

BECOMING A GUITAR HERO:
DOES IT ALTER MULTISENSORY PROCESSING SKILLS?

by

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Abstract

Three groups of novice gamers were trained for 10 hours using the music-genre game Rock Band©: one group played the game normally, another played using visual cues only, and a third simply listened to music. Pre- and post-test eye-tracking data was collected using a focused attention task in which participants quickly shifted their gaze toward a visual target; on some trials a to-be-ignored auditory tone was also presented. Past research has shown the tone to speed-up saccadic response time (SRT). We hypothesized that training on a music-genre video game would boost this intersensory facilitation effect, defined as the difference between SRTs on unimodal only trials minus SRTs on bimodal trials. There was an overall SRT decrease from pre- to post-test, but, more critically, the magnitude of the facilitation effect was not disproportionately enhanced in the full Rock Band© training group, relative to the controls. Future research avenues are considered.

Keywords

Music-genre video games; training; multisensory processing; focused attention paradigm; intersensory facilitation; saccadic response time; transfer.

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Introduction

Around the world, the video game industry is massive, ubiquitous, and extremely lucrative. In Canada the industry is booming, directly employing approximately 16500 people and impacting the economy to the tune of an estimated \$2.3 billion (ESAC, 2013). The Entertainment Software Association of Canada's 2013 factsheet showed that 61% of Canadian households own a game console; 80% own a cell phone, tablet, or other mobile device; and 95% own a computer. The report also classified 58% of Canadians as gamers, with 90% of children and teens falling into that same category (ESAC, 2013). When it comes to video game genres, action games are produced most readily, with 73% of Canadian companies developing games in that class (ESAC, 2013). With such staggering figures, it is not surprising that video games have become the focus of scientific investigation.

In the 1980s, when video gaming moved from the arcade to the home, research pertaining to the effects of violence within video games gained momentum. Although this bulk of research produced conflicting outcomes (Barlett, Anderson, & Swing, 2009), it nonetheless resulted in video games acquiring a bad reputation due to the violence found therein. Video gaming's bad rap endured and early reports of the benefits of gaming (e.g., Dorval & Pépin, 1986; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994) were obscured by the violence research, and thus largely ignored. In 2003, a groundbreaking paper published in *Nature* (Green & Bavelier, 2003) marked a paradigm shift in the field; it opened the floodgates for cognitive and perceptual research to take hold, showcasing that video games had more than just deleterious effects, and could in fact be of benefit to those who played them.

Through the use of several visuospatial paradigms, Green and Bavelier (2003) found that when compared to non-gamers, those with extensive video gaming histories (gamers) had enhancements in a variety of visual skills. Gamers were shown to have an enhanced attentional capacity, an increase in the number of visual items that could be accurately attended to at once, an enhanced ability to allocate spatial attention over the visual field, and an enhancement in the temporal resolution of visual attention and task-switching abilities.

One of the tasks used by Green and Bavelier (2003) was the flanker compatibility task, in which participants were required to indicate whether a square- or a diamond-shaped target had been presented in one of six rings arranged in a circled array (see Figure 1), while ignoring the presence of a flanker distractor (also shaped as either a square or a diamond, presented outside of the rings). When the distractor was the same shape as the presented target, it was considered compatible; whereas when the two differed it was considered incompatible. Previous findings show that the presence of the distractor can influence performance on the target task, as the distractor is processed to some extent. The authors were interested in what is called the ‘compatibility effect,’ which is the difference in target processing speed between the two trial types (compatible and incompatible), and is considered a measure of available attentional resources. The target task was made progressively more difficult by presenting an increasing number of shapes (other than a square or a diamond) in the five empty rings. When the task becomes more difficult, those with less attentional resources will no longer be affected by the flanker distractor as their resources will be exhausted by the target detection task alone; whereas, those with an increased attentional capacity will still have spare resources ‘left over’ to process the distractor and will thus still be affected by its presence. Green and Bavelier (2003) found, as they had hypothesized, that gamers continued to show the compatibility effect at higher difficulty

levels than non-gamers who had used-up their resources on the target task, thus indicating that gamers possess spare attentional resources when compared to non-gamers. The concept of extraneous attentional resources in gamers was central in the present thesis.

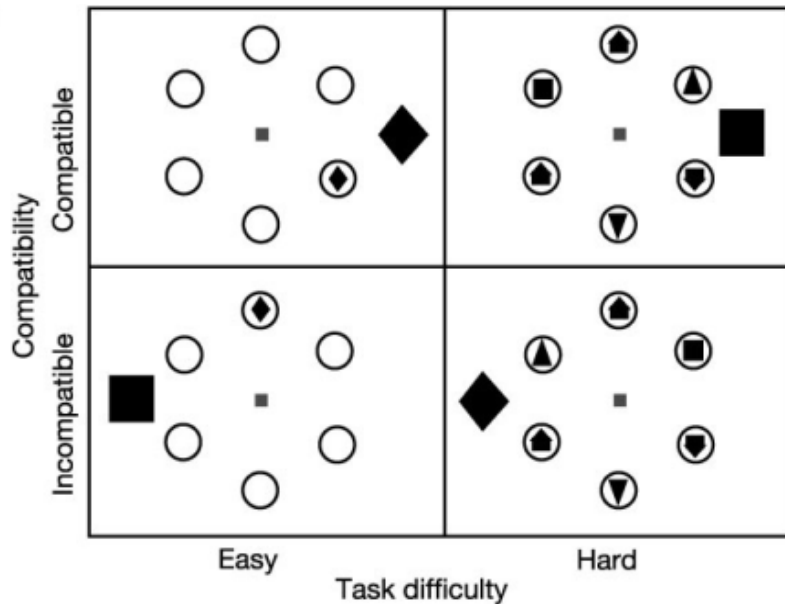


Figure 1. Flanker compatibility task; measure of attentional resource. *Note:* Reprinted by permission from Macmillan Publishers Ltd: Nature, 423(6939), 534-537, copyright 2003.

Additionally, Green and Bavelier used an enumeration task to more directly confirm this increase in visual attentional capacity by having participants report how many squares were briefly presented in an array. When fewer numbers of squares are presented, participants accomplish this task through a process called subitizing, which is quick, automatic, and accurate; whereas when the number of squares increases, participants must engage in counting the items displayed, which is by nature a slower process. By measuring the greatest number that can be subitized, it can be inferred that this is the largest amount that can be attended to at once. Through the use of the enumeration task, it was found that gamers were able to subitize significantly more squares

than non-gamers (4.9 versus 3.3 items). This finding further indicated that extensive video gaming experience could lead to an enhancement in attentional capacity.

The previous two tasks measured visuospatial attention within what is considered the video game training zone, which is 0° to 5° from the centre of the screen. Green and Bavelier wanted to investigate whether the enhancements from video gaming extended beyond this zone, into the periphery of the visual field as far as 30° from central fixation. To do this, they adapted the ‘useful-field-of-view’ task to measure the spatial distribution of attentional resources. For this task, participants were required to indicate on which spoke a small target (a circle containing a triangle) was presented amongst distractors (see Figure 2). By having the target appear at differing eccentricities, Green and Bavelier were able to show that gamers were better at locating the target than non-gamers at all eccentricities, even those found beyond the video game training zone. Thus, these results indicate that the deployment of spatial attention is enhanced in those with extensive video gaming experience, and that these enhancements are not limited to the visual area in which most of gaming takes place.

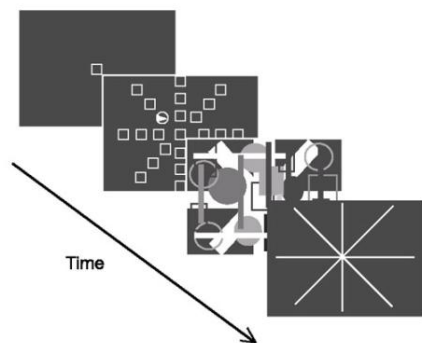


Figure 2. Useful-field-of-view task; measure of attention over space. *Note:* Reprinted by permission from Macmillan Publishers Ltd: Nature, 423(6939), 534-537, copyright 2003.

Through the use of these visuospatial paradigms, Green and Bavelier (2003) were able to show that those with extensive video gaming histories exhibited enhancements in attentional capacity, an increase in the number of visual items that could be accurately attended to at once, and an enhanced ability to allocate spatial attention over the visual field. In their own words, they found that “video-game playing ... is capable of radically altering visual attentional processing” (p. 536).

From 2003 on, research pertaining to the cognitive/perceptual effects of video gaming took-off. Powers, Brooks, Aldrich, Palladino, & Alfieri (2013) recently compiled the extant literature to conduct a quantitative meta-analysis; the undertaking was the first in the field to measure the effects of video-game play on information processing. Using random-effects models, the data from the 118 studies included in the meta-analysis indicated significant effects of video gaming experience on information-processing skills. They looked at both quasi-experimental (gamers vs. non-gamers) and truly experimental (training) paradigms; reliable effects were found for both design types, with some differences. Further, Powers et al. (2013) looked at differing aspects of information processing by sorting the video gaming data into the following domains: auditory processing, executive functions, motor skills, spatial imagery, and visual processing. Although there were gains found in all domains, it was shown that the augmentation in executive functioning was the most negligible. The 2013 meta-analysis included studies investigating the effects of games from differing categories; however, historically, the games that have been studied most readily are those that fall into the action genre.

Action-genre games became the focus of empirical investigation as gamer-participants reported that they were the offerings they were playing most often. Characteristically unpredictable,

action games require skillful accuracy, hurried decision making, quick reflexes, rapid sensory information processing, precise timing, and the distribution of attention both in the centre of vision and the periphery. First-person shooter games, those in which the player is engaged in combat from the perspective of the character they are controlling, have been the most readily studied action genre games; examples of these include *Medal of Honour*, *Call of Duty*, and *Halo*. Oei & Patterson (2013) pointed out that, while action-games have been found to be beneficial, they may not be appropriate for all players as they generally tend to depict scenes of violence and mature scenarios which render them unsuitable for use with impressionable players. Because of this, there is a definite need to determine whether more-innocuous games from differing genres (such as music or driving games) can lead to the same cognitive and perceptual enhancements produced by action video gaming (Wu & Spence, 2013).

When examining the literature pertaining to the enhancements produced by action-genre games, the highest percentage of studies have employed a design in which those with extensive action video gaming experience were compared to those without (gamers versus non-gamers); however this type of research design is purely correlational in nature and thus the findings therein may simply have been due to the fact that gamers are inherently different than non-gamers (Green & Bavelier, 2008). That is to say, it could be that individuals who are innately good at hand-eye coordination tasks would be drawn to, and rewarded by video games more-so than those who are not inherently coordinated in such a way (Bavelier, Green, Han, Renshaw, Merzenich, & Gentile, 2011).

The first to eliminate these confounds of self-selection and population bias, and establish a causal link, were Green and Bavelier (2003). In addition to comparing gamers to non-gamers,

these researchers also implemented a video game training regimen to show that exposure to video gaming itself produced the effects found. Green and Bavelier (2003) demonstrated that, with only 10 hours of training, participants exhibited cognitive enhancements causally linked to gaming itself. They did this by recruiting all non-gamer participants and then trained half on the action-genre video game *Medal of Honor*, and the other half on the puzzle game *Tetris*. *Tetris* was chosen to train the control group because it did not require the deployment of attention to more than one object at a time; as such, it would not be expected to impact on visuospatial attentional capabilities, but would serve to monitor for improvements derived from visuo-motor activation and test-retest experience. Through the use of training, Green and Bavelier (2003) were able to show that it was the action video gaming itself that led to the augmentations found.

Training studies are now the gold-standard in video game research; many subsequent studies have found that non-gamers who are trained on a video game (generally between 10 and 50 hours) exhibit benefits from this exposure (Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003, 2006a, 2006b, 2007; Li, Polat, Makous, & Bavelier, 2009; but see Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Sims & Mayer, 2002). Each of these findings strengthen the claim that it is the gaming experience itself that leads to the effects found and not the result of preexisting population differences.

According to Green, Li, and Bavelier (2010), a well-designed training study should include not only an experimental training group, but also a control group to account for the many possible confounds that are inherent to studies that involve a training program. Confounds such as test-retest effects (i.e., improvements found from taking the test a second time), as well as the Hawthorne effect, in which an improvement in performance is found to be simply due to the

motivation activated by participants having attention paid to them by the researcher. If a study were to only employ a no intervention/no contact control group, it could not be definitively determined that the training itself produced the effects as these psychological and motivational aspects would not be accounted for.

Although many initial training experiments specifically targeted visuospatial attentional processes, studies using such regimens have also investigated other aspects of perceptual and cognitive abilities. In the previously discussed 2003 offering from Green and Bavelier, video game training was found to have beneficial effects on performance in the useful-field-of-view, flanker compatibility, and enumeration tasks. In the training research since Green and Bavelier's seminal work, action video gaming has been found to result in perceptual enhancements pertaining to peripheral vision (Green & Bavelier, 2006a; Feng et al., 2007), spatial perceptual resolution (crowding effects) (Green & Bavelier, 2007), backward masking (Li, Polat, Scalzo, & Bavelier, 2010) and contrast sensitivity (Li, Polat, Makous, & Bavelier, 2009). Cognitive abilities have also been found to be enhanced by video game training such as the ability to attend to multiple objects at once (Cohen, Green, & Bavelier, 2008; Green & Bavelier, 2006b), spatial skills (Feng et al., 2007), and a reduction in attentional blink (Green & Bavelier, 2003). In addition, improvements have been found in higher-order executive control functions such as task switching (Basak, Boot, Voss, & Kramer, 2008; Green, Sugarman, Medford, Klobusicky, & Bavelier, 2012; Strobach, Frensch, & Schubert, 2012) and working memory (Boot et al., 2008).

Although training-induced performance enhancements have long been established in perceptual learning, video game training proved to be the strongest example where the learning that occurred generalized to tasks unrelated to the trained task itself (Spence & Feng, 2010). Oei and

Patterson (2013) trained groups of participants on several different video game types (hidden-object, match-3, action, memory matrix, agent-based life simulation), to determine whether different game types would produce different effects on a test-battery comprised of diverse tasks (attentional blink, visual filter, visual search/spatial memory, complex verbal span). They found that participants performed best on tasks that most-resembled the demands of the video game on which they were trained; however, participants also showed improvements on other, less-similar tasks. From their findings, they concluded that transfer effects are thus maximized when the task contains elements similar to the training game (near transfer), but that transfer effects also occur for tasks that are dissimilar to the game (far transfer). Overall, Oei and Patterson (2013) found that training using an action video game resulted in the widest transfer effects; thus the researchers suggested that action gaming may result in improvements in overall high-level general processes (such as working memory, attention, or learning), and that these overarching enhancements can be employed in differing ways depending on the given task.

Due to the outstanding transfer effects produced by video gaming, research into the use of game training regimens to induce cognitive changes has taken-off within the field of applied psychology, with a major impact on ideas about rehabilitation. Already, studies have delved into the use of video games for dyslexia (Franceschini, Gori, Ruffino, Viola, Molteni, & Facoetti, 2013), ageing (Spence & Feng, 2010), obesity (Powers et al., 2013), mental health intervention (Ceranoglu, 2010), health care and medical training (Kato, 2010), ADHD, anxiety, and autism spectrum disorders (Wilkinson, Ang, & Goh, 2008), and education (Boyan & Sherry, 2011).

Ideally with this type of research, further testing would take place to measure whether the effects produced by the training are long-lasting. Both Feng et al. (2007) and Li et al. (2009) employed

this long-term testing practice and both found that (from months to years later) the majority of the augmentations that had been attributed to video game training had endured. These findings are important as they lend credence for the use of video games as training tools in applied settings (Green, et al., 2010).

Thus far we know that a causal link between action video game training and enhancements in cognitive and perceptual functioning has been established. From the main interpretations of such literature, two general themes emerge: one is that video gaming results in quicker reaction times (without a decrease in accuracy) (Dye, Green, & Bavelier, 2009), and the other is that gamers have at their disposal spare attentional resources (Green & Bavelier, 2003). Regarding the second overarching interpretation, to refresh, gamers and trainees alike have been found to be more affected by distractors than non-gamers or control trainees (Green & Bavelier, 2003); non-gamers 'use up' their attentional capacity before gamers do, and thus are not able to detect distractors under increasing mental workloads. Gamers on the other-hand use less of their attentional capacity to perform the task at hand, and thus can use their 'leftover' resources to enhance their performance.

To illustrate this point, imagine someone who is new to public speaking making their first presentation. A novice presenter would be far less likely to notice a loud clock ticking or an audience member shuffling uncomfortably in their seat because they would be focusing the bulk of their attention on the task of presenting itself, whereas a seasoned presenter, who no longer has to focus their attention intently on the act of presenting, can use their additional 'leftover' resources to attend to extraneous stimuli in the room. It is from this interpretation of the literature that the current study bases the idea that video gaming results in the availability of extraneous

attentional resources the player can employ to improve task performance. This hypothesis is not necessarily vision-specific and is in fact very cognitive in nature. It is thus extrapolated that this enhancement should extend beyond vision, reaching to other modalities.

In fact, Green and Bavelier (2003) found that video gaming's effects went beyond the spatial characteristics of attention to the temporal aspects as well; through the use of a modified attentional blink task, they found that gamers were better able to identify one target and then quickly detect a second. Previous studies have shown that participants are less accurate at reporting a second target when a first target has been presented in close temporal proximity; as the time between the first and second target increases, participants are better at reporting the second target accurately. This 'blink' in attention is due to the processing of the first target, and is considered a measure of how quickly attentional resources can recover (Achtman, Green, & Bavelier, 2008). For Green and Bavelier's attentional blink task (see Figure 3), participants were rapidly presented black letters amongst which a white letter was shown (at differing times depending on the trial). Then, at varying time intervals after the presentation of the first target, a second target (an 'X') was presented 50% of the time; this second target was also presented amongst serially presented black letters. Green and Bavelier's modified paradigm involved task-switching between identification and detection: participants were to identify the first target by naming the white letter, and then report on the presence of a second target (detected or not detected). Through the use of this task, it was found that gamers had a reduced attentional blink and were better able to task-switch between identification and detection; thus showing that, video gaming has the capacity to augment not only spatial, but also temporal, aspects of attention.

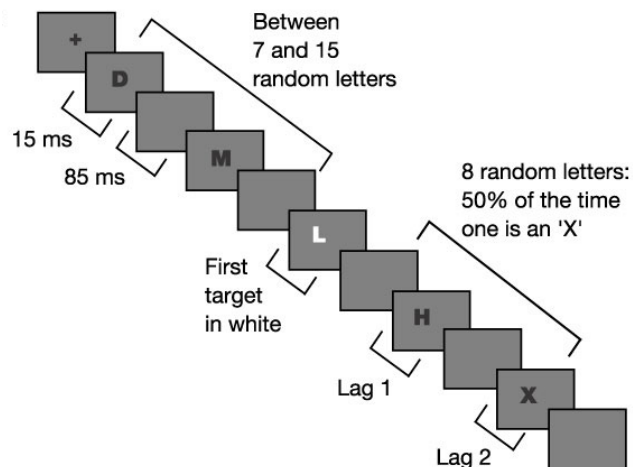


Figure 3. Attentional blink task; measure of attention over time. *Note:* Reprinted by permission from Macmillan Publishers Ltd: Nature, 423(6939), 534-537, copyright 2003.

From Visual to Intersensory Processing

Cumulative evidence, in both spatial and temporal domains, indicates a causal link between action video game play and aspects of visual attention; however, until 2010, there were no studies investigating whether the benefits of action video gaming extend beyond visual enhancements to multisensory processing. The first to undertake the task were Donohue, Woldorff, and Mitroff (2010); they examined multisensory temporal processing abilities, looking specifically at participants' ability to judge whether audio and visual stimuli occurred at precisely the same moment in time or were slightly off-set in their presentation (simultaneity judgment task), as well as perceptual discrimination abilities, by having participants report which stimulus modality was presented first (either auditory or visual) at various stimulus onset asynchronies (multisensory temporal-order judgment task).

The stimuli used for both tasks were a black and white checkerboard square presented on a computer screen with a black background, and an auditory tone presented through evenly spaced speakers (see Figure 4). The visual stimulus appeared on-screen just below a fixation point, and

was presented at either the centre of the screen or off-set to the left or right (depending on the trial); the auditory tone was presented centrally throughout. Trials consisted of the stimuli being presented either simultaneously, or with one modality slightly ahead of the other. For the simultaneity judgment task, participants were instructed to report whether the visual and auditory stimuli had been presented simultaneously or asynchronously by selecting on a keypad 1 for simultaneous and 2 for non-simultaneous; for the temporal-order judgment task, participants were to report which modality had been presented first, again using the keypad. Overall, it was found that gamers were in fact better at judging whether audio and visual stimuli occurred simultaneously or asynchronously at narrower temporal intervals than non-gamers, and action gamers were also better than non-gamers at discerning which stimulus modality was presented first. The findings by Donohue et al. (2010) suggest that the benefits of playing action video games affect not only the visual modality but also multisensory temporal processing abilities.

Historically, the senses were studied as separate, modular functions, working independently of one another with information later integrated into a unified percept (Shimojo & Shams, 2001). This approach has changed, and the senses are now most readily studied from the viewpoint that multisensory interaction occurs from the moment of perception, with multiple senses sharing neural pathways; thus, the study of multisensory processing has become one of the fastest growing areas of research in the perceptual domain (Shimojo & Shams, 2001). That being said, it has been known for at least a century that responses tend to be faster when stimuli from two modalities are presented simultaneously (bimodal stimulus) than when one modality is presented alone (unimodal stimulus) (Colonus & Arndt, 2001). This phenomenon (defined quantitatively as the mean unimodal reaction time minus the mean bimodal reaction time) is generally referred

to as the **intersensory facilitation effect**, and was first reported by Todd in 1912 (as cited in Colonius & Arndt, 2001, and Colonius & Diederich, 2012).

A commonly used task to study intersensory facilitation is the focused attention paradigm (Colonius & Arndt, 2001). In this task, participants must respond as quickly as possible to the onset of a pre-defined target stimulus from one modality (for example, a visual target), that is presented along with a to-be-ignored (distractor) stimulus from another modality (for example, an auditory tone) (Colonius & Arndt, 2001; Colonius & Diederich, 2012). The participant is explicitly instructed to ignore the distractor and focus their attention solely on the target (Colonius & Arndt, 2001; Colonius & Diederich, 2012). Previously, responses were generally recorded as manual button presses, but with the advent of eye-tracking technology, saccadic reaction times (henceforth: SRTs) are now often used to measure reaction times within the focused attention paradigm. Saccades are the rapid, stepwise, jerk-like movements the eyes make when the point of fixation is moved from one location to another. An advantage of using SRTs is that our eyes are able to make movements toward many more target positions than manual responses (Diederich & Colonius, 2004). From the focused attention paradigm, the typical result is that SRTs tend to be faster when responding to bimodal than to unimodal stimuli (Colonius & Diederich, 2012). Additionally, when the modalities that make up a bimodal stimulus are presented on the same side (ipsilaterally) the effect has been found to be larger than when the stimuli are presented on opposing sides (contralaterally) (Diederich, Colonius, Bockhorst, & Tabeling, 2003).

In the real-world, humans are constantly bombarded with sensory input from every modality, thus it is highly adaptive to be able to process multisensory information as quickly and

accurately as possible. By being better able to combine these differing sensory cues into a coherent and meaningful percept, we can make sense of the world around us more efficiently and effectively, especially in situations that are ambiguous or noisy (Rach, Diederich, & Colonius, 2011). The speeding of reaction times due to intersensory facilitation is especially adaptive in situations where a quick response is required, for example in situations where our safety is threatened; thus, uncovering ways in which intersensory facilitation can be enhanced has real-world applications.

Stemming from the literature, it seems likely that a video game from the action genre would have an impact on the intersensory facilitation effect, as suggested by Donohue et al. (2010); however, all games are not created equal. Perhaps a game from the music genre would bring about such enhancements more effectively, being that these types of games require the player to pay attention to not only what is occurring on-screen, but also to an auditory component, resulting in a truly multimodal gaming experience. Despite their mainstream popularity, music genre games have yet to be studied within the video gaming literature. The first music genre game to gain massive public appeal was *Guitar Hero*, released in late 2005. *Guitar Hero* used a guitar-shaped controller to simulate playing lead guitar along to well-know rock songs. On the heels of the success of *Guitar Hero*, Rock Band© was released which added additional instrument controllers to the mix.

To play Rock Band©, players must click coloured fret buttons on the neck of the guitar-shaped controller, while toggling a strum bar located on the body of the guitar. On-screen, players are presented with coloured targets scrolling along a stylized fret-board towards a marked zone at the bottom of the screen. The scrolling targets are displayed in sync with popular rock songs; players

must hit the colour-coded fret buttons on the guitar controller and toggle the strum bar at that exact moment when a same-coloured music note reaches the marked zone on-screen. Precise timing and accuracy in this task result in the correct music notes being played in sync with the song making it sound as it should, whereas inaccuracy results in an incorrect note being played making the song sound distorted.

Rock Band© has four levels of difficulty; easy, medium, hard, and expert. The easy setting requires the player to use only three of the five fret buttons while the on-screen component shows the least total number of music note targets synched along to the song. As the player ups the difficulty setting, they are required to incorporate more fret buttons, and are presented with greater numbers of music-note targets on-screen which are displayed more quickly as the levels increase. The music-genre game Rock Band© was chosen for the present study as it provides a non-violent, engaging, multimodal gaming experience that has yet to be investigated within the literature.

The Present Study

The paucity of data pertaining to multisensory processing is likely due to the recency of the abovementioned paradigm shift in the study of how the senses function; however, as stated, the first to undertake the task within the realm of video game research were Donohue et al. (2010) who found that individuals with action video game experience performed better on behavioural measures of multisensory temporal processing than did non-video game players. Thus, we posit that if experience playing an *action* video game impacts multisensory temporal processing abilities, then experience playing a *music* video game should augment multisensory processing to a greater degree. Also, since we know that *action* video game players are better able to allocate

attention across space locations and time frames, we ask, will experience playing a *music* video game augment players' ability to allocate attention across sensory modalities?

The present study introduces two original aspects to the investigation of video gaming; it is the first study to investigate the effects of playing a game from the music genre, and it is the first multisensory processing study to employ a video game training regimen, an element that is state of the art in the field. The study design had participants complete a pre-test eye-tracking session using the focused attention paradigm; they were then assigned to one of three groups for the 10-hour training phase, which was followed-up by a post-test eye-tracking session again using the focused attention task.

In terms of transfer, the link between the focused attention task and the game Rock Band© is notably in the timing. To play Rock Band© effectively, motor activation must be quickly and accurately generated in response to visual stimuli on-screen (button presses to scrolling music notes). Rock Band© also incorporates an auditory component that is facilitatory when paired with the visual targets, as the music gives the player a rhythmic cue to help sync the timing of manual responses. Likewise, in the focused attention task, motor activation must be quickly and accurately generated in response to visual stimuli on-screen (saccades to visual targets), and like the game, the task also incorporates an auditory component that is facilitatory when paired with the visual target (due to the intersensory facilitation effect). Although the focused attention task does not exactly replicate the demands of the gaming experience, it does combine elements that are similar in nature and thus at the very least, 'far transfer' effects in the sense evoked by Oei and Patterson (2013) should be feasible given the similarity between the two.

As stated, following completion of the pre-test eye tracking session, participants were assigned to one of the three groups;

- Rock Band© Regular – participants played Rock Band© normally.
- Rock Band© Mute – participants played Rock Band© without the audio component.
- Music Only – participants did not play the game at all and instead listened to the music found therein.

The Rock Band© Mute and Music-Only groups served as controls to determine whether different modal aspects of the video gaming experience lead to different effects. The Rock Band© Mute group served to control for whether the visuo-motor component of the game alone resulted in an impact on the results of the post-test measure, whereas the Music Only group served as a control in the same way, but to determine whether the auditory component alone had an effect.

It was hypothesized that after 10 hours of training using the game Rock Band©, participants would have an augmented attentional capacity that would provide them with increased resources to process stimuli from two modalities and that these enhancements would be measured as an improvement in performance on the focused attention paradigm in the following ways;

- Hypothesis 1: Following training (from pre- to post-test), the Rock Band© Regular group would show the greatest SRT difference between unimodal and bimodal trials (i.e. the greatest intersensory facilitation effect).
- Hypothesis 2: Following training (from pre- to post-test), the Rock Band© Regular group would show the greatest SRT difference between bimodal ipsilateral and bimodal contralateral trials.

Both of these predicted results were proposed to be a result of extraneous attentional resources (gained via Rock Band© training), ‘spilling-over’ to the distractor rendering the participant unable to ignore it. Thus the distractor would be processed (as was the distractor in the flanker compatibility task), which would result in the auditory component of the bimodal stimulus being processed as more than just ‘noise’, and instead it would serve to boost the facilitation effect.

Method

Participants

Thirty-seven Laurentian University students who reported normal or corrected-to-normal vision were recruited on-campus to participate in the experiment in return for a monetary compensation of fifty dollars and course credits where applicable. The average age of participants was 20.5 years ($SD = 4.039$). Only females were recruited due to the scarcity of males who qualify as non-gamers. The experiment was approved by the Laurentian University Research Ethics Board, and participants signed an informed consent form prior to participating.

To begin, participants completed two brief questionnaires (adapted from Dye, Green & Bavelier, 2009) to gather demographic information and video gaming histories (see Appendix). From these questionnaires it was determined whether the participant met the criteria to be included in the study. To be considered non-gamers and thus eligible to participate, participants needed to have played video games for less than 10 hours per week for the past year (all genres included), and they must not have played Rock Band© for more than 10 hours total in their lifetime; it was found that the groups did not differ significantly on any required criteria (all $p \geq .061$). Of the 37 participants included in the study, only 7 had never before played Rock Band©.

Apparatus

The experiment was programmed and implemented using SR Research Experiment Builder software (SR Research Ltd., Mississauga, Ontario, Canada) in combination with the Eyelink II video-based eye-tracking system. The Eyelink II is a head mounted eye-tracking device that uses two adjustable cameras to record eye positioning; the device also incorporates an infrared sensor

(integrated into the headband) that tracks the point of gaze to compensate for head movements.

The Eyelink II system is highly accurate ($<0.5^\circ$) and employs a high sampling rate (500 Hz).

The experimental program ran on a Lenovo desktop computer equipped with a 1.60 GHz processor. The auditory stimuli were delivered at a comfortable level through Sony stereo headphones (MD-ZX300, Thailand), and the visual components were presented at eye-level on a 21-inch ViewSonic monitor. Participants were seated with their heads approximately 57 centimeters from the screen; their seating position was monitored by the researcher during testing to ensure there were no significant variations. Eye-tracking took place in a dimly-lit, sound-attenuated booth, whereas training took place in a small, dedicated training room equipped with one desktop computer and two video-gaming systems (Nintendo Wii with Rock Band© 3).

Eye-Tracking Procedure

For successful eye-tracking, a standard calibration procedure must be implemented prior to data collection. To do this, participant's gaze positioning was established using a nine-point calibration and validation scheme. Following calibration, participants completed the experimental task which took approximately 40 minutes and was modeled after Colonius and Arndt (2001). Before the start of data recording, participants completed a practice block of 10 trials to become familiar with the task. Each trial began with a drift-correct dot in the middle of the screen to verify calibration. Once verified, the drift-correct dot was replaced by a fixation-point positioned in the exact middle of the screen. Following a randomized time interval ranging from 800 to 2500 milliseconds, the fixation-point was replaced by the visual target; participants were instructed to shift their gaze as quickly as possible to the visual target when it appeared, and to always ignore the auditory distractor as it was irrelevant to the task. Randomized time

intervals were employed to prevent the participant from anticipating the onset of the target stimulus and thus initiate a saccade based on temporal preparation alone (Colonius & Arndt, 2001).

Both the auditory and visual stimuli were presented for a duration of 500 milliseconds, after which a blank white screen was displayed for 1500 milliseconds; at this point the participant was free to rest her eyes while waiting for the sequence to begin again. From this sequence, SRTs were recorded (at the nearest milliseconds) as the time between the onset of the visual target and the **initiation** of the primary saccade toward it. Initiation was defined as the exact moment the eye gaze leaves the fixation-point.

The visual target consisted of a black dot (13 pixels wide by 13 pixels high) on a white background; the dot was presented to either the left or right of the fixation-point (at the same height, at a distance of 386 pixels). The auditory distractor was a white-noise burst with a bandwidth of 500 Hz, which is within the spectrum of human speech (Colonius & Arndt, 2001). Depending on the trial, the visual target was presented either alone (unimodal trial), or simultaneously with the auditory distractor (bimodal trial) on either the same (ipsilateral) or opposing (contralateral) side. These pairings resulted in six possible stimuli combinations:

- Unimodal – Visual Left
- Unimodal – Visual Right
- Bimodal Ipsilateral – Visual/Audio Left
- Bimodal Ipsilateral – Visual/Audio Right
- Bimodal Contralateral – Visual Left/Audio Right
- Bimodal Contralateral – Visual Right/Audio Left

Each participant was presented with 300 trials total: 100 unimodal (50 left, 50 right), 100 bimodal ipsilateral (50 left, 50 right), and 100 bimodal contralateral (50 visual left/auditory right, 50 visual right/auditory left). Randomized trial presentations were different for each participant and were presented in three blocks of 100 trials each. Participants were given short breaks between blocks and were allowed additional time if required, as avoidance of fatigue and discomfort.

Training Procedure

Following the pre-test eye-tracking session, participants were matched based on their performance and assigned to one of three experimental training groups. As per Spence & Feng (2010), matching was used to prevent differences based on naturally occurring variations. For the training phase of the experiment, participants assigned to the Rock Band© Regular condition played Rock Band© normally while wearing headphones to deliver the audio component of the game, participants assigned to the Rock Band© Mute condition played the game without sound while wearing industrial earmuffs to block out ambient noise, and participants assigned to the Music Only condition listened to music via headphones while wearing blacked-out glasses to eliminate visual stimulation. At the end of the study, the Rock Band© Mute group finished with one additional member when compared to the other two groups; this was due to a participant who had dropped-out of the study but subsequently returned. It was found that including her data in the analyses did not affect the results obtained in any significant way, and thus her data was retained.

For each training session, all three groups were provided with a list of five song titles they were to play as many times as possible during the one-hour time period. The list changed every two

sessions and the songs were specifically chosen to eliminate the effect of familiarity. To determine familiarity, the 83 songs found within Rock Band© were assessed based on their *YouTube* popularity (as measured by view-count); the 25 least-popular titles were included in the training regimen. At the completion of training, the number of songs played averaged 108 ($SD = 11.48$) and did not significantly differ across groups ($F(1, 23) = .919, p = .348$).

As mentioned earlier, Rock Band© allows the player to customize the difficulty level at which they play, ranging from easy to expert. Participants were instructed to begin playing on the easy level and to progress to more advanced levels when they felt they were no longer being challenged. This was done to ensure participants remained engaged-in and stimulated by the game throughout the training process. Participants were to undertake their 10 hours of training at a maximum rate of one hour per day; those in the Rock Band© Regular group took an average of 17 days ($SD = 4.95$), those in the Rock Band© Mute group took an average of 22 days ($SD = 4.63$), and those in the Music Only group took an average of 19 days ($SD = 5.43$). The groups did not differ significantly in the amount of time it took to complete the training ($F(2, 34) = 3.230, p = .052$).

All post-test eye-tracking sessions took place on the day immediately following the final training session. The post-test timing ensured two things: one, that the eye-tracking results were not due to the arousal that occurs when one has just played a video game or listened to music, and two, it ensured that there was not an extended period between the training and the post-test during which other factors could influence the results obtained (Green, Li, & Bavelier, 2010).

Results

Training

To determine whether the 10 hours of video game training augmented participants' playing abilities, gaming scores from Day 1 of training were compared to scores from Day 10 using a repeated-measures analysis of variance (ANOVA), with Time as the repeated within-subjects factor (pre, post) and Group as the between-subjects factor (Rock Band© Regular, Rock Band© Mute). For both groups, the same song was played at medium difficulty on Day 1 and 10, and scores were recorded after playing for one hour. The results showed that scores differed significantly between time points ($F(1, 23) = 72.546, p < .001, \eta_p^2 = .759$), with scores increasing from an average of approximately 19500 at pre-test to approximately 39000 at post-test. It was also shown that the percentage of correct responses increased significantly from 75% to 93% ($F(1, 23) = 36.020, p < .001, \eta_p^2 = .610$), as did the number of notes in a streak which rose significantly from 45 to 133 ($F(1, 23) = 25.830, p < .001, \eta_p^2 = .529$). Of note, it was also found that those in the Rock Band© Regular group outperformed those in the Rock Band© Mute group on all measures of playing ability, however not at a statistically significant level. From these results, it can be concluded that the 10 hours of training elicited a statistically significant increase in Rock Band© playing abilities in approximately the same way for both groups.

Eye-tracking Data Treatment

For all eye-tracking measurements, SRTs that fell below 100 ms and above 500 ms were manually checked by the researcher (Colonius & Arndt, 2001). It was found that in all such cases the participant made an eye movement into the target zone before the stimulus was presented (anticipatory) or that no response was made at all (miss). These recordings totaled less than 1%

of all trials and the amount did not differ significantly across groups ($F(2, 34) = .350, p = .707$); as such, SRTs below 100 ms and above 500 ms were omitted from analyses, as per Colonius and Arndt (2001). To determine whether the groups were adequately matched, pre-test eye-tracking results were analyzed to ensure that there were no group differences at baseline; the analysis revealed that the groups were not significantly different at baseline on any of the trial types used in the focused attention task (all $p \geq .225$).

Focused Attention Task

Presented in Table 1 are the pre- and post-training mean SRTs for all groups, broken-down by trial type. From this data, a repeated measures GLM, with Time (Pre, Post) and Trial Type (Unimodal, Bimodal Ipsilateral, Bimodal Contralateral) as within-subjects factors, and Group (Rock Band© Regular, Rock Band© Mute, Music Only) as a between-subjects factor ($2 \times 3 \times 3$), revealed a main effect of Time ($F(1, 34) = 14.086, p = .001, \eta_p^2 = .293$), indicating that mean SRTs were significantly quicker at post-test ($M = 225.681, SE = 3.077$), when compared to pre-test ($M = 232.024, SE = 3.730$). A main effect of Trial Type was also found ($F(1.797, 61.101) = 28.942, p < 0.001, \eta_p^2 = .460$). Bonferroni post hoc comparisons revealed that the two bimodal trial types (ipsilateral and contralateral) did not differ significantly from one another ($p = .271$), they did however both differ significantly from the unimodal trial type ($p < .001$), in that SRTs were significantly quicker for both bimodal ipsilateral trials ($M = 226.100, SE = 3.285$) and bimodal contralateral trials ($M = 227.371, SE = 3.162$), when compared to unimodal trials ($M = 233.086, SE = 3.618$). Therefore, to simplify the design, subsequent analyses were conducted with the two bimodal categories collapsed into one bimodal variable. It is important to note that the main effect of Trial Type was anticipated as it shows that the classic intersensory facilitation

effect was produced; the trials with bimodal stimuli resulted in a significant speeding-up of reaction times when compared to unimodal trials. Thus, it can be confirmed that the focused attention paradigm task (implemented and programmed by the researcher) successfully elicited the intended effect.

After collapsing the two bimodal trial types into one variable, a second repeated measures GLM ($2 \times 2 \times 3$) again revealed a main effect of Time ($F(1, 34) = 14.318, p = .001, \eta_p^2 = .296$), and a main effect of Trial Type ($F(1, 34) = 38.015, p < .001, \eta_p^2 = .528$). The predicted three-way interaction among Time, Trial Type, and Group, was not significant ($F(2, 34) = 0.491, p = .616, \eta_p^2 = .028$). All other main effects and interactions were non-significant and irrelevant to the hypotheses (all $F_s \leq 2.157$; all p values $\geq .131$). These results are illustrated in Figure 4.

Table 1

Pre- and Post-training Mean Saccadic Response Times (SRT; in milliseconds) for Unimodal and Bimodal Trials, in each Group.

		Training Group			Overall ($n = 37$)
		Regular ($n = 12$)	Mute ($n = 13$)	Music ($n = 12$)	
Pre	All trials	232.2 (18.9) 5.5	239.4 (26.7) 7.4	224.5 (21.3) 6.2	232.2 (22.9) 5.5
	Unimodal	238.8 (21.4) 6.2	241.8 (27.5) 7.6	228.3 (22.7) 6.6	236.4 (24.2) 6.2
	Bimodal	228.9 (17.9) 5.2	238.2 (26.6) 7.4	222.6 (21.0) 6.1	230.1 (22.6) 5.2
	Ipsilateral	227.5 (17.4) 5.0	236.6 (27.8) 7.7	220.6 (21.2) 6.1	228.5 (23.1) 5.0
	Contralateral	230.3 (18.6) 5.4	239.8 (25.8) 7.2	224.5 (21.2) 6.1	231.8 (22.5) 5.4
Post	All trials	224.7 (20.1) 5.8	232.7 (19.3) 5.4	219.7 (16.4) 4.7	225.9 (19.0) 5.8
	Unimodal	230.5 (22.0) 6.4	236.1 (20.0) 5.6	223.1 (21.1) 6.1	230.1 (21.2) 6.4
	Bimodal	221.7 (19.5) 5.6	231.0 (19.1) 5.3	218.0 (14.6) 4.2	223.8 (18.3) 5.6
	Ipsilateral	222.0 (22.3) 6.4	231.7 (19.8) 5.5	218.1 (13.9) 4.0	224.2 (19.4) 6.4
	Contralateral	221.4 (17.2) 5.0	230.4 (19.1) 5.3	217.9 (15.7) 4.5	223.4 (17.8) 5.0

Note. Mean values are provided with standard deviations in parentheses followed by one standard error.

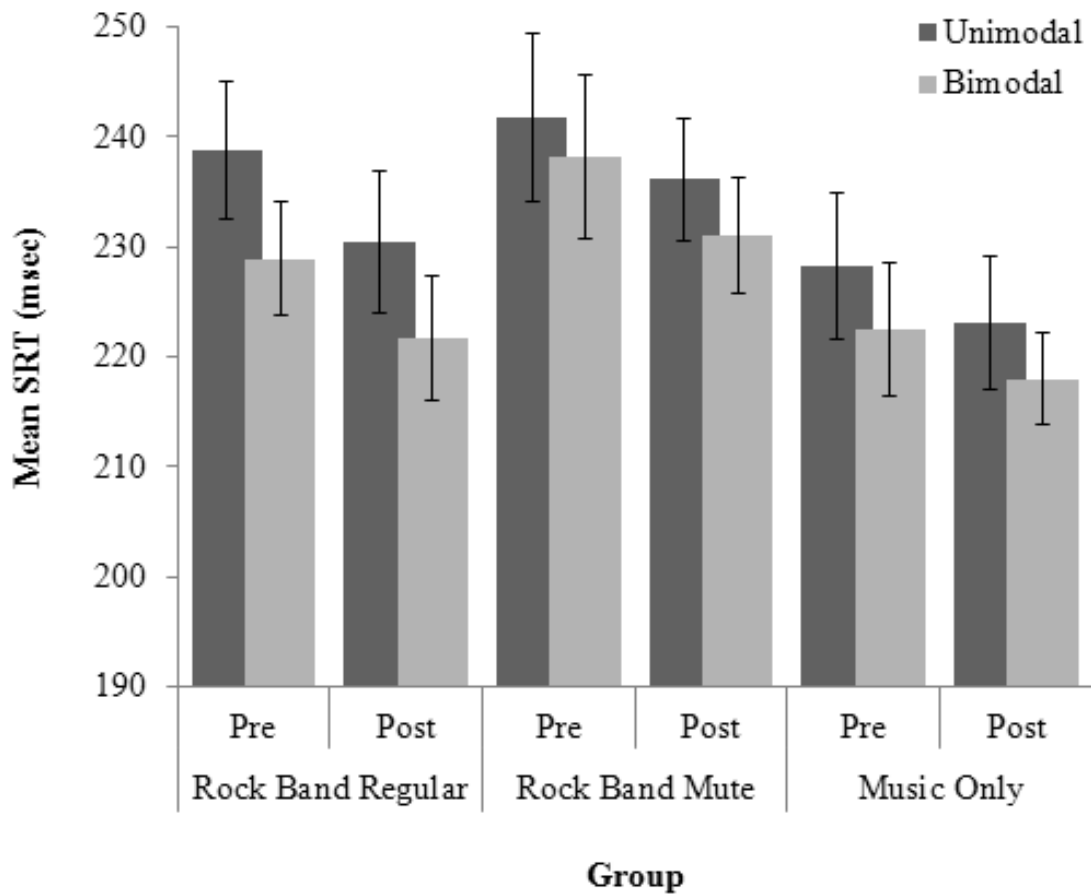


Figure 4. Pre- and Post-training Mean Saccadic Response Times (SRT; in milliseconds) for Unimodal and Bimodal Trials, in each Group. *Note.* Error bars represent one standard error of the mean.

Discussion

Around the world, the video game industry is immense; due to their overwhelming popularity, video games have become the focus of scientific investigation. In 2003, a groundbreaking paper published in *Nature* (Green & Bavelier, 2003) marked the beginning of a surge of cognitive and perceptual research showcasing the beneficial effects video gaming had on the player. By employing several visuospatial paradigms (such as the useful-field-of-view, enumeration, and flanker compatibility tasks), Green and Bavelier (2003) were able to show that, when compared to non-gamers, action video gamers exhibited enhancements in the spatial characteristics of visual processing. Through the use of the attentional blink task, Green and Bavelier (2003) also found that action video gaming affected temporal aspects of visual processing as well, in that gamers were better able to identify a target and quickly detect a second. In 2010, Donohue et al. questioned whether the effects of playing action video games would stretch beyond the visual modality to multisensory processing; they looked specifically at the temporal aspects of multisensory processing to see whether action video gamers were better able to judge whether audio and visual stimuli occurred at precisely the same moment in time or were slightly off-set in their presentation, they also measured perceptual discrimination abilities. What they found was that individuals with action video game experience performed better on behavioural measures of multisensory temporal processing than did non-video game players.

One of the main interpretations of these findings is that, as a result of action video gaming, players develop an enhanced attentional capacity resulting in extraneous attentional resources that 'spill-over' and allow them to attend to and process stimuli that non-gamers do not. From this interpretation, and the extant literature, we posited that since experience playing an *action* video game was found to impact multisensory temporal processing abilities, perhaps experience

playing a *music* video game would augment multisensory processing to a greater degree. Also, since we knew that *action* video game players were better able to allocate attention across space locations and time frames, we asked, would experience playing a *music* video game augment players' ability to allocate attention across sensory modalities?

To investigate these questions, a training regimen using a music-genre game was employed. Early video gaming studies compared action gamers to non-gamers; however, the training of novice participants has become the norm as it can establish a causal link to show that the video gaming itself led to the augmentations found. It is for this reason that the current study incorporated a training regimen. A music-genre game was chosen to train participants as it was considered to be the closest match to the visual/audio multimodal focused attention task that was chosen to measure changes in the intersensory facilitation effect at pre- and post-test. This choice was in-line with the thinking of Oei and Patterson (2013) who stated that transfer effects are maximized when the task contains elements similar to the training game (near transfer).

In the aforementioned focused attention task, participants must respond as quickly as possible to the onset of a pre-defined target stimulus from one modality (in this case, a visual target), that is presented along with a to-be-ignored (distractor) stimulus from another modality (in this case, an auditory tone); the participant is explicitly instructed to ignore the distractor and focus their attention solely on the target (Colonius & Arndt, 2001; Colonius & Diederich, 2012). From the focused attention paradigm, the typical result is that reaction times tend to be faster when responding to bimodal than to unimodal stimuli, which is referred to as the intersensory facilitation effect (Colonius & Diederich, 2012).

The design of the current study had novice, female gamers complete a pre-test eye-tracking session using the focused attention paradigm; they were then assigned to one of three groups for the 10-hour training phase, which was followed-up by a post-test eye-tracking session again using the focused attention task. Participants were assigned to either play Rock Band© normally, on mute, or to listen to music with no exposure to the game. It was hypothesized that after 10 hours of video game training, participants would have an augmented attentional capacity that would provide them with increased resources to process stimuli from differing modalities, and that these enhancements would be measured as an improvement in performance on the focused attention paradigm, in that the Rock Band© Regular group would show the greatest saccadic reaction time difference between unimodal and bimodal trials (i.e. the greatest intersensory facilitation effect), and that the Rock Band© Regular group would show, after training, a disproportionately enhanced intersensory facilitation effect, that is, a greater unimodal/bimodal SRT difference at the post-test relative to the pre-test. Both of these predicted results were proposed to be a result of Rock Band© Regular trainees' extraneous attentional resources 'spilling-over' to the auditory non-target rendering them unable to ignore it, thus making the auditory component more than just 'noise' and instead it would serve to enhance the facilitation effect.

Through statistical analyses, an overall saccadic reaction time decrease from pre- to post-test was found, in that all participants' performance on the focused attention task improved after the 10 hours of training; this enhancement in performance can be accounted for by test-retest/practice effects. These effects are inherent in repeated-measures designs which are employed to study changes in behavior at more than one point in time, and are due to repeated exposures which allow the participant to practice and hone their ability to perform the task. There were no

significant differences between groups in this overall improvement, thus it can be inferred that these reductions in saccadic reaction times were not a result of the training regime.

Further, and more critically, it was shown that the hypothesized results were not observed; the magnitude of the facilitation effect was not found to be disproportionately enhanced in the Rock Band© Regular group after 10 hours of training, relative to the Rock Band© Mute and Music Only controls. As stated, the game Rock Band© was chosen as it was seen to provide a more simplified visual/audio multimodal gaming experience when compared to action genre games; because of this, the game was considered to be a closer match to the visual/audio multimodal focused attention task, and thus transfer effects were expected. The results indicated that playing a music-genre game did not lead to changes in multisensory processing in the predicted ways.

Although the findings did not confirm the predictions of this study, they did fall in-line with what Oei and Patterson found in 2013. Oei and Patterson (2013) investigated whether differing game types would produce differing effects on a test-battery comprised of diverse tasks. They found that training using an action video game resulted in the widest transfer effects, when compared to games from non-action genres. The researchers posited that action gaming may result in improvements in higher-order executive control processes, and that these overarching enhancements could be employed in differing ways depending on the given task, thus leading to the varied transfer effects found.

Oei and Patterson (2013) also suggested that maximal transfer effects occur when the task is similar to the training game; this is referred to as Thorndike's theory of identical elements (Thorndike, 1913). Although the focused attention paradigm was chosen as a task that matched the demands of Rock Band©, there is no specified level at which the task and training game must

match to determine whether transfer will occur. The focused attention task and Rock Band© share the element of timing, however beyond that the two tasks are also quite different; Rock Band© requires hand-eye coordination to be successful, whereas the focused attention task does not require motor activation beyond the generation of a saccade, which is a different motor movement entirely. Timing was the element that was identified as the link between the training video game and the task; however, we suggest that, in this case, the timing element alone was not enough to allow for any specific transfer to occur.

In 2012, Green and Bavelier remarked on what they refer to as the ‘curse’ of learning specificity; applied to our case, what resulted from training participants on Rock Band© were individuals who learned the specific rules and strategies to play the game, however, this learning may be of no benefit to any task other than playing Rock Band© itself. One of the reasons for this, Green and Bavelier posited, is that for generalizable learning (called “learning to learn” skills) to occur it is optimal to have variety in the demands of the training task/stimuli. The demands of Rock Band© are far less varied than the demands that are found within the first-person shooter games that have been shown to lead to the greatest cognitive and perceptual enhancements, including improvements on an intersensory task (Donohue et al., 2010). Although Rock Band© offers differing difficulty levels at which it can be played, to master the game one must become very good at the specific task of syncing motor responses with on-screen visual cues. The demands of the game do not deviate from this, and as such the process that is trained is highly specialized. In contrast, the demands of a first-person shooter game are highly varied and more general, in that the player faces unpredictable opponents, must make hurried and diverse decisions, use quick reflexes amid rapid sensory information, and must react with precisely timed and strategized responses, all the while distributing their attention across the scene; due to these varied demands,

improvement on a wider array of tasks are evident after training. These improvements are likely due to the varied demands of action video games impacting on ‘high-level’ abilities such as top-down control and/or “learning to learn” skills.

From the present study, it can be concluded that training using a music-genre video game does not lead to multisensory processing enhancements of the intersensory facilitation effect. It can be inferred from previous literature that Rock Band© itself does not contain varied enough demands to affect general processes (such as working memory, learning, or attention) and thus lead to transfer effects in the hypothesized ways.

Limitations

The current study was conducted with the utmost care to address and ameliorate any concerns that arose during the process; still however, some limitations remain. The following are those that could not be avoided. Fortunately these limitations can serve as suggested areas of improvement for future researchers to consider.

Although typical of similar training studies, the sample size for this study was relatively small. Despite having many students interested in participating, the number included had to be limited due to the sheer amount of time that was necessary to complete the process. Each participant was required to return a total of 12 times, for at least an hour per session; this totaled approximately 450 lab hours for the period of training and data collection. For every additional participant (across three groups), 36 hours were added to that overall total. It is for this reason that the sample size was limited.

Additionally, because of the time commitment required, it was difficult to get participants to complete the process in a consistent manner. Although there were no significant group differences in the number of days it took to complete the process, ideally all participants would progress at the same pace to ensure the distribution of the training did not factor into the results found. Although previous research has shown that as little as 10 hours of training can result in cognitive changes, there is the possibility that music-genre games require longer training periods to produce effects.

Ideally a study such as this would only include participants who had never played the training game before. Because Rock Band© is a highly popular game it was found that almost all participants had played at least once before, usually at a social gathering. Although it is unlikely that these prior exposures had an affect on the results, in an ideal situation all participants would start from the exact same level of inexperience.

Future Directions

Beyond the above suggestions stemming from the limitations, other avenues exist for future researchers to consider when delving into this still-emerging area of study. Extending from the current study, the next logical step would be to employ the same overall design, but train participants on an action video game rather than a music-genre selection (or compare action gamers to non-gamers) using the focused attention task. Past research (Donohue et al., 2010) suggested that action video gaming alters some aspects of multisensory processing, the creation of a test-battery comprised of diverse tasks tapping into differing aspects of multisensory processing (including the focused attention paradigm) would be highly useful to explore how far the transfer effects of the action game extend.

Summary

Research indicates that video gaming can lead to various changes in cognition and perception; the purpose of the present study was to investigate how video gaming affects multisensory processing. Three groups of female participants with little or no gaming experience were trained for 10 hours: one group played the music-genre game Rock Band© with both visual cues and musical score on (full training group), another group played by following visual cues without music, and another group simply listened to music. Prior to, and following training, eye-tracking data was collected using a focused attention task in which participants were required to shift their gaze as quickly and accurately as possible to a visual target presented in the left or right visual field; on some trials an irrelevant, to-be-ignored tone was also presented. Past research has shown the tone to speed-up saccadic response time (SRT) when incoming from the same side as the visual target, an intersensory facilitation effect. We hypothesized that training on a music-genre videogame that emphasizes visual-auditory sensory integration would boost the intersensory facilitation effect, defined as the difference between SRTs on unimodal (visual target only) trials minus SRTs on bimodal (target + tone) trials. There was an overall SRT decrease from the pre- to the post-test (test-retest effect) but, more critically, the magnitude of the facilitation effect was not disproportionately enhanced in the full Rock Band© training group, relative to the two control groups. It is likely that the focused attention task and the training game were not similar enough in their demands to allow for transfer to occur, which is in line with the theory of identical elements. It is equally likely that, unlike first-person shooter action-genre games, training on a music-genre game does not impact ‘high-level’ abilities, such as attention and learning.

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Appendix: Video Gaming and Background Information Questionnaire

Video Game Playing History

Please list the video games that you have spent the most time playing over the past year
If the answer is zero, stop here.

Game Types:

Action (FPS, games with lots of fast motion – ie Burnout, Call of Duty, Counter-Strike, Crysis, Far Cry, Grand Theft Auto, Half-Life, Halo, Left 4 Dead, Marvel vs. Capcom, Resident Evil, Rogue Spear, Super Mario Kart, Unreal Tournament etc)

Music (Guitar Hero, RockBand, etc)

Fighting (Soul Caliber, Mortal Combat, Street Fighter, etc)

Strategy (Warcraft, Civilization, SIMS, etc)

Fantasy (Zelda, Final Fantasy, KOTOR, etc)

Sports (Madden Football, FIFA Soccer, etc)

Other (any not listed, cards, pinball, Snood, etc)

Number	Name of Game	Game Type	Average Time Per Week
<i>Example 1</i>	<i>Guitar Hero</i>	<i>Music</i>	<i>2 hours</i>
<i>Example 2</i>	<i>Counterstrike</i>	<i>Action</i>	<i>3 hours</i>

Background Information

How old are you?

If applicable, what age did you begin playing video games?

Have you ever played a music genre video game? (*Guitar Hero, Rock Band*)

If so, how many times would you estimate you have played?

How many hours total would you estimate you have played?

Regarding music genre games, do you consider yourself (*circle one below*):

Completely inexperienced / A beginner / Fairly good / Better than most / An expert

Please list below any hobbies that you engage in for more than 5 hours a week (e.g. the arts, athletics, academic clubs)	
Activity	Hours Per Week
<i>Example: Baseball</i>	<i>3</i>

Musical Background:

Do you play a musical instrument? (*If no, stop here*)

What instrument(s) do you play?

At what age did you begin playing?

Do you have formal training, if so for how long?

Can you read music?