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The Effects of Training in Bejeweled Blitz on Useful Field of View in Older Adults

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Presented by

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ABSTRACT

Title: **The Effects of Training in Bejeweled Blitz on Useful Field of View in Older Adults**

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There is substantial evidence that links increased age with cognitive declines in attention, processing speed, and working memory. Researchers have recently begun to investigate the idea that video games can be used as an intervention to improve cognitive abilities in older adults. This study investigated whether or not repeated training in the casual video game Bejeweled Blitz (BJB) results in improved attention abilities in 9 adults ages 65 and older, as measured by the Useful Field of View (UFOV) task. Pre-post improvements in BJB scores were correlated with improvements in UFOV scores, suggesting that BJB training produced transfer of skills to this measure of attention.

Keywords: older adults, video games, training intervention, useful field of view

The older adult population is increasing as life expectancy in the U.S. grows higher. In fact, the population of adults ages 65 and older has increased from 12.4% of the total population in 2000 to 13% in 2010 (U.S. Census Bureau, 2000; U.S. Census Bureau, 2010). Helping this population maximize their health and functioning would therefore be a valuable goal of psychological research.

This study focuses on deficits in attentional abilities in older adults and attempts to intervene on the common declines in attention seen in older adults. Because attentional abilities are pivotal for almost all activities we encounter, deficits in these domains impair one's ability to function properly in daily life (Hoffman, Xiangdong, Bovaird, & Embretson, 2006). Declines in older adult cognitive abilities also impact the cost of health care in the U.S. due to increased demands for older adult care in hospitals and nursing homes (Ball et al., 2002). Stimulus duration, central task difficulty, addition of secondary tasks, conspicuity, and presence of distracters all have an impact on visual attention. These factors impact older adults more so than younger adults (Edwards et al., 2006; Green & Bavelier, 2006; Lawo, Philipp, Schuch, Koch, 2012).

Cognitive Declines in Older Adults

Researchers have documented a number of age-related changes in cognition particularly in attention and information processing as measured by speeded performance. Among these declines include divided and selective visual attention, processing speed, manual dexterity, spatial orientation or mental rotation, reasoning, and working memory, (Achtman, Green, & Bavelier, 2008; Ball & Owsley, 1993; Basak, Boot, Voss, & Kramer, 2008; Basak, Voss, Erickson, Boot, & Kramer, 2011; Edwards et al., 2006; Green & Bavelier, 2006; Lawo et al.,

2012; Lee et al., 2012; Maillot, Perrot, & Hartley, 2011; Salthouse, 1996; van Muijden, Band, & Hommel, 2012; Zeintl & Kliegel, 2009).

According to Salthouse, cognitive declines in older adults can be attributed to “a reduction...in the speed with which many cognitive operations can be executed”, which he referred to as the *processing-speed theory* (Salthouse, 1996, p. 403). Salthouse (1996) also proposed the *simultaneity mechanism*, which states that the ability to complete complex tasks, which require many simultaneous tasks to be synchronized at once, is dependent on how rapidly an individual is able to perform processing operations. Information processed early on may be lost while later information is processed. Declines in speed of processing abilities are evident in tests involving the manipulation of abstract or familiar material (Salthouse, 2010). Processing speed is a strong indicator of age-related cognitive deficits, such as spatial ability and memory (Lunsman et al., 2008; Baudouin, Clarys, Vanneste, & Isingrini, 2009). Processing speed is affected by “general limitations”, such as variations in the “efficiency or effectiveness of specific processes” or limitations in declarative, procedural, or strategic knowledge (Salthouse, 1996; Lee et al., 2012). When controlling for speed of processing abilities, age-related variance is reduced or eliminated for free recall and cued recall (Baudouin et al., 2009). Cued recall is a task in which a participant must recall information obtained in a “learning phase” with the assistance of cues (Ramratan et al., 2012).

Neuroplasticity.

Fortunately, deficits in older adult cognition can be shown to be reversed, as attributed to neuroplasticity. Neuroplasticity, also called neural plasticity, is defined as “the ability of the nervous system to change in response to experience or the environment” (Breedlove, Watson, &

Rosenzweig, 2010). Neuroplasticity endures throughout life as evidenced by animal and human studies. Such cognitive abilities that can be maintained with neuroplasticity include inductive reasoning and selective attention (Ball et al., 2002; Mailott et al., 2011; van Muijden et al., 2012).

Selective and divided attention are measured in the current study. Attention is defined as “the mechanism by which certain aspects of the environment are selected for further processing” (Hoffman et al., 2006, p. 985). Two forms of attention are selective attention and divided attention (Breedlove et al., 2010). Selective attention is the ability to focus on targets and ignore distractors (Bavelier, Achtman, Mani, & Focker, 2012; Kellogg, 2012). Divided attention involves allocating one's attention to more than one target (Kellogg, 2012).

Useful Field of View

The term Useful Field of View (UFOV) refers to the field of vision from which an individual can derive information in a glance without movement from the eyes or head. UFOV tasks require the observer to detect a target in the periphery (Ball & Owsley, 1993; Edwards et al., 2006; Lunsman et al., 2008; Visual Awareness Research Group Inc.).

Performance on the UFOV has been shown to be predictive of the following: mobility, extent of one's travel, falls, vehicle crashes, on-road driving, and driving simulator performance for older adults (Edwards et al., 2006; Green & Bavelier, 2008; Lunsman et al., 2008).

Interestingly, Ball & Owsley (1993) found that out of the individuals who had both failed the UFOV task and had a history of vehicle crashes, only around half of these individuals had eye health impairments. This implies that the ability to perform well on the UFOV task is not dependent on the abilities of the eyes alone. The UFOV task is a measure of an individual's

“attentional resources” (Green & Bavelier, 2003).

Performance on the UFOV is dependent upon one’s processing speed abilities, so older adults tend to do poorly on this task as compared to younger adults because of a decline in speed of processing skills (Edwards et al., 2006; Lunsman et al., 2008). Other variables that factor into one's UFOV performance are mental status, vision, education, and health. Because performance on the UFOV is dependent on cognitive abilities, the UFOV task is a reliable means for measuring processing speed, divided attention, and selective attention in older adults.

Furthermore, research has shown that performance on the UFOV can be improved with speed of processing training. Such training can also improve driving abilities for up to eighteen months following training (Edwards et al., 2006).

The present study seeks to find if training in the casual video game, Bejeweled Blitz (BJB), would have the same effects as speed-of-processing training, in that it results in improved UFOV performance. More details on Bejeweled Blitz and its relevance to the UFOV task are provided in the section of the introduction titled “Bejeweled Blitz and Cognition”.

Training in Video Games and its Effect on Cognitive Abilities

Due to evidence of neuroplasticity in later life, researchers have investigated interventions that could assist older adults in improving cognitive abilities (Ball et al., 2002; van Muijden et al., 2012). For example, Ball et al. (2002) conducted a study in which older adults (ages 65-94) went through ten sessions of cognitive training. Participants were trained in one of the following: memory, inductive reasoning, or speed of processing. They found that older adults had immediate improvement on the tasks, with improvement in 87% of participants trained on the speed-of-processing task. Cognitive tasks, though effective, are not necessarily an enjoyable

or desirable task for individuals to complete in their leisure time, however. Thus, researchers have recently begun to investigate whether or not video games have the ability to behave as a cognitive intervention while being an enjoyable and stimulating pastime. In general, video games have the potential to help people in various aspects of their lives. Video games are used as a means of communicating a lesson to the public, such as health education, knowledge and self-management of diabetes and asthma, and fire safety. Distracting one from chronic pain, increasing conflict-resolution skills, and “supporting psychotherapeutic treatment” are more examples of the potential of video games to elicit positive changes in one’s life (Primack et al., 2012).

A significant amount of research has found that training in video games is promising in that they provide some far transfer for individuals of a range of ages. Far transfer is defined as the transfer of ability in one cognitive task to a separate but related cognitive task (Spence & Feng, 2010). Because different genres of video games tax different skills of the player, only certain genres result in far transfer for certain cognitive abilities (Spence & Feng, 2010). The current study investigates if gameplay in BJB can produce far transfer to the UFOV task. Some genres of video games show more potential than others, with first-person shooter (FPS) games and action video games showing promising results (Achtman et al., 2008; Basak et al., 2008; Bavelier et al., 2012; Green & Bavelier, 2003; Green & Bavelier, 2006; Spence & Feng, 2010). Variables that will affect whether or not training (video game or otherwise) provides far transfer include the following: the difficulty of the task, feedback, arousal, motivation, and stimulus variability (Maillot et al., 2011; van Muijden et al., 2012).

There are limited data on the effect of video game training on far transfer in older adults.

Mailott et al. (2011) recruited 32 older adults (ages 65-78) for a study investigating the impact that training in “exergame” Nintendo Wii has on executive control tasks, processing speed tasks, and visuospatial tasks. “Exergames” are defined by Maillot et al. (2011) as “video games that combine game play with significant physical exercise by using physical input devices” such as the Nintendo Wii or the Microsoft Xbox 360 Kinect. The training group had a total of 24 hours of exergame training: twice every week for twelve weeks, while the control group maintained their regular sedentary lifestyle without exergames. There were no gains seen in visuospatial abilities, but the training group showed improvement in speed of processing skills upon follow-up analyses. This study varies from the current study, however, in that the current study does not involve any physical exercise. Maillot et al. (2011) contended that the cardiovascular gains helped promote the far transfer, though this is uncertain because there was no control group involving a sedentary video game.

Another study conducted by van Muijden et al. (2012) investigated video game training in 54 older adults (60-77), along with a control group of 20 older adults (ages 61-73). The older adults were trained in five online “cognitive training games”. They were instructed to play for 30 minutes each day for seven weeks. The control group was instructed to watch and answer responses on a documentary. Results showed that the training group improved on a task of inductive reasoning (Raven-SPM) and on a task of inhibition (Stop-Signal task). The control group improved on selective attentional abilities as measured by the UFOV-3 task.

Another study by Goldstein et al., (1997) investigated the effect of gameplay in Super Tetris on 22 older adults (ages 69-90) from The Netherlands. They found that after playing for five or more hours every week for five weeks (25 hours of gameplay), older adults showed

improvement in their performance on the Sternberg reaction time test.

Basak et al. (2008) conducted a study involving 40 older adults, 20 of which were assigned to a control group and the remaining 20 assigned to video game training in a popular, real-time strategy game titled Rise of Nations (RON). Older adults were trained for a total of 23.5 hours. Results found that trained individuals were quicker at a test involving task-switching, which requires the participant to switch between multiple tasks (Lawo et al., 2012). No differences were seen for the operation span task, a task that requires the participant to complete math equations while memorizing words presented before the equation (Zeintl & Kliegel, 2009).

Dustman, Emmerson, Steinhaus, Shearer, and Dustman (1992) conducted a study on 60 older adults ages 60-79 in which participants were assigned to one of three conditions: video games, watching movies, or a control condition. Participants assigned to the video game condition played thrice a week for an hour at a time for approximately 11 weeks. Participants were given the option to choose whichever video game they desired for that session, out of an array of video games provided by the study including Ms. Pacman and Frogger. Those assigned to the movie watching condition would watch 2 movies with a duration of an hour and a half every week for 2 and a half months. Results found that those assigned to the video game condition had significantly faster reaction times than those of the other groups.

There is a broader base of research on video gaming in younger adults, involving both video game training and research on video game players. Within this research, FPS games and action video games show promising results in the way of far transfer. FPS games have been shown to transfer to spatial selective attention tasks, mental rotation tasks (Spence & Feng, 2010) as well as to the UFOV task, subitizing, and real-life complex tasks such as flight performance

(Basak et al., 2008). Subitizing refers to the ability to discern numbers of 6 and under (Kaufman, Lord, Reese, & Volkman, 1949). However, prior studies have indicated that FPS games do not appeal to older adults due to their violent nature, so it is important to investigate alternative gaming genres that may appeal to an older crowd (McKay & Maki, 2010). Already it has been documented that older adults enjoy playing casual video games (CVG; Whitbourne, Ellenberg, & Akimoto, in revision).

Research on action video games also shows promising results for the transfer of skills. Green & Bavelier (2003) trained non video game players (NVGPs; ages 18-23) in an action game titled *Medal of Honor* for one hour every day for 10 days. A control group was utilized and played a popular tile-matching game titled *Tetris*. Those trained in the action video game had improved scores as compared to the control group in the following tasks: UFOV task, enumeration, and attentional-blink. Attentional blink is defined as “the phenomena wherein subjects have difficulties reporting a second target when it appears a few hundreds of milliseconds after the onset of a first target” (Green & Bavelier, 2003). A review by Achtman, Green & Bavelier (2008) showed that video game players (VGPs) have improved abilities as compared to non-video game players in a variety of tasks, such as an ability to “process a rapid stream of visual information with increased efficiency as compared to NVGPs”. Action VGPs are also able to track about two more objects than NVGPs. Achtman et al., (2008) also reported that training in action video games are better at the attentional blink task as compared to those trained in non-action video games. Furthermore, training in action video games improves one’s ability to efficiently allocate attention over space and time. Lastly, training in the real-time strategy video game *Rise of Nations* was found to elicit transfer to mental rotation, working

memory, reasoning, and task-switching (Basak et al., 2008).

Bejeweled Blitz and Cognition

Bejeweled Blitz was chosen for this study because it requires attentional abilities of the player, the ability to react quickly, and the ability to ignore distracting stimuli. These elements are all required of the UFOV Divided and Selective Attention tasks, as the UFOV task not only measures attentional abilities, but relies on processing speed and, specifically in task 3, requires the participant to ignore an array of distracters (Lunsman et al., 2008). Distracting stimuli involved in BJB includes music and constant comments given by the male voice as well as explosive sounds and visual, flashing “explosions” when matches are made. Also, when special combinations are made, special gems will appear, such as a gem that appears to be “on fire” when a match of 4 is made and a spinning “hypercube” that appears when a match of five is made. These visual stimuli could possibly be a distraction. Van Muijden et al. (2012) proposed that the following characteristics must be involved in a video game for it to facilitate far transfer: frequent presentation of feedback, motivating nature, reinforcement schedules, and stimulus variability. Because BJB embodies these qualities, it is possible that it enables far transfer. Additionally, BJB is widely popular among a variety of age groups. According to the Information Solutions Group (2011), BJB and FarmVille were the most popular social video games in the U.S. and the U.K.

In a survey of over 10,000 adults ages 18 to 64, Whitbourne et al., (in revision) investigated the perceived main effect that BJB had on each age group. The authors predicted that older adults would report playing CVG in order to obtain cognitive benefits, while younger adults would report playing for social reasons. Contrary to the hypothesis, younger adults were

more likely to report playing CVG for both social reasons and for cognitive benefits. The reported main effects of BJB on cognitive abilities differed by age group. Older adults reported that BJB gives them greater confidence in their cognitive abilities, while younger adults reported that BJB assists them in focusing their attention. Furthermore, older adults were more likely to report playing BJB because they enjoy the graphics, whereas the younger adults were more likely to report playing for the competition among friends.

Gargiulo, Stroud, and Shaw (2013) conducted a study involving BJB and the visual search task. This study involved two experiments. The first experiment required 18 participants to play 10 rounds of BJB followed by a visual search task and 19 participants to engage in the visual search task without any rounds of BJB. The visual search task required the participant to indicate if the target was present or absent. They did not find any difference in these two groups for either search task condition. The second experiment of this study required 19 participants to engage in 30 rounds of BJB followed by the same visual search task. Following 30 rounds of BJB, participants improved in their ability to respond quickly to the visual search task while still maintaining accuracy.

Preceding Studies

Prior to the current study, our lab conducted a similar study investigating BJB, a reaction time test, and the visual search task. This study involved fifty-six older adults (ages 65 and older) who were recruited through newspaper ads and flyers. Participants completed the following tasks in this order: reaction time test (Allen, 2002), 100 rounds of a visual search task, twenty rounds of BJB, and a questionnaire. Results showed a correlation between age and performance on BJB and the reaction time test. Results also found a negative correlation ($r = -.49$) between age and

internet self-efficacy. Furthermore, both prior gameplay and single-feature visual search time was predictive of BJB performance ($r = .31$; Proctor, 2011).

Furthermore, this study was preceded by a pilot study conducted with twenty younger adults involving training in BJB. The younger adults (ages 18-24) were recruited from the University of Massachusetts Amherst. One participant reported being age 29. The pilot study's procedure differed from the current study in various ways. The study took place in one session as opposed to the current study's six weekly sessions. Also, the procedures differed from one another. The younger adults were given the tasks to complete in the following order: a reaction time test (Allen, 2002), three subtests of the UFOV task, three rounds of BJB without training, ten rounds of BJB with training, five rounds of BJB without training, three subtests of the UFOV task, and a questionnaire. Similarly to the current study, we recorded their BJB gameplay during the training rounds.

Summary

Because BJB requires attentional abilities of the player, the ability to react quickly, and the ability to ignore distracting stimuli, training in BJB may lead to improvement in UFOV performance. Comparing pre- and post-training UFOV scores will be indicative of any improvements in processing speed and visual attention. Furthermore, because speed of processing training has been documented to improve performance on the UFOV, which, itself, is predictive of a plethora of age-related deficits, it is possible that training in BJB gameplay can serve as a motivating substitute for speed-of-processing training (Edwards et al., 2006). We predicted that training in BJB gameplay would lead to improved UFOV performance.

Method

Participants

This study originally had a sample of ten older adults. However, because one participant spontaneously reported having had a convergence disorder, this participant's data was excluded from the present study, resulting in a sample of nine individuals (56% female). Ages of the participants ranged from 66 through 87 ($M=77.2$). Six out of nine of these participants had participated in a previous study examining the relationship between BJB and attentional search. The remaining participants were recruited through flyers posted in local senior centers.

Materials

Bejeweled Blitz. Bejeweled Blitz was the casual video game chosen for this study because it involves attentional abilities, reaction time, and requires the ability to ignore distracting stimuli. Developed by Popcap, BJB is a highly popular casual video game and three-match game played by a range of age groups (Whitbourne et al., in revision). BJB involves one 8X8 grid of variations of gemstones that differ in shape and color. The order of the gemstones is random, and the gameplay consists of matching up three or more gemstones of the same kind in a row. The row cannot be diagonal. To move the gemstones, one must be shifted either up and down or left and right. The gemstone can only be moved one space to the side, in which the gemstone beside it would swap places with the first gemstone. Once a match of three or more gemstones is made, the gemstones explode and disappear, while more gemstones fall down from the top of the screen to replace them. The pieces do not move on their own unless they are being added to the grid by the game itself when others are destroyed.

The game also has a great deal of sound involved in it. During gameplay, a tune plays in

the background, a sound occurs when matches are made and the sound of a male voice will utter “excellent” when multiple matches are made. The sound of the voice also reminds the player of the halfway point of the game and voices “Go!” when the game begins. Special gemstones exist and appear as a result of one's gameplay. For example, if the player makes a match of five gems in a row, the middle gem will transform into what is called a “hypercube”, which, when moved again, will destroy all gems of one color throughout the entire grid. The player will also obtain “badges” at the end of a round if the player has achieved something significant during gameplay, such as a particularly high speed or high score. BJB requires the player to scan one's visual field while ignoring distracting stimuli, such as irrelevant gems, background music, and accompanying game voices.

UFOV. This present version of the UFOV is comprised of three consecutive subtests, each measuring a different cognitive ability. Subtest one measures processing speed. Subtest two measures divided attention. Subtest three measures selective attention.

Though there are various versions, the current study uses version 6.1.4 which involves three subtests (as opposed to four in more recent versions). Each subtest requires the individual to first process a stimulus presentation on the screen then respond to a prompt about the stimulus following the stimulus presentation. The UFOV task automatically shortens the stimulus presentation time for the next stimulus if the individual responds correctly twice. If the individual responds incorrectly, the stimulus presentation time is lengthened. The number of stimulus presentations per subtest varies depending upon the individual's consistency of responses. Stimulus presentations cease when the individual responds 75% correctly (Visual Awareness Research Group, Inc.).

The first subtest begins with four introductory trials and four practice trials. Following these trials is the subtest itself. In the first subtest, the screen displays a cartoon image of a vehicle surrounded in a white box. On the following screen, the screen displays an image of two vehicles, a truck or a car, and the participant is asked to select which cartoon vehicle was displayed on the previous screen.

The second subtest also begins with introductory trials but lacks the practice trials. For this test, the screen displays an image of a cartoon vehicle in the center of the screen. This vehicle is surrounded in eight radial spokes that point outwards in eight directions. In addition, there is an outside vehicle that is upon the end of one of the eight spokes. The test displays the image of the central vehicle as well as a peripheral vehicle that exists on one spoke. The following screen prompts the participant to identify the central vehicle in addition to the spoke the peripheral vehicle was on.

The third subtest is exactly alike to the second subtest. The only difference between these two tests is that the peripheral vehicle is embedded within an array of 47 distractors.

Each subtest of the UFOV yields a different score. Scores are measured in milliseconds. All subtests of the UFOV have a score that can range from 0 to 500, with lower scores indicating better performance (Visual Awareness Research Group, Inc). Again, the first subtest measures processing speed, the second test measures divided attention, and the third test measures selective attention. A score that ranges between 0 and 30 on Subtest 1 indicates normal processing speed and central vision. On Subtest 2, a score between 0 and 100 indicates normal divided attention. A score between 0 and 350 indicates normal selective attention. Using parameters provided in the User Manual, one can determine an individual's "risk statement",

with a low score in category one, indicating very low risk and a high score in category five, indicating a very high risk (Visual Awareness Research Group, Inc).

Stoplight reaction time test. Participants completed five trials of an online reaction time test (Allen, 2002). Reaction time was measured in seconds. The task involved an image of a stoplight with an illuminated red signal. When the red signal was to switch to a green signal, the participant would immediately click on a box alongside the stoplight.

Questionnaire. A 38-item questionnaire was administered at the very end of the last session. This questionnaire obtained demographic and health data about the individual. This questionnaire was administered online as a Google survey. (See appendix).

Procedure

Participants were trained in BJB over a 4-week period, in which they played 20 total games while receiving training from a research assistant. Before conducting the training sessions, research assistants were provided with a compilation of tips to improve gameplay in BJB. (See appendix). During this training period, participants attended one weekly session on the same day each week for the same length of time. Prior to the training phase, participants completed three tasks of the UFOV test, a reaction time task, and three rounds of BJB. After training, participants completed three tasks of the UFOV test, five rounds of BJB, and finished with an online questionnaire.

Upon arriving for the first session, participants were greeted and introduced to the research assistant. Participants were then asked to sign a consent form. After signing the consent form, participants were seated and asked if they had any trouble seeing the screen. If so, they were asked to adjust the screen accordingly.

Next, the research assistant explained that the first task to be completed would be the UFOV task. The researcher would instruct the participant in the following rules: “We are going to begin the study with the UFOV task, which stands for ‘Useful Field of Vision’. Whenever you are ready, please put on the headphones then you will just follow the instructions on the screen.” After participants completed all three tasks of the UFOV, the research assistant instructed the participant that the next task involved completing a reaction time test. The research assistant explained the following instructions to the participant.

For your next task, you will be completing a reaction time test. You will begin by clicking on the square labeled “Click here to start”, but do not click it just yet because when you do, the light will turn red. After a certain amount of seconds the light will turn green. You will need to click on that same square the instant the light turns green. Once it has recorded your first reaction time, you will need to click on that same box, again, which will read “Click here to continue” and will repeat this process a total of five times.

Following the reaction time test, participants were asked if they had ever played Bejeweled or Bejeweled Blitz. If the participant reported never having played, the research assistant took approximately five minutes to explain the mechanics of the game to the participant. In explaining the rules, the research assistant showed the participant a photograph of the layout of the Bejeweled board to allow the participant to gain a basic understanding of the game beforehand. Next, participants completed five rounds of BJB. Participants wore noise-cancelling headphones during each round of BJB. At the end of this session, participants were given a debriefing form containing contact information. Participants were also compensated with twenty dollars in cash as payment for their participation.

At the beginning of the second session, participants were informed that he or she would play five rounds of BJB while each round was recorded with screen-capturing software. Participants wore noise-cancelling headphones during each round of BJB. During gameplay, the research assistant sat behind the participant while watching the participant's gameplay, but refrained from speaking so as to not distract the participant. After each round of BJB was complete, the research assistant stopped the recording and immediately played it back for the participant and researcher to watch together. While viewing the recording of the participant's gameplay, the research assistant provided tips to improve the participant's gameplay. The research assistant also provided positive feedback on the participant's gameplay when viewing the recording. Subjects were also encouraged to give verbal feedback concerning the effectiveness of the tips previously given. At the end of each session in the training phase, each participant was compensated twenty dollars.

For the third phase of the study, participants completed all three tasks of the UFOV. Next, participants were told that they would play five rounds of BJB without any recording or training. Participants played five rounds with the noise-cancelling headphones. The research assistant did not record the gameplay. The research assistant also did not instruct in any training techniques during this session. Next, participants were asked to complete an online questionnaire.

Participants were compensated twenty dollars at the end of this session. In total, participants were compensated \$120 in cash.

Results

The purpose of this study was to determine if the difference in means in pre- and post-

training UFOV scores was significant due to training in BJB. The mean for all BJB scores pre-training ($M=6118.51$, $SD=3746.69$) is shown in Table 1 and Figure 1. The mean for all BJB scores post-training ($M=9102.22$, $SD=4603.78$) is shown in Table 1 and Figure 1. The higher scores post-training indicate improvement in BJB gameplay. For UFOV Divided Attention, means showed improvement from pre-training ($M=154.22$, $SD=78.54$) to post-training ($M=113$, $SD=96.77$), as shown in Table 2 and Figure 2, with lower scores indicating better performance. For UFOV Selective Attention, there was improvement in performance from pre-training ($M=246.33$, $SD=141.66$) to post-training ($M=190.11$, $SD=92.08$), as shown in Table 3 and Figure 3. To determine whether people who improved in BJB also improved in UFOV, a correlation was computed between pre-training and post-training differences in BJB and UFOV scores as well as the mean score of Trial 5 of the Reaction Time test (RT). The correlation between BJB and UFOV Selective Attention change scores was $-.689$, $p = .04$, $p < .05$ (Table 4). This negative correlation indicates that as BJB scores increased, UFOV scores decreased. In other words, BJB and UFOV scores improved with one another. Results were not found to be significant for Divided Attention.

The highest score obtained on the UFOV task was a 500. One participant had obtained this high risk score on the UFOV Selective Attention task. The lowest mean reaction time score was 0.2058 seconds, while the highest mean reaction time score was 0.6750 seconds.

We also obtained demographic and personal data from each participant with an online questionnaire. All but one participant reported having good or excellent health in general. Six out of nine (67%) participants reported living with their spouse. Five out of nine participants (56%) reported having earned a graduate degree (M.A., M.F.A., M.B.A.). One participant reported

having earned a doctorate degree (Ph.D., J.D., M.D.) and three participants (34%) reported having earned a 4-year college degree (B.A., B.S.). Eight out of nine (89%) participants reported being retired. All participants reported that they are white/Caucasian. All participants reported living in a private residence. All participants reported that they still drive a car (although one participant indicated still being able to drive a car while also responding “No” when asked if still capable of driving). Two participants reported having had careers/jobs as a school counselor in the past. Other careers/jobs that participants reported include: computer developer, professor, consultant, secretary, business owner, and field representative. All participants reported needing no help whatsoever in carrying out the following tasks: eating, walking on a level surface, bathing, using a telephone, taking medication, toileting (using bathroom facilities and handling clothing), and transferring in and out of a chair.

Discussion

The present study investigated if training in Bejeweled Blitz has the potential to improve performance on the UFOV task. Because the UFOV task is predictive of a plethora of capabilities, including vehicle crashes and driving performance, it is a reliable means of measuring improved attentional abilities in older adults (Edwards et al., 2006; Lunsman et al., 2008). We found that there was a significant relationship between pre- and post-training UFOV Selective Attention scores and the difference in pre- and post-training BJB means. We can reasonably conclude from this data that four weeks of training in BJB is correlated with improved scores on the UFOV Selective Attention task for normally functioning older adults.

Bejeweled and Non-Action/FPS Games

Though it seems as though action and FPS games take precedence over other genres of

video games when it comes to far transfer, other genres of video games lend a great deal of helpfulness for both younger and older adults, too. Bejeweled has the potential to improve the mood of the player. Przybylski et al. (2012) reported that Bejeweled received “above average ratings on factors of self-confidence, imagination, and openmindedness”. Baccus, Baldwin, and Packer (2004) found that self-esteem can be improved with gameplay of a video game that paired “self-relevant information with smiling faces”. Another example was reported by Russoniello et al. (2009), who found that after playing Bejeweled 2, electroencephalographic (EEG) changes were consistent with increased mood. According to the Entertainment Software Association (2012), action, sport, and role-playing video games come in second to puzzle, board, trivia, card, and game show games in terms of games most often played. Another example includes Nelson & Strachan (2009), who conducted a study on 20 individuals (ages 19-23) comparing the effects of an FPS game and a puzzle game on accuracy and reaction time on a special-location task. Results showed that those assigned to the puzzle game condition had higher accuracy but lower reaction time as compared to those assigned to the action game condition. In a separate but similar experiment done by Nelson & Strachan (2009), those assigned to the puzzle game condition also showed superiority in accuracy but slower reaction times as compared to action game players on a matching-figures task. Furthermore, Spence & Feng (2010) contend (on assumption) that puzzle and maze games require the following skills: analytical abilities, long-term memory, spatial abilities, and divided attention to some extent.

Questionnaire

The questionnaire was administered as the final task of this study in order to avoid any aging stigma. The questionnaire contained many questions that can relate only to older adults; it

involved questions about age-related daily incapacities. Being exposed to what are highly stigmatizing deficits found in old age could have possibly affected performance on BJB, the reaction time task, or the UFOV task. Older adults and other groups of individuals that are wrongly associated with negative stereotypes will be negatively affected by stereotype threat; their performance on more difficult tasks is worsened (O'Brien & Hummert, 2006). Chasteen et al. (2005) found that memory performance in older adults can be worsened by "subliminal exposure to negative aging stereotypes". See appendix for the complete questionnaire administered in this study.

Participant Feedback

The researchers also actively took notes on feedback given by the participant throughout the training aspect of the study as well as any other significant information. This feedback was primarily used to assess what training tips were most helpful for the participant to advance in his or her BJB performance. Some strategies provided by the researcher that the participant reported as being helpful are the following: looking for pairs, staying concentrated in one area on the grid, noticing hints when they come along, honing in on one color in particular. Participants varied in what colors they honed in on, with some reporting that the orange and yellow gem were too alike and were difficult to discriminate from one another, and others reporting that yellow gems stood out most for them. In general, participants reported that they found it helpful to look for particular patterns in the grid, such as a triangle or pairs, that could be rearranged to make a match of three.

Limitations and Future Directions

There were some limitations to this study. This honors thesis lacks the data from the

control group that is currently being processed. Also, one participant reported having a convergence disorder. This participant admitted having great difficulty with the UFOV task. This participant also admitted to not reading the instructions on the UFOV task in the post-training session and had been looking outside of the target box during this task instead of within it. These factors were unusual and thus the data had to be discarded when computing our last correlation.

Another participant also reported having trouble hearing when using the noise-cancelling headphones, so the volume was changed from 30% to 60% on the computer. This participant also requested to postpone the last session of the study to one week later due to sickness.

Furthermore, it is important to consider that UFOV scores may have improved simply due to having had practice on the UFOV task. In other words, participants may have been unfamiliar with the UFOV task during pre-training, while in post-training, they had had more familiarity and experience with the task, which may have led to improved UFOV scores. One way to address this issue is by conducting a study in which older adults take one UFOV test on the first week and take a second UFOV test on the sixth week with no BJB in between. The same is applicable for BJB, in that BJB scores may have improved simply because of practice, rather than training tips, which is a question we are currently examining in a control group for this study.

Another important variable is the fact that three out of nine participants had not previously participated in a previous study involving BJB. However, out of the six individuals that did return from participating in the previous study, only one of these individuals reported having played BJB since participating in that study.

It is also important to note that these older adults may have been representative of a

higher-functioning population of older adults. For example, a majority of participants (56%) reported having earned a graduate degree (M.A., M.F.A., M.B.A.) and another 34% reported having earned a 4-year college degree (B.A., B.S.). According to the U.S. Census Bureau (2012), out of 41,506,000 American civilians ages 65 and older, only 2,911,000 (0.07%) have obtained a Master's degree. When including both those who have Masters or Professional Degree (excluding Doctoral Degree), only 3,517,000 (0.08%) of this population are included. Seeing as the general population of older adults with a Masters or Professional Degree is just below 1%, our sample was certainly an example of a higher-functioning group of older adults. This may also be attributed to the fact that our study required participants to have computer competence and driving abilities, which excludes a portion of the older adult population.

In sum, improved scores on the video game Bejeweled Blitz is correlated with improved scores on the UFOV Selective Attention Task. Perhaps this effect was not seen for the scores on the UFOV Divided Attention task because it needed to involve more training sessions or more rounds of BJB in each session. Future research could investigate the effect that more (or less) training has on UFOV performance. It could also involve a different video game that would be likely to appeal to the older adult crowd, such as a different CVG or a puzzle game. Future studies could also alternate the order of the tasks administered throughout the study between subjects. Future research could also investigate this exact procedure using individuals of a different demographic, such as older adult patients diagnosed with Alzheimer's or those who needed assistance in traveling to and from the study location.

Conclusion

The present study investigates if training in BJB over a span of four weeks (excluding pre- and post-training sessions) can improve performance on the UFOV task. Increased scores in BJB are correlated with higher scores on the UFOV task. The UFOV task gives an excellent representation of one's attentional abilities and processing speed – two cognitive abilities that underlie a plethora of daily activities.

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Table 1

Descriptive Statistics: Pre-training and Post-training BJB Means

Measure	Mean	Std. Deviation	N
Pre-Training	6118.5185	3746.69711	9
Post-Training	9102.2222	4603.78860	9

Table 2

Descriptive Statistics: UFOV Divided Attention Scores

Measure	Mean	Std. Deviation	N
Pre-Training	154.22	78.544	9
Post-Training	113.00	96.773	9

Table 3

Descriptive Statistics: UFOV Selective Attention Scores

Measure	Mean	Std. Deviation	N
Pre-Training	246.33	141.669	9
Post-Training	190.11	92.089	9

Table 4

Correlations: BJB, UFOV Divided and Selective Attention, RT

		Pre-Post BJB	Pre-Post UFOV Div	Pre-Post UFOV Sel	Reaction Time Test 5
Pre-Post BJB	Pearson	1	-.008	-.689*	-.140
	Correlation				
	Sig. (2-tailed)		.984	.040	.719
	N	9	9	9	9
Pre-Post UFOV Div	Pearson	-.008	1	.551	.437
	Correlation				
	Sig. (2-tailed)	.984		.124	.240
	N	9	9	9	9
Pre-Post UFOV Sel	Pearson	-.689*	.551	1	.166
	Correlation				
	Sig. (2-tailed)	.040	.124		.670
	N	9	9	9	9
Reaction Time Test 5	Pearson	-.140	.437	.166	1
	Correlation				
	Sig. (2-tailed)	.719	.240	.670	
	N	9	9	9	9

*. Correlation significant at the 0.05 level.

Figure 1

Increase in Mean BJB Score from Pre- to Post-Training: Means and SD

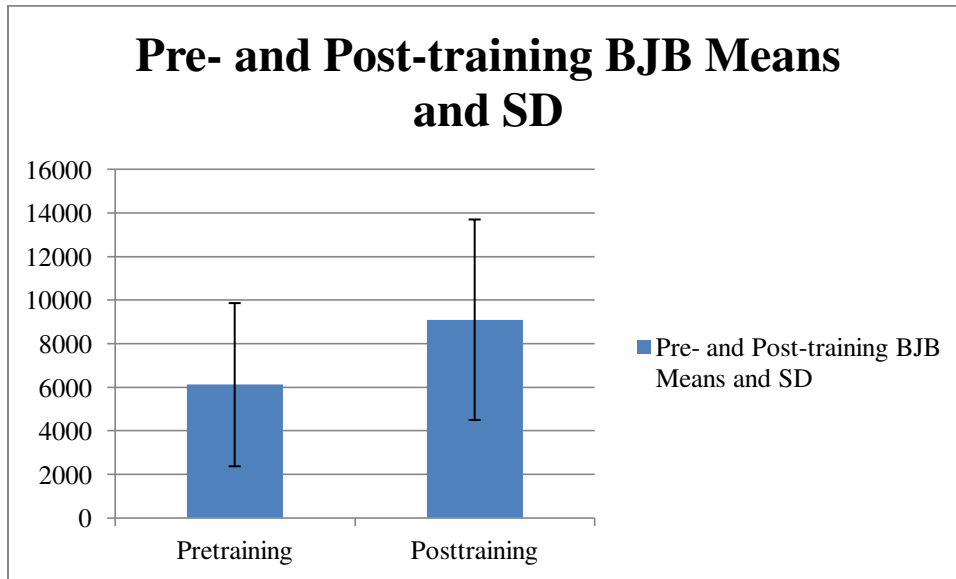


Figure 2

Changes in UFOV Divided Attention Scores from Pre-Training to Post-Training: Means and SD

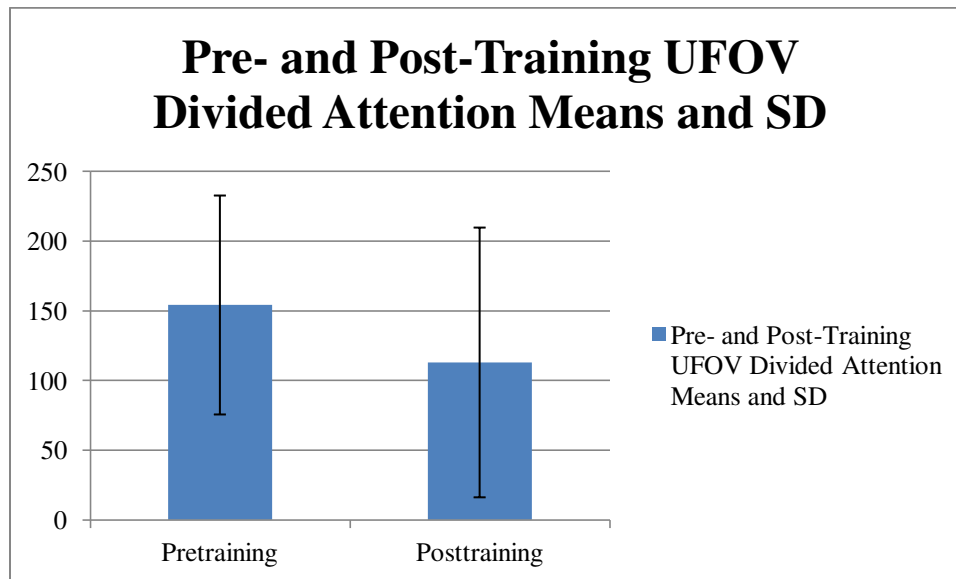
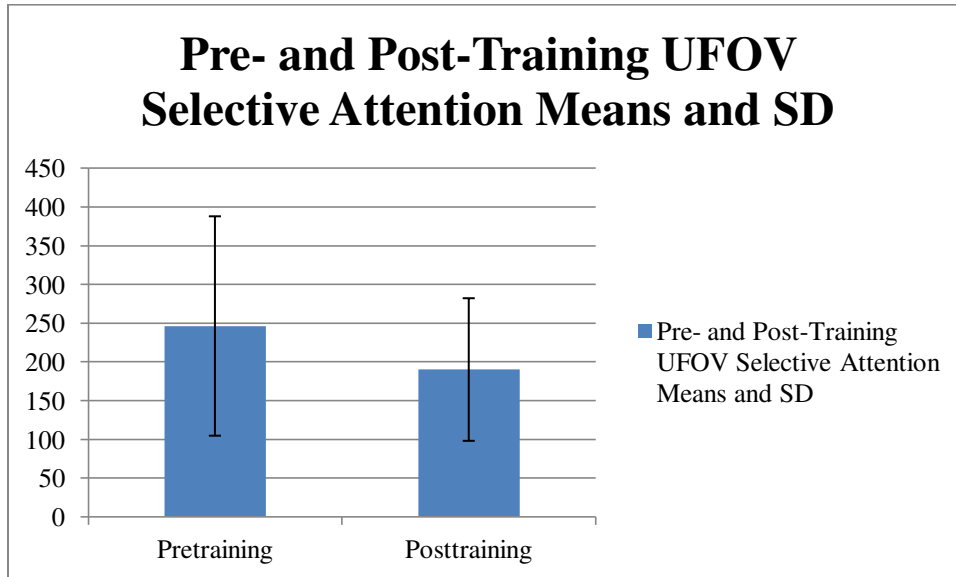


Figure 3

Changes in UFOV Selective Attention Scores from Pre-Training to Post-Training: Means and SD



Appendix

ABC Study Questionnaire

We would like to ask you to complete this brief questionnaire to tell us about your computer game habits, your health, and some basic information about you.

1. What computer games do you play? (If none, please say “none”)

2. How often do you play computer games?
 - a. Once a week or less
 - b. 2-3 times a week
 - c. Once a day
 - d. Several times a day
 - e. Never

Next, we'd like to ask you questions about your health and ability to carry out daily tasks.

1. What other games and activities do you enjoy?
 - a. Board games
 - b. Crossword puzzles
 - c. Number puzzles (Sudoku, KenKen, etc.)
 - d. Jigsaw puzzles
 - e. Video games (Sega, Nintendo, PlayStation, etc.)
 - f. Card games (Bridge, Poker, Canasta, etc.)
 - g. Other _____
2. In general, how is your health now?

- a. Excellent
 - b. Good
 - c. Fair
 - d. Poor
3. Where do you live?
- a. Private Residence
 - b. Nursing Home
 - c. Other institution (Self-care retirement village)
4. How does your health compare to that of most people your own age?
- a. Better than most my age
 - b. About the same
 - c. Worse than most my age
5. During the past 6 months (180 days) how many days were you so sick that you were unable to carry out your usual activities?
-
6. During the course of a normal day, how do you carry out the following activities? (No help needed, Need help with a device, Need some help from another person, Need complete help from another person, Do not do during a normal day)
- ___ Bathing (including getting in and out of the tub or shower)
- ___ Eating
- ___ Walking on a level surface about 50 yards

- Walking up and down one flight of stairs
- Using a telephone
- Taking your own medications
- Transferring in and out of a chair
- Toileting (using bathroom facilities and handling clothing)

7. Have you used the following services? (No, Yes, within the last month, Yes, within the last 2 yrs)

- Home health aides
- Homemaker visits
- Visiting nurses
- Rehabilitation including physical therapy, occupational therapy, or speech therapy
- Meals on Wheels
- Community day program (in a nursing home)

8. For each of the following, please indicate whether you can perform the activity: (No, Yes)

- Do heavy work around the house, like shovel snow or wash windows, walls, or floors without help?
- Walk half a mile (4-6 blocks) without help
- Drive a car

9. If you don't drive now, please indicate why:

- Health
- Non-health reason
- Never drove a car

Still drive a car

Finally, please answer a few questions about yourself

1. What is your date of birth?

2. What is your gender?

Male

Female

Would rather not say

3. What is your marital status?

Never Married

Married or living with partner

Separated

Divorced

Widowed

4. Please indicate whether you live with any of the following: (No, Yes (less than 3mos/yr),

Yes (more than 3 mos/yr))

Spouse or significant other

Child(ren)

Friend(s)

Other relative(s)

Roommate (not a friend or relative)

5. What is your race/ethnicity?

Asian

Black

Caucasian/White

Hispanic

Latino/a

Native American

Other: _____

6. What is the highest level of education you have completed?

Some high school

High School/GED

2-Year College degree

4-Year College degree (B.A., B.S.)

Graduate degree (M.A., M.F.A., M.B.A)

Doctorate degree (Ph.D., J.D., M.D.)

7. What best describes your current work status?

Employed full-time

Employed Part-time

Homemaker

Retired

Unemployed (not retired)

8. Please name your current (or most recent) occupation? (if not applicable, please write

N/A)

9. If you speak any languages other than English, please indicate below: (type N/A if English is your only language)
-

Training Tips used by Research Assistants

1. Start at the bottom of the screen. That way there are more gems falling from the top, which means there is a greater possibility that additional matches will be made.
2. There is usually at least one combination of 4 to start with, so if you can quickly spot that you can start the game off by making a flame gem, which leads to more points when it explodes.
3. When you make a combination, don't wait and watch the gems explode. Quickly move your eyes to the rest of the board and find a new combination.
4. If you get stuck, look at the top for new combinations that may have just fallen in.
5. Multiplier gems are really good to get. When used they multiply your score for the rest of the game. You get them by exploding 12 gems at the same time, so for example if you have two flame gems next to each other and you explode one you are likely to get a multiplier.
6. If you can't find anything, you can always press the hint button on the side. This will point you in the direction of a combination you may not have seen.
7. Hypercubes are a really good gem because when you use it they explode every gem on the board of the color you match it with. To get a hypercube you have to match 5 gems in a row.
8. It can be helpful to look for doubles of the same color, or triangle shapes that can make a combination.
9. There is a bonus for speed, so make sure to keep going and not wait for gems to fall.

10. You don't need to wait for the game to say "GO", once the gems appear you can start the game which will give you a few extra seconds.
11. If you get stuck you can try focusing on one color, instead of getting overwhelmed by all the different gems.
12. What do you think you could have done to improve this round?

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