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# Comparison of children's gaming scores to NEPSY-II scores: Validation of computer games as cognitive tools

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ABSTRACT

This exploratory quantitative study compared schoolchildren's scores on 15 computer games to their scores on the neuropsychological test, NEPSY-II, to determine whether these games utilize predicted cognitive skills. Forty-three children aged 7–12 from different ethnic groups participated in this study. There was an almost equal split between girls and boys, some of whom reported mild learning difficulties. Many a priori predicted correlations were confirmed, with a medium to high effect. Eleven games shared their highest correlation with one or more of the predicted cognitive skills as measured by the NEPSY-II, which provided evidence that these computer games use specific cognitive functions. This suggests that similar computer games could be used to assess, practice, or monitor cognitive skills among schoolchildren.



## 1. Introduction

Computer games have become the main source of entertainment, rivaling the popularity of movies and TV, for both children and adolescents (Olson, 2010; Spence & Feng, 2010), to the extent that 21st century youth, growing up in the era of videogames, may be called the videogame generation (Bogost, 2007; Leonard, 2003; for the purpose of this paper, the terms "computer game" and "videogame" are used interchangeably). Although most videogame research has until recently focused on the impact of these games on academic performance and aggression (Lenhart et al., 2008), there is now an increasing interest in understanding the potential of computer games for enhancing cognitive development and learning. This interest has been expressed by adolescents themselves as well; in a study by Karakus, Inal, and Cagiltay (2008), approximately half of 1224 high school students claimed that such games could help them on an educational level by improving their mental abilities and aiding them in their coursework.

Many studies thus far have demonstrated that experienced videogame players perform better than non-videogame players in areas such as visual tracking (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Sekuler, McLaughlin, & Yotsumoto, 2008), attention (Greenfield, deWinstanley, Kilpatrick, & Kaye, 1994), spatial resolution (Green & Bavelier, 2007), task switching (Boot et al., 2008; Cain, Landau, & Shimamura, 2012), visual search (Hubert-Wallander, Green, Sugarman, & Bavelier, 2011), visual short-term memory (Boot et al., 2008), and hand-eye coordination (Griffith, Voloschin, Gibb, & Bailey, 1983). Experienced videogame players, both adults and children, have also been shown to have faster reaction times compared to non-experienced players (Orosy-Fildes & Allan, 1989; Yuji, 1996).

These findings, most of which involved young adults suggest that videogames may enhance a player's cognitive abilities and studies examining transfer effects offer great support for the cognitive benefits of gaming.

Links between playing selected games and cognitive improvements have been established to support this thesis. For instance, Helms and Sawtelle (2007) found significant cognitive skill improvements in areas such as "visual processing, auditory processing, memory, attention, sensory integration and thinking" (p. 19) in elementary school students who played *BrainWare Safari* (BWS, a computer game program designed to enhance cognitive skills in children aged 6–12) over an 11-week period.

In another study, Green and Bavelier (2003) established a connection between visual selective attention and playing action videogames. Their results demonstrated that videogame players had an increased attention capacity and were significantly better than non-gamers at localizing a target within a group of

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distractors. Green and Bavelier (2003) also observed that non-game players, who were trained in the action game *Medal of Honor* for one hour a day, over a 10-day period, were able to significantly increase their visual attention capacity. Other similar studies have found that playing videogames may improve executive functions such as task switching, working memory, visual short-term memory, and reasoning (Basak, Boot, Viss, & Kramer, 2008), as well as problem-solving among children (Ko, 2002).

Additionally, Mackey, Hill, Stone, and Bunge (2011) discovered that playing simple but entertaining computerized and non-computerized games for one hour a day and two days per week, over an eight-week training period, significantly improved children's fluid reasoning and processing speed. In this study, the 7–9 year olds were split into two groups; the reasoning group played games that involved "the joint consideration of several task rules, relations, or steps required to solve a problem," while the speed training group played games that "involved rapid visual processing and rapid motor responding based on simple task rules" (Mackey et al., p. 585). While children in both groups improved in the trained ability, children in the reasoning group also showed moderate improvements in working memory. Although the results of this study are promising with regard to the enhancement of cognitive abilities through games, it is important to note that the children in this study were of low socioeconomic status; therefore, the study's generalizability may be limited.

While brain-training games, such as *Brain Age*, have been shown to improve executive function, working memory, and processing speed (Nouchi et al., 2013), popular mainstream games may also lead to improvements in cognition. For example, the game *Tetris* was found to increase visuospatial abilities and attention among adolescents (Nouchi et al., 2013). Therefore, even simple computer games may contribute to the cognitive development of youth.

Given that mobile devices are so important in today's society, Oei and Patterson conducted a study in 2013 which showed that games played on iPhone and iPod Touch could enhance different aspects of cognition. They demonstrated this by having non-gamers play one of five games (i.e., hidden object, memory, matching shapes, action, or life simulation game) for one hour per day for 20 days. Each game was found to enhance certain cognitive skills, including visual search, spatial memory, cognitive control, attentional blink, multiple-object tracking, and complex span.

Since many children may experience academic and behavioral challenges and not all children develop in the same way and at the same pace, alternative, low-cost, and pervasive programs are needed to address these problems. If computer games engage different cognitive functions in players, can we then consider them as vehicles for brain exercise and start developing brain fitness programs based on gaming? Could these remediation programs incorporate playing "cognitively responsible" (Martinovic et al., 2014, p. 141) computer games in the recognition of one's cognitive strengths and weaknesses, and in the exercise of related cognitive skills?

It is important to realize that computer games will not enhance a cognitive skill unless playing the game requires that specific skill (Subrahmanyam, Greenfield, Kraut, & Gross, 2001). According to Baniqued et al. (2013), many cognitive training games have not been scientifically tested. To determine whether a computer game will improve cognitive abilities, the game being used must be systematically evaluated to determine which cognitive processes it requires. Baniqued et al. (2013) attempted such an examination with simple, casual computer games that are widely available (e.g., *Bejeweled*, *Solitaire*, and *Minesweeper*). Results for the most part demonstrated that working memory and reasoning games were highly correlated with cognitive measures of working memory and fluid intelligence. On the other hand, perceptual or visuomotor speed games as well as attention or multiple-object tracking games did not correlate with their respective cognitive abilities.

A similar approach was used by McPherson and Burns (2008) to examine the ability of the video game-like tests to measure processing speed and working memory. Although one of these tests, *Space Matrix*, did in fact measure working memory and fluid intelligence, the other, *Space Code*, seemed to require multiple abilities and was not a valid measure of processing speed alone. Therefore, in developing programs that use videogames to improve cognitive abilities, it is important to first determine whether these games actually tap the targeted abilities.

While there is plenty of research to support the claim that video games significantly improve cognition, there is also literature that states otherwise. According to Boot, Blakely, and Simons (2011), studies focusing on gamer versus non-gamer performance may be methodologically flawed. It is possible that gamers outperform non-gamers on gaming tasks not because the games train them, but because they may possess certain abilities that permit them to excel at gaming and thus predispose to become gamers (Boot et al., 2011). Furthermore, if gamers are aware that they will be participating in a study that evaluates their gaming prowess, they may be motivated to perform well; however, non-gamers see no such incentive. The researchers also suggest that improvement in game-play might be the result of changes in strategy, rather than cognitive ability. Moreover, there is a lack of independent replication of training studies that focus on the benefits of gaming, as they are an expensive endeavour.

In addition, Ke (2008) conducted a study in which fifteen students in grades 4 and 5 played computer math games for a five week period. Results showed that the game training sessions had "no significant effect [...] on the students' cognitive test performance or metacognitive awareness development" (Ke, 2008, p. 1609). In another study, Lorant-Royer, Munch, Mesclé, and Lieury (2010) observed 88 ten-year-old students who took part in 11 sessions of video game training; one group played Dr. Kawawshima's *Brain Training* (an educational game), another played *Super Mario* (a recreational game), the third group played paper–pencil games, while the control group played nothing. When the students were tested on visual attention, manual dexterity, and visuospatial memory, the results showed that the recreational game training sessions were neither specific nor long enough to significantly enhance cognitive abilities (Lorant-Royer et al., 2010).

Recently, Powers, Brooks, Aldrich, Palladino, and Alfieri (2013) conducted two meta-analyses, one based on 72 quasi experimental studies and the other based on 42 studies designed as true experiments. As possible moderators, the authors used, among else: (a) information-processing domain (e.g., executive functions, motor skills, spatial imagery, and visual processing); (b) game type (i.e., game genre), (c) age, and (d) gender. The meta-analysis revealed heterogeneous effects that may have been inflated in quasi experimental studies (for example, when stating significance of association between playing video games and enhanced information-processing skills). Powers et al. found "evidence that game training can enhance specific perceptual and motor skills, including visual and spatial processing and hand–eye coordination. However, [...] true experiments failed to show positive gains for multiple aspects of executive functioning, such as multitasking, nonverbal intelligence, task switching, and working memory" (p. 1074). Lastly, according to Owen et al. (2010), subjects who participated in a 6-week online brain training program showed notable improvements in the training tasks, yet there were no significant transfer effects observed in untrained, cognitively-related tasks.

This review of the literature reflects a major debate regarding the reliability of findings that suggest major and significant effects of game play on cognitive development and training. Also, the studies that claim no effect may have not tested if the games actually require these skills. The goals of the current study are similar to those of Baniqued et al. (2013): to determine (a) whether computer games