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The effects of video game training on the cognitive functioning of older adults: A community-based randomized controlled trial

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ABSTRACT

Context: Using video games may enhance older adults' cognitive skills, including executive function, processing speed, and spatial ability.
Objective: We examined the impact of video game training on the cognitive functioning of community-dwelling adults aged 65 or older and tested the hypotheses that larger training effects would be uncovered for practiced measures and that the employed time-compressed approach would reveal effects comparable to those reported in prior studies on this approach.
Methods: Thirty-five participants from four Senior Centers located in Los Angeles County, California completed the study. Participants were randomly assigned to either an intervention group partaking in 15 h of supervised video game training over five weeks or to a control group completing an assessment battery before and after a five-week period.
Results: After statistically controlling for pretest performance and performance on the Memory Alteration Test, we found significant group differences regarding brief syllable count (p = .001, d = 1.28) and arithmetic assessments (p = .003, d = 1.10), as well as marginally significant differences on the Stroop Interference Test (p = .02, d = 0.89). We also found larger effects among practiced outcome variables (d = 0.72) than non-practiced outcome variables (d = 0.03); the effects were comparable to those reported in time-extended intervention studies (d = 0.35 and 0.36, respectively).
Conclusions and implications: Results suggest that playing an easily accessible video game in older age can enhance cognitive functioning, especially in areas directly tied to the video gaming activities.

1. Introduction

In the present study, we employed an experimental paradigm designed to examine the impact of a video game − a commercially available game purported to enhance cognitive skills − on the cognitive functioning of older adults without major health conditions. Indeed, video games requiring players to make use of the same skills that people utilize while playing a game such as Candy Crush Saga could improve cognitive functioning, particularly in older age (e.g., Ackerman, Kanfer, & Calderwood, 2010; Anguera et al., 2013, Basak, Boot, Voss, & Kramer, 2008; Maillot, Perrot, & Hartley, 2012; McDougall & House, 2012). In early research in this area, non-institutionalized older experimental participants who played a videogame for two months twice a week in 1.5-h sessions achieved significant positive gains on the Wechsler Adult Intelligence Scale − Revised (WAIS-R; d = 0.89) and eye-hand coordination (d = 1.02; Drew & Waters, 1986). Moreover, among community-dwelling older individuals residing in Holland (aged 69 to 90), those who trained at home for 5 h per week for 5 weeks on Nintendo's Super Tetris improved their scores on Card Sorting Tasks (White & Cunningham, 1987), in contrast to those not receiving training (d = 1.75; Goldstein et al., 1997). Furthermore, in a randomized pilot study on cognitively impaired older adults, respondents who played a computer game designed to enhance cognitive rehabilitation for a period of 12 weeks (3 weekly 20 min sessions) exhibited less cognitive impairment on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) immediately after the 12-week intervention period (d = .32) and at a 12-week follow-up (d = 0.47; Tarraga et al., 2006). More recently, older adults who received the 20 one-hour game training sessions of a web-based brain-training package, Lumosity, demonstrated a significant decrease in distraction (d = 0.77) and a significant increase in alertness, unlike the control group (d = 0.82; Mayas, Parmentier, Andrés, &

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Ballestros, 2014). Although the benefits of using video games in older age are well documented, is it possible to transfer these new skills to non-practiced tasks? The next paragraph succinctly covers this issue.

1.1. The rationale and empirical evidence regarding transferability of cognitive skills

A central issue pertinent to the discussion of video games and cognitive functioning is the extent to which the skills that older adults acquire when playing a game are transferable to other tasks not directly practiced in the game (Hertzog, Kramer, Wilson, & Lindenberger, 2009). If this is the case, it has repercussions on the generalizability of the benefits derived from playing the game. For example, to experience broad gains in cognitive functioning, perhaps an individual would have to potentially engage in an assortment of mentally stimulating tasks and/or games. If the generalizability of the skills acquired via games is limited, that would suggest that video games have only a superficial impact on cognitive abilities. In this scenario, rather than affecting core underlying cognitive mechanisms with broad-based gains in various cognitive skills, games may simply serve as tools to sharpen very specific skill sets via extensive practice. On the other hand, if games are found to have a broad-based impact on cognitive functioning, with specific gaming activities associated with gains on an array of cognitive outcomes − whether practiced or not − then such findings would lend credence to the notion that games can serve as robust tools for improving cognitive functioning.

Current empirical evidence in the context of video game interventions does support the transferability hypothesis among older adults. For instance, training for 15 sessions of 1.5 h each over 4 to 5 weeks, in a real-time strategy computer game (i.e., an adapted version of a commercially available game called Rise of Nations), led to posttest improvements across wide-ranging cognitive skills like task switching ($d = 1.02$), working memory ($d = 0.82$), and reasoning ($d = 0.55$; Basak et al., 2008). Similarly, in a study in which the video game training group played several Nintendo Wii games requiring physical exercise on the part of the gamer, after 24 one-hour gaming sessions, trainees demonstrated significant gains across host of cognitive performance measures (11 of the 18 measures yielded *ds* of 0.50 or greater), many of which were not directly practiced in the Wii game (Maillot, Perrot, & Hartley, 2012). Using a specially designed video game and a month-long intervention paradigm, Anguera et al. (2013) also found gains in cognitive abilities such as sustained attention and working memory that were not specifically trained via the game (*ds* range from 0.75 to 0.98). What these three studies have in common is that RPs played video games requiring highly coordinated responses and/or required participants to simultaneously attend to competing stimuli. In the case of Basak et al., participants had to coordinate a host of cognitive processes in order to maintain information in short-term memory and shift attention between various stimuli to make decisions concerning resources and gaming strategies. Maillot et al. asked RPs to play Nintendo Wii games requiring a great deal of cognitive as well as physical coordination. Meanwhile, Anguera et al. specifically compared the effects of single versus multitasking training modes within their video game, finding that the multitasking mode − one that required RPs to simultaneously complete a perceptual discrimination task while correctly maneuvering a vehicle using a joystick − led to the transferability effects not observed among those completing either of the aforementioned tasks in isolation.

Additional support for the transferability of cognitive skills stems from the examination of action, first-person shooter, video games (Achtman, Green, & Bavelier, 2008). In a review of the empirical literature linking cognitive training to visual skills, the authors connected specific skills required by action video games to broader skills like visual function. They argued that what underlies this link is the notion that such games require constant visual attention to unpredictable distractor and target stimuli that call for quick aiming movements. They posited that this cognitive effort, characterized by high levels of attention due to the unpredictable nature of the events and stimuli being presented by the game, is what drives the broad improvement in visual function. This conclusion is further reinforced by additional empirical findings indicating that playing action video games increases the scope of visual attention across one's field of view (e.g., Green & Bavelier, 2006) and that experienced video gamers are more adept than are less experienced gamers at completing eye-hand coordinated activities not specifically practiced in any video game (Granek, Gorbet, & Sergio, 2010).

Given the collective evidence succinctly reported above, it is possible that the extensive use of various coordinated cognitive skills resulted in the aforementioned observed gains across a host of outcome measures. This body of preliminary research supports the notion that cognitive training that goes beyond the practicing of specific skills and focuses on the coordination among complex cognitive strategies could be associated with broad-based gains in cognitive functioning. However, given the limited literature on the topic, especially as it pertains to video game interventions, this is an area that clearly warrants further study.

1.2. Limitations of the available experimental literature

Although past studies' findings point to transferability of skills, upon conducting an in-depth examination of the published results, we could not document any instances of an intentional emphasis on grouping outcome measures on the basis of transferability and on comparing corresponding average effect sizes to discern the relative impact of video game training. Moreover, we found that in most of the previous studies on older adults without cognitive impairments or major health conditions, video game interventions (eight out of 12 based on our review of the literature, see Table 1) offered video game training over a span of up to 12 weeks (10 weeks on average). Given the total hours of offered training (on average 24 h), this corresponds to an average of 2.5 h of training per week. Thus, what is uncertain, given the limited available literature, is whether video game training in a more time-compressed format − for instance, across five weeks rather than 10 weeks − will produce larger (or smaller) effects on cognitive functioning. Although in the eight studies cited in Table 1 researchers reported, on average, a combined effect size (d) of 0.36, in two studies with five or more hours of training per week over five weeks (Basak et al., 2008 & Goldstein et al., 1997) they reported effects of 0.21 and 0.77, respectively, suggesting that a time-compressed format may still yield comparable positive effects. Moreover, the findings of experiments on learning in multimedia contexts indicate that time-compressed formats (defined as 25% faster than normal-paced instruction) result in cognitive gains that are comparable to those found in slower

Table 1
Number of Weeks, Average Number of Hours Per Week, and Effect Size ds of Articles on More Than Five-Week Video Game Interventions.

Article	Number of Weeks	Avg. Hours Per Week	Effect Size (d)
Ballesteros et al. (2014)	11	1.8	0.16
Bozoki et al. (2013)	6	3.6	0.12
Dustman (1992)	11	3.0	0.29
Eggenberger et al. (2016)	8	1.5	0.14
Maillot, Perrot, and Hartley (2012)	12	2.0	1.09
Mayas et al. (2014)	11	1.8	0.61
Muijden, Band, and Hommel (2012)	7	3.5	0.19
Stern et al. (2011)	12	3.0	0.26
Averages	9.75	2.5	0.36

Note. The effect size d values reflect the average d across all the outcomes reported in each corresponding article.