Effects of Friend vs. Foe Discrimination Training in Action Video Games

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Action video games have received intensive study because they improve players' visual attention and perception abilities more than other types of video games. However, experimenters' ability to attribute visual functioning improvements to particular action video game components has been hampered due to the use of non-action video games as controls. Here, we employ a newly developed, tightly controlled experimental paradigm in which two groups of participants trained in two versions of the same custom video game world. One version contained both friends and foes and the other contained foes only. A third group of participants served as a no-training control. People trained for two hours in friend vs. foe discrimination showed several modest improvements in their visual skills, including a significant increase in attentional filtering and a marginal decrease in flanker interference. This experimental design establishes that friend vs. foe discrimination *per se* led to the observed visual improvements.

INTRODUCTION

The Entertainment Software Rating Board (2012) estimates that 67% of US households play video games, with eight hours per week being the time spent by the average gamer. "Action" video games, such as *Halo, Call of Duty,* and *Half Life 2*, are the most popular, accounting for approximately 22% of software purchases, totaling more than $3 billion in annual sales (Entertainment Software Association, 2010).

This entertainment medium has spawned an active field of research examining the various ways that action video games, in particular, can lead to improvements in visual functioning (see Spence & Feng, 2010 for a review). Action video games, most of which require the user to navigate a three-dimensional environment using the first-person perspective of the character in the game while eliminating enemies to reach a goal, have proven to be the most potent form of video game in terms of their training potential for visual functioning.

Research indicates that playing action video games improves perception and attention skills, even after only a few hours of training (Achtman, Green, & Bavelier, 2008). Enhancements in visual functioning attributed to playing action video games have been reported for peripheral vision (Green & Bavelier, 2006a), mental rotation skills (Sims & Mayer, 2002), change detection (Clark, Fleck, & Mitroff, 2011), spatial resolution of attention (Green & Bavelier, 2007), contrast sensitivity (Li, Polat, Makous, & Bavelier, 2009), task switching (Karle, Watter, & Shedden, 2010), and distractor rejection in a visual search (Castel, Pratt, & Drummond, 2005), to name a few.

While the benefits of action video games for visual functioning are widely accepted (but see Boot, Blakely, & Simons, 2011 for some important cautions), the particular aspects of action video games that lead to specific improvements in visual functioning have not been identified. The reason that these connections have not been firmly established is because typical studies of the effects of action video gameplay have used non-action video games as the control condition (e.g., Feng, et al., 2007; Green & Bavelier, 2003, 2006a, 2006b, 2007; Green et al., 2010; Li et al., 2009; Li et al., 2010). In these studies, one group of participants was trained on an action video game such as *Medal of Honor*, while a control group was trained on a non-action video game such as *Tetris* or *The Sims 2*. Any observed differences between the groups may be attributed to playing the action video game but the particular component within the action video game that led to the observed improvements is unknown.

Researchers have speculated that action video games are beneficial for visual perception and attention because they require players to distribute their attention to several targets (Green & Bavelier, 2003), because players must process multi-sensory information (Donohue, et al., 2010), and because players' attention must be spread widely across the entire visual field (Feng, et al., 2007). However, logically, the improvements might also be due to the differing story lines, sound effects, viewing perspective, or music used in the two games, or any other trivial or non-trivial difference. Since two entirely different games are being compared, it is impossible to say precisely which components of the action video game caused the observed changes in visual perception performance.

Here, we introduce a new experimental methodology to isolate and identify which components of action video games lead to which visual processing improvements. In this design, two groups are trained on the exact same action video game with only a single game aspect differing between the two groups. If, after training, the group that experienced the game component of interest improves in visual functioning but the group not experiencing the component does not, then the improvement in functioning may clearly be attributed to the game component of interest. To strengthen the assignment of causality, a third group receiving no video game training serves as a comparison to benchmark the improvement in visual functioning expected just due to experience with the visual test itself.

Here, we seek to determine the beneficial effects (if any) of discriminating between friends and foes in an action video game. Friend vs. foe discrimination is an essential part of action video game play since foes must be eliminated quickly since they seek to eliminate the player, but accidentally injuring friendly characters may result in a failed mission. Additionally, friendly fire incidents caused an alarming number of U.S. military casualties in recent conflicts, estimated to be 52% of all U.S. casualties in the Iraq War and 13% of all casualties in Afghanistan (American War Library, 2012). Any insights into the perceptual processing of friends vs. foes may additionally prove useful for training military personnel to avoid such incidents in the future.

EXPERIMENT

Here we seek to identify, in a tightly controlled study, whether friend vs. foe discrimination in an action video game leads to particular visual processing improvements in the user. To test this, we custom-designed an action video game world in which the presence of either friends or foes could be manipulated. One group of participants, the experimental video game group, experienced a custom video game world populated by both friendly and enemy characters while other participants, the control video game group, experienced an identical world populated by enemies only. Before and after the video game training, both the experimental and control video game groups were tested on three visual tasks, allowing for comparison of visual functioning pre- and post-training. A third no-training control group did not play the video game and merely completed the pre- and post-training tasks on two separate days.

To best be able to detect any improvements in visual functioning, we recruited only non video game players for the study. The assessment of non video game player status was accomplished covertly, through a survey inquiring about media multitasking habits (Ophir, Nass, & Wagner, 2009) for another study. Individuals who indicated that they never played action video games in the media multitasking survey were invited to participate in the current study. This form of covert recruitment avoids potential self-stereotyping behavior that may occur when individuals self identify as either a “gamer” or “non-gamer” (Boot, et al., 2011).

We hypothesized that discriminating between similar-looking friends and foes in an action video game would lead to improvements in discriminatory attentional processing and filtering, as measured by the flanker task (Eriksen & Eriksen, 1974) and the filter task (Vogel, et al., 2005), respectively. Further, we hypothesized that playing action video games in general, regardless of the presence of both friends and foes or foes only, would improve visual working memory capacity (Luck & Vogel, 1997) compared to no video game training.

METHODS

Participants

Forty-five college undergraduate and graduate psychology students from Wichita State University, 39 females (ages 18-59, M: 26.9, SD: 9.8) and 6 males (ages 21-52, M: 32.8, SD: 10.4), participated in the study in exchange for course credit. Participants were recruited through an online survey about media multitasking (Ophir, et al, 2009). Individuals who selected “I don’t play video games,” were invited to the study. This cover recruitment strategy minimized potential bias in the study (c.f., Boot, Blakely, & Simons, 2011).

Participants were randomly assigned to either the friends and foes experimental video game condition, foes only control video game condition, or to the no-training control condition. All participants completed a pre-test battery of three perceptual tasks on day one and took the same post-test battery (in a different order) on day four. The two video game training groups played a custom-designed video game (described below) for two hours, spread over three days (Figure 1).

Materials

Pre- and Post-Training Tasks. The three pre-/post-training tasks were administered on a 2-GHz Mac Pro computer driving a 17-in. (diagonal) Dell M991 CRT monitor with 1,400 x 1,050 resolution at 75 Hz. The tasks were programmed using MATLAB 2010A (MathWorks, Natick, Massachusetts) and the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Responses were gathered with an Apple USB extended keyboard.

Video Game Training. The video game training levels were run on a Mac Mini computer with an Intel Core 2 Duo 2.53 GHz processor running Windows 7 connected to a 22-in. ViewSonic HD monitor with 1920 x 1080 resolution at 60 Hz. A Microsoft brand Xbox 360 game controller was used to navigate and shoot in the video game world.

Video game worlds were built with the Source game engine using the Source Software Developer Kit (SDK) and the Hammer Editor, all of which were produced by Valve Corporation (Morris, & Bernier, 2010; Newell, & Harrington, 2010).

Design

Flanker Task. The flanker task (Eriksen & Eriksen, 1974) consisted of a fixation point followed by an array of arrows, each subtending 2.98° x 1.19° visual angle. The target arrow was surrounded by frame corners and orientated either leftwards or rightwards. Either two or 14 distractor arrows flanked the target and either pointed in the same or opposite direction as the target arrow. Participants pressed an arrow key corresponding to the direction of the target arrow as quickly as possible. Flanker interference was operationalized as the difference in average response time between trials in which the distractor arrows pointed in the opposite direction as the target and trials in which the distractor and target arrows pointed in the same direction, averaged across set size.

Visual Working Memory Capacity. Visual working memory capacity was evaluated using the procedure reported by Luck & Vogel (1997). An initial display with four, eight, or twelve colored squares was briefly presented, followed by a blank screen for approximately 1 sec, and then another display with colored squares was presented until response. The second display was identical to the first, except that one of the squares changed colors on 50% of the trials. Visual working memory capacity was operationalized as (hits – false alarms) * set size, and averaged across set sizes.

Filter Task. The filter task is similar to the visual working memory task, except that it measures visual working memory capacity in the face of distracting visual information (Ophir, et al., 2009; Vogel, et al., 2005). During the filter task, participants saw two arrays of rectangles, with each rectangle subtending 0.85° x 1.05° of visual angle. The first array was presented for 100 ms and contained two red rectangles and zero, two, four, or six irrelevant blue rectangles. After approximately 1 sec, a second array was presented that had the same red and blue rectangles, except that one of the red rectangles changed orientation on 50% of the trials. Participants reported whether one of the two red rectangles changed orientation. Filter capacity was defined as the difference between visual working memory capacity (defined above) for two items when there were no distractors versus the average visual working memory capacity for two items in the presence of two, four, or six distractors.

Video Game Training Levels. There were two video game training conditions in this study, experimental and control. The video game worlds for the two conditions were identical, except that the experimental video game training condition contained both friend and foe characters while the control video game condition contained only foe characters.

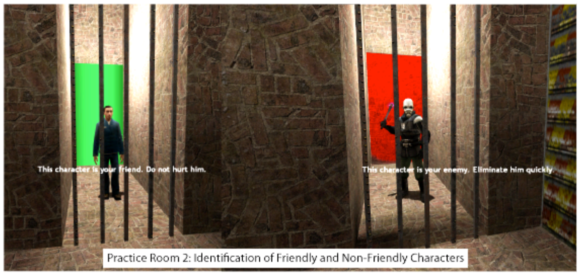


Figure 1. The second practice room, teaching the user about the non-player characters they would encounter.

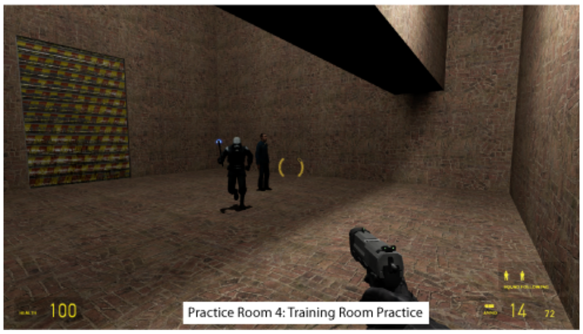
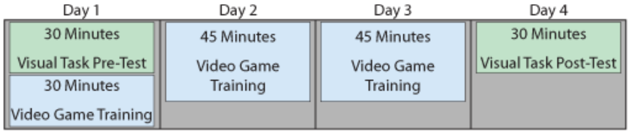


Figure 2. The final practice room providing the player with practice of the following training rooms.

Since non video game players were used in this study, it was important to introduce these participants to the mechanics of the game and teach them how to use the video game controller. The first room in the game was a tutorial for establishing basic use of the controller, the second room instructed participants about the non-player characters in the game (identifying friends and foes, Figure 1), the third room was a practice room for firing the character's primary weapon, and the final room was a duplicate of the actual training rooms, but with only one of each type of non-player character (Figure 2). Additionally, on the first day of training, the experimenter explained the use of the game controller, the game information portrayed on the monitor, and gave some basic tips about navigating through the game world.

Design of Game Levels (Training). The video game consisted of four levels of increasing difficulty, with each level containing four rooms (16 rooms total). The player entered a room and faced between two and ten enemy characters (and between two and ten friendly characters in the experimental video game condition). Both friendly and enemy characters wore dark clothing, with the difference being that the enemy characters were also wearing a white mask and a jacket with a white stripe on the shoulder. The player had to eliminate the enemy characters before being allowed to leave the room. If the player was killed by the enemies before clearing the room, the player started over at the first room of the current difficulty level.



Day 1	Day 2	Day 3	Day 4
30 Minutes Visual Task Pre-Test 30 Minutes Video Game Training	45 Minutes Video Game Training	45 Minutes Video Game Training	30 Minutes Visual Task Post-Test

Figure 3. A graphical depiction of the experimental schedule. Participants in the experimental and control video game groups completed all events on four successive days, while participants in the no-training control group just completed the two 30 minute pre- and post-test batteries on days one and four.

Procedure

The overall design of the study was a four day long experiment with one pre-test session, one post-test session and two hours of video game training for the two video game training groups or two days of no video game playing for the control group. Day one consisted of a half hour of pre-test tasks for all groups, and a half hour of training in the video game world for the experimental and control video game training groups. Days two and three consisted of 45 minutes of training in the video game world for the two video game training groups. On day four, all groups completed a half hour of post-test tasks that were the same as the pre-test tasks but in a different order(Figure 3). The video game training groups both experienced a 24 hour separation from the last session of video game playing until the post-test tasks in an attempt to eliminate improvements in visual functioning due to mere physiological arousal from the stressful and exciting game play (Carnagey, et al., 2007; Green, Li, & Bavelier, 2009).

RESULTS

Flanker Task. A mixed 2 x 3 (Time x Condition) ANOVA was performed on the flanker compatibility reaction time data, with condition treated as a between-subjects variable. This analysis detected a marginally significant main effect of time, $F(1,87) = 3.01$, $p = .086$, $\eta_p^2 = .033$, indicating the participants modestly decreased the amount of flanker interference they experienced over time. To further explore this finding, t-tests were run comparing flanker compatibility before and after training for each condition. These analyses established that participants in the friends and foes training condition showed a significant reduction in flanker interference $t(14) = 2.76$, $p = .015$, two-tailed, whereas participants in the other two conditions did not, both $p > .05$ (Figure 4). The ANOVA detected no other significant effects (all $p > .05$).

Visual Working Memory. The effects of training on visual working memory capacity were analyzed using a 2 x 3 (Time x Condition) mixed ANOVA. The analyses failed to detect any significant differences in visual working memory capacity (all $p > .10$). Figure 5 shows the change in visual working memory capacity from pre-test to post-test in each condition.

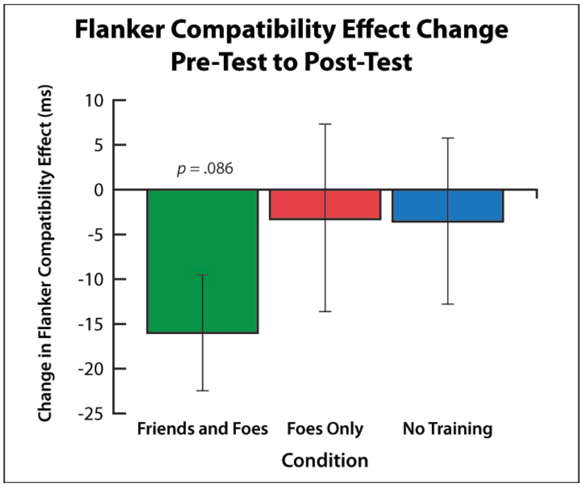


Figure 4. Change in flanker compatibility from pre-test to post-test. Participants in the friends and foes video game training condition showed a marginal decrease in flanker interference after training.

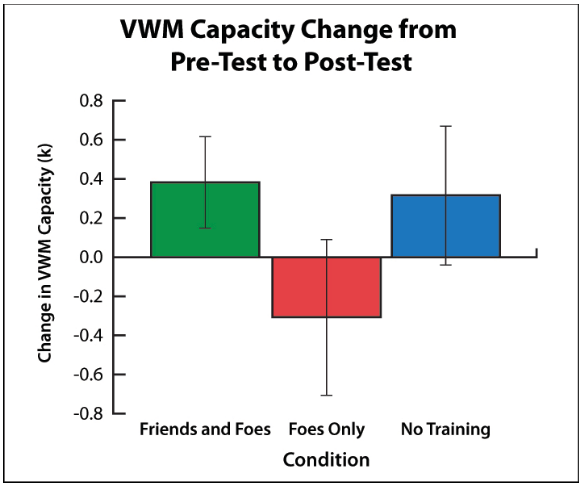


Figure 5. Changes in visual working memory capacity from pre-test to post-test. No significant differences were observed.

Attentional Filtering. A 2 x 3 (Time x Condition) repeated measures ANOVA was run on participants' filtering capacity. The analysis detected a significant main effect of condition on filter capacity, $F(2,87) = 6.51$, $p < .01$. To further explore this result, t-tests were performed to determine which conditions had filtering scores reliably greater than 0. Results indicated that participants in the friends and foes video game training condition had a filtering capacity reliably greater than 0 after training, $t(14) = 2.95$, $p = .004$, two-tailed, but no other condition reliably differed from 0 (all $p > .10$). The ANOVA did not return any other significant effects (all $p > .10$).

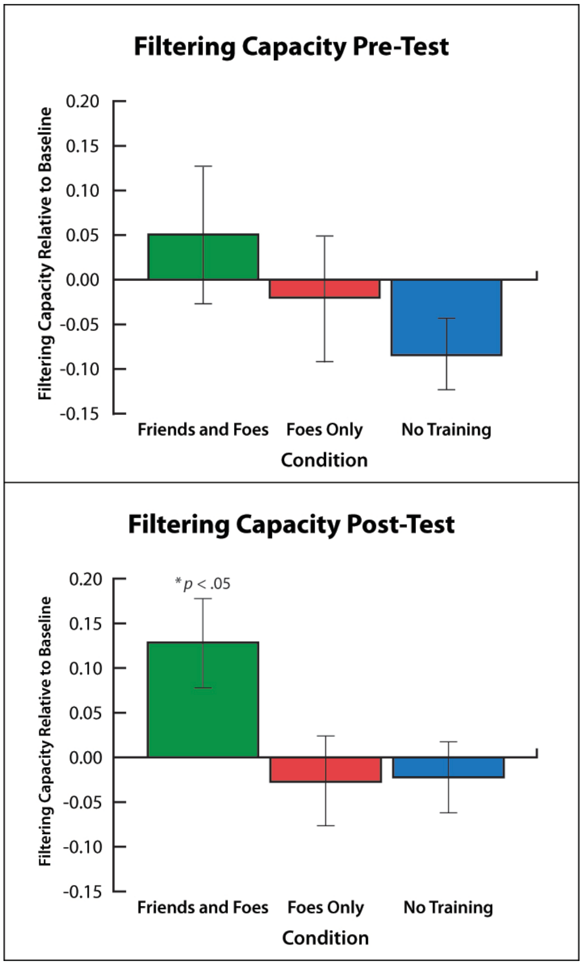


Figure 7. Filter capacities during pre-test and post-test for the three training conditions. Participants trained in friend vs. foe discrimination showed significantly positive attentional filtering after training but not before.

DISCUSSION

Our exploration of the effects of friend vs. foe discrimination training in action video games indicates that it has some specific beneficial effects on visual functioning. Participants who played a custom designed video game world containing both friends and foes had a marginal reduction in flanker interference and a significant increase in filtering capacity after training. On the other hand, neither participants who played through an identical video game world occupied by foes only nor participants who received no video game training showed any improvements in visual processing.

The strength of our study is that we are able to make a causal attribution about the effect of friend vs. foe discrimination on visual processing since we 1) performed a training study with pre- and post-tests, and 2) specifically manipulated the presence of friend vs. foe discrimination while controlling all other aspects of the video game world. Owing to this design, changes in visual processing after training in the experimental video game condition can be attributed to friend vs. foe discrimination *per se*, rather than to any other factor. Other studies in this field have used completely different games (e.g., *Tetris*) as controls, limiting their ability to make such a claim.

It is important to note that these modest improvements in visual functioning were observed after only two hours of training spanning the course of three days. More extensive training within the video game world, as well as a larger sample size could improve our power.

In conclusion, discriminating between friends and foes in an action video game contributes to improved visual attentional processing, particularly with regard to focusing on targets and filtering out distractors.

REFERENCES

Achtman, R., Green, C,. & Bavelier, D. (2008). Video games as a tool to train visual skills. *Restorative Neurology and Neuroscience, 26*(4), 435-446.

American War Library (2012). Friendly fire estimates since WW2. Retrieved from http://www.americanwarlibrary.com/ff/ff.htm, [Accessed Jul 2012].

Boot, W., Blakely, D., & Simons, D. (2011). Frontiers: Do Action Video Games Improve Perception and Cognition. *Frontiers in Psychology: Cognition, 2,* 1-6.

Castel, A., Pratt, J., & Drummond, E. (2005). The effects of action video game experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychologica, 119,* 217-230.

Clark, K., Fleck, M,. & Mitroff, S. (2011). Enhanced change detection performance reveals improved strategy use in avid action video game players. *Acta Psychologica, 136,* 67-72.

Donohue, S. E., Woldorff, M. G., and Mitroff, S. R. (2010). Video game players show more precise multisensory temporal processing abilities. *Attention, Perception & Psychophysics,* 72, 1120–1129.

Entertainment Software Association. (2011). Sales & Genre Data. Retrieved from http://www.theesa.com/facts/salesandgenre.asp, [Accessed Feb 2012].

Entertainment Software Rating Board. (2012) Video Game Industry Statistics. Retrieved From http://www.esrb.org/about/game-industry-statistics.jsp, [Accessed Feb 2012].

Eriksen, B., & Eriksen, C. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143-149.

Feng, J., Spence, I., and Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science,* 18, 850–855.

Green, C. S., Pouget, A., and Bavelier, D. (2010). A general mechanism for learning with action video games: Improved probabilistic inference. *Current Biology,* 20, 1573– 15792.

Green, C., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423,* 534-537.

Green, C. S., and Bavelier, D. (2006a). Effect of action video games on the spatial distribution of visuospatial attention. *Journal of Experimental Psychology: Human Perception & Performance, 32*(6), 1465–1468.

Green, C. S., and Bavelier, D. (2006b). Enumeration versus multiple object tracking: The case of action video game players. *Cognition,* 101, 217–245.

Green, C., & Bavelier, D. (2007). Action-video-game experience alters the spatial resolution of vision. *Psychological Science, 18*(1), 88-94.

Karle, J., Watter, S., &Shedden, J. (2010). Task switching in video game players: Benefits of selective attention but not resistance to proactive interference. *Acta Psychologica, 134*(1), 70-78.

Li, R., Polat, U., Makous, W,. & Bavelier, D. (2009). Enhancing the contrast sensitivity function through action video game training. *Nature Neuroscience, 12*(5), 549-551.

Li, R., Polat, U., Scalzo, F., and Bavelier, D. (2010). Reducing backward masking through action game training. *Journal of Vision, 10*(33), 1–13.

Luck, S., & Vogel, E. (1997). The capacity of visual working memory for features and conjunctions. *Nature, 390,* 279-281.

Morris, B, & Bernier, Y. (2010). Valve Hammer Editor [Software]. Available from http://developer.valvesoftware.com/wiki/Main_Page, [Accessed Feb 2012].

Newell, G., & Harrington, M. (2010). Source Software Development Kit [Software]. Available from http://developer.valvesoftware.com/wiki/Main_Page, [Accessed Feb 2012].

Ophir, E., Nass, C., & Wagner, A. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences, 106*(37), 15583-15587.

Sims, V., & Mayer, R. (2002). Domain specificity of spatial expertise: The case of video game players. *Applied Cognitive Psychology, 16,* 97-115.

Spence, I. & Feng, J. (2010). Video games and spatial cognition. *Review of General Psychology, 14*(2), 92-104.

Vogel, E., McCollough, A., & Machizawa, M. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature, 438*(24), 500-503.