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Possible Benefits of Playing Music Video Games

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POSSIBLE BENEFITS OF PLAYING MUSIC VIDEO GAMES

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Abstract

Music video games, such as Rock Band, are an emerging and popular genre of video game that allows non-musicians a taste of what it is like to be a musician. For most people, developing musicianship (or the process of becoming competent with a particular musical instrument) to an expert level is a long and difficult process that can take up to 10 years or over 7,500 hours to complete. Yet musicians tend to outperform non-musicians on a variety of tasks—showing greater motor coordination, better synchronization skills, and better pitch and tempo discrimination—and possibly show differences in related cognitive processes. However, no research has been done on the possible cognitive benefits of being a video game musician. Three groups (a group of trained musicians, a group of video gamers and a group of non-gamer non-musicians) were tested on a music video game (Rock Band), a musical perception task (PROMS), a personality inventory (Big Five Inventory), and a visual perception task (Useful Field of View). While the Rock Band gamer group showed the highest accuracy scores on the music video game, trained musicians outperformed non-musicians on the game as well for the lowest two difficulty levels, suggesting an overlap of skills. Rock Band gamers also outperformed non-musicians on the PROMS, even matching the trained musicians, suggesting that participants who play Rock Band do benefit from enhanced musical perception skills (though it is uncertain as to when and how they develop these skills). Rock Band gamers also showed enhanced useful fields of view, with no differences between trained musicians and non-musicians. Finally, Rock Band gamers differed from trained musicians and non-musicians on two dimensions of personality—scoring lower than both other groups on Neuroticism and Conscientiousness. The results of this study suggest the need for further examination using randomly assigned, short- and long-term training with music video games.

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Possible Benefits of Playing Music Video Games

Since the release of Pong in 1972 and the subsequent release of the Nintendo Entertainment System in 1985, there has been debate in both literature and popular media over the possible benefits and detriments of video games (Egli & Meyers, 1984; Funk, 1993; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). While most of the research has focused on the—typically violent—first-person shooter (FPS) games and their effects on a variety of factors (ranging from possible aggression to the enhancement of the visual system) there are a plethora of unstudied yet diverse genres of video games requiring unique skill sets and cognitive processes. One emerging and popular genre is music video games, with popular titles such as Guitar Hero, Rock Band, Rocksmith, and Rhythm Heaven; these games bring in millions of dollars in revenue each year (video game analysts NPD Group reported that music games accounted for $291 million out of the $18.25 billion total for the U.S. in 2010).

One possible reason these games are so popular is that they allow non-musicians a taste of what it is like to be a musician. For most people, developing musicianship (or the process of becoming competent with a particular musical instrument) to an expert level is a long and difficult process that can take up to 10 years (Macnamara, Holmes, & Collins, 2008) or over 7,500 hours to complete (Ericsson, Krampe, & Teschromer, 1993), but it is ultimately correlated with a variety of benefits—from greater motor coordination and better synchronization skills, to better pitch and tempo discrimination (Koeneke, Lutz, Wüstenberg, & Jäncke, 2004; Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995; Kishon-Rabin, Amir, Vexler, & Zaltz, 2001; Franěk, Mates, Radil, Beck, & Pöppel, 1991; Micheyl, Delhommeau, Perrot, & Oxenham, 2006). However, no research has been done on the possible benefits of being a music video gamer. This project aimed to explore what unique benefits might be predicted for a music video gamer.

Chapter 1 Research on Musical Training: What Makes Musicians Special?

Many studies have examined the effects of music training on music-related skills, while others have examined music training's effects on more general and widespread aspects of life. While is it difficult to prove directly, it is assumed that training on an instrument provides the musician with associated skills (although the possibility exists that they are born with these skills enhanced); we observe this as musicians showing greater motor coordination, better synchronization skills, and better pitch and tempo discrimination when compared to non-musicians. Playing a musical instrument may involve cognitive skills as well; classically trained musicians must learn the symbolic language of written music to sight read pieces (a skill tapping visual and cognitive processing), must recognize aspects of relative pitch and formal music theory (at least implicitly) to improvise melodies, and must be able to memorize entire songs (requiring enhanced auditory working memory processes). Because of the complex nature of music and musicianship, researchers have begun to examine whether these music-specific abilities generalize to related cognitive processes.

Functional Differences

The complexity of music training requires the processing of spectrally complex sounds, and pitch recognition and discrimination appears to be enhanced in musicians when compared to non-musicians. Micheyl, et al. (2006) presented professional musicians and non-musicians with a frequency discrimination task using pure tones and complex tones. Musicians, on average, showed discrimination thresholds that were 6 times smaller than their non-musician counterparts, and showed a larger advantage when discriminating complex tones than simple pure tones. When non-musicians were given seven training sessions instead of just one, thresholds for pure tones were not statistically different from those of musicians. Additional studies have also observed lower frequency discrimination thresholds in musicians as compared to non-musicians, with years of experience related to their discrimination ability (Kishon-Rabin et al., 2001); Bidelman, Krishnan, and Gandour (2011) found that these threshold differences are also correlated with faster neural synchronization and stronger brainstem encoding for both in- and out-of-key chords in musical sequences in musicians (as opposed to diminished responses for detuned chords in non-musicians).

As areas of the brain devoted to speech and music processing have been shown to overlap (Meyer, Alter, Friederici, Lohmann, & von Cramon, 2002; Rogalsky, Rong, Saberi, & Hickok, 2011), increased musical processing skills may be related to increased verbal processing skills. Musicianship may be related to increased verbal memory skills (Chan, Ho, & Cheung, 1998; Ho, Cheung, & Chan, 2003), and as the act of reading musical scores and reading the written word share similar processes, musicianship may also be related to reading and language acquisition and development of verbal processing (Nakada, Fujii, Suzuki, & Kwee, 1998; Moreno, et al., 2009).

When compared to non-musicians, trained musicians have shown better and more rapid learning and discrimination of syllables and words – even if the musical training was restricted to childhood and practice had lapsed (White-Schwoch, Carr, Anderson, Strait, & Kraus, 2013; Strait, O'Connell, Parbery-Clark, & Kraus, 2013; Zuk, et al., 2013), as well as improved language-learning ability and expanded vocabulary as measured by increased verbal memory (Chan, et al., 1998; Ho, et al., 2003). Time spent in music classes has been correlated to improved reading and verbal ability as measured via letter detection tasks and academic reading achievement (Mado Proverbio, Manfred, Zani, & Adorni, 2012; Southgate & Roscigno, 2009; however, see Lessard & Bolduc, 2011 for a review of possible limitations).

Musicians also out-perform non-musicians in ignoring competing sounds in speech-to-noise tasks as assessed by the Hearing in Noise Test (Strait & Kraus, 2011; see Shahin, 2011 for a review examining the neurophysiology of musical training on speech perception in non-musicians with hearing loss). These findings may be corroborated by a study by Parbery-Clark, Tierney, Strait, and Kraus (2012) that found that when compared to non-musicians, musicians showed enhancement of subcortical discrimination of closely related speech sounds (such as /ba/ /ga/ and

/da/) as measured via earlier brainstem responses; these earlier brainstem responses also correlated with speech-in-noise perception.

Additional studies have found a correlation between musicianship and IQ (Schellenberg, 2004), and even spatial and mathematical skills (Hetland, 2000; Rauscher & Hinton, 2011; Rauscher et al., 1997; Rauscher & Zupan, 2000); however, these benefits are moderate at best, and may reflect a spurious relationship. Follow-up research by Schellenberg (2011a; 2011b) discusses the possibility of SES influencing the relationship between music training and IQ, while a study by Elpus (2013) found that music students did not differ from non-music students on the SAT when factors such as demography, prior academic achievement, time use, and attitudes toward school were accounted for. Mehr, Schachner, Katz, and Spelke (2013) conducted two randomized controlled trials using preschool children and found no cognitive effects (measured via tasks of spatial-navigational reasoning, visual form analysis, numerical discrimination, and receptive vocabulary) of a brief series of music classes as compared to a similar but non-musical form of arts instruction (visual arts classes) or to a no-treatment control.

Physiological Differences

The brains of trained musicians also differ from those of non-musicians. While it is difficult to prove that training is responsible for these differences (and not some pre-existing difference that leads to musicians starting lessons), being a musician is related to greater motor and auditory representations and coordination. Musicians possess a larger area devoted to motor function for the hands (Koeneke, Lutz, Wüstenberg, & Jäncke, 2004), and Elbert, et al. (1995) found that right-handed string players showed increased cortical representations for the digits of the left hand (which are required to apply pressure to the strings of their instruments), but not their right (which generally are wrapped around a bow) when compared to non-musician controls. Since this difference was not found in both hemispheres, and only in the one corresponding to the practicing hand, the authors suggested that training was involved; any pre-existing differences in representations should be found in both hands, and not for the non-dominant hand.

The main connection between the two cerebral hemispheres, the corpus callosum, is also larger in musicians (Lee, Chen, & Schlaug, 2003), implying a greater degree of information transfer between right and left sides of the brain. This is supported by work by Schlaug, Jancke, Huang, Staiger, and Steinmetz (1995) who found differences in the midsagittal area of the anterior half of the corpus callosum (which transfers motor information) between musicians and non-musicians, which led the authors to suggest that training on an instrument is related to changes in the amount of myelination between areas responsible for motor control. These differences may explain why musicians are better than non-musicians at synchronizing finger tapping to auditory sequences (Franěk, et al., 1991) and therefore integrating motor and auditory inputs than non-musicians.

Trained musicians also appear to show differences in brain areas dealing with pitch processing. Schlaug Jancke, Huang, and Steinmetz (1995) found greater volume of grey matter in the primary auditory cortex, in the right lateral surface of the superior temporal gyrus, slightly posterior to Heschl's gyrus, as well as in a portion of the cortex slightly anterior to Heschl's gyrus in the planum polare. These areas have been previously implicated in pitch perception and the processing of complex sounds (see Zatorre, Belin, & Penhune, 2002 for a review), and differences in volume in these areas between non-musicians and musicians could be due to musicians' greater exposure to pitch processing. Schneider et al. (2002) found that larger concentrations of grey matter in the right-lateralized Heschl's gyrus were dependent on the amount of experience participants had with music (as measured by level of professional play and results of a tonal aptitude test). Musicians showed larger grey matter (but not white matter) volumes in the anteromedial portion of Heschl's gyrus than amateur musicians, who showed larger volumes than non-musicians. These structural differences correlated with enhanced brain responses as measured via magnetoencephalography, or (MEG). This suggests that training (which includes active processing of pitch and complex sounds) may relate to the structural differences seen in musicians, and that the length of exposure to music training seems to predict these structural changes. However, this does not preclude the possibility that the brains of musicians are predisposed to make stronger connections in these areas.

Additional Influences

It is difficult to implicate training as the primary source of the differences we see between trained musicians and non-musicians. There is still considerable debate as to whether all of these behavioral and structural differences are either due to training, or that initial differences between them have led musicians to seek out training. The possibility also exists that training is more effective in musicians if they are biologically more prepared to develop skills relating to music, like frequency or pitch discrimination. While there have been studies training non-musician children, the majority of research on musicianship has been correlational and based on differences between highly trained or professional musicians and complete musical novices (see Norton, et al., 2005, Pantev, et al., 1998; Pantev, Engelien, Candia, & Elbert, 2001; and Margulis, Mlsna, Uppunda, Parrish, & Wong, 2009 for evidence for possible causal relationships and a discussion that musicians exhibit enhanced responses to their primary instrument of training—and not because they are predisposed to respond to all tones).

However, there may be additional factors influencing these differences. For example, musicianship does require dedication, discipline and hard work; it may be that some of the cognitive effects discussed above are related to personality traits as well. There have been studies implicating differences in personality traits between non-musicians and musicians; Corrigall, Schellenberg, and Misura (2013) found that musicians were more likely than non-musicians to score higher on the five-factor personality trait (Costa & McCrae, 1992) of openness to experience, while in children, duration of music lessons was related to both conscientiousness and openness to experience. Openness to experience is related to imagination, preference for variety, and intellectual curiosity, and conscientiousness is related to diligence, self-discipline, and aiming for achievement; presumably, these traits would be helpful in musicians choosing to practice an instrument long-term. However, not all of these studies are related to positive personality traits:

Dunn, Ruyter, and Bouwhuis (2001) found that preference for and duration of listening to classical music was correlated to higher levels of Neuroticism as measured via the Revised NEO Personality Inventory (NEO PI-R).

While being a formally trained musician may be related to a variety of skills, training on an instrument is still a long and difficult process that requires regular practice (which many parents may find difficult to enforce). As it is easy to get children to play video games (Fisher, 1994 estimates that at least 60% of children are social gamers), playing music video games may lead to similar results as formal training, but with higher compliance with practicing; however, this does assume that any effects of music training are due to training, and not preexisting differences. There seems to be a relationship between the desire to play video games and the strength of their effect; a recent study using the platformer game Super Mario found significant gray matter increase in the right hippocampal formation, right dorsolateral prefrontal cortex (DLPFC) and bilateral cerebellum in participants playing the game for two months for at least 30 minutes per day as compared to control group who did not play video games (Kühn, Gleich, Lorenz, Lindenberger & Gallinat, 2013). These increases correlated with participants' desire to play. Given the popularity of video games (discussed next), music video games may be a more popular (and therefore effective) way to train musical (and related) skills. However, we must first establish whether there are any differences between those who play music video games and those who do not.

Chapter 2 Possible Effects of Music Video Games

While the majority of research on action video games deals with the harmful effects of violent FPS games (Anderson & Dill, 2000; Bartholow, Bushman, & Sestir, 2006; Carnagey, Anderson, & Bushman, 2007), these games have also been examined for their effects on visual attention, navigation, mental rotation and 2D to 3D translational skills. Being able to successfully control a character in a modern video game and overcome digital obstacles requires the ability to scan the screen and allocate visual attention. The continuous development of more sophisticated technology has led to a far more complex visual environment (sometimes especially for music games), and players must master certain cognitive challenges in order to succeed.

While no studies so far have dealt with music video games specifically, the more well-researched action video games might share some traits with music video games: for example, both generally have complex heads up displays (HUDs), requiring players to constantly allocate visual attention over a wide area. Action video gamers appear to be better than non-gamers at ignoring distracters, better at subitizing (quickly and automatically counting) during counting tasks, and they show less of an attentional blink (Green & Bavelier, 2003; Green & Bavelier, 2006a; Green & Bavelier, 2006b). Action video gamers also appear to be better at detecting visual signals (Greenfield, et al., 1994), show enhanced spatial resolution as measured by better visual acuity and smaller regions of spatial interaction (Green & Bavelier, 2007) and studies have shown that training on action games can even reduce the gender differences seen in spatial processing (Feng, Spence, & Pratt, 2007).

Many of these studies use the Useful Field of View task (UFOV), in which participants respond as to the direction of movement or location of a target stimulus in a field of distracters. This task has not yet been given to music video gamers; it may be helpful in assessing any possible benefits of navigating the complex visual environment of music games. Music video gamers must track symbolic representation of notes, ignore distracting stimuli, and attend to multiple objects on the display: all skills requiring visual and spatial processing. "Sight-reading" in music games often include identifying targets in a series of scrolling shapes, which at higher difficulties are numerous and travel through the visual field rapidly.

While there is still some debate as to how much of the spatial effects transfer to non-gaming situations, Greenfield, et al. (1994) found transfer of their attentional visual task beyond their video game task, and Green and Bavelier (2007) found that spatial skills transferred beyond the viewing angle trained by video games to other viewing angles (suggesting an overall refinement of spatial resolution in the visual system). While these studies typically focus on younger adults, Anguera, et al. (2013) trained older adults on a driving simulation game which focused on multitasking and found that training produced increases in cognitive control abilities that generalized to untrained cognitive control tasks.

Outside of action video games, other games that train skills virtually translate convincingly to real world performance. Rosser, et al. (2007) found that laparoscopy surgeons benefited from playing video games; video game play predicted surgical skill better than years of practice in the operating room. When the mechanism of play is similar to the real-life version, training is enhanced; this is true of development of golfing skills (Fery & Ponserre, 2001), enhancement of cognitively-related driving skills in the elderly (Cassavaugh & Kramer, 2009), and pilots' skills using a video game simulator (Gopher, Weil, & Bareket, 1994). While we do not yet know whether music games affect music skills, the similarity between game play and real play may result in overlap between music video game skill and musical perception skills.

If virtual music game skills relate to real world performance, a game that may result in overlap with the skills seen in real musicianship is Rock Band (developed by Harmonix). Rock Band is a music video game in which the user “plays” a guitar-shaped peripheral controller in a way that mimics real guitar play; the game allows users to play their favorite popular songs in a simplified and user-friendly way. The guitar controller uses a series of 5 color-coded buttons instead of frets, and when these buttons are held down, a tab on the body of the controller is used to “strum”. Colored shapes on the television screen represent notes, which scroll down the screen, and can be “played” when the corresponding colored “fret button” is held and the controller strummed. Rock Band has four levels of difficulty (easy, medium, hard, and expert) and each new level adds more fret buttons to keep track of, new “chords” to learn, and complex skills like hammer-ons and pull-offs to master. The second installment of the Rock Band series also includes a practice mode, in which participants can play songs without the visual and auditory distractions that provide a “concert-like” atmosphere during normal game play. This practice mode also provides accuracy scores for the selected song.

While there has been research showing structural and functional differences between musicians and non-musicians, as well as research showing differences between gamers and non-gamers, there has been no research examining possible differences between music video gamers and non-gamers, nor have there been any comparisons to formally trained musicians. While the previously mentioned studies on personality (Corrigall, Schellenberg, & Misura, 2013; Dunn, Ruyter, & Bouwhuis, 2001) have found differences between trained musicians and non-musicians, the personality traits of music gamers have not been established. If they exist, personality differences may contribute to music video gamers’ desire to play video games instead of pursuing formal music lessons. For example, music video gamers may get discouraged by the steep learning curve of musicianship, and music video games may provide access to musical experience without the rigidity of music lessons. It may also be possible that music video gamers are biologically predisposed with either existing enhanced musical skills or an enhanced ability to learn musical skills, but still choose not to pursue formal training. Conversely, it may be that regular practice with music video games train related musical perception skills (which may or may not be initially enhanced in music video gamers). While the underlying cause of any differences (biological, structural or functional) would fall beyond the scope of this study (and require short- and long-term training studies with video game novices), the possible benefits of playing a music video game are clearly worth studying.

Chapter 3 Methods

The current study examined the personality, music perception abilities, and visual spatial abilities of three groups (a group of trained musicians, a group of video game musicians, and a group of non-gamer non-musicians) using the Big Five Inventory (BFI), accuracy on a music video game, the results of a musical perception task, and the Useful Field of View (UFOV) task.

Participants

Three groups of participants were recruited via the UNLV subject pool and the surrounding community via an online questionnaire. This questionnaire detailed basic demographic information, (including the participant's age, race, and parent's educational level), experience with music training and video games, and a brief medical history (see Appendix A). Specific questions focused on whether participants had formal music training, how many and what kinds of instruments participants played, as well for how long and from what age participants played. Questions also covered types of genres of video games played, types of consoles used, how often participants played and from what age. Participants were also asked if they played music games like Guitar Hero or Rock Band, what instruments they played on those games, and the level of difficulty they were comfortable playing at.

The inclusion criteria were: healthy adults aged 18-65 years old with normal or corrected-to-normal vision and normal hearing. Participants included a group of trained musicians (who had been studying music formally for at least six years and had played within the last five years), a group of music video gamers (who were able to play on the hard or expert level on Rock Band with at least 80% accuracy on the hard difficulty), and a group of non-gamer non-musicians. The Rock Band gamer group consisted of participants with experience with Rock Band's guitar or bass settings, but had no formal musical training, and were not currently practicing music. The trained musician and non-musician group did not have any experience playing video games other than occasional experience with smart phones or casual games.

Each group contained 15 participants. The gamer group contained a higher proportion of males than the other two groups (Rock Band = 11 male, Musicians = 2 male, and Controls = 3 male). This does however approach the estimated proportion of male to female gamers (42% Female; ESA, 2010; ESA, 2011). The average age of participants was not different across groups (Rock Band: M= 26.13 years, SD=3.5; Musicians: M= 23.13 years, SD = 6.22; Controls M = 26.27 years, SD=7.55); a one way analysis of variance (ANOVA) showed no significant difference between the three groups on age, $F(2, 42)=1.31$, $p>.05$. However, an additional one-way ANOVA showed there was a significant difference between the three groups on SES (as measured via a question detailing parents' highest level of education), $F(2,42)=3.71$, $p<.05$. A Tukey's post hoc analysis revealed that musicians (M=4.2, 95% CI [3.72, 4.68]) had parents who were significantly higher educated than those of non-musicians (M=3.27, 95% CI [2.66, 3.88]). Rock Band gamers were not statistically different from either group (M=3.47, 95% CI [2.92, 4.02]). Musicians tend to come from families who have higher parent education and family income than non-musicians (Orsmond & Miller, 1999; Schellenberg, 2006, 2011a); it is also worth noting that Rock Band gamers fall between the two groups.

Musicians. All musicians had been playing their instrument for at least six years, and on average had 12.6 years of experience (SD = 7.19). The musicians reported playing between 1 and 4 different instruments (M=2.16, SD=1.19), with 60% playing more than one instrument. Five of the musicians played a string instrument as either their primary or back-up instrument (violin or guitar), while nine played a woodwind as a primary instrument (including flute, oboe, piccolo, trumpet and saxophone) and one musician was primarily a singer. Seven of the musicians had experience with piano as one of their instruments. All but one musician listed classical music as their primary genre of music practiced, with jazz being the next popular (N=4), followed by contemporary (N=3), and folk (N=2); pop, opera, and easy listening genres were also listed (N=1 for each). Only three musicians were currently taking private music lessons at the time of the study, and eight musicians were currently practicing at least an hour a week (M=4.63, SD=4.57).

Only one musician reported playing video games on a regular basis, and then for only an hour a week (they did not report playing music video games regularly).

Gamers. Only three of the gamers had any musical training, with two participants having one year of formal instruction in middle school, and one subject playing in a middle school and high school band. None of the participants had been practicing music at the time of the study or for at least five years prior. All gamers reported playing on at least three different types of gaming consoles or smart phones, (M=4.8, SD=2.9). Ten gamers reported playing video games on a regular basis, with an average of 12 hours per week (SD=12.19). These games were from the puzzle, music, fighting, role playing, strategy, sports, first-person shooters, side-scrollers and action genres. On average, Rock Band gamers generally started playing video games at age 7.55 (SD=4.82), and had been playing for 19.55 years (SD=5.61).

Eight participants reported preferring music video games, and ranked them within the top five genres played (listed mostly after role-playing, strategy, and first-person shooters, and chosen from seven possible options). However, only two participants reported playing music games regularly (from 1-2 hours a week). We were unable to determine how long gamers had been playing Rock Band; however, the first iteration of Rock Band was released in 2007, and many of the Rock Band musicians informally reported that they had not played for a few years, giving an approximate range of play from one year to seven years.

All gamers reported playing the Rock Band game guitar, with 12 reported being able to play the bass, 5 reported playing the drums, and 5 reported being able to play on vocals. According to their questionnaire responses, six participants reported being comfortable playing on hard, while nine reported being comfortable on expert.

Since there may be an influence of previous musical training on Rock Band performance, musicians may have an advantage over non-musicians on the game; however, since practice is needed to achieve mastery at the hard and expert levels, this advantage may be limited. As an additional validation of the gamers' status as gamers, participants took the Useful Field of View

(UFOV) task (explored in more detail below) to assess their attentional allocation and processing. As differences have been found on this measure between action video gamers and non-gamers (Green & Bavelier, 2007), we expected to find differences between our groups on total UFOV scores.

Controls. Non-musician, non-gamer controls did not play video games on a regular basis with the exception of two who reported casually playing sports, strategy or puzzle games for 8 hours a week. Two participants reported having experience playing musical instruments for less than three years; neither were practicing regularly (more than an hour a week) at the time of the study, nor had they played within the past least five years.

Measures and Stimuli

Profile of Music Perception Skills. As musical perception skill was the main dependent variable of interest, each group was tested on a musical perception battery. This also served to ensure that musicians met criteria of musicianship. The Profile of Music Perception Skills (PROMS) task is a general musical perception battery which objectively tests for musical skill without relying on self-reported level of musicianship (Law & Zentner, 2012). This measure is more desirable to use with a mixed population ranging from no training to informal (video game) training to formal training (as opposed to other measures better suited for determining musicianship in trained musicians only, or those meant to compare trained musicians to non-musicians). The brief PROMS consists of two sensory subtests (dealing with tuning and tempo) and two sequential subtests (focusing on melody and accent).

The PROMS provides instructions and practice before presenting 18 trials of each subtask. The tuning task uses a C chord and shifts the E note out of its proper frequency from a range of 10 to 15 cents. The tempo task presents comparison stimuli that differ from a standard by anywhere from 1 to 7 beats per minute, and differs in the number of layers of instruments. The melody task presents standard and comparison melodies and increases difficulty by increasing note density and atonality. Finally, the accent task presents standard and comparison rhythmic patterns that vary in the number of notes that are decreased in intensity; the easy comparisons have more intensity changes than the more difficult comparisons. After completing the PROMS, participants are given immediate feedback as to where they fall in terms of their musical perception skills.

Rock Band. In order to quantify music video game ability, we chose Rock Band as a validation measure. Rock Band is a music video game in which the user “plays” a guitar-shaped peripheral controller in a way that mimics real guitar play; the game allows users to play their favorite popular songs in a simplified and user-friendly way. The guitar controller uses a series of 5 color-coded buttons instead of frets, and when these buttons are held down, a tab on the body of the controller is used to "strum". Colored shapes on the television screen represent notes, which scroll down the screen, and can be "played" when the corresponding colored "fret button" is held and the controller strummed. Rock Band has four levels of difficulty (easy, medium, hard, and expert) and each new level adds more fret buttons to keep track of, new “chords” to learn, and complex skills like hammer-ons and pull-offs to master. It also includes a practice mode, in which participants can play songs without the visual and auditory distractions that provide a “concert-like” atmosphere during normal game play. This practice mode also provides accuracy scores for the selected song.

All participants played the music video game Rock Band to establish level of expertise with that game, as we expected differences between our Rock Band gamers and the two other groups. The second iteration of the Rock Band series was used for stimuli, as it provided a tutorial and practice mode. The game was played via a wireless Rock Band brand guitar controller on an Xbox 360 console connected to a LG 65” cinema 1080p 120 Hz LED TV. As large TVs can sometimes induce a video or auditory lag, the TV was set to game mode, and the game’s lag calibration was set to 200 ms for auditory information and 40 ms for visual information (as per the game’s instructions listed on the Harmonix website: http://www.rockband.com/support/how-do-i-calibrate-my-rock-band-2-instruments). Participants were situated at 200 cm from the TV at a comfortable viewing distance. Each group first went through the game's built-in tutorial (to familiarize the non-gamer and the musician group to the rules of play). The tutorial covers the basic layout of the controller, how to play the onscreen notes, and additional specifics of play. The tutorial does not progress until each skill section is completed, ensuring that each participant knew the basics of how to play the game.

All participants played four songs selected from the “apprentice” and “solid” categories of the game; these songs are in the second and third easiest categories out of seven possible (ranging from “warmup” to “impossible”). Each song was played on a specific difficulty setting: easy, medium, hard and expert. Participants played: 1) “Drain You”, by Nirvana, on easy 2) “Our Truth” by Lacuna Coil, on medium 3) “Pump it up” by Elvis Costello, on hard, and 4) “Spirit in the Sky” by Norman Greenbaum, on expert. The duration (min:sec) and tempo (beats per minute, bpm) for each song was 3:43, 137bpm; 3:26, 103bpm; 3:14, 140bpm; and 3:57, 129 bpm respectively. This provided a consistent set of songs with similar durations and tempos, with a variety of genres (grunge, metal, rock, and classic), and exposure to these songs should be similar across groups. After each song was played, an accuracy score was recorded for each participant’s performance. In order to verify that our Rock Band gamers weren’t overstating their ability on the questionnaire, accuracy on the “hard” song had to have reached 80% to be included in the study.

Useful Field of View. While no studies currently have examined music video gamers, the research (mentioned previously) on action video gamers suggest that they possess enhanced visual and spatial processing (Green & Bavelier, 2003; Green & Bavelier, 2006a; Green & Bavelier, 2006b; Greenfield, et al., 1994). As our gamers have played other genres besides music (notably first person shooters and action games), it is difficult to determine whether our music video gamer group would show differences in visual processing related to playing music video games or from these addition games (or if pre-existing differences had lead them to play games). However, since others have previously observed differences between gamers and non-games, an additional way to distinguish our gamer group from the non-gamers is to measure a form of visual processing via the Useful Field of View (UFOV) task (based on Green & Bavelier, 2003), which assesses visual processing (Edwards, et al., 2005). The UFOV is a reliable measure of the speed of information processing that may also be susceptible to training (Ball, Beard, Roenker, Miller, & Griggs, 1988). The UFOV task was presented on a PC via a custom computer program (Presentation; neurobehavioral systems). The measure is a stimulus identification task in which participants identify a target in the periphery while looking at a fixation point.

An initial fixation point is presented for 500 ms, followed by the appearance of an array of boxes arranged like spokes radiating from the center for an additional 25 ms (see figure 1). A target is presented randomly in one of the boxes for a short amount of time (50 ms for the closest eccentricity, 66 ms for the middle eccentricity, and 83 ms for the furthest eccentricity), and is followed by a visual mask for 500 ms. The subject must then respond as to which spoke the target was located. The ability to correctly identify the targets at the outermost eccentricity would reflect a larger UFOV than someone only attending to the middle or closest eccentricity.

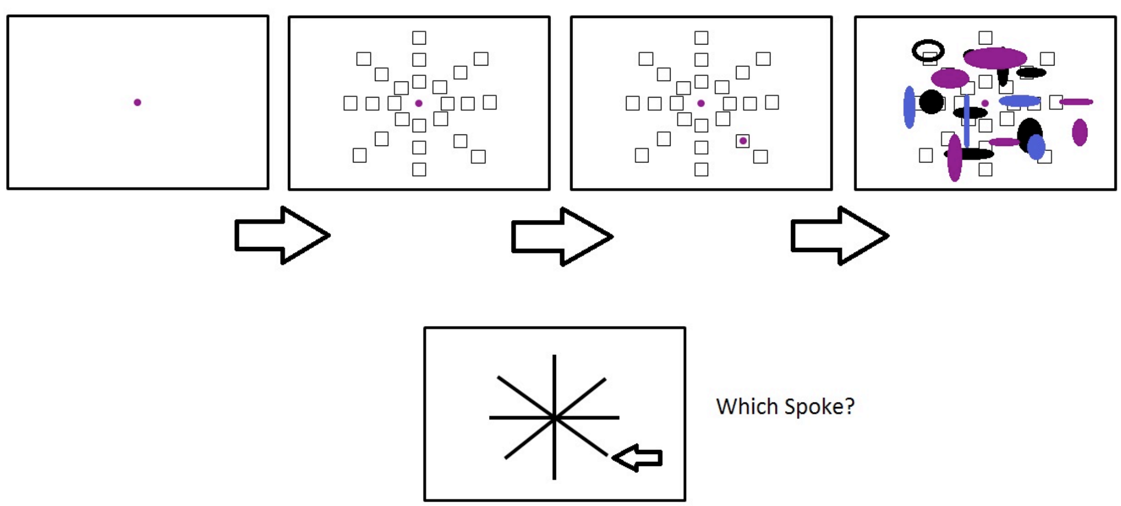

Figure 1. Useful Field of View stimulus example

Participants were seated at a comfortable viewing distance of approximately 60 cm from a 23" IPS LED LCD Monitor at a resolution of 1920 x 1080. Participants judged the location of the target and responded via mouse click. While it may be hypothesized that the video game group would have a natural advantage in this task, prior computer experience does not appear to enhance UFOV performance in any systematic way (Edwards, et. al, 2005).

Our Rock Band gamers have extensive experience in games other than Rock Band, including first person shooters, which are classically considered to fall in the genre of action video games. Training on action video games has been shown to increase UFOV scores (Green & Bavelier, 2003), and the visual environment of Rock Band contains elements of action games: the heads up display (HUD) for the game includes multiple elements for tracking scores, progress, accuracy (albeit not directly), and repeated exposure to the rapid scrolling of notes on harder difficulties may influence the allocation of visual attention. We expected our Rock Band gamers to outperform our other groups in terms of total UFOV scores; this may simply reflect their background with video games, and it may also mean that this group has higher levels of visual attention and allocation. Since some studies have found a possible relationship between spatial reasoning and music production (Hetland, 2000; Rauscher & Hinton, 2011; Rauscher et al., 1997; Rauscher & Zupan, 2000; however, these may reflect a spurious interaction with SES), UFOV was included as a measure of possible far effects, in addition to its inclusion to verify the Rock Band gamers' expertise with video games over non-gamers.

Big Five Inventory. Because underlying personality characteristics may be responsible for both musicians and video game musicians practicing their skills long-term, all groups took a digitally administered Big Five Inventory (BFI; developed by John, Donahue, & Kentle, 1991 and John, Naumann, & Soto, 2008). The BFI scores participants on the Big 5 (or five-factor model) personality traits: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1992). The BFI is a short battery based on initial work done with the NEO Personality Inventory – Revised (NEO-PI-R, Costa & McCrae, 1992), which contains

240 items; however, this scale is too long for many research studies. The 44-item BFI presents prototypical components of the big five traits, which were selected based on large sample factor analyses of junior college and public university students (John, Naumann, & Soto, 2008). Participants respond to items on a one-to-five (strongly disagree to strongly agree, respectively) Likert scale. This scale is ideal when there is no need to measure the more differentiated individual facets of each factor (which would require the longer 240 item NEO-PI-R).

Instead, the BFI uses prototypical adjectives consistent with each factor in its items: for example, the adjective "original" is associated with the factor of openness to experience, so the BFI includes the item "Is original, comes up with new ideas". This allows for brief items that are less ambiguous. In U.S. and Canadian samples, Rammstedt and John (2005; 2007) have found the alpha reliabilities of the BFI scales range from .75 to .90 with an average about .80, and that there was substantial convergent and divergent validity with the other Big Five instruments (like the 60 item NEO FFI, developed by Costa & McCrae, 1989; 1992). This abbreviated NEO-FFI scale is substantially correlated with the longer NEO-PI-R scale and peer ratings.

The factor of conscientiousness refers to a person's need to be self-disciplined, motivated, and to fulfill a sense of duty. Those scoring high on this dimension are likely to prefer activity that is structured and planned as opposed to spontaneous. Openness to experience refers to a person's need to foster an active imagination, to appreciate the arts and literature, or to be intellectually curious. Questions on the BFI referring to conscientiousness may reflect attitudes that allow musicians and video game musicians to spend a great deal of time practicing, while questions referring to openness to experience may reflect a general appreciation for the arts and creativity.

Data analysis. Data includes accuracy scores for Rock Band (total accuracy for each difficulty: easy, medium, hard and expert) as well as subtest (tuning, tempo, melody, and accent) and total scores for the brief PROMS. The BFI provides mean scores for each of the five factor domains. The UFOV scores are expressed as the percentage of correct target identifications for each eccentricity. Each continuous variable was correlated against the others, to determine if any conditions fit the assumptions for an Analysis of Covariance (ANCOVA).

Chapter 4 Results

Profile of Music Perception Skills Task

This study primarily examined possible differences in the musical perception skills (as measured via the PROMS) of three groups: a trained musician group, a group of Rock Band gamers, and a group of non-musician, non-gamers. To determine if there were group differences with regards to overall PROMS performance, a one-way Analysis of Variance (ANOVA) was conducted to compare the three groups (non-musician, rock band gamer, and musician) on total PROMS scores (see Table 1). There was a significant main effect of group on total PROMS scores, $F(2, 42)=6.92$, $p<.01$, $\eta_p^2=.248$. A Tukey's post hoc analysis was included to compare the differences between groups on total PROMS scores (see Table 2). Both Rock Band Gamers and trained musicians scored significantly higher than non-musicians; however, they did not differ significantly from each other.

To examine whether experience with Rock Band correlated with musical perception skills, the total PROMS scores for each group were correlated with the Rock Band accuracy scores at each difficulty level. Total PROMS scores correlated with performance on the hard and expert levels of Rock Band for only the Rock Band gamer group (and not the musician or non-musician group): for the hard level, $r(43)= .52$, $p<.05$ and for the expert level, $r(43)= .56$, $p<.05$. This suggests that for this group only, their expertise on Rock Band does relate to their level of musical perception. This suggests the possibility of overlap between Rock Band skills and musical perception skills.

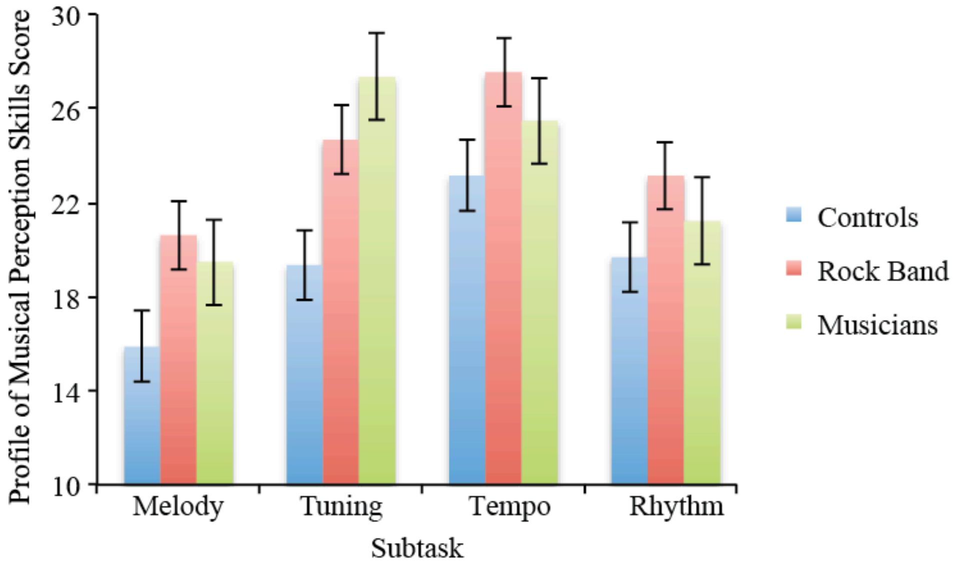

Figure 2. Differences in Profile of Music Perception Skills scores by group

To see if group differences existed on any of the PROMS subtasks, a 3 (Rock Band gamer, musician, non-musician) x 5 (melody, tuning, tempo, rhythm and total PROMS scores) repeated measures ANOVA was conducted. There was a significant main effect of group $F(2, 42)=11.36$, $p<.001$, $\eta_p^2=.351$ and a significant interaction between subtask and group $F(2, 42)=6.04$, $p<.001$, $\eta_p^2=.223$. To determine the nature of these differences between groups on the PROMS subtasks, four separate one-way ANOVAs were conducted (one for each PROMS subtask), using group as a between-subjects variable. A Tukey's post hoc analysis was included to compare the differences between groups on PROMS scores.

Table 1
Results of Separate One-way Analysis of Variance (ANOVA) for Group Differences in Profile of Music Perception Skills

	F	Degrees of freedom	*p*<	η_p^2
Melody	3.84	(2, 42)	.05	.155
Tuning	11.36	(2, 42)	.001	.351
Tempo	3.97	(2, 42)	.05	.159
Total	6.92	(2, 42)	.001	.248

Table 2
Tukey Honestly Significant Difference Comparisons for Means of Profile of Music Perception Skills Scores by Group

	Mean PROMS Scores [C.I.]		
	Non-musicians	Rock Band Gamers	Trained Musicians
Melody	15.87_a [13.2, 18.53]	20.6_b [17.35, 23.85]	19.47_{ab} [17.41, 21.53]
Tuning	19.33_a [15.95, 22.71]	24.67_b [22.7, 26.64]	27.33_b [25.13, 29.54]
Tempo	23.13_a [20.90, 25.37]	27.53_b [24.71, 30.36]	25.47_{ab} [23.49, 27.44]
Total	78_a [69.17, 86.83]	95.93_b [87.74, 104.13]	93.47_b [86.88, 100.05]

Note. Means that do not share subscripts differ at $p < .05$ in the Tukey honestly significant difference comparison. Numbers in brackets are 95% confidence intervals of the means.

There were significant differences between groups across three of the PROMS subtests in addition to the PROMS total scores (see Table 1). As with the total PROMS scores, for the tuning task both Rock Band Gamers and trained musicians scored significantly higher than non-musicians; however, they did not differ significantly from each other (see Table 2), and musicians appeared to have a (non-significant) advantage over the Rock Band gamers. In regards to the Melody and Tempo subtasks, Rock Band gamers scored significantly higher than non-musicians, whereas trained musicians did not differ from either group. There was not a significant difference between groups in regards to the Rhythm subtask, $F(2, 42)=2.54$, $p=.09$, $\eta_p^2=.108$.

While the average PROMS subtask scores for the Rock Band musicians were higher than those of the musicians, the musician group seemed to perform best in terms of tuning (see Figure 2 for performance for each group across all four subtasks). Rock Band gamers do not have to tune their controllers before playing, while trained musicians must learn when the strings of their instrument are out of tune and how to correct it. This is a skill that takes string musicians time to develop, and depending on the instrument, may be involved in advanced techniques such as the micro-adjustments of hand position required to adjust the tuning of a note as it is being played. However, since this difference did not reach significance, it may be that Rock Band gamers show a generally higher musical perception aptitude, and that training with Rock Band increases the skills measured in the other subtasks, but not tuning.

While differences between Rock Band gamers and trained musicians were our main focus, we also needed to make sure that any advantage Rock Band gamers might have over musicians was not due to a musically inept musician group. As trained musicians were found previously to score higher on the PROMS than non-musicians, we chose to verify that our musician group outperformed the non-musician group on total PROMS scores; to do this, we replicated the analysis of the Law and Zentner (2012) study, which computed a point biserial correlation using total PROMS scores as a continuous variable and group as a dichotomous variable. For the current study (removing the Rock Band gamer group), there was a significant correlation between group and total PROMS scores: $r_{pb}(43) = .50$, $p = .005$, with musicians scoring higher than non-musicians. This suggests that overall, the PROMS partially accounts for the group differences between musicians and non-musicians. Our results for the total PROMS scores also partially matches what Law and Zentner (2012) found for their results: the significant point biserial correlation found in the current research of $r_{pb}(43) = .50$, $p = .005$ is actually stronger than the point biserial correlations found for their two groups – the first of which took the first half of the full PROMS while the second took the second half: $r_{pb}(37) = .39$, $p < .05$ and $r_{pb}(37) = .47$, $p < .01$. However, the average total PROMS scores for our musicians was lower than that of theirs, even for their group removing professional and semi-professional musicians. Our musicians averaged a total score of 93.47 (SD = 11.89) while the musician group of Law and Zentner averaged 104.68 (SD = 18.60). This may be due to a lack of currently practicing musicians.

When point biserial correlations were run for each subtask (again, only for musicians and non-musicians), group correlated with the melody and tuning subtasks ($r_{pb}(43) = .40$, $p < .05$ and $r_{pb}(43) = .63$, $p < .01$, respectively), but not the tempo and rhythm; it may be that our musicians may not show enhanced rhythm perception due to their instruments of choice, as they were primarily non-percussion instrumentalists. When years of formal music training and each PROMS subtask were correlated across all participants, there was a significant correlation between years spent playing an instrument and scores on the tuning subtask $r(43)=.49$, $p<.01$.

This matches our previous finding of superior musician performance on the tuning subtask.

Validation of Participant Groups

Useful Field of View. Rock Band is a game with a complicated heads-up display (HUD); notes rapidly scroll down the screen, and the player must attend to performance cues located at the screen's periphery. These elements resemble the complex visual displays found in action video games. As action video gamers have shown higher UFOV scores (Green & Bavelier, 2003), and as many of our Rock Band gamers also had experience with action games, it is possible that there may be differences in visual processing between groups (as measured via the UFOV task). As part of our initial analyses, all continuous variables were correlated with each other to examine the possibility of meeting the assumptions of a covariate. The total UFOV scores were found to correlate significantly with all four levels of Rock Band accuracy scores (for the easy level, $r(43) = .40$, $p < .01$; medium level, $r(43) = .40$, $p < .01$; hard level, $r(43) = .46$, $p < .01$; and expert level, $r(43) = .39$, $p < .01$), but not with the PROMS scores. This suggests that while generally better visual and spatial skills may be related to Rock Band performance, they did not appear to relate to musical perception skills.

As we cannot determine the extent of the influence of higher UFOV scores on performance on Rock Band (as both tasks involve perceiving rapid changes in a cluttered visual environment), additional analyses were conducted to determine if there were differences between groups with regards to visual perception (as would be predicted from previous studies on action video games), and if UFOV scores should be included as a covariate when looking at Rock Band accuracy scores. A one-way Analysis of Variance (ANOVA) was conducted to compare the three groups (non-musician, rock band gamer, and musician) on total UFOV scores. The UFOV scores of one subject (a Rock Band gamer) were low enough to be considered outliers (see Figure 3), as observed via stem-and-leaf and boxplots (scores for this individual were greater than 2 SD from the mean). All subsequent analyses concerning UFOV were run both with and without the data from this participant.

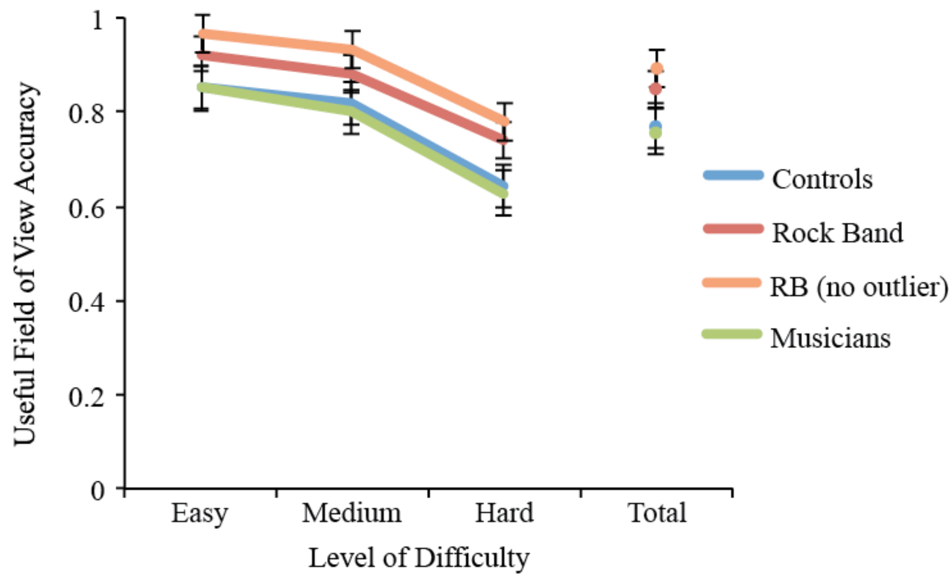

Figure 3. Differences in Useful Field of View accuracy scores

As it is difficult to detect differences between young individuals with this task (Ball, et al., 1988; Green & Bavelier, 2003), the effects of this outlier were strong enough to render the group effects as not significant. When the outlier was removed, there were significant differences between groups on total UFOV scores (see Table 3). Tukey post-hoc comparisons of the three groups indicate that Rock Band gamers (M = .89, 95% CI [.85, .93]) scored significantly higher on the Total UFOV than the trained musicians (M = .76, 95% CI [.67, .85]), or the non-musicians (M = .77, 95% CI [.70, .84]), $p < .001$, who were not statistically significantly different from each other at $p < .05$.

To see if this remained true for each level of the UFOV (and not just the total scores) additional follow-up analyses were conducted to determine the nature of any differences between groups on each difficulty level of the UFOV (for targets at the center, middle or outer eccentricities). Three additional, separate one-way ANOVAs were conducted (one for each eccentricity), using group as a between-subjects variable. A Tukey's post hoc analysis was included to compare the differences between groups on UFOV accuracy scores. As with the total UFOV scores, the effects of the outlier rendered the effects as not significant; however, when the outlier scores were removed, there were significant differences between groups on all levels of the UFOV scores (see Table 1). The Tukey's post hoc indicated that for each eccentricity, Rock Band gamers scored significantly higher on the UFOV than the trained musicians and non-musicians, who were not significantly different from each other at $p < .05$; this matched the differences found for total UFOV scores. Overall, the performance of the Rock Band group was consistently more accurate than that of the trained musicians or non-musicians, reflecting the gamer group's experience with video games.

Table 3
Results of Separate One-way Analysis of Variance (ANOVA) for Group Differences in Useful Field of View Scores

	F	Degrees of freedom	$p<$	η_p^2
Easy	3.68	(2, 42)	.05	.152
Medium	3.87	(2, 42)	.05	.159
Hard	3.38	(2, 42)	.05	.141
Total	4.75	(2, 42)	.05	.188

As no Rock Band gamer reported playing exclusively music video games, it is unclear whether the higher accuracy shown on the UFOV task by the Rock Band gamers is from playing Rock Band or from one of the other genres they reported playing (such as action, first person shooter, or fighting games). There were no differences between the Rock Band gamers who reported playing FPS games versus those who did not in terms of any UFOV scores, and the average scores for this group were similar to those reported by Green and Bavelier (2003) for action video gamers on this task (with action gamers showing an average accuracy above 75%). However, direct comparisons are difficult; this computerized version of the UFOV includes a small difference in the presentation of the array from the 2003 version, and the study did not explicitly report group means for each eccentricity (only significant differences between groups). Overall, UFOV scores do validate that our Rock Band gamer group differs from the other two groups on a measure where gamers have shown previous advantages.

Rock Band. While Rock Band is a game meant to be enjoyed by novices, it does appear to take practice to play well at the hard and expert levels of the game. While we verified that our Rock Band gamer group could reach at least 80% accuracy on these difficulty levels, we also wanted to verify that Rock Band gamers could outperform the other groups on this task. When Rock Band accuracy scores were collapsed across all difficulty levels, a one way ANOVA with group as a between-subjects variable revealed a main effect of group on accuracy scores $F(2, 42)= 30.792$, $p<.001$. A Tukey's post hoc analysis found that the gamer group (M=89.5, 95% CI [85.16, 93.84]) scored significantly higher than the musician group (M=64.03, 95% CI [55.30, 72.77]), who scored significantly higher than non-musicians (M=51.43, 95% CI [42.94, 60.03]).

As mentioned above, Rock Band is a game with a complicated visual environment. Because of this game's similarity to an action video game, and as our Rock Band gamer group showed higher UFOV scores (similar to what is found with action gamers), it is possible that the enhanced visual processing of this group is in part influencing their Rock Band performance. To determine if there were differences between groups on Rock Band accuracy while still accounting for UFOV scores, a 3 (Rock Band gamer, musician, non-musician) x 4 (level of difficulty: easy, medium, hard, and expert) mixed Analysis of Covariance (ANCOVA) was run total UFOV scores as a covariate. There was a significant main effect of group $F(2, 42)=4.16$, $p<.05$, $\eta_p^2=.092$ and a significant interaction between level of difficulty and group $F(2, 42)=13.94$, $p<.001$, $\eta_p^2=.405$. As this is an omnibus comparison, further analyses were needed to determine the nature of group differences for each difficulty level.

While we expected the Rock Band group to outperform non-musicians, there was a possibility that musicians could make use of their enhanced musical skills to outperform non-musicians on Rock Band performance for at least the easiest difficulty. To determine the nature of the differences between groups on Rock Band, four separate one-way ANCOVAs were conducted (one for each difficulty level), using group as a between-subjects variable and total UFOV scores as a covariate. A Tukey's post hoc analysis was included to compare the differences between groups on Rock Band accuracy scores. There were significant differences between groups across all four difficulty levels (see Table 4). Even when accounting for their higher UFOV scores, Rock Band gamers showed significantly higher accuracies for all four difficulties on Rock Band (easy, medium, hard and expert) when compared to non-musicians (see Table 5). Rock Band gamers also showed significantly higher accuracies for the medium, hard, and expert levels of play when compared to musicians; at least for the easy condition, the performance of musicians on Rock Band was similar to that of the gamer group.

While it appears that there is overlap between Rock Band and musical perception skills in the Rock Band gamers (via the correlations between hand and expert level Rock Band accuracy and total PROMS scores), it is also worth noting that musicians appeared to show similar overlap of musical skills and Rock Band performance. Musicians scored significantly higher than non-musicians for only the easy and medium levels of difficulty of Rock Band. This indicates that our musicians appeared to have an advantage as compared to non-musicians, but only for the beginner level of play. When examining correlations between Rock Band performance and PROMS ability for each group separately, musicians (but not non-musician) showed a correlation between performance on the melody subtask and performance on the easy level of Rock Band: $r(43) = .49$, $p < .01$, suggesting that enhanced melody processing appears to correspond to increased performance in at least the easiest level of Rock Band.

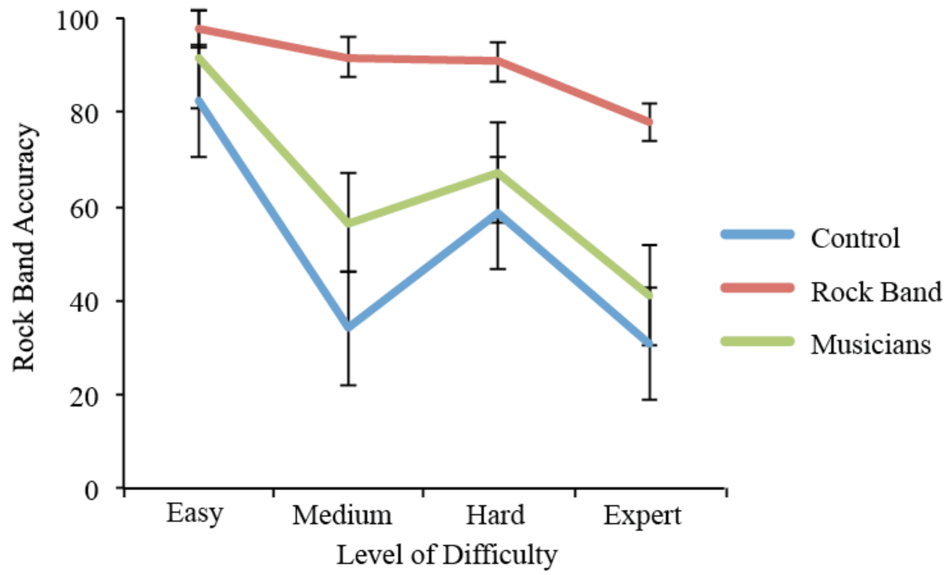

Figure 4. Differences in Rock Band accuracy scores by group

Table 4
Results of Separate One Way Analysis of Covariance (ANCOVA) for Group Differences in Rock Band Accuracy Scores Using Total Useful Field of View Scores as a Covariate

	F	Degrees of freedom	*p*<	η_p^2
Easy	9.91	(2, 42)	.001	.326
Medium	23.46	(2, 42)	.001	.534
Hard	25.71	(2, 42)	.001	.556
Expert	26.64	(2, 42)	.001	.565

Table 5
Tukey Honestly Significant Difference Comparisons for Means of Rock Band Accuracy Scores by Group

	Mean Accuracy Scores [C.I.]		
	Non-musicians	Rock Band Gamers	Trained Musicians
Easy	82.47_a [74.9, 90.03]	97.73_b [96.11, 99.36]	91.40_b [87.79, 95.01]
Medium	34_a [20.54, 47.46]	91.67_c [86.24, 97.1]	56.53_b [45.72, 66.44]
Hard	58.67_a [50.59, 66.75]	90.67_b [86.83, 94.51]	67.13_a [59.96, 74.31]
Expert	30.8_a [22.31, 39.29]	77.93_b [69.24, 86.62]	41.07_a [28.97, 53.16]

Note. Means that do not share subscripts differ at $p < .05$ in the Tukey honestly significant difference comparison. Numbers in brackets are 95% confidence intervals of the means.

Because Rock Band allows for non-musicians to learn the game quickly, but makes each subsequent level more difficult, there were sharp decreases in performance for each difficulty level for the control group (see Figure 4). Accuracy scores for all groups appear to dip at the medium difficulty level; despite being selected from the same difficulty tier as the easy song, participants appeared to have a disproportionate amount of difficulty with the “medium” level song. This could be for a few reasons: for example, the contour of this song appears to vacillate more than the other selected songs, which requires participants to use fret buttons at different ends of the fret board in a syncopated manner, which may not be intuitive for those who are unfamiliar with the song. As each group shows this dip in accuracy (with rock band gamers showing the least dip), this may be due to the mechanics of game play for this specific song, and the difficulty estimate provided by the game may be incorrect.

Big Five Inventory

As musicians have been shown previously to differ from non-musicians on personality inventories (Corrigall, Schellenburg, & Misura, 2013), it is also important to examine possible personality differences between Rock Band gamers and both musicians and non-musicians. To determine if there were differences between groups for certain personality dimensions, five separate one-way ANOVAs were conducted for each factor of the BFI (openness, conscientiousness, extraversion, agreeableness, and neuroticism), using average scores on the personality factor as a within-subjects variable and group as a between-subjects variable. A Tukey’s post hoc analysis was included to compare the differences between groups on personality factors.

There were significant differences between groups for only the factors of Neuroticism, $F(2, 42) = 5.01$, p=.01, η_p^2=.192, and of Conscientiousness, $F(2, 42) = 3.78$, p<.05, η_p^2=.153 (see figure 5). Tukey post-hoc comparisons of the three groups indicate that Rock Band gamers (M = 2.13, 95% CI [1.71, 2.54]) scored significantly lower on Neuroticism than the trained musicians (M = 3.29, 95% CI [3.03, 3.55]), and the non-musicians (M = 3.08, 95% CI [2.7, 3.45]) were not statistically significantly different from either group at $p < .05$. Tukey post-hoc comparisons indicate that Rock Band gamers (M = 2.51, 95% CI [3.31, 3.89]) scored significantly lower on Conscientiousness than the trained musicians (M = 3.29, 95% CI [3.03, 3.55]), and the non-musicians (M = 3.08, 95% CI [2.7, 3.45]) were not statistically significantly different from either group at p < .05.

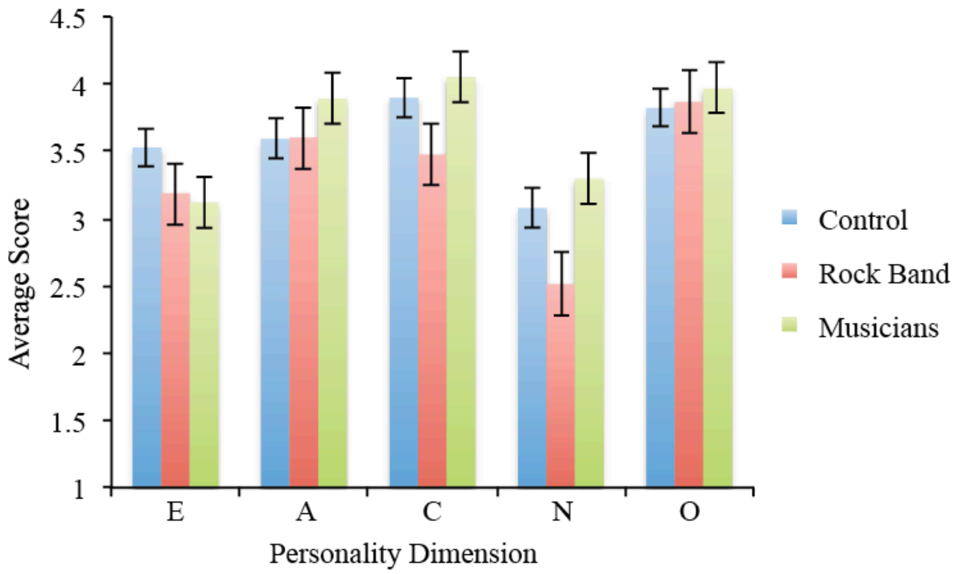

Figure 5. Differences in Big Five Inventory Traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness) by group

Chapter 5 Discussion

Conclusions and Limitations

While there has been substantive research showing structural and functional differences between musicians and non-musicians, as well as research showing differences between gamers and non-gamers, there has been no research examining possible differences between music video gamers and non-gamers, nor have there been any comparisons to formally trained musicians. The current study examined the musical abilities, spatial abilities, and personality of three groups (a group of trained musicians, a group of video gamers, and a group of non-gamer non-musicians) using the results of a musical perception task, the Useful Field of View task, accuracy on a music video game, and the Big Five Inventory. While this study cannot distinguish whether any of the differences (and similarities) found currently between groups are due to preexisting differences or the direct result of specialized training, this exploratory study lays the foundation to conduct short- and long-term training studies to determine if playing Rock Band can develop skills in non-gamer non-musicians. Conversely, if Rock Band training cannot improve the musical perception skills of non-musicians, it may support the notion of pre-existing differences in Rock Band gamers.

Participants with previous experience on the music video game Rock Band consistently outperformed non-musicians on total PROMS scores; additionally, their performance was on par with that of musicians. This suggests that Rock Band gamers do show enhanced musical perception skills (though it is uncertain as to when and how they develop these skills). While the means for Rock Band participants were higher than musicians for the melody, tempo and total PROMS, this difference was not statistically significantly higher. For the tuning subtask, trained musicians showed non-significantly higher scores; it may be that Rock Band musicians show a generally higher musical perception aptitude, and that training with Rock Band increases the skills measured in the other subtasks, but not tuning. If training has no influence, it may mean that

Rock Band musicians are not as predisposed with regards to tuning abilities (while still being more predisposed when compared to non-musicians), or may not be as prepared to learn those specific skills.

The performance of the trained musicians on the PROMS may be more difficult to interpret; trained musicians were not statistically better than non-musicians on the melody, tempo, or rhythm subtests of the PROMS. While most comparisons between musicians and non-musicians in previous research show trained musicians outperforming non-musicians (Chan, Ho, & Cheung, 1998; Micheyl, Delhommeau, Perrot, & Oxenham, 2006; Moreno, et al., 2011), the batteries chosen by those researchers may be measuring aspects of low-level auditory perception and not music perception. Many batteries aim to find deficits in music processing instead of individual differences in musical skills (Peretz, Champod, & Hyde, 2003; Wallentin, Nielsen, Friis-Olivarius, Vuust, & Vuust, 2010). Previous musical aptitude tests also may measure a combination of related skills instead of identifying unique musical skills. For instance, in trying to make rhythm and timing tests more ecologically valid by incorporating tones to make them more "musical", it may become more difficult to differentiate between performance on one type of skill (timing) from another (melody or pitch) (Karma, 2007). Additionally, timbre, tuning, or tempo skills are not assessed with traditional batteries, a problem which is addressed by the full PROMS (Law & Zentner, 2012).

In previous studies, the PROMS has shown convergent validity with existing musical ability tests, and criterion validity with external indicators of musical proficiency (Law & Zentner, 2012). In the current study, trained musicians did outperform non-musicians for the tuning subtask as well as the total PROMS; overall, the test did capture the musical perception skills of the trained musicians. For subtests in which trained musicians did not perform better than non-musicians, it may be due to lack of current practice. Only 3 musicians were currently taking private music lessons at the time of the study, and only 8 musicians were currently practicing at least an hour a week; it is possible that the non-practicing musicians lowered the overall scores.

There does appear to be overlap between Rock Band skills and musical perception skills; the accuracy scores of trained musicians on the easy and medium difficulty levels of Rock Band were higher than those of non-musicians, suggesting that there is some advantage conferred via their enhanced musical perception skill. While their scores on easy were not statistically different from the Rock Band gamers', their scores on the medium difficulty were, suggesting that even early in the game, practice is important. Trained musicians' accuracy scores on the hard and expert level were not statistically different from non-musicians, implying that all modes of the game require practice to master, with the hard and expert modes requiring more practice than can be accounted for by the musicians' enhanced musical skill.

While the finding of possible overlap between musical skills and music video game skills is a novel one, the enhanced performance of our Rock Band gamers on both the UFOV and Rock Band was as predicted for gamers with experience with action video games, Rock Band gamers scored significantly higher on all levels of the UFOV, and total UFOV scores were significantly correlated with Rock Band accuracy scores for all difficulties. Even when accounting for this relationship, Rock Band gamers showed the highest accuracy scores across all difficulty levels for that game. Most of these Rock Band gamers were not currently practicing music video games, suggesting that perhaps if training is involved, the skills developed while practicing Rock Band are well-maintained through time, or general video game play may transfer to the play of music video games and help maintain those skills. Additional research should include a group of gamers without Rock Band experience to verify that general gamers (or puzzle or FPS gamers) do not show an increase of musical perception skills. For the current study, none of the Rock band gamers played only music games; for this reason, it is difficult to remove the effects of general video game play from any of the results in this study, especially UFOV scores, which have been previously found to be enhanced in participants who play action video games (Green & Bavelier, 2003).

The lack of regularly practicing Rock Band gamers as well as the lack of currently playing musicians may have skewed the personality results as well; while Corrigall, Schellenburg, and Misura (2013) found that the duration of music lessons was related to both conscientiousness and openness to experience (at least in children), there was no difference between musicians and non-musicians on those two factors in the current study. There was however a difference between trained musicians and Rock Band gamers on both conscientiousness and neuroticism, with Rock Band gamers scoring lower on both. The lower scores of conscientiousness in Rock Band gamers may explain why they prefer music video games to actual musicianship; they may get disillusioned with the rigidity of formal music lessons and prefer the less structured video games.

It may also be that these lower scores on conscientiousness and neuroticism are more generally related to their general game play or musical preference. Graham and Gosling (2013) used the Big Five to examine the personality traits of World of Warcraft (WOW) players: their gamers scored 3.17 (SD=.82) for extraversion, 3.46 (SD=.67) for conscientiousness, 3.72 (SD=.62) for agreeableness, 2.59 (SD=.79) for neuroticism, and 3.92 (SD=.54) for openness to experience. These averages are very similar to those in the Rock Band gamer group (3.18 (SD=.90) for extraversion, 3.47 (SD=.67) for conscientiousness, 3.60 (SD=.52) for agreeableness, 2.51 (SD=.89) for neuroticism, and 3.87 (SD=.76) for openness to experience), suggesting that personality traits may predict preference for general video game play. Additionally, Williams, Yee, and Caplan (2008) found that online gamers playing the massive multiplayer online game EverQuest 2 had lower incidences of anxiety than the general population; however they did not measure personality directly, only self-report health status; regardless, these findings may relate to a lower level of neuroticism among gamers in general. Graham, et al. (2013) also found that playing WOW for the purpose of socialization was related to lower levels of conscientiousness while achievement motivation was negatively correlated with conscientiousness; while Rock Band is advertised as a social game (emphasizing the creation of a band with friends), it also provides players with leader boards that compare your scores to those of your friends, promoting competition. It may be that lower levels of conscientiousness are related to a preference for playing any game with a social or competitive aspect. However, there are few current studies relating personality to video game play, and others have not find personality differences in children with regards to video games (Witt, Massman, and Jackson, 2011).

General music preference may account for some of the personality differences as well; Dunn, Ruyter, and Bouwhuis (2001) found that preference for and duration of listening to classical music was correlated to higher levels of neuroticism as measured via the NEO PI-R; since our musicians reported primarily playing classical music, this may explain our finding of higher levels of neuroticism in our musician group. However, since our non-musician group was not significantly different from either Rock Band gamers or trained musicians, it is likely that preference to play classical music did not outweigh a tendency to listen to music genres other than classical. While participants primarily reported listening to a wide variety of music, it is possible that greater exposure to rock music via Rock Band may be related to an initial preference for rock. Rentfrow and Gosling (2003) found that higher levels of conscientiousness was related to music preferences for songs that were upbeat and conventional (but found no relationship between music preference and neuroticism); however, Swami, et al., (2013) found that out of the big five factors, only openness to experience correlated to preference for heavy metal music.

However, there are debates as to the role of personality in predicting musical preference. Chamorro-Premuzic, Swami, and Cermakova (2012) found that personality was not predictive of how people consume music (what they buy, what concerts they attend, or what musicians they research), but instead of how they used music (emotionally, cognitively, or in the background), with neuroticism positively predicting an emotional use of music. As we did not measure listening preference in detail (only basic self-reported genres, many of which were reported as "any genre" or "almost anything"), a further study could examine whether rock band gamers have significant differences in genre preferences which might relate to personality factors.

Future Directions

If video game musicianship promotes comparable skills found in trained musicians, music video games may be a useful teaching tool for schools. Training studies using non-musicians and Rock Band would help clarify the extent of pre-existing differences versus specialized experience, and determine the applicability of using Rock Band in classrooms. Formal music training may be related to verbal processing and dyslexia (Corrigall & Trainor, 2011), and musical training that deals with beat modulation detection and basic sound processing may be effective at treating it (Goswami, et al., 2002). Prolonged exposure to playing music video games may also encourage younger children to eventually transfer to a "real" musical instrument, and equip these children with the basic motor and auditory skills needed to play. The social aspect of these games is also important, considering the role music plays in our social interactions with others (Clayton, 2008). Because of the length of time necessary to develop proficiency (especially on the most difficult levels) with music video games such as Rock Band, the scope of this current research is limited. Future studies should consider short- and long-term training studies using music video games, and their effect on musical perception, production, verbal processing or brain responses.

Appendix A

Sex: ○ Male
○ Female

Year: ○ Fresh. ○ Soph. ○ Jr.
○ Sr. ○ Non-degree seeking

Background Information

Age: ______________________________________

Are you Spanish/Hispanic/Latino? (*Check one)*

○ No, not Spanish/Hispanic/Latino
○ Yes, Puerto Rican
○ Yes, Mexican, Mexican-American, Chicano
○ Yes, Cuban
○ Yes, other Spanish/Hispanic/Latino:
____

What is your race? *Check all that apply*

☐ White ☐ Black/African American ☐ American Indian/Alaska Native
☐ Asian Indian ☐ Chinese ☐ Filipino ☐ Japanese
☐ Korean ☐ Vietnamese ☐ Other Asian: ____________________
☐ Native Hawaiian ☐ Guamanian/Chamorro ☐ Other Pacific Islander: ______________
☐ Samoan ☐ Some other race: ____________

Parent's Highest Education Level?

○ No H.S. diploma ○ H.S. diploma ○ Some college
○ 4-year College degree ○ Graduate school degree ○ Technical school

Hearing History

Have you ever had frequent ear infections (more than three per year)?

○ Yes, at what age(s)? ________________
○ No

Does your family have a history of hearing impairment?

○ Yes, describe: ____________________
○ No

Do you have a history of hearing impairment?

○ Yes, describe: ____________________
○ No

Have you been in any unusually noisy environments?

○ Yes, describe: ____________________
For how long? ____________________
○ No

Musical Information

Have you ever taken private music lessons? ○ Yes ○ No

Type of music practiced (Classical/Jazz/Folk)?
____

Instrument(s):
____

Beginning at what age? ______________

No. of years? ______________________

Solo or ensemble? (please describe ensemble type)	______________________
Are you currently taking private lessons?	O Yes O No
Do you currently practice music on a regular basis?	O Yes, hours/week ______________ O No
Have you ever taken music courses at the university level?	O Yes, which course(s)? ______________ O No
Do you have absolute pitch?	O Yes O No
How many hours per week do you listen to music?	______________________
Type of music?	______________________

<u>Video Game Information</u>

Do you play video games on any devices? (check any that apply)	O Smart phone O Nintendo Wii or WiiU O Xbox360 or XboxOne O Playstation 3 or 4 O Handheld (PSP, PSVita, Nintendo DS, etc) O Gaming PC O Other ______________
Do you currently spend time playing video games on a regular basis?	O Yes, hours/week ______________ O No
What genres of games do you play? (select any that apply, and rank them from most played to least played)	O Puzzle O Music O Fighting O Role Playing O Strategy O Sports O First Person Shooters O Other ______________
Beginning at what age? ____________	No. of years? ______________
Which genre do you play most?	______________________
Do you play any games like Guitar Hero or Rock Band? If so, select any instruments you play, and what level you are comfortable playing at.	O I do not play O Guitar O Bass O Drums O Vocals O Easy O Medium O Hard O Expert
Do you currently practice music video games on a regular basis?	O Yes, hours/week ______________ O No

<u>Language Information</u>

Country of Birth:	______________________
Country of Parents' Birth:	______________________
Language… a. learned as child:	______________________
b. age English learned, if not first:	______________________
Do you speak a language other than English?	O Yes O No, what other language(s)? ______________________
a. Non-English language competence	O Beginner O Intermediate O Advanced/Fluent

References

Anderson, C. A., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology, 78*(4), 772-790. doi:10.1037//0022-3514.78.4.772

Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., … Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature, 501*(7465), 97-101. doi:10.1038/nature12486.

Ball, K. K., Beard, B. L., Roenker, D. L., Miller, R. L., & Griggs, D. S. (1988). Age and visual search: Expanding the useful field of view. *Journal of the Optical Society of America*, *5*, 2210-2219.

Bartholow, B. D., Bushman, B. J., & Sestir, M. A. (2006). Chronic violent video game exposure and desensitization to violence: Behavioral and event-related brain potential data. *Journal of Experimental Social Psychology, 42*(4), 532-539. doi:10.1016/j.jesp.2005.08.006

Bidelman, G.M., Krishnan, A., & Gandour, J.T. (2011). Enhanced brainstem encoding predicts musicians' perceptual advantages with pitch. *European Journal of Neuroscience, 33*(3), 530-538.

Carnagey, N. L., Anderson, C. A., & Bushman, B. J. (2007). The effect of video game violence on physiological desensitization to real-life violence. *Journal of Experimental Social Psychology, 43*(3), 489-496. doi:10.1016/j.jesp.2006.05.003

Cassavaugh, N. D., & Kramer, A. F. (2009). Transfer of computer-based training to simulated driving in older adults. *Applied Ergonomics, 40*(5), 943-952. doi:10.1016/j.apergo.2009.02.001

Chamorro-Premuzic, T., Swami, V., & Cermakova B. (2012). Individual differences in music consumption are predicted by uses of music and age rather than emotional intelligence, neuroticism, extraversion or openness. *Social and Personality Psychology Compass, 6*(5), 402-416.

Chan, A. S., Ho, Y. C., & Cheung, M. C. (1998). Music training improves verbal memory. *Nature, 396*(6707), 128-128. doi:10.1038/24075

Clayton, M. (2008). The social and personal functions of music in cross-cultural perspective. In S. Hallam, I. Cross, and M. Thaut (Eds.), *The Oxford Handbook of Music Psychology.* Oxford, UK: Oxford University Press, (pp. 35–44).

Corrigall, K. A., & Trainor, L. J. (2011). Associations between length of music training and reading skills in children. *Music Perception, 29*(2), 147-155. doi:10.1525/mp.2011.29.2.147

Corrigall, K. A., & Schellenberg, E. G. (2013). Music: The language of emotion. In C. Mohiyeddini, M. Eysenck, & S. Bauer (Eds.) *Handbook of psychology of emotions: Recent theoretical perspectives and novel empirical findings*, Vol. 2, (pp. 299-325). Hauppauge, NY: Nova Science Publishers.

Corrigall, K. A., Schellenberg, E. G., & Misura, N. M. (2013). Music training, cognition, and personality. *Frontiers in Psychology, 4*(222). doi:10.3389/fpsyg.2013.00222

Costa, P. T., & McCrae, R. R. (1989). The NEO-PI/NEO-FFI manual supplement. Odessa, FL.: Psychological Assessment Resources.

Costa, P. T., & McCrae, R. R. (1992). Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual. Odessa, FL: Psychological Assessment Resources.

Dunn, P. G., de Ruyter, B., & Bouwhuis, D. G. (2011). Toward a better understanding of the relation between music preference, listening behavior, and personality. *Psychology of Music 40*(4) 411–428.

Edwards, J. D., Vance, D. E., Wadley, V. G., Cissell, G. M., Roenker, D. L., & Ball K. K. (2005). The reliability and validity of the useful field of view test as administered by personal computer. J*ournal of Clinical and Experimental Neuropsychology, 27*, 529–543.

Egli, E. A., & Meyers, L. S. (1984). The role of video game playing in adolescent life–is there reason to be concerned. *Bulletin of the Psychonomic Society, 22*(4), 309-312.

Elbert, T., Pantev, C., Wienbruch, C., Rockstroh, B., & Taub, E. (1995). Increased cortical representation of the fingers of the left hand in string players. *Science, 270*(5234), 305-307. doi:10.1126/science.270.5234.305

Elpus, K. (2013). Is it the music or is it selection bias? A nationwide analysis of music and non-music students' SAT scores. *Journal of Research in Music Education, 61*, 175-194. doi:10.1177/0022429413485601

Entertainment Software Association (2010). 2010 Essential facts about the computer and video game industry. Retrieved from http://www.theesa.com/facts/pdfs/ESA_Essential_Facts_2010.PDF

Entertainment Software Association (2011). 2011 Essential facts about the computer and video game industry. Retrieved from http://www.theesa.com/facts/pdfs/ESA_EF_2011.pdf

Ericsson, K. A., Krampe, R. T., & Teschromer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363-406. doi:10.1037/0033-295x.100.3.363

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science, 18*(10), 850-855. doi:10.1111/j.1467-9280.2007.01990.x

Fery, Y. A., & Ponserre, S. (2001). Enhancing the control of force in putting by video game training. *Ergonomics, 44*(12), 1025-1037.

Fisher, S. (1994). Identifying video game addiction in children and adolescents. *Addictive Behaviors, 19*(5), 545-553.

Franěk, M., Mates, J., Radil, T., Beck, K., & Pöppel, E. (1991). Finger tapping in musicians and nonmusicians. *International Journal of Psychophysiology, 11*(3), 277-279. doi:10.1016/0167-8760(91)90022-p

Funk, J. B. (1993). Reevaluating the impact of video games. *Clinical Pediatrics, 32*(2), 86-90.

Gopher, D., Weil, M., & Bareket, T. (1994). Transfer of skill from a computer game trainer to flight. *Human Factors, 36*(3), 387-405.

Goswami, U., Thomson, J., Richardson, U., Stainthorp, R., Hughes, D., Rosen, S., & Scott, S.K.. (2002). Amplitude envelope onsets and developmental dyslexia: A new hypothesis. *Proceedings of the National Academy of Sciences of the United States of America, 99*(16), 10911-10916. doi:10.1073/pnas.122368599

Graham, L. T., & Gosling, S. D. (2013). Personality profiles associated with different motivations for playing World of Warcraft. *CyberPsychology, Behavior & Social Networking, 16*(3), 189-193.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*(6939), 534-537.

Green, C. S., & Bavelier, D. (2006a). Effect of action video games on the spatial distribution of visuospatial attention. *Journal of Experimental Psychology-Human Perception and Performance, 32*(6), 1465-1478. doi:10.1037/0096-1523.32.6.1465

Green, C. S., & Bavelier, D. (2006b). Enumeration versus multiple object tracking: The case of action video game players. *Cognition, 101*(1), 217-245. doi:10.1016/j.cognition.2005.10.004

Green, C. S., & Bavelier, D. (2007). Action-video-game experience alters the spatial resolution of vision. *Psychological Science, 18*(1), 88-94. doi:10.1111/j.1467-9280.2007.01853.x

Greenfield, P. M., DeWinstanley, P., Kilpatrick, H., & Kaye, D. (1994). Action video games and informal education: Effects on strategies for dividing visual attention. *Journal of Applied Developmental Psychology, 15*(1), 105-123. doi:10.1016/0193-3973(94)90008-6

Hetland, L. (2000). Learning to make music enhances spatial reasoning. *Journal of Aesthetic Education, 34*(3-4), 179-238. doi:10.2307/3333643

Ho, Y. C., Cheung, M. C., & Chan, A. S. (2003). Music training improves verbal but not visual memory: Cross-sectional and longitudinal explorations in children. *Neuropsychology, 17*(3), 439-450. doi:10.1037/0894-4105.17.3.439

John, O. P., Donahue, E. M., & Kentle, R. L. (1991). The Big Five Inventory--Versions 4a and 54. Berkeley, CA: University of California, Berkeley, Institute of Personality and Social Research.

John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative big-five trait taxonomy: history, measurement, and conceptual issues. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (pp. 114-158). New York, NY: Guilford Press.

Karma, K. (2007). Musical aptitude definition and measure validation: Ecological validity can endanger the construct validity of musical aptitude tests. *Psychomusicology: Music, Mind and Brain 19*, 79-90. doi:10.1037/h0094033

Kishon-Rabin, L., Amir, O., Vexler, Y., & Zaltz, Y. (2001) Pitch discrimination: Are professional musicians better than non-musicians? *Journal of Basic Clinical Physiological Pharmacology, 12*(suppl)125-143.

Koeneke, S., Lutz, K., Wüstenberg, T., & Jäncke, L. (2004). Long-term training affects cerebellar processing in skilled keyboard players. *Neuro-Report, 15*(8):1279–1282.

Kühn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2013). Playing Super Mario induces structural brain plasticity: Grey matter changes resulting from training with a commercial video game. *Molecular Psychiatry advance online publication, 29*, doi:10.1038/mp.2013.120

Law, L. N. C., & Zentner, M. (2012). Assessing musical abilities objectively: Construction and validation of the Profile of Music Perception Skills. *PLoS ONE 7*(12): e52508. doi:10.1371/journal.pone.0052508

Lee, D. J., Chen, Y., & Schlaug, G. (2003). Corpus callosum: Musician and gender effects. *NeuroReport, 14*(2), 205–209.

Lessard, A., & Bolduc, J. (2011). Links between musical learning and reading for first to third grade students: A literature review. *International Journal of Humanities and Social Science, 1*(7), 109.

Macnamara, A., Holmes, P., & Collins, D. (2008). Negotiating transitions in musical development: The role of psychological characteristics of developing excellence. *Psychology of Music, 36*(3), 335-352. doi:10.1177/0305735607086041

Mado Proverbio, A., Manfred, M., Zani, A., & Adorni, R. (2012). Musical expertise affects neural bases of letter recognition. *Neuropsychologia, 51*(3), 538–549.

Margulis, E. H., Mlsna, L. M., Uppunda, A. K., Parrish, T. B., & Wong, P. C. M. (2009). Selective neurophysiologic responses to music in instrumentalists with different listening biographies. *Human Brain Mapping, 30*(1), 267-275. doi:10.1002/Hbm.20503

Mehr, S.A., Schachner, A., Katz, R.C., Spelke, E.S. (2013). Two randomized trials provide no consistent evidence for nonmusical cognitive benefits of brief preschool music enrichment. *PLoS ONE 8*(12): e82007. doi:10.1371/journal.pone.0082007

Meyer, M., Alter, K., Friederici, A. D., Lohmann, G., & von Cramon, D. Y. (2002). FMRI reveals brain regions mediating slow prosodic modulations in spoken sentences. *Human Brain Mapping, 17*(2), 73-88. doi:10.1002/Hbm.10042

Micheyl, C., Delhommeau, K., Perrot, X., & Oxenham, A. J. (2006). Influence of musical and psychoacoustical training on pitch discrimination. *Hearing Research, 219*(1-2), 36-47. doi:10.1016/j.heares.2006.05.004

Moreno, S., Bialystok, E., Barac, R., Schellenberg, E. G., Cepeda, N. J., & Chau, T. (2011). Short-term music training enhances verbal intelligence and executive function. *Psychological Science, 22*(11), 1425-1433. doi:10.1177/0956797611416999

Moreno, S., Marques, C., Santos, A., Santos, M., Castro, S. L., & Besson, M. (2009). Musical training influences linguistic abilities in 8-year-old children: More evidence for brain plasticity. *Cererbral Cortex, 19*(3), 712-723. doi: 10.1093/cercor/bhn120

Nakada, T., Fujii, Y., Suzuki, K., & Kwee, I. L. (1998). 'Musical brain' revealed by high-field (3 Tesla) functional MRI. *Neuroreport, 9*(17), 3853-3856. doi:10.1097/00001756-199812010-00016

Norton, A., Winner, E., Cronin, K., Overy, K., Lee, D. J., & Schlaug, G. (2005). Are there pre-existing neural, cognitive, or motoric markers for musical ability? *Brain and Cognition, 59*(2), 124-134. doi:10.1016/j.bandc.2005.05.009

Orsmond G. I., & Miller L. K. (1999). Cognitive, musical, and environmental correlates of early music instruction. *Psychology of Music 27*, 18–3710.

Pantev, C., Engelien, A., Candia, V., & Elbert, T. (2001). Representational cortex in musicians. *Annals of the New York Academy of Sciences, 930*(1), 300-314. doi:10.1111/j.1749-6632.2001.tb05740.x

Pantev, C., Oostenveld, R., Engelien, A., Ross, B., Roberts, L. E., & Hoke, M. (1998). Increased auditory cortical representation in musicians. *Nature, 392*(6678), 811-814. doi:10.1038/33918

Parbery-Clark, A., Tierney, A., Strait, D. L., & Kraus, N. (2012). Musicians have fine-tuned neural distinction of speech syllables. *Neuroscience, 219*(6), 111-119.

Peretz, I., Champod A. S., & Hyde, K. L. (2003). Varieties of musical disorders. The Montreal Battery of Evaluation of Amusia. *Annals of the New York Academy of Sciences 999*, 58–75. doi:10.1196/annals.1284.006

Rammstedt, B., & John, O. P. (2005). Kurzversion des Big Five Inventory (BFI-K): Entwicklung und validierung eines okonomischen inventars zur erfassung der funf faktoren der personlichkeit. (Short version of the Big Five Inventory (BFI-K): Development and validation of an economic inventory for assessment of the five factors of personality), *Diagnostica, 51*, 195-206.

Rammstedt, B., John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality, 41*, 203–212.

Rauscher, F. H., & Hinton, S. C. (2011). Music instruction and its diverse extra-musical benefits. *Music Perception, 29*(2), 215-226. doi:10.1525/mp.2011.29.2.215

Rauscher, F. H., Shaw, G. L., Levine, L. J., Wright, E. L., Dennis, W. R., & Newcomb, R. L. (1997). Music training causes long-term enhancement of preschool children's spatial-temporal reasoning. *Neurological Research, 19*(1), 2-8.

Rauscher, F. H., & Zupan, M. A. (2000). Classroom keyboard instruction improves kindergarten children's spatial-temporal performance: A field experiment. *Early Childhood Research Quarterly, 15*(2), 215-228. doi:10.1016/s0885-2006(00)00050-8.

Rentfrow, P. J., & Gosling, S. D. (2003). The do re mi's of everyday life: The structure and personality correlates of music preferences. *Journal of Personality and Social Psychology, 84*(6), 1236-1256.

Rogalsky, C., Rong, F., Saberi, K., & Hickok, G. (2011). Functional anatomy of language and music perception: Temporal and structural factors investigated using functional magnetic resonance imaging. *The Journal of Neuroscience, 31*(10), 3843-3852. doi:10.1523/jneurosci.4515-10.2011

Rosser, J. C., Lynch, P. J., Cuddihy, L., Gentile, D. A., Klonsky, J., & Merrell, R. (2007). The impact of video games on training surgeons in the 21st century. *Archives of Surgery, 142*(2), 181-186. doi:10.1001/archsurg.142.2.181

Schellenberg, E.G. (2004). Music lessons enhance IQ. *Psychological Science, 15*, 511-514.

Schellenberg, E. G. (2011a). Examining the association between music lessons and intelligence. *British Journal of Psychology, 102*, 283-302. doi:10.1111/j.2044-8295.2010.02000.x

Schellenberg, E. G. (2011b). Music Lessons, Emotional Intelligence, and IQ. *Music Perception, 29*(2), 185-194. doi:10.1525/mp.2011.29.2.185

Schlaug, G., Jancke, L., Huang, Y. X., Staiger, J. F., & Steinmetz, H. (1995). Increased corpus-callosum size in musicians. *Neuropsychologia, 33*(8), 1047-&. doi:10.1016/0028-3932(95)00045-5

Schlaug, G., Jancke, L., Huang, Y. X., & Steinmetz, H. (1995). In-vivo evidence of structural brain asymmetry in musicians. *Science, 267*(5198), 699-701. doi:10.1126/science.7839149

Schneider, P., Scherg, M., Dosch, H. G., Specht, H. J., Gutschalk, A., & Rupp, A. (2002). Morphology of Heschl's gyrus reflects enhanced activation in the auditory cortex of musicians. *Nature Neuroscience, 5*(7), 688-694. doi:10.1038/nn871

Shahin, A.J. (2011). Neurophysiological influence of musical training on speech perception. *Frontiers in Psychology 2,* 126.

Southgate, D.E. & Roscigno, V.J. (2009). The impact of music on childhood and adolescent achievement. *Social science quarterly, 90*(1), 4-21.

Strait, D. L., Hornickel, J., & Kraus, N. (2011). Subcortical processing of speech regularities underlies reading and music aptitude in children. *Behavioral and Brain Functions, 7,* doi:10.1186/1744-9081-7-44.

Strait D.L., & Kraus N. (2011). Can you hear me now? Musical training shapes functional brain networks for selective auditory attention and hearing speech in noise. *Frontiers in Psychology, 2*, doi:10.3389/fpsyg.2011.00113.

Wallentin, M., Nielsen, A. H., Friis-Olivarius, M., Vuust, C., Vuust, P. (2010). The Musical Ear Test, a new reliable test for measuring musical competence. *Learn Individ Differ 20*, 188–196. doi:10.1016/j.lindif.2010.02.004

White-Schwoch, T., Carr, K.W., Anderson, S., Strait, D.L., Kraus, N. (2013). Older adults benefit from music training early in life: Biological evidence for long-term training-driven plasticity. *J Neurosci, 33*(45): 17667–17674.

Williams, D., Yee, N., & Caplan, S. E. (2008). Who plays, how much, and why? Debunking the stereotypical gamer profile. *Journal of Computer-Mediated Communication, 13*(4), 993–1018.

Witt, E. A., Massman, A. J., & Jackson, L. A. (2011). Trends in youth's videogame playing, overall computer use, and communication technology use: The impact of self-esteem and the big five personality factors. *Computers in Human Behavior, 27*(2), 763–769.

Zatorre, R. J., Belin, P., & Penhune, V.B. (2002) Structure and function of auditory cortex: Music and speech. *Trends in Cognitive Sciences, 6,* 37-46.

Zuk, J., Ozernov-Palchik, O., Kim, H., Lakshminarayanan, K., Gabrieli, J.D.E. Tallal, P., Gaab, N. (2013). Enhanced syllable discrimination thresholds in musicians. *PLoS ONE, 8*(12):e80546. doi:10.1371/journal.pone.0080546.

Curriculum Vita

EDUCATION UNIVERSITY OF NEVADA, LAS VEGAS

Graduated Magna Cum Laude with a B.A. in Psychology with a minor in Linguistics Studies - Spring, 2007

M.A. in Experimental Psychology, emphasis in Neuroscience - Spring 2012

Doctorate in Experimental Psychology with an emphasis in Neuroscience - Fall 2014

TEACHING PART-TIME INSTRUCTOR

Psychology 405 Sensation and Perception, NSC Fall 2014: An introduction to the study of psychophysics, sensory systems, and perceptual phenomena and theories.

Psychology 442 Psychology of Aging Spring, UNLV 2013 - Spring 2014: Exploration of the changes that occur in late adulthood. Areas of study include physiology, sensory and cognitive processes, personality, psychopathology, and death and dying.

Psychology 420 Learning, UNLV Fall 2013: Analysis of the principles, theories, and phenomena of learning.

Psychology 341 Abnormal, UNLV Fall 2013: An introduction to the psychology of abnormal behavior stressing symptomatology, etiology, dynamics, and problems in diagnosis.

Psychology 101, UNLV, NSC Fall 2009-Present: Classes cover a wide variety of topics, including introductory treatment of sensation-perception-cognition, physiological psychology, learning, personality, development, social psychology, assessment, and history.

Math 95, NSC Fall 2014: Topics include solving linear equations and inequalities in one variable, linear graphs, polynomials, and factorable quadratic equations.

PUBLICATIONS PSYCHOPHYSIOLOGY

Snyder, J., Pasinski, A. & McAuley, J. (2011). Listening strategy for auditory rhythms modulates neural correlates of expectancy and cognitive processing. Psychophysiology, 48, 198-207.

Weintraub, D.M., Ramage, E.M., Sutton, G., Ringdahl, E., Boren, A., Pasinski, A.C., Thaler, N., Haderlie, M., Allen, D.N., & Snyder, J.S. (2012). Auditory stream segregation impairments in schizophrenia. Psychophysiology, 49, 1372-1383.