Video game training to improve selective visual attention in older adults

Patricia Belchior a,⁎, Michael Marsiske b,⁎, Shannon M. Sisco b, Anna Yam b, Daphne Bavelier c, Karlene Ball d, William C. Mann e

a School of Physical and Occupational Therapy, McGill University, Canada
b Department of Clinical and Health Psychology, University of Florida, United States
c Department of Brain and Cognitive Sciences, University of Rochester, United States
d Department of Psychology, University of Alabama-Birmingham, United States
e Department of Occupational Therapy, University of Florida, United States

A R T I C L E   I N F O

Article history:
Available online 1 March 2013

Keywords:
Aging
Visual attention
Training
Videogames
Older adults

A B S T R A C T

The current study investigated the effect of video game training on older adult’s useful field of view performance (the UFOV test). Fifty-eight older adult participants were randomized to receive practice with the target action game (Medal of Honor), a placebo control arcade game (Tetris), a clinically validated UFOV training program, or into a no contact control group. Examining pretest–posttest change in selective visual attention, the UFOV improved significantly more than the game groups; all three intervention groups improved significantly more than no-contact controls. There was a lack of difference between the two game conditions, differing from findings with younger adults. Discussion considers whether games posing less challenge might still be effective interventions for elders, and whether optimal training dosages should be higher.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

The focus of the current study was to examine whether off-the-shelf video games, particularly so-called first person action video games, could boost useful field of view (UFOV, a widely studied measure of speed of processing and visual attention) in older adults. UFOV yields an estimate of the size of the visual area within which targets can capture attention during a brief inspection period, and has been shown to be negatively related to age (Ball, Beard, Roenker, Miller, & Griggs, 1988; Sekuler, Bennett, & Mameliak, 2000). The deterioration of the UFOV is characterized by a decrease in the efficiency with which individuals can extract information from a cluttered scene, rather than by a shrinking of the field of view per se. Furthermore, the decrease in efficiency is increased when conditions require the division of attention between central and peripheral tasks (Sekuler et al., 2000). When there is training, the primary goal of the UFOV is to improve processing speed/efficiency by which central and peripheral targets can be identified (Ball, Edwards, & Ross, 2007).

UFOV performance appears to have practical implications: Better UFOV has been associated with better driving (De Raedt & Ponjaert-Krystoffersen, 2000; Roenker, Cissell, Ball, Wadley, & Edwards, 2003) and everyday task performance (Ball et al., 2007), and UFOV testing has been integrated into some elder driving assessment contexts (Clay et al., 2005; Myers, Ball, Kalina, Roth, & Goode, 2000). It follows that UFOV improvements are expected to be related to maintained mobility and everyday functioning.

The UFOV test is comprised of three subtasks: speed of processing, divided attention and selective attention, which build on top of each other in complexity. Several training studies have found that UFOV can be improved with fairly brief computer-based instruction on the criterion task (Edwards et al., 2005). Training is usually adaptive, beginning at the lowest level of skill in which the participant shows performance below a defined criterion. Training goals are to increase speed of processing as well as the peripheral eccentricity of detected targets. In ACTIVE, a multi-site clinical trial of adults aged 65 years and older, initial UFOV intervention effects were maintained up to 5 years post-intervention (Ball et al., 2002; Willis et al., 2006).

The rationale for examining video games as an alternative approach to training UFOV-related visual attention stems from prior research with younger adults and from practical considerations. Studies by Green and Bavelier (2003, 2006a) and colleagues...
(Achtman, Green, & Bavelier, 2008) have shown that the training of young adult non-gamers in action video games (Medal of Honor, Unreal Tournament) improves UFOV, as well as other aspects of attention including attention to objects, attention in time, and more basic aspects of vision such as reduced crowding and greater contrast sensitivity. From a practical point of view, video game consoles are widely available at low cost and most older adults already own a television set. Training at home, and in the context of leisure play, might facilitate intervention compliance and increase training dosage (Hertzog, Kramer, Wilson, & Lindenberger, 2009). This would address challenges inherent in prior laboratory based research. When interventions require travel to centralized facilities during defined office hours, only more persistent or committed participants are likely to remain compliant. Furthermore, “business” hours limit the exposure time to the training program. In addition, Park, Gutchess, Meade, and Stine-Morrow (2007) have argued that active leisure (“productive engagement”) which encourages the formation of new schema will be more likely than “receptive engagement” (e.g., reading, listening to music) to lead to the development of improved cognition. Furthermore, recent work employing strategy-based video games with older adults, has documented improvements in executive skills such as the ability to switch between task sets (Basak, Boot, Voss, & Kramer, 2008).

The mechanisms by which action video games impact visual and cognitive skills are still unknown. It has been posited that action video game play facilitates a general speed of processing improvement, presumably by (a) the game demands for fast and frequent decisions (Green, Pouget, & Bavelier, 2010), (b) the use of a dynamic display and a rich environment to explore, (c) the need for divided attention at all times, and (d) the rapid pace requiring non-stop decision making (Achtman et al., 2008). In addition, Clark, Fleck, and Mitroff (2011) found that video game players (VGP) and non-video game players (NVGP) use different search patterns when exploring a visual scene. VGP are more likely to search the visual scene broadly while NVGP are more likely to persevere in a given region. Furthermore, VGP require fewer exposures to the change stimulus to detect its presence. It can be the case that VGP are able to capitalize on their visual processing abilities and explore larger areas of the image or alternatively they might use a different strategy to employ a broad search strategy.

Another study found that video game playing can alter fundamental characteristics of the visual system such as the spatial resolution of visual processing across the visual field (Green & Bavelier, 2007). The spatial resolution of visual attention was measured by the smallest distance a distracter could be from a target without compromising target identification. Results showed that, compared with a non-video game player, an action video game player could tolerate smaller target-distracter distances.

Prior work employing video game interventions also suggests that video games, due to their multimodal engagement of resources, might facilitate enhancement of processing components with more widespread consequences, which as Hertzog et al. (2008) argue, might be particularly appropriate for individuals with better-preserved latent cognitive potential.

The current study sought to augment the video game literature by (a) extending a previously employed video game training approach to older adults (i.e. Medal of Honor, Green & Bavelier, 2003), (b) including a no-contact control group, and (c) including a clinically validated training condition (UFOV training), which has been shown to effectively enhance UFOV skills in prior studies (Ball et al., 2002). This clinically validated group could serve as a benchmark for gauging video game training effect sizes. This study was also intended as a feasibility/pilot study to investigate the use of video games to train visual attention in a group of older adults. As such, beyond the goal of finding statistically significant training group differences (as reported in this paper), we also sought to achieve effect size determination (as also reported in the paper) to permit the powering of future larger scale trials.

2. Materials and methods

2.1. Ethics statement

All research was approved by the Institutional review board (IRB02, FAW00005790, DHHS Institutional Profile Code: 513806, Federal Entity Identification Number: 1596002052A1) of the University of Florida. Informed consent was obtained for all participants, and the investigation was conducted according to the principles expressed in the Declaration of Helsinki.

2.2. Sample

As is typical for almost all studies in this field of research, the sample was a community-solicited volunteer group from the community surrounding University of Florida. Participants’ characteristics were reflective of the local community. Fifty-eight non-gamers completed the entire study: they were generally young-old (mean age = 74.5 years, SD = 6.7, range = 65–91), college-educated (mean education = 16 years, SD = 2.4, high school to doctorate), and all were White. There were 30 women and 28 men. Participants were recruited by phone calls, by mail, and through flyers that were distributed in the community.

Three randomized participants (one from each intervention group – MOH, UFOV, Tetris) dropped out prior to the onset of training and were not included in the analysis. No participant dropped out after the training had initiated. Given the small sample size, it is not surprising that there were no differences between dropout and completing participants in age, years of education, gender, MMSE, or visual acuity (p > .05).

As described in greater detail below, participants were randomized into four groups (Medal of Honor n = 14; Useful Field of View n = 16; Tetris n = 15; Control n = 13). With an average group size of 14.5, this design was powered to detect an omnibus effect size Cohen’s f or 0.45 at power = 0.80. This corresponds to an eta-squared of 0.17.

2.3. Inclusion and exclusion criteria

Included participants were (a) 65 years or older, (b) had very little or preferably no video game usage in the past 6 months (same criteria used by Green & Bavelier, 2003), (c) scored 24 or higher on the Mini Mental State Examination (MMSE), (d) were willing to participate in 6 training sessions, and (e) had visual acuity of 20/70. Visual acuity tests were used because eye sensory function plays an important role in UFOV test performance and training effects could be compromised by a lack of visual acuity. Participants with composite scores of 200 (combined scores from speed, divided and selective attention tasks) or lower on the UFOV were excluded from the study because of limited room for improvement (i.e., their baseline performance already exceeded the established criterion for training). With regard to participants’ status as novice gamers, no participants reported playing any of console games prior to this study. The only game that a subset of participants reported playing was solitaire on a computer; those participants were not excluded, since there was no clear association between that game and the demands of the console game. It should be further noted that fewer than five of 58 participants reported playing even these simple computer games.
2.4. Measures

Three subtasks from the UFOV® test were included as dependent measures (same as in Ball et al., 2002). Each subtask presented stimuli at speeds ranging from 16 to 500 ms. For each subtask, a double staircase method determined an individual's threshold of 75% correct performance. This value, assessed in milliseconds, was the individual's score on the task. UFOV training focused on increasing speed of processing and speed of responding is not important. The subtasks (see Fig. 1), in order of incremental difficulty, were:

2.4.1. Speed

This subtask required accurate identification of a centrally-presented object (two-dimensional line drawing of a car or truck).

2.4.2. Divided attention

This subtask required both accurate object identification and simultaneous accurate localization of a peripherally-presented car.

2.4.3. Selective attention

This subtask was similar to Divided Attention, but added visual clutter (multiple equilateral triangles that filled most of the blank areas of the screen), requiring rapid visual search to localize the peripheral target.

The analysis was conducted using each subscore as a separate within-person level of a task factor. The score for each subtask could range from 16 ms (the minimum frame rate the computer could detect) to 500 ms (a maximum time-out criterion). Lower scores indicated better speed of processing skills. Specifically, the score assigned to each subtask reflected the presentation time needed to achieve at least 75% accuracy on the central task (for Speed) and on the peripheral task as well (for Divided and Selective Attention).

To permit comparisons with the ACTIVE study (Ball et al., 2002), we used the identical UFOV presentation platform as the ACTIVE study, which was a DOS based platform, with no chin rest. The training procedure was identical to that reported in Ball et al. The UFOV testing and training were conducted in a darkened room, with normal office (fluorescent) lighting, using low-glare television screens.

For the three training conditions, training consisted of six 90-min sessions administered over 2–3 weeks. Training was scheduled according to participants' preferred time of day. For consistency, to control time-of-day effects within subject, participants were trained at the same time of day for all subsequent sessions. Trainers were undergraduate student assistants who had extensive self-reported experience with action video games. All trainers received instruction in the implementation of the training protocol, which was manualized. Manuals with step by step instructions on game play were developed for both video game conditions. For the UFOV condition, a training manual previously used in the ACTIVE (Ball et al., 2002) study was used. Trainings were provided individually or in groups of 2. Training is summarized below, and full copies of the training manual are available from the authors upon request.

For both video game conditions (Medal of Honor, Tetris), the trainer played the game for about 10 min in order to model game play and the requisite skills. Next, the trainer demonstrated use of the controller to the participants.

2.5. Design and procedure

Participants were randomized to one of four groups: (1) Medal of Honor training (MOH; target intervention for this study, n = 14); (2) clinically validated UFOV training (Ball et al., 2002, n = 16); (3) Tetris (placebo control) training (Green & Bavelier, 2003, n = 15); or (4) no-contact control (pre- and posttest only, n = 13). Pre- and post assessments were completed within 1 week of interventions.

The two video game training conditions (MOH and Tetris) employed a Sony PlayStation 2 (PS2), console model 97060 and a dual shock 2 analog controller, model 97026. The games were presented on a 19” TV monitor. The UFOV training was administered via a desktop computer. A CPU was connected to a 21” Elo touch screen.

For the three training conditions, training consisted of six 90-min sessions administered over 2–3 weeks. Training was scheduled according to participants’ preferred time of day. For consistency, to control time-of-day effects within subject, participants were trained at the same time of day for all subsequent sessions. Trainers were undergraduate student assistants who had extensive self-reported experience with action video games. All trainers received instruction in the implementation of the training protocol, which was manualized. Manuals with step by step instructions on game play were developed for both video game conditions. For the UFOV condition, a training manual previously used in the ACTIVE (Ball et al., 2002) study was used. Trainings were provided individually or in groups of 2. Training is summarized below, and full copies of the training manual are available from the authors upon request.

For both video game conditions (Medal of Honor, Tetris), the trainer played the game for about 10 min in order to model game play and the requisite skills. Next, the trainer demonstrated use of the controller to the participants.

2.5.1. Medal of Honor training

In this training, participants played the “first person shooter” video game Medal of Honor – Rising Sun, first with guidance from a student trainer and then more independently. The MoH training was conducted in a lighted room with normal office (fluorescent) lighting, using low-glare television screens.

The MOH game is quite challenging for novice elders, so difficulty level was made manageable by use of step by step instructions on how to play the game, which were presented by an experienced trainer/coach, using a Microsoft Power Point presentation on a computer that was placed next to the participants. Training broke the game into missions, and manualized all the steps needed to successfully solve a mission. The experienced coach/interventionist first modeled successful game play, talking aloud as they progressed through the mission. The coach then had participants execute all the manualized steps themselves, starting and stopping as much as needed, until they had successfully completed a mission. Finally, participants played through the mission from beginning to end, and continued to play until they had successfully completed the mission. This shaping by steps ensured that all participants could perform all of the steps.}

Fig. 1. Useful field of view subtasks.
participants could experience some progress. Trainers were available to offer guidance and support throughout game play. Once participants had mastered a mission on their own (achieving all mission objectives, as detailed in the training manual), they could “graduate” to the next mission. All trained participants experienced progress in game play: 21% completed missions 1–3, 50% completed missions 1–4, and 29% completed missions 1–5.

2.5.3. Useful field of view (UFOV) training

In this placebo training condition, participants played the video game Tetris (Tetris Worlds for PS2, arcade mode). In the game, which is a classic 1980s arcade game, seven randomly rendered tetrominoes—shapes composed of four blocks each—fall down the playing field. The object of the game is to manipulate these tetrominoes to create a horizontal line of blocks without gaps. When such a line is created, it disappears, and the blocks above (if any) fall. As the game progresses, the tetrominoes fall faster, and the game ends when the stack of tetrominoes reaches the top of the playing field. Unlike MOH, the Tetris game scenario did not change over the course of the following sessions. The participants had to repeat the same task over and over again; however, as game play improved, the speed of tetramino dropping increased. It should also be noted that participants had to visually process the tetramino at the bottom of the screen. Thus, Tetris required continual visual scanning and spatial manipulation, although tetrominos were usually presented more in the central and less in the peripheral fixation region.

2.5.2. Tetris training

For this training, a manual previously employed in ACTIVE (Ball et al., 2002) was used. In the initial assessment, participants received a preliminary score on the each of the three UFOV subtasks. Participants were considered not in need of further training on a subtask if they were scoring 30 ms or better on Speed, 40 ms or better on Divided Attention, or 80 ms or better on Selective Attention. Training began at participants’ current skill level, starting at the most challenging level (speed followed by Divided Attention followed by selective attention) at which the participant was performing worse than the pre-specified training criterion. Within a given task, training started at roughly the presentation time at which they performed with high accuracy (75%) on the screening measure and with peripheral targets close to the center of the screen. As participants mastered performance at that level, peripheral eccentricity was gradually increased to maximum, then presentation time was decreased by 40 ms, and the localization ladder from central-to-peripheral was repeated until the training criterion was reached.

3. Results and discussion

3.1. Assessment of baseline differences between treatment groups

An analysis of variance was conducted to determine whether there were differences between the four intervention groups in demographic status, age, years of education, gender, race, cognitive status (MMSE), and visual acuity. The omnibus test revealed that there were no significant differences between the four groups, suggesting that randomization had distributed participant characteristics similarly across the groups. Table 1 shows the characteristics of the sample on the variables assessed, both for the total group and by intervention subgroup. P-values shown reflect the absence of a significant overall difference between groups.

3.2. Training effect on visual attention

In UFOV training, goal performance on the Speed subtask is ≤30 ms and on the Divided Attention subtask ≤40 ms. Preliminary analyses revealed that the majority of participants were performing at or better than this criterion on the Speed (93%) and Divided Attention (53% at ≤40 ms) subtasks at baseline. In contrast only one participant (1.7%) was at or below the ≤80 ms training goal for Selective Attention. This applied to all groups, and meant reduced sensitivity to change for these first two outcomes.

A 3 × 2 × 4 ANOVA was conducted with two within-person factors (UFOV® Task: Speed, Divided Attention, Selective Attention and Test: Pretest, Posttest) and one between-person factor (Training Group: Medal of Honor, UFOV, Tetris, no-contact). A significant main effect was revealed for Test (prepost), F(1,54) = 23.49, p < .001, η² = .30, Cohen’s f = .65 and UFOV® task, F(2,108) = 178.36, p < .001, η² = .77, Cohen’s f = 1.83 but no significant main effect was found for Group, F(3,54) = 1.27, p = .294, η² = .07, Cohen’s f = 0.27. A significant two-way interaction effect

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Sample characteristics both for the total group and by intervention subgroup.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total sample (N = 58)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>74.7 (6.4)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>16.0 (2.4)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male N (%)</td>
<td>28 (48.3)</td>
</tr>
<tr>
<td>Female N (%)</td>
<td>30 (51.7)</td>
</tr>
<tr>
<td>MMSE</td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>29.8 (5.2)</td>
</tr>
<tr>
<td>Vision</td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>85.2 (11.5)</td>
</tr>
<tr>
<td>Snellen equivalent</td>
<td>20/18</td>
</tr>
</tbody>
</table>

Note: MOH = Medal of Honor; UFOV = useful field of view; MMSE = Mini Mental State Examination.
was revealed for Test × UFOV® task, \(F(2,108) = 11.44\), \(p < .001\) \(\eta^2 = .18\), Cohen’s \(f = .47\), but no significant interaction effects were revealed for UFOV® task × Group, \(F(6,108) = .945\), \(p = .467\), \(\eta^2 = .05\), Cohen’s \(f = .23\) or Test × Group, \(F(3,54) = 2.37\), \(p = .081\), \(\eta^2 = .12\) Cohen’s \(f = .37\). All lower order effects were qualified by a significant three-way interaction: Test × UFOV® task × Group effect, \(F(6,108) = 3.40\), \(p < .004\), \(\eta^2 = .16\), Cohen’s \(f = .44\).

Followup univariate ANOVAs were conducted for each UFOV® task (Speed, Divided Attention, Selective Attention). Main effects and interaction of Test (2: pretest, posttest) and Group (4: Medal of Honor, UFOV, Tetris, no-contact) were examined, as summarized in Table 2. As Table 2 and the means/standard deviations in Table 3 show, for Divided Attention and Selective Attention, faster posttest performance for all groups produced the Test main effect.

To decompose the Test × Group interaction for the Selective Attention task, a simple effects post-hoc analysis compared pre-post change by group; results showed greater improvement for (1) UFOV-trained participants than controls, \(t(54) = 3.51\), \(p = .001\) \(\eta^2 = .19\), Cohen’s \(f = .48\), Cohen’s \(d = .99\), (2) Medal of Honor-trained participants than controls, \(t(54) = 2.13\), \(p = .038\), \(\eta^2 = .08\), Cohen’s \(f = .29\), Cohen’s \(d = .59\) and (3) Tetris-trained participants than controls, \(t(54) = 2.81\), \(p = .007\), \(\eta^2 = .13\), Cohen’s \(f = .39\), Cohen’s \(d = .77\). None of the three intervention groups differed from one another (all \(ps > .05\)). Table 3 demonstrates that UFOV-trained participants gained about 90.34 ms in Selective Attention, while Medal of Honor and Tetris gained about 53.00 and 71.60 ms respectively. Control participants, on the other hand, performed about 9.15 ms slower at posttest than at pretest. If Bonferroni corrections had been used to keep family-wise error rates below .05, only tests with \(p\)-values of .008 and lower would be judged significant, meaning that the Medal of Honor effect would not be judged significantly greater than controls.

### 4. Conclusion

The current study findings are promising but should be interpreted with caution due to low sample size, minimal training dosage and the lack of racial/ethnic diversity in the sample. Clearly, generalizability of the current findings to a larger and more diverse population of elders is a necessary goal for future research. This study, which employed action video games to train older adults’ visual attention skills, partially replicated previous findings with younger adults (Green & Bavelier, 2003), in that playing a first-person shooter game was associated with significant improvement in selective visual attention relative to no contact controls. Unlike in the younger adults from the Green and Bavelier (2003) study, Tetris play (an arcade puzzle game utilized as a placebo control condition) also improved selective attention in our older adult sample. All participants were novice players; thus, no participant reported playing any of console games prior to this study.

The UFOV training program produced marginally (but not significantly) greater improvement than the video games, which was expected given high isomorphism between the training conditions and the tests used to evaluate change. Unfortunately, the low sample size in this study compromised the power to detect differences among the training conditions. The biggest surprise in this study was the apparent effect of Tetris play on selective visual attention, which was not observed in the Green and Bavelier (2003) study with younger adults. Speculatively, given that Tetris appears to demand whole-screen scanning and mental rotation which, for non-gamer older adults, may have been sufficiently

### Table 2

ANOVA summary tables for three visual attention outcomes.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Speed</th>
<th></th>
<th>Divided Attention</th>
<th></th>
<th>Selective Attention</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(F)</td>
<td>(\eta^2/f)</td>
<td>(F)</td>
<td>(\eta^2/f)</td>
<td>(F)</td>
<td>(\eta^2/f)</td>
</tr>
<tr>
<td>Between-subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group (G)</td>
<td>3</td>
<td>0.75</td>
<td>0.04/0.20</td>
<td>1.77</td>
<td>0.09/0.31</td>
<td>0.94</td>
<td>0.05/0.23</td>
</tr>
<tr>
<td>Error</td>
<td>54</td>
<td>198.84</td>
<td></td>
<td>7020.19</td>
<td></td>
<td>21436.67</td>
<td></td>
</tr>
<tr>
<td>Within subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test (T)</td>
<td>1</td>
<td>2.74</td>
<td>0.05/0.23</td>
<td>5.93**</td>
<td>0.10/0.33</td>
<td>26.49***</td>
<td>0.10/0.33</td>
</tr>
<tr>
<td>Group × Test</td>
<td>3</td>
<td>1.45</td>
<td>0.08/0.29</td>
<td>1.05</td>
<td>0.06/0.25</td>
<td>4.49**</td>
<td>0.20/0.50</td>
</tr>
<tr>
<td>Error</td>
<td>54</td>
<td>183.64</td>
<td></td>
<td>2255.33</td>
<td></td>
<td>2881.05</td>
<td></td>
</tr>
</tbody>
</table>

Note: values enclosed in parentheses represent mean square errors. \(\eta^2 = \) partial eta squared, \(f = \) Cohen’s \(f\), estimate of effect size.

\* \(p < .05\).

\** \(p < .01\).

\*** \(p < .001\).

### Table 3

Change of useful field of view performance by group from pretest to posttest.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training group</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UFOV (n = 16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>19.88</td>
<td>16.94</td>
<td>18.29</td>
<td>19.43</td>
<td>20.13</td>
<td>18.53</td>
</tr>
<tr>
<td>SD</td>
<td>5.48</td>
<td>2.11</td>
<td>3.27</td>
<td>4.22</td>
<td>8.92</td>
<td>3.62</td>
</tr>
<tr>
<td></td>
<td>UFOV divided</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>41.69</td>
<td>24.56</td>
<td>85.36</td>
<td>43.43</td>
<td>95.73</td>
<td>66.67</td>
</tr>
<tr>
<td>SD</td>
<td>20.52</td>
<td>11.55</td>
<td>86.24</td>
<td>37.96</td>
<td>100.61</td>
<td>70.68</td>
</tr>
<tr>
<td></td>
<td>UFOV selected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>209.00</td>
<td>118.63</td>
<td>225.64</td>
<td>172.64</td>
<td>256.93</td>
<td>185.33</td>
</tr>
<tr>
<td>SD</td>
<td>54.44</td>
<td>72.71</td>
<td>114.76</td>
<td>108.39</td>
<td>131.91</td>
<td>119.85</td>
</tr>
</tbody>
</table>

Note: Lower scores represent faster (better) performance. M = mean, SD = standard deviation, UFOV = useful field of view.
challenging to produce the observed selective attention improvements.

Anecdotally, Tetris may also have inadvertently conferred a higher training dosage than Medal of Honor. Trainers observed that Tetris was easier for elders to learn, such that participants may have spent less time learning the game mechanism and engaged in more active play than in Medal of Honor. Similar findings have been reported in adults with amblyopia; both Medal of Honor and the non-action game Sim City improved visual attention and acuity (Li et al., 2008). Also, it is possible that participants were more engaged in the Tetris game, which is a puzzle-like game that might be more appealing to an older adult population than a first person shooter game.

A special question emerging from the current investigation is why the Tetris condition might have produced UFOV improvement in older adults, when it did not in younger adults (Green & Bavelier, 2003)? The answer likely includes the idea that our participants were older and were gaming novices. For novice older adults (who play Tetris against a backdrop of declining speed and perceptual abilities), Tetris likely offered a much higher level of perceptual, cognitive and motor challenge than it would for younger adults. The perceptual and motor demands of making relatively fast responses to falling blocks (novel stimuli requiring mental rotation), the need to divide attention between the falling object and the receptor site (located at different vertical ends of the game), the need to predict where the falling object would best fit, and the game-delivered feedback of decisions (“clearing a row” or failing to do so) likely all contributed to making Tetris much more of an “action” video game for older adults than it would have been for younger participants.

As a preliminary study with relatively few participants, the current investigation can offer relatively little insight into the mechanisms or mediators of our video game training effects on UFOV. The growing literature in this area, however, suggests several speculative reasons regarding why video games might be effective. These include: (1) improvement in basic speed of processing (video games demand rapid and accurate response to transient objects with fast velocity; as participants increase speed in game play, this may generalize to speed in other tasks (Edwards et al., 2005; Roenker et al., 2003 & Dye, Green, & Bavelier, 2009a); (2) improvement in executive control (video games require balancing among a large number of concurrent demands, including fast response, high cognitive/perceptual/motor loads, peripheral and central visual field processing, predicting what may happen next, maintaining items in short-term memory, rapid task switching, and reasoning); practice with coordination may then generalize to the coordinative demands of UFOV (Green et al., 2010; Scalf et al., 2007 & Anderson-Hanley et al., 2012); in general, “gamification” increases the need to engage high-level planning and spatial working memory (Green & Bavelier, 2012). (3) improvements in attentional control, including improvements in both the spatial and temporal operation of attention (Donohue, Woldorf, & Mitroff, 2010; Dye, Green, & Bavelier, 2009b; Green & Bavelier, 2006b; Hubert-Wallander, Green, & Bavelier, 2011); (4) improvements in the ability to quickly perceive the relations between multiple objects and events, since video games require differential response to different virtual objects; this may generalize to the simultaneous perceptual identification and object localization demands of the UFOV selective attention task (Green et al., 2006a; Basak et al., 2008); (5) an fMRI study suggests that UFOV practice may increases activation in the right inferior frontal gyrus and right precentral gyrus; this raises the question of whether video game play might also increase activation in brain regions associated with the ability to recruit and re-orient stimulus-driven attention to novel and unpredictable target locations outside the current focus of attention (Mishra, Zinni, Bavelier, & Hillyard, 2011; Scalf et al., 2007; West, Stevens, Pun, & Pratt, 2008); (6) practice in the specific skills needed for UFOV performance (fast response, whole field visual search, feature matching)—this argument suggests that video games share enough processing feature with UFOV that transfer would be expected based on the law of identical elements (Thordike, 1913); and (7) motivation/arousal/engagement/reward/feedback/enjoyment (Csikszentmihalyi, 2008) (for example, in another study, we found that Tetris and Medal of Honor play were associated with increases in perceived flow (Belchior, Marsiske, Sisco, Yam, & Mann, 2012) throughout the period of training, something that was not true for traditional UFOV training; might this suggest that high levels of engagement and effort mean that games encourage older players to ‘stick with it’ and ‘try harder’, and that these factors contribute to the training potential of games? This motivational interpretation is consistent with recent work by Anderson-Hanley et al. (2012), who showed that video-game based exercycling was more effective than traditional cycling in boosting executive function in older adults. The authors argued that the enjoyment and motivational value of games, including visual stimulation and personal challenge to beat previous performance levels, may make them particularly potent intervention tools. If the games maximize engagement, individuals may exert maximal effort.

While the present study used a randomized experimental design with more control conditions than previous research (i.e., Tetris as control game, gold-standard training condition, and no-contact controls), given our sample of healthy, educated, White older adults, many of whom were performing quite well at baseline, the generalizability of findings is limited. Other studies using participants with slower baseline processing have found much larger training effects (Edwards et al., 2005). The modal intervention dosage of 6–9 h was brief, especially for the MOH condition, in which necessary “game learning” reduced time spent actively playing the game.

Future research can expand on the current findings in several key ways: (a) recruitment of a more ability-diverse sample with fewer high performers at baseline; (b) increase of exposure dosage or additional dose-response studies to determine optimal amount of game play needed to produce larger and broader visual attention training effects; and (c) expansion of the outcome battery to examine possible transfer effects and game differences in transfer to other measures of visual attention, spatial cognition, and everyday function. In addition, more work aimed at identifying the processes by which games improve visual attention and other cognitive skills are necessary. The present study contributes to the growing body of intervention work, termed “third generation” by Hertzog et al. (2009), aimed at capitalizing on neural plasticity and boosting underlying cognitive-behavioral processes that might generalize to novel environments. Findings suggest that “off-the-shelf” video-games may be one accessible vehicle for achieving cognitive performance improvements in older adults.

**Funding**

This research was supported by the National Institute on Disability and Rehabilitation Research Grant H133E010106 awarded to W.C.M. Patricia Belchior’s work on the manuscript was also supported by a Supplement to Enhance Diversity Grant U01-AG-014276-S1 to M.M. Anna Yam was supported, in part, by Robert Wood Johnson Foundation Grant 64441 to P.B. Additional study support in the form of discounted software licenses was provided by Systems Technology Inc. (http://www.stsimdrive.com/) of Hawthorne, CA. The funding sources had no involvement in research design, data collection or data analysis.
Acknowledgments

We acknowledge the support of undergraduate colleagues at the University of Florida who assisted with data collection and training activities. These include Jason Bendezu, Eric Gonzalez-Mule, Brian Huei, Matt Mustard, Sean Weisbrot, Emily Ricketts, and Claudia Ramirez. We also thank Jason Rogers for technical and IT-related support with this Project.

References


