post-test difference scores.

Tests with identical measures (SET 1)

The MANOVA was performed on the difference scores of five dependent variables: Cancellation Test Time, Cancellation Test Omissions, Cancellation Test Comissions, Trail Making Time, and Trail Making Errors. The MANOVA showed that the tests of attention and planning were not significantly affected by video game play, $F(5,24) = 1.71$, $p = .17$. See Table III for descriptive statistics.

TABLE III. Descriptive statistics for difference scores for tests with identical measures (SET 1)

	GROUP	MEAN GAIN	STANDARD DEVIATION	N
Cancellation Test Time	C	12.13	13.79	15
	E	12.73	11.66	15
Cancellation Test Omissions	C	1.93	1.91	15
	E	1.53	2.72	15
Cancellation Test Comissions	C	0	0	15
	E	-.20	.56	15
Trail Making Time	C	21.93	15.67	15
	E	10.07	15.35	15
Trail Making Errors	C	.13	.92	15
	E	-.04	1.45	15

Note: C=Control Group; E=Experimental Group

Tests with alternate form measures (SET 2)

The MANOVA was performed on the difference scores of six dependent variables: Digit Span Forward, Digit Span Backward, Calculation Test, Reading Words Per Minute, Reading Free Recall, and Reading Probed Recall. The MANOVA showed that the tests of short-term memory, math, and reading were not significantly affected by video game play, $F(6,24) = 1.15$, $p = .37$. See Table IV for descriptive statistics.

TABLE IV. Descriptive statistics for difference scores for tests with alternate form measures (SET 2)

	GROUP	MEAN GAIN	STANDARD DEVIATION	N
Digit Span Forward	C	-.20	1.01	15
	E	-.60	.82	15
Digit Span Backward	C	.33	.98	15
	E	-.40	.91	15
Calculation Test	C	-.60	3.25	15
	E	-1.87	3.60	15
Reading Words Per Minute	C	6.87	18.40	15
	E	.73	33.20	15
Reading Free Recall	C	-.27	1.62	15
	E	.07	1.28	15
Reading Probed Recall	C	.13	1.60	15
	E	-.40	1.55	15

Note: C=Control Group; E=Experimental Group

Brain Waves

Beta and theta measures (SET 3)

The MANOVA was performed on the difference scores of eight dependent variables: Eyes Open Theta, Eyes Open Beta, Eyes Open Uv Theta/Beta Ratio, Eyes Open Power Theta/Beta Ratio, Reading Theta, Reading Beta, Reading Uv Theta/Beta Ratio, and Reading Power Theta/Beta Ratio. Due to incomplete pre-test data files for one control and two experimental participants, data analysis for the beta and theta waves was run for 14 control and 13 experimental participants. The MANOVA showed that the tests of beta and theta were not significantly affected by video game play, $F(8,18) = 1.39$, $p = .28$. See Table V for descriptive statistics.

TABLE V. Descriptive Statistics for difference scores for beta and theta measures (SET 3)

	GROUP	MEAN GAIN	STANDARD DEVIATION	N
Eyes Open Theta	C	-.59	1.71	14
	E	-1.01	2.84	13
Eyes Open Beta	C	-.51	.59	14
	E	-.94	.89	13
Eyes Open Uv Theta/Beta Ratio	C	.11	.32	14
	E	.07	.31	13
Eyes Open Power Theta/Beta Ratio	C	.37	1.35	14
	E	.20	1.27	13
Reading Theta	C	-.15	.92	14
	E	-.26	1.93	13
Reading Beta	C	-.53	1.18	14
	E	-.52	.85	13
Reading Uv Theta/Beta Ratio	C	.06	.21	14
	E	.07	.27	13
Reading Power Theta/Beta Ratio	C	.08	.86	14
	E	.75	1.20	13

Note: C=Control Group; E=Experimental Group

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Many school-aged children enjoy playing video games. A review of the literature on video game play addressed the short- and long-term effects of play, reasons for video game play, and possible therapeutic uses for video games. Only a few studies examined the relationship between grades and video game play. Studies directly linking academic tasks to video game play were absent from the literature. Very little research exists on the effect of video games on beta and theta waves.

This study was intended to determine the immediate effects of video games on selected cognitive functions of middle school-aged children. When the middle school participants in this study played mildly rated recreational video games without blood, gore, and carnage for up to an hour, the play did not appear to disrupt the participants' ability to perform certain academic tasks. Beta and theta

brain wave production was not significantly altered by one hour of video game play.

Conclusions

Parents and teachers often worry about the effect of video game playing. This preliminary study indicates that when middle school-aged students spent 60 minutes playing video games, there was no significant impact on academic task performance or brain wave activity. For example, the results of this study suggest that video game playing will be no more disruptive to doing subsequent homework assignments than board game playing as an after school relaxation activity. This study failed to show a negative impact, and some literature suggests it may even be beneficial in certain instances to make video game play contingent upon specific goals for student performance or learning. It appears that teachers and parents may choose video games to increase skills in areas such as mathematics and fine motor control (Griffiths, 1996). Selected video games might even be used as contingency rewards during or after school (Strein and Kachman, 1984; Salend and Santora, 1985). However, it appears reasonable that a responsible adult needs to be involved in terms of controlling usage time and selection of appropriate video games (Funk and Buchman, 1994).

Limitations of the Study

Several limitations to the study should be noted. Due to the small sample size (n=30), statistically analyzing difference scores was challenging. High variations in scores of both experimental and control participants on some of the tests made statistical significance more difficult to achieve. Because only one-third ($n \cong 5$) of the 15 participants in each group--experimental and control--were females, statistical comparison of males versus females could not be accomplished.

The sample of children studied included average to above average students. The students were not separated into groups based on academic ability. The study therefore cannot be generalized to groups other than average to above average. Although a few participants' parents indicated a diagnosis of learning disability or ADHD, no attempt was made to confirm the diagnoses. No comparisons of ethnicity and video game effects could be made because only one minority was recruited.

Only children who already played video games were recruited, so a comparison of video game effects on children who play video games versus children who do not play video games was not collected. Only mild rated video games (E for Everyone) were examined in this

study. The results should not be generalized to video games rated with higher ratings, such as T for Teen or M for Mature. Also, although the video games employed were within the same rating, the participants were given a choice of two different video games, the Mario Kart 64™ or NFL Blitz™. Possible differences between participants who chose one game over the over was not made because of the small numbers.

Recommendations

This video game study offers several areas of reference for parents, educators, and researchers. Parental monitoring of children's activities is important. This also can be applied in the realm of video game play in regard to playing time and game selection. Parents can monitor video game play by reading accompanying literature, knowing the specifics of each game, and discussing these specifics with children. Discussion can include things such as the difference between real and simulated violence. Parents should also know ESRB game ratings and routinely watch their children while they play. Precise guidelines should be established and enforced regarding limits to amount of time spent (Funk and Buchman, 1994).

Although this study did not show significant correlations between academic task performance or brain wave activity and video

game play, the results cannot be generalized to imply that any video game play will not affect these measures regardless of time spent or ESRB game rating. Since the average length of play greatly varies between individuals, it is important for parents to be aware of how long their children engage in video game play. According to this study, an hour of video game play of an ESRB E-rated game does not have any greater affect than playing board games does on a child's ability to do homework.

For educators, using an ESRB E-rated video game as an incentive for certain performances in the classroom is not necessarily harmful, according to this study. Ample studies have shown that many students, especially males, enjoy playing video games. If students view this activity as a high motivator for classroom performance, then rewarding work completed with an hour or less of video game play should be seen as a viable alternative to other rewards. Video game play should not affect the students' subsequent classroom performance any more than would board game activity.

Because of the large population of students playing video games, it is increasingly important to examine the relationship of video games and their effects on academic task performance and brain wave activity. Although there are many published studies on video

games, much of the literature is outdated, referring to video arcade play and games that are no longer played. With the rapid technological advances of the last decade, many of the studies involved games or activities that are not popular today. These changes have greatly enhanced sound, picture, interaction, and overall game quality. The combined effects of these advances could possibly influence children's academic task performance and brain wave activity in ways not realized in previous studies. Research of a more timely nature needs to be conducted to examine these effects with games that employ the latest technology.

Another area that has been insufficiently researched is short-term effects versus long-term effects. Although this study did not show significant negative correlation between academic task performance and brain wave activity as it relates to video game play, only short-term effects were examined. In order to examine long-term effects, research would have to compare children who have never played video games with those who have played them for most of their lives. A longitudinal study is needed to analyze differences between those children who play video games and those who never have. This study only looked at the immediate short-term effects of video game play after one hour of video game play. A repetitive study that looked

at the short-term effects of video game play over ten sessions would be useful.

Another population to investigate includes adults who grew up playing video games. This group has only recently emerged. The population can be divided into two primary categories: those who grew up playing video games and no longer play them and those who continue to play them. A longitudinal study is needed to compare performance differences in these groups. Another study should compare this new population to its contemporaries who have never played video games.

With short-term studies, such as this study, larger samples need to be used. Because of the large standard deviations in the data collected, a larger pool of data needs to be gathered with an even distribution of socio-economic status. Further study should also include students of average to above average ability. Comparing students of average ability to special populations, such as students with learning disabilities and ADHD, could be beneficial. Another aspect is the effect video games have on males versus their effect on females. Because the games used in this study were ESRB E-rated, further study needs to be conducted comparing video games with

higher ratings, such as T for Teen or M for Mature, with video games rated E for Everyone.

Children often exhibit increased rates of aggression after playing violent video games (Cooper and Mackie, 1986; Funk, 1993; Silvern and Williamson, 1987). Second grade boys who engaged in violent video play game were more verbally and physically aggressive toward peers and inanimate objects than those who played a nonviolent game (Irwin and Gross, 1995). Children who played violent video games demonstrated aggressive verbal responses and hostile attributions (Kirsh, 1998). Calvert and Tan (1994) found college students who played a violent video game had more cases of dizziness, nausea, higher heart rates, and aggressive thoughts than their counterparts who observed violent video games. Additional research is needed to determine the extent of the link between violent video games and aggressive behavior (Funk, Germann, and Buchman, 1997).

Technology has become an integral part of our lives. Each new improvement, while possessing benefits, also carries with it potential effects that warrant studying. Although video games have both immediate and long-term effects on players, little research has been conducted in these areas. One essential aspect of the effects of video game play is the cognitive and educational impact on children. Current

research is inconclusive. This investigation raises a range of questions for further research. Until research demonstrates specific effects of video game play, supervision of video game play is beneficial.

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APPENDICES

APPENDIX A-1

Hobbies and Special Interests [a]

Activities	% Total	% Males	% Females
1. Music	67.5	62.8	72.3
2. Sports/fitness	61.2	69.4	53.4
3. Movies	57.2	52.5	61.8
4. Video games	48.7	70.2	28.2
5. Computers	46.8	52.7	41.0
6. Reading	43.3	30.0	56.1
7. Cooking and baking	32.4	19.3	45.0
8. Art	32.1	30.6	33.4
9. Dancing	16.3	4.8	27.3
10. Internet/on-line services	15.0	17.9	12.4
11. Photography	11.9	6.6	17.2
12. Sewing/crocheting	7.8	2.6	12.6

[a] National Association of Secondary-School Principals (NAASP) (1996). The Mood of American Youth 1996. Reston, Virginia: Horatio Alger Association of Distinguished Americans, Inc, p. 33.

APPENDIX A-2

Non-school Activities[a]

Activities		% Total	% Males	% Females
1.	Listening to music	87.4	83.2	91.6
2.	Spending time with friends	82.2	78.8	85.7
3.	Watching television/videos	81.9	84.0	79.8
4.	Hobbies	57.9	62.4	53.6
5.	Playing video games	48.9	68.3	30.3
6.	Going to movies	45.4	40.7	50.0
7.	Shopping	44.7	23.9	64.7
8.	Sports/fitness activities	43.2	52.1	34.9
9.	Using personal computers	40.6	46.4	35.3
10.	Reading for enjoyment	40.3	26.0	54.0
11.	Working	39.0	43.1	35.1
12.	Participating in church/religious group	33.2	27.4	38.7
13.	Watching sports activities in person	30.9	35.4	26.7
14.	Playing a musical instrument	22.6	21.9	23.5

Non-school Activities Continued[a]

Activities		% Total	% Males	% Females
15.	Exploring the Internet/on-line services	14.1	15.5	12.8
16.	Participating in clubs	12.5	14.4	10.7
17.	Volunteering	11.9	7.7	16.0

[a] National Association of Secondary-School Principals (NAASP) (1996). The Mood of American Youth 1996. Reston, Virginia: Horatio Alger Association of Distinguished Americans, Inc, p. 30.

APPENDIX B-1

ESRB Ratings, Classifications, and Definitions for Video Games[a]

Rating Symbol	Classification	Definition
EC	Early Childhood	Content suitable for persons ages 3 and older
E	Everyone	Content suitable for persons ages 6 and older
T	Teen	Content suitable for persons ages 13 and older
M	Mature	Content suitable for persons ages 17 and older
AO	Adults Only	Content suitable for adults
RP	Rating Pending	Product has been submitted to the ESRB and is awaiting final rating

[a] Entertainment Software Rating Board (1998). The ESRB's guide to interactive entertainment. New York: ESRB/IDSA.

APPENDIX B-2

ESRB Content Descriptors for Video Games [a]

Content Descriptors	Definition
Mild Animated Violence	Content suitable for persons ages 3 and older
Mild Realistic Violence	Contains scenes depicting characters in unsafe or hazardous acts or violent situations in photographic detail
Comic Mischief	Contains scenes depicting activities characterized as slapstick or gross vulgar humor
Animated Violence	Contains depictions of aggressive conflict involving cartoon/animated/pixilated characters
Realistic Blood and Gore	Depictions of mutilation or dismemberment of body parts in realistic or photographic-like detail
Animated Blood	Animated/pixilated or cartoon like depictions of blood
Realistic Blood	Representations of blood in realistic or photographic-like detail
Suggestive Themes	Mild provocative references or material
Mature Sexual Themes	Contains provocative material; including depiction of the human body in either animated or photographic-like formats

ESRB Content Descriptors for Video Games Continued [a]

Content Descriptors	Definition
Strong Sexual Content	Graphic depiction of sexual behavior and/or the human form (i.e., frontal nudity) in either animated or photographic-like detail
Mild Language	Product contains the use of words like "damn"
Strong Language	Commonly referenced four-letter words
Gaming	The depiction of betting-like behavior
Use of Tobacco and Alcohol	Product contains images of the use of tobacco and/or alcohol in a manner which condones or glorifies their use
Use of Drugs	Product contains images of the use of drugs in a manner which condones or glorifies their use
Informational	Overall content of product contains data, facts, resource information, reference materials or instructional text
Edutainment	Content of product provides user with specific skills development or reinforcement for learning within an entertainment setting. Skill development is an integral part of product
Some Adult Assistance may be Needed	Early Childhood Descriptor only

[a] Entertainment Software Rating Board (1998). The ESRB's guide to interactive entertainment. New York: ESRB/IDSA.

APPENDIX C-1

Parent Questionnaire

1. How many hours a week do you and your child play video games?

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Child							
You							

2. How long does your child play video games in one sitting?_____

3. Over the past year has your child increased video game play? *(circle one)*

   increased *decreased* *stayed same*

4. Do you monitor the video games your child plays? Y N

5. List any video games you do NOT allow your child to play:

   _____ _____

   _____ _____

6. Do you notice any certain behaviors in your child during or after video game play?

   During :_____

   After :_____

7. How long does your child spend doing homework each night?

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Time:							

8. Does your child have any difficulties doing homework after playing video games?

   (circle one) *Y* *N* *Don't Know*

9. How long does your child play video games:

   _____*before homework* _____*during homework* _____*after homework*

Parent Questionnaire Continued

10. What type of academic student is your child?

(circle one) *above average* *average* *below average*

11. Over the past year have your child's grades:

(circle one) *increased* *decreased* *stayed same*

12. Has your child ever been labeled with: *(circle one)*

*ADHD, Learning Disabilities, Other (specify):*_____

13. What were your child's grades last grading period?

Area	Language Arts	Math	Science	Social Studies	Reading
Grade					

14. How would you rate your child's memory? *(circle one)*

above average *average below average*

15. How would your rate your child's ability to concentrate? *(circle one)*

above average *average below average*

16. Does your child live with *(check one)*
two biological parents; parent & step-parent; single parent; guardian/other

17. Annual household family income is *(check one)*
under $20,000; $20-$40,000; $40-$60,000; above $60,000

APPENDIX C-2

Student Questionnaire

1. How many hours a week does you and your child play video games?

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Hours							

2. How long do you play video games in one sitting?___

3. List your favorite video games?

_____ _____

_____ _____

_____ _____

_____ _____

4. Where do you play video games most of the time?

_____

5. What do you enjoy most about video games? _____

_____

_____

_____

6. Tell us about your typical homework schedule. Circle your response below.

Homework	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Assigned	Y N	Y N	Y N	Y N	Y N	Y N	Y N
Completed	Y N	Y N	Y N	Y N	Y N	Y N	Y N

Student Questionnaire Continued

7. Do you have any trouble doing homework after playing video games?
   (circle one) *Y* *N*

8. How long do you play video games:

   _____*before homework* _____*during homework* _____*after homework*

9. What type of academic student are you?

   (circle one) *above average* *average* *below average*

10. What were your grades last grading period?

Area	Language Arts	Math	Science	Social Studies	Reading
Grade					

11. What school do you go to? _____

12. What grade are you in?_____ How old are you?_____

13. How would you rate your memory? *(circle one)*

    above average *average* *below average*

14. How would your rate your ability to concentrate? *(circle one)*

    above average *average* *below average*

APPENDIX D

Video Game Research Format				
Time	**Test Instrument**	**SUBTEST**	**What it measures**	**Testing Form**
10 min.	Parent & Student Questionnaires			
5 min.	WJ-R (Ach)	Math	school math skills	Form A
4 min.	WISC-R	Digit Span • Forward • Backward	immediate auditory memory immediate / representational memory	Form A
2 min.	Trail Making Test		attention & planning	
2 min.	Cancellation Test		attention	
5 min.	Stieglitz Reading	• Word List • Reading Passage	Reading level Reading rate / comprehension (free recall & probed recall)	Reading Level List Passage B Comp. B
10 min.	Break			
15 min.	Autogencis A620 Assessment Software	• Theta/Beta eyes open • Theta/Beta reading	Theta activity Beta activity Theta/Beta ratio	
60 min.	Video game or Board games			
15 min.	Autogencis A620 Assessment Software	• Theta/Beta eyes open • Theta/Beta reading	Theta activity Beta activity Theta/Beta ratio	
10 min.	Break			

Video Game Research Format Continued				
Time	**Test Instrument**	**SUBTEST**	**What it measures**	**Testing Form**
5 min.	WJ-R (Ach)	Math	school math skills	Form B
4 min.	WISC-R	Digit Span • Forward • Backward	immediate auditory memory immediate / representational memory	Form B
2 min.	Trailmaking Test		attention & planning	
2 min.	Cancellation Test		attention	
5 min.	Stieglitz Reading	Reading Passage	Reading rate / comprehension (free recall & probed recall)	Passage D Comp. D
60 min	Video game or Board games	Groups switched activities to allow for video game play by all participants.	No data recorded.	
Appr. 4 hours TOTAL				

APPENDIX E-1

INFORMED CONSENT

VIDEO GAME STUDY

I,_____, as the parent/legal guardian of____ _____, agree to the participation of my child in the research study entitled, "The Effect of Video Game Playing on Academic Task Performance of Middle School-Aged Children."

I understand that participation in this research study is strictly voluntary, and I may withdraw at any time with no penalty. I have been informed that the total time involved in participating in the study is about 4 hours and that participation in this study involves no-risk to my child and that there are no direct benefits of participation in this study. I understand my child will be given a choice to play the Super Mario Brothers or College Football video game and will have time to play board games. After signing this form, I am willing to fill out a 10-minute questionnaire.

The information collected in this study will remain confidential. The data gathered during this research project may potentially be shared professionally, but will include numerical coding to insure the privacy of the participants. The information gained may be used as part of data collection for these and/or future educational studies. I will be given detailed information concerning the evaluation procedures that will be used during this study. I have been given the opportunity to ask questions about this research study. My child's participation is voluntary without coercion or undue influence.

This consent form will be stored for three years past the completion of the study at a University of Tennessee location. If I have any questions about this study, I may contact the following:

Dr. Dianne Whitaker, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-1086 or 974-8145
Sheryl Brim, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-3222 or 974-8145
Amanda Monville, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-8145
Christine Vaupel, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-8145

I have read the above information. I understand that participation is voluntary. I agree to have my child participate in this study. I will receive a copy of this form.

Legal guardian's name (print) _____

Signature_____ Date _____

APPENDIX E-2

CHILDREN'S ASSENT FORM

VIDEO GAME STUDY

To be read to the participant and signed by the participant prior to study, and after the Signed Consent has been signed by the participant's parents/legal guardians. Date _____

Your parents signed permission for you to be a part of this research study using video games. This information will be used as part of a research study. If you have any questions as I explain the study, please feel free to ask them.

The beginning of this study involves filling out a ten minutes questionnaire. You will then be doing five different quick tests similar to some tests given in school. After this you can take a 10-minute break if you want. Next we will place an ear clip electrode on each ear and another one will be placed on the top of your head. It will not hurt at all, but will show us what kind of brain waves you have. You can see them too on the computer screen. Then you will either be assigned to play board games or play video games. If you are assigned to play video games, you can choose to play the Super Mario Brothers or College Football video game for an hour. Immediately after your hour is up, we will place an ear clip electrode on each ear and another one will be placed on the top of your head again to look at your brain waves. Then you can take a 10-minute break again if you want. Finally, you will be asked to do five quick tests again similar to some tests given in school. You will then have an opportunity to do the opposite activity (board games or video games) for an hour. The entire study will take about 4 hours. Do you have any questions?

At this time I want to know if you want to be a part of this study. Your participation is voluntary, and that means that you do not have to be a part of it if you don't want to. If you decide at any time that you do not want to continue in the study, then you may stop without any penalty and no one will get mad at you.

You will be given a personal number. This will make sure that all of your information is private, and that no one besides Dr. Whitaker, Sheryl Brim, Amanda Monville, and Christine Vaupel will know who you are. We will use the information we get from this study to look at the effects of playing video games on doing schoolwork.

There is no risk of being harmed by this study, and there are no direct benefits of participation in this study. If you have any questions about this study, please contact the following:

Dr. Dianne Whitaker, College of Education, Psychoeducational Studies University of Tennessee, Knoxville, (423) 974-1086 or 974-8145

Sheryl Brim, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-3222 or 974-8145

Amanda Monville, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-8145

Christine Vaupel, College of Education, Psychoeducational Studies, University of Tennessee, Knoxville, (423) 974-8145

If you would like to be in this study, please sign here. You will receive a copy of this form.

Child's name (print) _____

Signature_____ Date _____

APPENDIX F

Experimental Group (SET 1)										
ID	PRE CANT	POST CANT	PRE CANO	POST CANO	PRE CANC	POST CANC	PRE TMT	POST TMT	PRE TME	POST TME
1	120	100	1	0	0	0	46	46	0	0
3 -	88	88	1	0	0	0	66	49	0	0
5	120	120	7	2	0	1	106	85	0	0
7	65	57	1	0	0	0	86	76	0	0
9	59	43	7	1	0	0	90	66	2	2
11 *	90	59	0	0	0	0	80	38	0	0
13	59	55	1	1	0	0	54	42	0	1
15	88	88	1	1	0	0	85	105	0	1
17	78	59	3	5	0	0	77	61	0	0
19	58	46	1	0	0	0	69	59	0	0
21	82	49	0	0	0	0	86	70	0	0
23 *	82	69	4	2	0	0	72	53	0	0
25 *	73	67	1	0	0	0	66	77	2	0
27	120	120	9	1	0	2	118	120	0	5
29	91	62	2	3	0	0	95	98	1	2

* ADHD
\- LD
Grey indicates: female
White indicates: male

Control Group (SET 1)										
ID	PRE CANT	POST CANT	PRE CANO	POST CANO	PRE CANC	POST CANC	PRE TMT	POST TMT	PRE TME	POST TME
2	108	59	3	1	0	0	113	86	0	0
4 -	94	86	0	0	0	0	128	113	0	0
6 -	59	67	4	0	0	0	129	132	4	4
8	88	88	1	0	0	0	92	90	0	1
10	65	55	4	1	0	0	76	50	0	0
12	53	41	1	1	0	0	65	39	0	0
14	88	88	6	1	0	0	59	52	0	0
16	79	72	4	2	0	0	127	76	3	2
18	98	66	1	0	0	0	67	55	0	0
20	85	70	3	1	0	0	118	101	0	1
22	77	70	0	1	0	0	120	78	2	0
24	75	60	4	0	0	0	114	67	2	0
26 *	79	59	1	2	0	0	91	69	0	0
28	72	67	3	0	0	0	88	75	0	0
30	120	110	4	0	0	0	120	95	0	1

* ADHD
\- LD
Grey indicates: female
White indicates: male

Experimental Group (SET 2)												
ID	PRE DSF	POST DSF	PRE DSB	POST DSB	PRE MATH	POST MATH	PRE RWPM	POST RWPM	PRE RFR	POST RFR	PRE RPR	POST RPR
1	5	6	5	5	18	24	206	169	2	2	3	1
3 -	3	4	4	4	23	24	167	119	2	1	2	4
5	2	4	3	3	16	15	130	104	4	2	0	2
7	2	4	2	4	17	21	138	151	2	1	1	4
9	4	4	4	4	22	24	120	113	4	4	1	2
11 *	4	3	2	2	18	23	126	201	1	1	4	4
13	5	6	4	5	23	29	213	177	3	3	2	2
15	3	3	3	3	13	13	130	138	2	2	1	2
17	4	4	3	2	14	9	120	124	5	4	0	1
19	4	4	4	5	20	20	165	179	3	4	1	1
21	3	4	4	4	22	20	143	145	2	5	2	0
23 *	4	5	1	2	15	22	112	144	3	4	0	0
25 *	3	4	2	4	25	24	163	120	3	3	2	2
27	3	3	3	4	16	22	104	129	1	2	4	2
29	2	2	3	2	19	19	138	151	5	3	0	2

* ADHD
\- LD
Grey indicates: female
White indicates: male

Control Group (SET 2)												
ID	PRE DSF	POST DSF	PRE DSB	POST DSB	PRE MATH	POST MATH	PRE RWPM	POST RWPM	PRE RFR	POST RFR	PRE RPR	POST RPR
2	3	4	2	2	14	19	137	124	0	2	2	3
4 -	2	4	2	2	12	14	61	59	3	3	0	2
6 -	2	3	1	2	17	14	108	108	1	3	3	1
8	3	3	2	2	15	19	110	88	1	1	4	4
10	4	5	3	3	17	13	103	117	1	4	4	1
12	4	3	4	3	19	23	137	105	1	1	1	2
14	5	5	3	3	11	10	124	153	3	2	2	2
16	2	2	5	4	20	23	128	128	3	1	2	3
18	5	5	7	4	25	23	64	63	1	1	3	3
20	4	5	2	2	24	23	94	94	1	0	4	5
22	4	2	2	3	16	11	85	82	3	3	2	2
24	2	2	5	5	18	19	185	135	2	3	2	1
26 *	3	4	3	2	23	23	141	128	1	4	4	1
28	3	2	3	3	17	22	169	164	3	2	2	1
30	3	3	2	1	15	16	154	149	3	1	1	3

* ADHD
\- LD
Grey indicates: female
White indicates: male

Experimental Group (SET 3)																
ID	PRE EOTHET	POST EOTHET	PRE EOBETA	POST EOBETA	PRE EOUVTB	POST EOUVTB	PRE EOPWTB	POST EOPWTB	PRE RETHET	POST RETHET	PRE REBETA	POST REBETA	PRE REUVTB	POST REUVTB	PRE REPWTB	POST REPWTB
1	15.69	***	8.88	***	1.77	***	3.12	***	15.86	17.99	8.34	9.03	1.90	1.98	3.62	3.94
3 -	12.05	13.46	6.17	6.45	1.95	2.09	3.81	4.35	11.87	13.04	5.95	5.91	2.16	2.21	3.99	4.87
5	16.15	16.16	6.12	6.56	2.51	2.50	6.97	6.06	16.89	17.10	6.17	6.24	2.74	2.74	7.49	7.50
7	15.27	15.21	5.83	7.01	2.62	2.17	6.86	4.71	12.79	12.35	5.06	6.03	2.47	2.05	6.39	4.19
9	13.87	12.96	8.98	9.53	1.55	1.36	2.39	1.85	12.78	13.08	7.63	9.11	1.67	1.44	5.14	2.06
11 *	13.33	12.32	8.17	7.71	1.63	1.60	2.66	2.55	14.34	13.54	7.36	7.40	1.95	1.83	3.80	2.35
13	20.43	20.43	17.08	17.08	1.20	1.47	1.43	1.43	18.62	19.89	16.29	15.24	1.14	1.31	1.31	1.70
15	16.75	***	9.27	***	1.81	***	3.27	***	16.62	15.90	8.08	8.46	2.06	1.88	4.23	3.53
17	16.35	20.71	7.48	8.11	2.19	2.55	4.78	6.52	17.96	17.08	7.51	8.14	2.39	2.10	5.72	4.40
19	14.76	18.38	7.27	9.65	2.03	1.90	4.13	3.63	14.59	18.99	8.01	10.43	1.82	1.82	3.32	3.31
21	14.41	18.14	8.62	10.18	1.67	1.78	2.80	3.17	13.93	16.18	9.38	10.28	1.48	1.57	2.20	2.48
23 *	13.34	19.47	6.90	9.04	1.93	2.15	3.74	4.67	12.95	14.05	7.02	7.11	1.84	1.98	3.40	3.91
25 *	13.98	12.70	6.09	6.26	2.29	2.03	5.27	6.76	13.94	12.51	6.24	6.36	2.20	1.97	4.85	3.87
27	16.07	17.57	8.28	10.23	1.94	1.72	3.77	2.95	15.97	15.81	7.77	8.73	1.34	1.81	4.22	3.28
29	16.89	12.55	8.13	9.52	2.08	1.32	4.32	1.74	16.65	13.03	7.94	8.10	2.10	1.61	4.39	2.58

* ADHD

\- LD

Grey indicates: female

White indicates: male

*** missing data

Control Group (SET 3)																
ID	PRE EOTHET	POST EOTHET	PRE EOBETA	POST EOBETA	PRE EOUVTB	POST EOUVTB	PRE EOPWTB	POST EOPWTB	PRE RETHET	POST RETHET	PRE REBETA	POST REBETA	PRE REUVTB	POST REUVTB	PRE REPWTB	POST REPWTB
2	15.68	15.07	8.28	8.98	2.19	1.28	3.59	2.81	14.87	14.40	7.67	7.89	2.52	2.09	3.76	3.33
4 -	14.66	15.06	7.71	8.27	1.90	1.82	3.61	3.32	14.13	14.81	6.86	6.69	2.06	2.21	4.25	4.89
6 -	11.23	11.81	7.37	7.99	1.52	1.48	2.32	2.19	11.62	10.67	8.40	7.97	1.38	1.34	1.91	1.79
8	21.65	24.53	11.39	12.38	1.90	1.98	3.62	3.93	21.13	20.76	10.03	9.11	2.11	2.22	4.44	4.92
10	15.23	14.91	6.28	6.94	2.43	2.15	5.89	4.61	15.85	15.67	6.70	5.96	2.36	2.63	5.59	6.92
12	18.76	20.68	8.21	8.58	2.28	2.41	5.22	5.81	16.61	17.91	8.40	8.77	1.98	2.04	3.91	4.17
14	18.34	16.58	10.53	12.50	1.74	1.33	3.03	1.76	18.39	***	12.55	***	1.47	***	2.15	***
16	23.71	25.76	5.24	6.37	4.53	4.04	20.50	16.34	22.05	23.62	5.49	5.65	4.02	4.18	16.13	17.46
18	14.13	17.33	7.46	7.42	1.89	2.33	3.58	5.45	14.39	16.01	7.57	8.53	1.90	1.88	3.61	3.52
20	13.60	12.33	10.06	9.93	1.35	1.24	1.83	1.54	13.80	14.24	11.20	11.95	1.23	1.19	1.52	1.42
22	18.28	16.62	7.31	6.39	2.50	2.60	6.25	6.76	16.38	15.58	6.69	7.44	2.45	2.09	5.99	4.39
24	16.48	16.77	8.32	8.39	1.98	2.00	3.92	4.00	18.22	18.17	5.26	9.08	2.11	2.00	4.45	4.00
26 *	26.81	25.27	12.13	12.93	2.21	1.95	4.88	3.82	26.46	25.94	11.55	13.23	2.29	1.96	5.25	3.87
28	12.55	11.96	8.02	9.02	1.56	1.45	2.45	1.76	13.18	12.18	8.05	8.16	1.64	1.49	2.68	2.23
30	19.04	21.95	9.57	10.84	1.99	2.02	3.96	4.10	20.82	21.72	8.92	9.79	2.33	2.22	5.44	4.92

* ADHD

\- LD

Grey indicates: female

White indicates: male

*** missing data

VITA

Christine Angela Vaupel was born in Lima, Ohio on November 7, 1971. She earned a Bachelor of Arts in psychology and English in 1994 from Tennessee Temple University in Chattanooga, Tennessee. In 1996 she was earned a Master of Science degree in education from The University of Tennessee, Knoxville where she majored in educational psychology with an emphasis in individual and collaborative learning. Mrs. Vaupel has been involved in various aspects of the educational system in Tennessee. Currently, she is employed by Cherokee Health Systems as a Developmental Therapist for physically and mentally impaired preschool children. She also works at The University of Tennessee Medical Center in research for the Departments of Obstetrics and Gynecology and receives field supervision at the Developmental and Genetics Center.