



Full Length Article

Using video game play to improve education-majors' mathematical performance: An experimental study

Elena Novak^{a,*}, Janet Tassell^b^a School of Teacher Education, Western Kentucky University, 1906 College Heights Blvd. #61030, Bowling Green, KY 42101, USA^b School of Teacher Education, Western Kentucky University, GRH 1104, 1906 College Heights Blvd. #61030, Bowling Green, KY 42101, USA

ARTICLE INFO

Article history:

Received 30 March 2015

Revised 27 June 2015

Accepted 1 July 2015

Available online 7 July 2015

Keywords:

Action video games
Mathematics learning
Spatial abilities
Mathematics anxiety
Working memory

ABSTRACT

Action video games (AVGs) is an effective way to improve attentional capabilities that are important for academic foundations. The present research sought to establish a link between enhanced attentional capabilities and mathematics performance and anxiety in education-majors. We examined group differences between experienced and inexperienced AVGeers and the effects of AVG practice on mathematics performance and mathematics anxiety as mediated by the effect of attention on working memory. Our first experiment showed that expert AVGeers had significantly higher working memory, spatial, and geometry abilities than non-gamers. In Experiment 2, undergraduates without prior AVG experience were randomly assigned to play either an AVG (*Unreal Tournament 2004*) or a non-AVG (*Angry Birds*). After 10 h of video game practice, both intervention groups significantly improved their mental rotation skills, working memory and geometry performance from pre- to post-test, closely approaching the average cognitive performance of expert AVGeers. Furthermore, student cognitive load significantly decreased from pre- to post-test for both groups. Our results suggest that both an AVG and a popular non-AVG, *Angry Birds*, can improve cognitive abilities. Implications for using the games to enhance cognitive skills are discussed.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Video gaming has become an integral part of today's culture, engaging individuals from various cultural, age, and occupational backgrounds in this seemingly unproductive activity. Yet, a considerable amount of literature published over the last two decades shows that playing video games can improve a wide variety of perceptual and cognitive processes. Playing a video game for as few as 10 h can improve, for example, reaction times of older adults (Clark, Lanphear, & Riddick, 1987), performance on a physics knowledge test (Frederiksen & White, 1989), laparoscopic surgical tasks (Schlickum, Hedman, Enochsson, Kjellin, & Fellander-Tsai, 2009), flight performance (Gopher, Weil, & Bareket, 1994), and various attentional and working memory skills (Green & Bavelier, 2007). Most notably, video game practice does not train individuals on either of these tasks or processes but helps improve skills that can be transferred to novel situations and tasks.

Recent research suggests that not all video game genres can improve skills that transfer from the actual act of the video gaming to novel tasks and stimuli. Games that fall into the Action Video Game (AVG) genre have been found to be the most beneficial for enhancing cognitive and perceptual skills. Playing AVGs improves selective attention or "the processes that allow an individual to select and focus on particular input for further processing while simultaneously suppressing irrelevant or distracting information" (Stevens & Bavelier, 2012, p. 30), which consequently improves individual's performance on various tasks. The "secret" of AVGs lies in the high speed of game events, a constant need to make predictions with regard to future game events, and emphasis on peripheral vision game features that pose high cognitive, perceptual, and motor loads (Green, Li, & Bavelier, 2010).

Recently, Stevens and Bavelier (2012) suggested a link between selective attention and academic achievement by examining the various cognitive processes that affect language, literacy, and mathematics learning. They believe that enhanced attentional control can improve working memory capacity thereby facilitating better learning. Our present interest is in examining the effects of AVGs on mathematics learning as mediated by the effect of attention on working memory. Particularly, we are interested in differentiating the effects of AVG play on three distinct

* Corresponding author.

E-mail addresses: elannovak@gmail.com (E. Novak), janet.tassell@wku.edu (J. Tassell).¹ Present address: School of Lifespan Development and Educational Sciences, Kent State University, Kent, OH 44224, USA.

mathematical skills focusing on geometry, word, and non-word math problem solving.

Cognitive processes like attentional processing and working memory resources can greatly affect a learner's mathematics performance. Students who have good selective attention control are likely to have a better academic achievement. In addition, meager mathematics performance is associated with poorer working memory performance and poorer spatial processing abilities (Andersson & Lyxell, 2007; Fuchs et al., 2006). Moreover, mathematics anxiety can negatively affect learner mathematics performance. People with high math anxiety suffer from lower working memory resources, because their fears drain their working memory (Ashcraft & Krause, 2007). As a result, lower working memory capacity negatively affects their mathematics achievement. The psychometric literature clearly shows that people with high math anxiety avoid mathematics. They perceive learning mathematics as a difficult task and have lower confidence in their mathematics abilities.

The goal of this research was twofold. First, we were interested in investigating group differences between students who had considerable AVG experience and those who did not play AVGs on cognitive and mathematical skills, and mathematics anxiety and confidence. Furthermore, we examined the effects of AVG play on education-major students' mathematics performance as mediated by the effect of selective attention on working memory. Specifically, we were intent in finding the link between enhanced attentional capabilities and mathematics performance on geometry, word, and non-word problems. In addition, we were interested in exploring the relationship between enhanced attentional capabilities and math anxiety and confidence in learning mathematics.

1.1. Action video games and learning

First- and third-person shooter games like *Halo*, *Medal of Honor*, *Call of Duty*, *Unreal Tournament 2004*, and *Grand Theft Auto* are considered the prototypical examples of AVGs. These games have been used extensively in previous AVG research to examine the effects of AVG play on various aspects of human cognition and performance (e.g., Green & Bavelier, 2007; Green, Sugarman, Medford, Klobusicky, & Daphne, 2012). To establish a causal role of AVG interventions, studies employed a carefully controlled pre-/post-test experimental design with video game intervention sessions lasting between 10 and 50 h. Participants with minimal video gaming experience are randomly assigned to either an AVG group or a non-AVG/no treatment group. Using a non-AVG group, an active control group playing a video game that does not have 'action' components, is considered a "gold standard training in training experiments" and has been increasingly recommended by cognitive training researchers (Green & Bavelier, 2012, p. 200; Klingberg, 2010).

Numerous behavioral studies with adult participants have explored the effects of AVGs on various aspects of human behavior. The majority of research in this domain has focused so far on perceptual and cognitive skills related to attention, vision, reaction times, performance accuracy, spatial abilities, and working memory capacity (for a meta-analysis review see Dye, Green, & Bavelier, 2009). While all perceptual and cognitive skills are relevant for human performance, spatial abilities and working memory capacity are particularly important for mathematics achievement.

Good spatial abilities positively correlate with high mathematics achievement, successful geometry learning and standardized test performance (Delgado & Prieto, 2004; Yang & Chen, 2010). In addition to AVGs, playing digital puzzle games like *Tangram* and *Tetris* was found to be an effective strategy for improving elementary school students' geometry skills (Olkun, Altun, & Smith, 2005; Yang & Chen, 2010). AVGs can improve participants' spatial

cognition and mental rotation abilities in adults as well (Feng, Spence, & Pratt, 2007). According to a recent meta-analysis of training studies aiming at improving spatial skills, studies that provided indirect learning via games were found equally effective as those that directly involved spatial tasks practice, producing positive durable improvements in spatial skills across all training methods (Uttal et al., 2013). The authors advocate that implementing formal interventions targeting spatial skills would approximately double the number of individuals with spatial abilities comparative to or higher than that of current engineers. In addition, given the malleability of spatial skills and the fact that both genders respond equally well to training, implementing spatial rich interventions can help even adult students, especially females who usually have lower spatial abilities than males (Feng et al., 2007). Such interventions can be particularly relevant for non-STEM students like education-related majors, predominantly females, who usually avoid taking advanced math classes and consequently have relatively low math and geometry skills (Rayner, Pitsolantis, & Osana, 2009).

1.2. Mathematics, anxiety, and working memory

Research in mathematical cognition shows that mathematics performance depends heavily on working memory, beyond simple memory retrieval (Ashcraft & Krause, 2007). Working memory is increasingly involved in mathematics problem solving as the numerical values within the problem grow larger and/or the problem is more complex and requires a considerable number of steps to reach the solution. The number of steps in solving a problem also strongly correlates with the response time, requiring working memory resources for finding the correct response (Ashcraft & Krause, 2007).

Solving mathematics word problems requires considerable working memory resources as well. In order to solve a math word problem, a person must keep track of an abundant amount of information. During this process, considerable storage of information occurs that has been read or heard, and is dependent on the working memory (Baddeley & Logie, 1999; Case, 1995). This storage of information is then available for retrieval at a later time, a function of a person's level of text processing. Several studies have shown that a large proportion of variance in accuracy of the problem solving is due to working memory (LeBlanc & Weber-Russell, 1996; Swanson, 2004; Swanson & Sachse-Lee, 2001).

Math anxiety plays a crucial role in mediating the effect of working memory on mathematics performance. Ashcraft and Krause (2007) argue that a math-anxious person's working memory resources are drained when the math anxiety is activated. In addition, highly anxious math students sacrifice accuracy for speed, especially when the problems become more challenging, as to complete the assessment faster (Faust, Ashcraft, & Fleck, 1996).

Simply put, as math anxiety increases, math achievement declines. A possible inherent relationship between anxiety and achievement, poses an obvious question, however: Is a poor performance on a math assessment/problem due to math anxiety or due to lack of mastery on the content? Scores on math achievement tests most likely underestimate the actual knowledge level of anxious students. When highly anxious students are participating in an achievement assessment, the likelihood of this disrupting their performance is very high. However, after participating in interventions aiming at combatting math anxiety, students' math achievement scores did approach the normal range (Hembree, 1990).

Mathematics anxiety has shown vast impact on numerous aspects of people's lives. Students, who are anxious about math, avoid it. This avoidance materializes as students do not take elective coursework in mathematics in high school and/or college, do

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات