VISUAL SEARCHING ABILITIES
IN VIDEO GAME PLAYERS AND NON-VIDEO GAME PLAYERS

by

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A thesis submitted to the

Graduate School-Camden

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of Master of Arts

Graduate Program in Psychology

written under the direction of

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Camden, New Jersey October 2010

ABSRACT OF THE THESIS

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With the surge in popularity of video games, many studies are examining how video games affect visual processing abilities. This study seeks to examine how video game players (VGPs) differ from non-video game players (NVGPs) on visual search tasks. This study predicts, based on previous findings, that VGPs will be faster and more accurate than NVGP on a battery of computerized visual search tasks. The computer-based tasks include a conjunction task involving simple shapes, a category search task involving images of real objects and a category search task involving images of scenes. This study found no significant differences between VGPs and NVGPs. Therefore, these results do not support previous claims that long-term experience with video games leads to superior visual and attentional performance.

Visual Searching Abilities in Video Game Players and Non-Video Game Players

Visual search is an ability we use in everyday situations to locate a target object among other objects or distractors; for example, searching for a friend’s face in a crowd. The friend we are searching for may have red hair and there may be other individuals in the crowd with red hair or other similar features, yet our visual abilities allow us to seek out that friend.

Attention plays an important role in visual search as it allows us to separate the target object from anything else in our point of view. While neurons will fire in response to an image that contains many objects, some neurons remain inactive until a certain stimulus is noticed. In active search the target is noticed through feature selection where a simple feature of the target such as “green” or “vertical” is selected preattentively; then attention is directed to the features so the individual is able to then select the target object (Sheinberg & Logothetis, 2001). For example, when searching for a ketchup bottle among other items in the fridge, certain features of the bottle such as red coloring with a white label or rectangular shape enable correct selection (Reddy & VanRullen, 2007; Goldstein, 2007; Wolfe, 1989, 2006).

In addition, many visual abilities are plastic and can be shaped by experience such as the ketchup bottle example, where the target’s distinctive features are learned (Kourtzi & DiCarlo, 2006). Video game play often engages the player in a variety of highly demanding visual tasks over long periods of time. Therefore, it seems likely that these visual workouts may be shaping the players' visual processing. For instance, Green and Bavelier (2007) have found that video game players (VGPs) are less susceptible to crowding because they can tolerate smaller target-distractor distances than those who do not play video games. Thus, the experience of video game play may in fact shape visual abilities.

In addition, there is evidence that training on video games is transferred to real world situations. The game Space Fortress was developed by Mane and Donchin (1989) to be a complex perceptual-motor task and has been used in studies such as Fabiani, M., Buckley, J., Gratton, G., Coles, M. G. H., & Donchin, E (1989) to show the transfer of these tasks to real world situations. This task was also used to train military fighter pilots in order to increase attentional capacity and problem solving. In a study by Gopher, D., Weil, M., & Bareket, T (1994), those trained on the video games performed much better on their flight analysis exams than those who had not been trained on Space Fortress. It was also found that training on video games improves cognitive and spatial functioning in the elderly (Ball, Berch, Helmers, Jobe, Leveck, Marsiske, Morris, Rebok, Smith, Tennstedt, Unverzagt, & Willis, 2002). Finally, laparoscopic surgeons have benefited from video game play in that their performance during surgery increases with fewer errors and faster completion (Rosser Jr., Lynch, Cuddihy, Gentile, Klonsky, & Merrell, 2007). Therefore, there is evidence that video games can be beneficial training tools to increase perceptual and cognitive abilities.

In 1984 Greenfield outlined how video games may affect visual processing and cognition and suggested that they should be considered as an area of interest for researchers and not just “mindless” play. Following this, many studies have examined how gaming affects various aspects of visual processing such as multiple object tracking, reaction time, attentional processes, enumeration, spatial abilities, memory and executive functions (Dorval & Pepin, 1986; Gagnon, 1985; Yuji, 1996; Orosy-Fildes & Allan, 1989, Castel, Pratt & Drummond, 2005; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). Most recently, consecutive studies examining various attentional and visual processes done by Green and Bavelier (2003, 2006a, 2006b & 2007; Achtman, Green & Bavelier., 2008) have shown that VGPs exhibit improved visual and attentional abilities over NVGPs. These studies have inspired others examining video games and the benefits they may have on vision, including this study.

Green and Bavelier (2003) examined how VGPs differ from NVGPs in four different visual tasks. The first task sought to measure the attentional capacity of the participants through identifying a target shape within a circle. VGPs had a greater attentional capacity in that they were able to attend to more distractors simultaneously than NVGPs. The second task examined enumeration where a certain number of squares were briefly flashed on the computer screen and the participants judged the amount. Here, VGPs were able to determine the number of more squares than the NVGPs. In the third task, the useful field of view, the focus point is manipulated, placing the target objects farther out in the periphery and the participants must identify them among distractors. Again, VGPs outperformed NVGPs indicating that their attentional capacity allows them to attend to peripheral objects more efficiently. The final task, attentional blink, is a phenomenon in which individuals are unable to detect a target when it is presented right after the first target. Green and Bavelier presented two targets over increasing lag times to test this effect. VGPs outperformed NVGPs by being able to correctly determine the second target over a shorter lag, indicating less attentional blink and better task-switching abilities.

To determine whether the results were due to individuals with superior visual abilities being more likely to play video games, Green and Bavelier trained NVGPs on video games and then retested them on the previous tasks. It was found that the group trained on an action video game rather than a strategy game improved on the tasks, indicating that action video games may enhance visual abilities (Green and Bavelier, 2003).

Another study by Green and Bavelier (2006b) examined an additional paradigm of visual attention: multiple object tracking. This task measures the number of independently moving objects that an individual can attend to at the same time. Green and Bavelier found that VGPs were able to attend to about two more objects at a time than NVGPs. They also trained the NVGP group on action video games and found that the training improved their multiple object tracking abilities.

A study by Castel et al.(2005) also sought to examine visual searching abilities in VGP and NVGPs. The authors first examined inhibition of return, which is a phenomenon of visual search that inhibits attention from focusing on previously searched areas when looking for a target. While VGPs and NVGPs were both good at inhibiting their return of attention, the search times were much faster for VGPs than NVGPs. Next, the authors examined visual searching abilities by employing a visual search task of finding a specific letter among a set of distractor letters. The level of task difficulty was varied by changing the similarity between the target and distractor letters. It was found the VGPs were again faster at searching for the target than NVGPs.

However, the RT x set size slope was similar between the two groups indicating that VGPs only had faster reaction times and not more efficient searching abilities than NVGPs. Since reaction time measures how fast an individual can process and thereby execute a correct response to a stimulus, a group with a shallower RT x set size slope would indicate faster processing (less time per item and thereby greater efficiency).

It is important to note that two studies were unable to replicate Green and Bavelier's findings. The first study by Boot et al. (2008) sought to not only examine differences in visual attention tasks previously covered by Green and Bavelier (such as enumeration, multiple object tracking and attentional blink) but to also train NVGP groups on action video games in order to test if the video games are in fact responsible for the players' enhanced abilities. Boot et al. found that the results of the visual attention tasks were not significant in a NVGP group that had been trained on action video games. They concluded that while VGPs did have superior abilities in these tasks, these abilities did not improve in non-gamers after being trained on video games. The authors' concluded that these results may be attributed to a self-selection effect of VGPs (gamers are types of people who have pre-existing abilities that cause them to be good at video games so they play them more) or that the VGP group has far more experience than the hours allotted by the training in this study. However, this study had some methodological differences from Green and Bavelier's work, most notably the use of an all-female NVGP group which suggests gender differences may have accounted for the findings in this study; given that gender differences in these types of tasks exists (Green and Bavelier, 2003, 2006; Linn & Peterson, 1985; Terlecki & Newcombe, 2005).

A second study by Murphy and Spencer (2009) replicated Green and Bavelier's 2003 study with a larger participant group (65 male subjects instead of 16). They examined the attentional blink task, useful field of view, inattentional blindness and repetition blindness tasks. They were unable to find significant differences between VGPs and NVGPs on these tasks. However, the authors' note that they were unable to get a VGP group that strictly played action video games. This is important because only the action genre of video games has been shown to enhance gamers' attentional abilities (Cohen, Green and Bavelier, 2007).

The majority of the literature on VGPs and NVGPs abilities has not examined visual search between these two groups. Since other studies have found that VGPs have enhanced attentional processes, it would seem likely that visual search would be another area of ability that VGPs excel in over NVGPs. Indeed, video games themselves often employ searching abilities as a central component behind completing or winning the game; such as in *Half Life 2*, the player must identify and retrieve certain medical items in order to remain alive and continue through the game. While the study by Castel, Pratt and Drummond (2005) examined visual search and was unable to conclude that VGPs had more efficient searching abilities than NVGPs, the authors' only examined one type of visual search. This present study sought to examine visual search in VGPs and NVGPs relative to VGPs efficiency of search over a battery of search tasks.

In this study we examined visual searching abilities in VGPs and NVGPs on three computer-based tasks: a conjunction task, an object task and a scene task. We hypothesized that VGPs would have better, more efficient searching abilities than NVGPs. Specifically, VGPs would have faster reaction times and shallower RT x set size slopes on the conjunction and object tasks than NVGPs and VGPs will be more accurate (lower error rates) on the scene task than NVGPs.

Method

Participants

Thirty-one undergraduate and graduate males from Rutgers University ranging in age from 18 to 30 participated in this experiment. Females were not selected for this study due to putative differences between genders on spatial tasks (Green and Bavelier, 2003, 2006; Linn & Peterson, 1985; Terlecki & Newcombe, 2005). All participants had normal or corrected-to-normal vision and normal color vision. The undergraduate participants received a one hour course credit for the Introduction to Psychology class. Participants provided written informed consent at the beginning of the experiment. All participants were placed into either a VGP group or NVGP group based upon the type of experiment they selected on the University's Experimental Participation website and this self-selection was later verified by a survey given at the beginning of the study.

The video game player (VGP) group was comprised of males who had played first-person shooter (FPS) or action genre video games for at least 5 hours a week for 6 months (this criterion is comparable to that of Green and Bavelier, 2007; Castel, Pratt and Drummond, 2005). Games reported as played by the participants included: *Call of Duty: Modern Warfare 2, Fallout 3, Halo 3, Assassin's Creed and Battlefield Bad Company 2.*

The non-video game player (NVGP) group was comprised of males who do not consistently play action or first-person shooter video games or any video games of any genre (this criterion is also comparable to that of Green and Bavelier, 2007; Castel, Pratt and Drummond, 2005). Of the NVGP group, one participant noted that he played sports games (*FIFA 10*) about one hour a week and another stated that he played video games not of the action or FPS genre for about two hours a week. The other participants stated that they do not play any video games of any genre.

There were a total of eighteen subjects in the VGP group and thirteen in the NVGP group. Three participants were eliminated because their answers to the survey were not consistent with the definitions of VGP or NVGP of this study. Four from the VGP were eliminated due to distraction during the tasks, misunderstanding of instructions and a failure of the software program to execute correctly. One participant from the NVGP group was eliminated due to his age and two were eliminated because of abnormal vision. Therefore, a total of twenty-one participants were utilized for this study (11 VGP, 10 NVGP).

Apparatus

The stimuli were run on Dell Optiplex GX 620 desktop computers with a screen resolution of 1024 x 768 and a 128MB X600 OUGA3 graphics card. E-Prime 2.0, a software program, was employed to create the stimuli, run the experiments and collect the data (Psychology Software Tools Inc, 2009).

Stimuli

Three computer-based tasks were presented. All three tasks included an instruction screen, a centered fixation point after each image and an end of trial screen that were all presented on a black background with white Courier New 18 point font. The first task was a conjunction task (illustrated in Fig.1). Participants had to search for a horizontal green bar among other green and red bars of different orientations on a grey background. Set sizes were 6, 12 and 24.

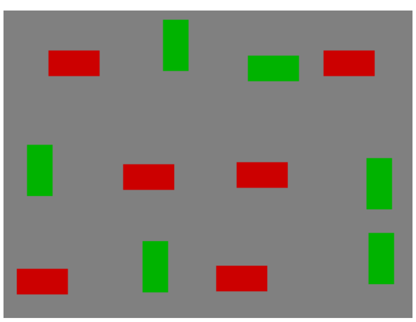

Fig. 1. An illustration of the conjunction task

Fig. 2. An illustration of the object task

The second task was the object task (illustrated in Fig. 2). In this portion of the experiment, participants were given images with various everyday objects (such as a hair brush) drawn from the Hemera Object Database. The objects were arranged in rows and rotated in various orientations along a grey background and the participants were asked to search for an item of food (i.e. an onion, a glass of wine). Set sizes were 6, 12 and 24.

The third task was the scene task (as shown in Fig. 3). In this task, participants were cued with the name of the target object. Each image depicted a real world scene such as a picnic. These images were selected from picture puzzle books (Adams, 2006, 2007; Sullivan, 2007, 2008; USA Today, 2009). The image was preceded by a target word (i.e. baseball, hiking boots) and by a fixation point.

Fig. 3. An illustration of the scene task

Procedure

After the survey was given as outlined previously, the subjects received brief instructions about the study and were asked to perform as accurately and as quickly as possible on each task. The participants each completed the conjunction, object and scene task in that order. The conjunction and object tasks consisted of 240 stimuli (40 present/absent per set size: 6, 12, 24) per task preceded by a fixation point for 500 ms. Each image was displayed until the participants provided a response (“1” on the keyboard for target present and a “0” for target absent). Reaction time was recorded and feedback in the form of a tone (duration of 250ms) was given on incorrect trials.

For the scene task, 120 images were shown in random order (60 present/absent) for a duration of 4000 ms after the target word and fixation point were displayed respectively (both at a duration of 500ms). Participants were asked to press “1” if the target was present and “0” if it was absent. Accuracy was recorded and feedback was given in the form of a tone (250ms) for incorrect responses and no response. At the end of each task an end-of-task screen was shown, at which point the investigator began the next task and allowed the subjects to take a break if needed.

Results

Prior to the analyses the data was cleaned. The first 20 trials of the conjunction and object tasks and the first 10 trials of the scene task for each subject were treated as practice trials and were therefore eliminated. In addition, any reaction time less than 200ms and greater than 10s was considered an outlier and eliminated. These eliminations are consistent with other studies (Castel et al., 2005). For the scene task, unanswered trials were removed.

Conjunction Task

The mean reaction times (RT)[1] are illustrated in Fig. 4a and 4b for target absent and present conditions respectively. Error bars represent standard error of mean. A 2(VGPs, NVGPs) X 3(set size: 6, 12, 24) mixed factor analysis of variance (ANOVA) was carried out on correct trials. As expected, a main effect of set size (6, 12, 24) was observed; absent condition: F (2, 40) = 184.64, $p < .0001$, present condition: F (2, 40) = 139.19, $p < .0001$, indicating that an increase in distractors (larger set size) resulted in longer reaction times. There was no between-subjects group effect (NVGP/VGP); absent:

F (1, 19) = .36, p = .55, present: *F* (1, 19) = .99, p = .33. Finally, there was no interaction between groups and set size; absent: *F* (2, 40) = 1.22, p = .31, present: *F* (2, 40) = .69, p = .51.

The error rates for NVGPs and VGPs are illustrated in Fig. 5. A 2(VGP/NVGP) X 3 (set size: 6, 12, 24) mixed factor analysis of variance (ANOVA) revealed insignificant results for accuracy between-subjects (VGP/NVGP); *F* (1, 19) = .75, p = .39 and within-subjects (set size) *F* (2, 40) = .5, p = .61. No interaction was found between set size and group (VGP/NVGP) *F* (2, 40) = 1.12, p =.33.

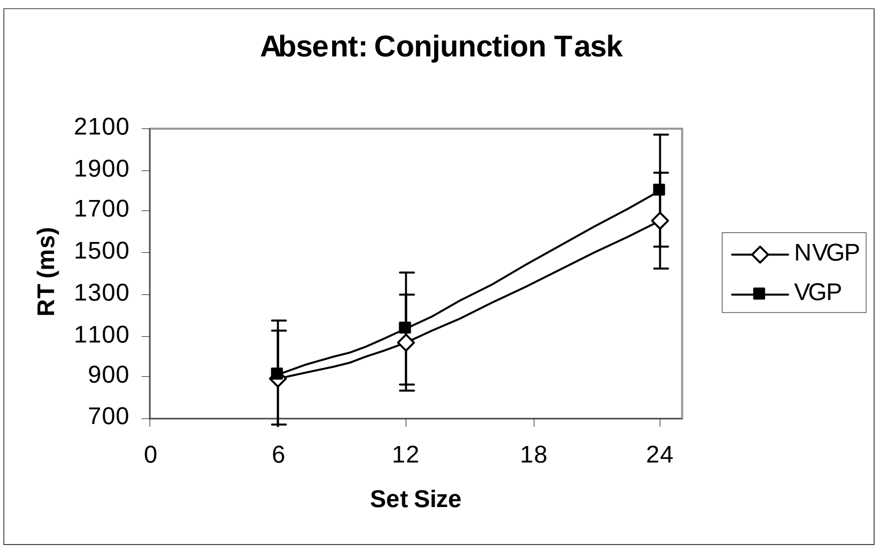

Fig. 4a. Reaction times between NVGPs and VGPs for the target absent condition.

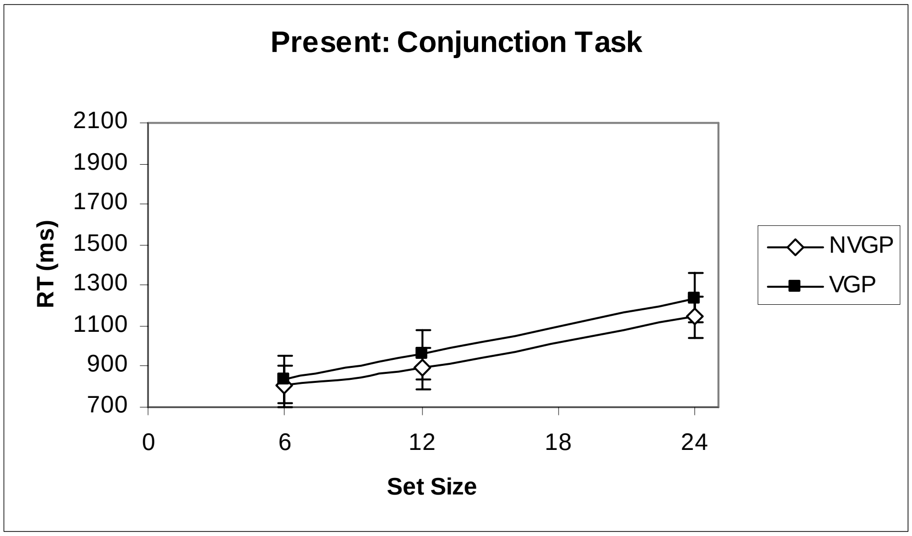

Fig. 4b. Reaction times between NVGPs and VGPs for the target present condition.

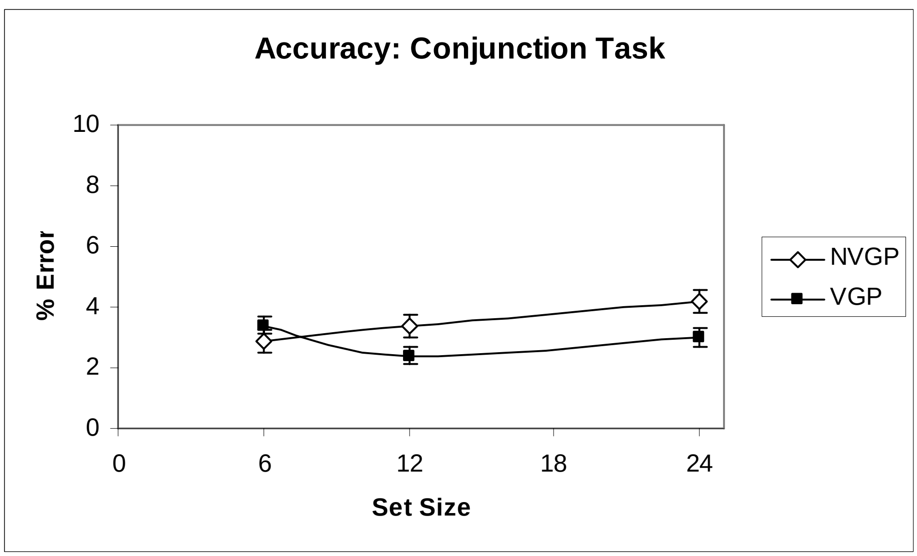

Fig. 5. Accuracy between VGPs and NVGPs for the conjunction task.

Object Task

It is important to note that an error occurred during this task that may have confounded the results. However, the results will still be presented here and this error and its repercussions will be discussed in the following section.

Reaction times for the object task are illustrated in figures 6a and 6b. Error bars represent S.E.M. A 2 (NVGP, VGP) X 3 (set size: 6, 12, 24) mixed factor analysis of variance (ANOVA) of correct trials was conducted. No significant differences were found for group; absent: $F (1, 19) = .57$, $p =.45$, present: $F (1, 19) = .33$, $p = .57$. As with the conjunction task, a main effect of set size was found; absent: $F (2, 40) = 35.69$, $p < .0001$, present: $F (2, 40) = 62.02$, $p < .0001$ indicating that reaction times increased with set size. Lastly, there was no significant interaction between groups and set size; absent: $F (2, 40) = .68$, $p = .51$, present: $F (2, 40) = .70$, $p = .50$.

Object task accuracy is illustrated in Fig. 7. A 2(VGP/NVGP) X 3 (set size: 6, 12, 24) mixed factor analysis of variance revealed two main effects. The between-subjects group effect (VGP/NVGP) was found; $F (1, 19) = 7.52$, $p = .01$. As expected, a within-subjects effect for set size was found, $F (2, 40) = 31.77$, $p < .001$. Finally, an interaction between groups and set size was found, $F (2, 40) = 4.01$, $p = .02$.

However, more data would likely show that there is a speed/accuracy tradeoff in this task; VGPs became slower and more accurate as set size increased (Fig 6a, 6b and 7) indicating that the VGPs were sacrificing speed in order to make less errors.

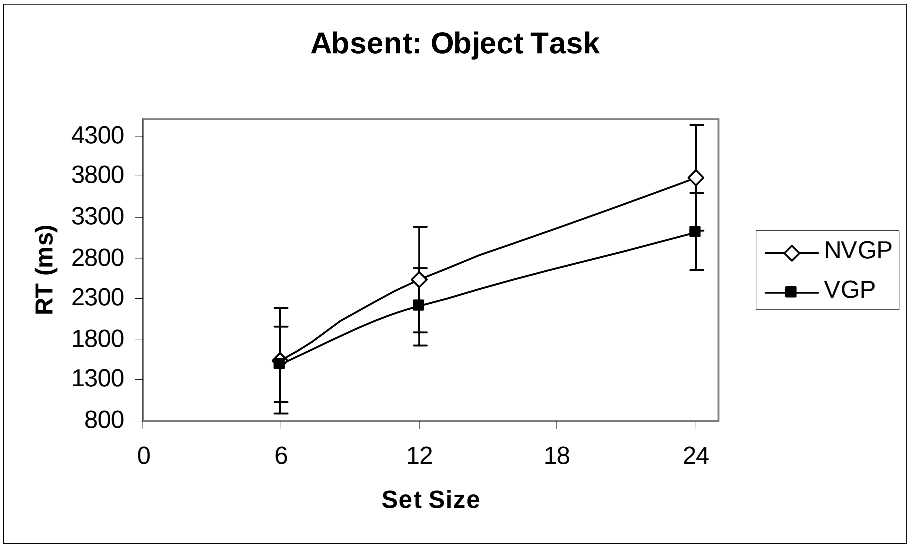

Fig. 6a. RT of the two groups in the absent condition of the object task.

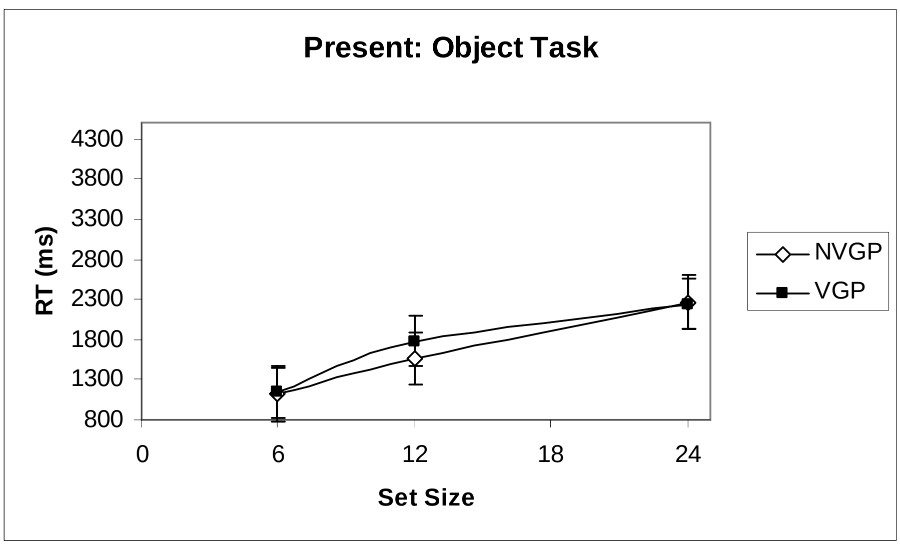

Fig. 6b. RT of the two groups during the present condition in the object task.

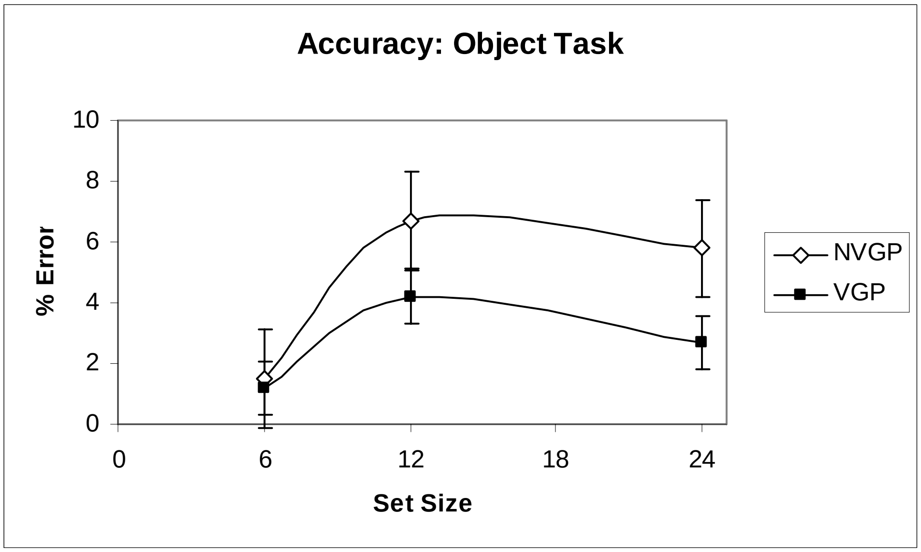

Fig. 7. Error rates for NVGPs and VGPs showing that VGPs are slightly more accurate.

Scene Task

In the scene task, we were only concerned with accuracy. Figures 8a and 8b illustrate accuracy in each of the absent and present conditions. Error bars represent S.E.M. A 2 (NVGP/VGP) X 2 (present/absent) mixed factor analysis of variance was conducted. There was no main effect of groups (VGP/NVGP), *F* (1, 18) = 1.42, p = .24. Nor was there a significant interaction of groups and condition (P/A), *F* (1, 20) = .14, p = .71. However, a significant effect of condition was found, *F* (1, 20) = 10.25 p = .004.

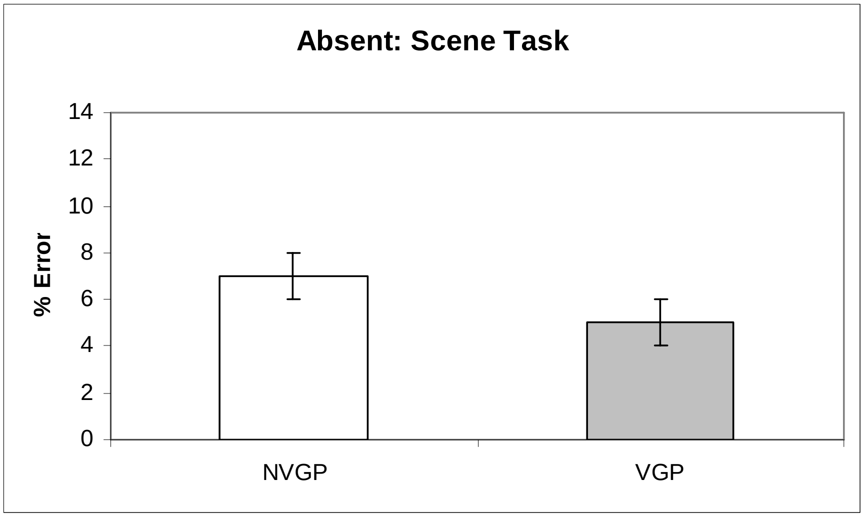

Fig. 8a. Error rates in the absent condition of the scene task.

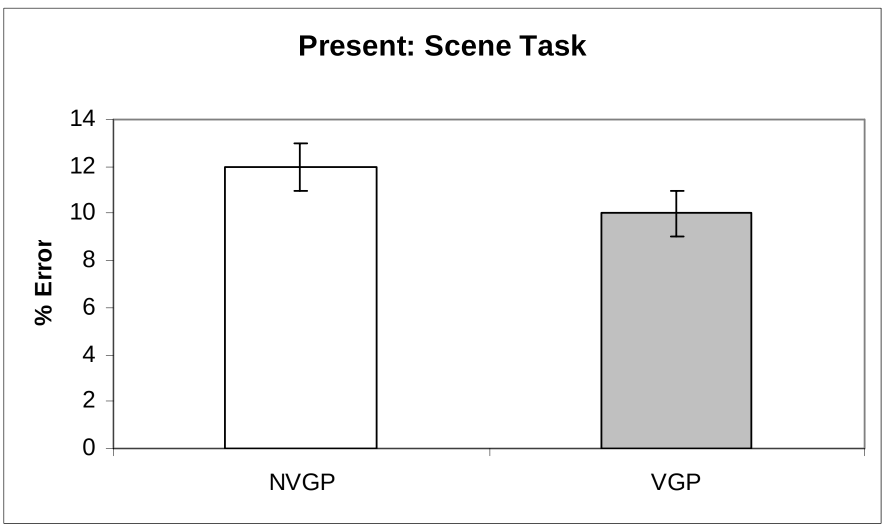

Fig. 8b. Error rates in the present condition of the scene task.

Discussion

The Conjunction Task

In this task selective attention is assumed to bind the features of the images such as color (red or green) and orientation (horizontal or vertical) used in this study. Given the findings discussed in the introduction it was expected that VGPs would be faster and more accurate at this task than NVGPs, however this was not the case. The groups were not significantly different on the task. Importantly, there was no difference in slope[2] between the two groups on the reaction time graphs (Fig. 4a and 4b). Hence, these results do not show a difference in the efficiency of visual search for NVGPs and VGPs.

Castel et al. (2005) did a study involving a similar type of simple visual search task in which the participants were asked to find a target letter among distractor letters in easy and hard conditions. They found that VGPs had faster reaction times than NVGPs but there was no difference in slope suggesting that VGPs were just faster at pushing the appropriate keys. It is interesting that the VGPs in this study were no different in RT than NVGPs, contrary to previous literature, given that the point of video game play is to execute as fast as possible the right key on the control pad in response to a stimulus. It may be that the VGP group was being more cautious and therefore slower because they knew they were being tested. Alternatively, they may have been more distracted and less interested in the task.

The Object Task

As noted in the results section, a computer error occurred during the execution of this task that caused some subjects to experience each stimulus in order (all of set size 6 present, set size 6 absent, set size 12 present and so forth) instead of randomly as outlined in the methods section. Unfortunately, the majority of the participants from each group were affected and therefore we cannot accurately make any conclusions about VGPs abilities from this task.

Scene Task

This task was meant to replicate visual search as we use in our everyday lives: selecting a target out of a scene full of distractors. The results of this task showed that there was no difference in accuracy between VGPs and NVGPs indicating that visual search used in everyday situations is similar between the two groups and video game play does not enhance this ability. It may be that the task itself was unable to capture the VGPs abilities as will be discussed in the following section.

General Discussion

This study sought to examine visual searching abilities in VGPs and NVGPs; an area of perception that has not been well examined in literature with the majority of the research concentrating on other attentional processes (Green and Bavelier, 2003, 2006, 2007). While one study (Castel et al., 2005) did include visual search, the results suggested that VGPs were simply faster button pressers rather than more efficient searchers. In line with their conclusions and based on the overall results of this study, we cannot claim that VGPs have enhanced visual searching abilities as compared to NVGPs.

This study employed the use of feedback to ensure that the participants answered as accurately as possible (this method was also used in Castel et al., 2005). However, the use of a feedback tone on incorrect responses may have shifted the participants' strategies (particularly the VGPs) to be more accurate and forgo speed. VGPs may be more competitive individuals and it may have been more desirable for them to get less wrong and therefore less unpleasant beeps that could be heard by other participants in the study. If the VGPs focus shifted to accuracy rather than speed *and* accuracy as they were asked to do, this may have caused the VGPs to be slower than they could have been. This may be the reason behind the lack of difference in RT between the two groups. In order to overcome this possible confound a simple text feedback could have been used, participants could have been run one at a time or given a target error rate; similarly accuracy and stimulus onset asynchrony (SOA) could have been examined rather than RT or the instructions could have been changed to emphasize speed.

Also, it is likely that the tasks used in this study are simply unable to elicit and capture a difference in visual search efficiency between NVGPs and VGPs. Perhaps more trials or harder stimuli would garner a difference between the two groups. An increase in trials would allow the participants more time to become acquainted with the task and may have decreased their response times. The stimuli may not have been difficult enough to tap into the VGPs abilities and so were unable to engender the faster processing that has been seen in previous literature.

The research in this area has certainly drawn the attention of numerous other authors who are publishing significant results that gamers have better visual abilities in many areas other than visual attention such as mental rotation, contrast sensitivity, Goldmann visual fields, crowding, and general cognitive abilities such as short-term working memory, mathematical decision making and auditory perception (Green and Bavelier, 2003, 2006a, 2006b & 2007; Achtman et al., 2008; Caplovitz and Kastner, 2009; Buckley et al., 2010; Barlett et al., 2009; Li et al., 2009). In addition, the military has used video games as training devices since the 1980's for pilots and ground forces (Greenfield, 1985, 1994; Gopher, Weil, & Bareket, 1994). There is certainly evidence that video games do have an impact on visual abilities and this impact is extendable to the real world

Indeed, these studies may share a common flaw that may lie in VGPs difference from NVGPs in motivation or arousal such as competitiveness to do well at these tasks in the same sense they are competitive in the games they play. In order to determine this, VGPs could be tested on tasks that are not part of video game play, such as the other cognitive abilities like math skills as was done in the study by Barlett et al. (2009). In that study, as mentioned previously, the VGPs were found to excel at those tasks which may suggest a difference in their motivation or arousal. On a similar note, most of the literature has been done by Green and Bavelier and recently there have been a few studies that were unable to replicate their findings (Boot et al., 2008; Murphy and Spencer, 2009) as discussed previously. While this study is unable to conclude that VGPs are better visual searchers, this study hopes to contribute to future research in this area.

Appendix A

Copy of Surveys

Visual Search Survey
VGP

Please fill in or circle the correct response for each question.

Gender: _____________

Age: _______________

1) Is your vision corrected to normal (20/20)? ________________

2) Are you colorblind? ______________

3) Do you play first person shooter/action RPG genre video games such as Call of Duty: Modern Warfare 2, Fallout 3, Assassin's Creed, Half-Life 2: Episode 1?

Yes.

No.

3) If so, how many hours per week would you say you spend playing these types of games?

____

4) If you play these games, have you played them consistently for at least six months or more?

Yes.

No.

5) Would you say you play first-person shooter/action RPG games **MORE** than any other genre of video game (i.e. sports games such as Madden, music/party games such as Rock Band or MMO/MMORPG games such as World of Warcraft.)?

Yes.

No.

6) Please list three games you are currently playing:

____

____

____

Visual Search Survey
NVGP

Please fill in or circle the correct response for each question

Gender: _____________

Age: _______________

1) Is your vision corrected to normal (20/20)? ________________

2) Are you colorblind? ______________

3) Do you play any video games (i.e. PC games such as Farmville, Wii games like Wii Sports, social games like The Sims)?

Yes.

No.

4) If you do play video games how often do you play them each week?

Days? ____________________

Hours? __________________

5) Have you played first person shooter or action video games (like Halo) in the past (a year ago or more)? If so estimate how long ago:

____

6) If you are currently playing any video games please list them:

____

____

Footnotes

[1] Median RTs were also examined for the conjunction and object tasks however; the data did not yield significant results and is therefore not reported.

[2] The slope intercepts for the conjunction task were examined in a t-test and did not yield significant results.

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