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BRIEF REPORT

How musical are music video game players?

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Abstract Numerous studies have shown that formal musical training is associated with sensory, motor, and cognitive advantages in individuals of various ages. However, the nature of the observed differences between musicians and nonmusicians is poorly understood, and little is known about the listening skills of individuals who engage in alternative types of everyday musical activities. Here, we show that people who have frequently played music video games outperform nonmusicians controls on a battery of music perception tests. These findings reveal that enhanced musical aptitude can be found among individuals who play music video games, raising the possibility that music video games could potentially enhance music perception skills in individuals across a broad spectrum of society who are otherwise unable to invest the time and/or money required to learn a musical instrument.

Keywords Musical aptitude · Video games · Learning · Useful field of view · Personality

John Blacking's influential book *How Musical Is Man?* challenged the notion that only composers and performers of Western art music are "musical," instead emphasizing the universality of human musicality (Blacking, 1973). The past two decades have nevertheless witnessed an abundance of reports suggesting that "musicians" outperform "nonmusicians" on measures of sensory, cognitive, and motor functions (Hannon & Trainor, 2007; Strait & Kraus, 2014). Studies with tightly controlled learning situations have demonstrated that remarkable behavioral and neural changes can occur as a result of auditory learning (e.g., Alain, Snyder, He, & Reinke, 2007; Lappe, Herholz, Trainor, & Pantev, 2008), or even passive exposure to musical stimuli (e.g., Hannon & Trehub, 2005). However, other evidence suggests that personality differences predict who undertakes music training and who does not (e.g., Corrigall, Schellenberg, & Misura, 2013). Furthermore, compared with nonidentical twins, identical twins tend to have more similar patterns of musical instrument practice, suggesting that experiential differences between musicians and nonmusicians may be influenced by genetics (Mosing, Madison, Pedersen, Kuja-Halkola, & Ullen, 2014). Thus, although musical ability is probably influenced by both preexisting and experiential factors, the nature of the observed differences between musicians and nonmusicians is still poorly understood.

Studies documenting training-related differences are important because they suggest that formal musical training might have beneficial effects across the lifespan, such as boosting sensory and cognitive function (Schellenberg, 2004; Zendel & Alain, 2012). One limitation to enacting the potential benefits of music in the broader population is that not everyone has the time, money, or perseverance to learn an instrument. A related limitation is that little is known about what specific aspects of training, if any, contribute to the observed differences between musicians and nonmusicians. The majority of studies have contrasted so-called nonmusicians with classically trained instrumental musicians, using retrospective self-reports of years of training or age first beginning music lessons, severely limiting our knowledge about the effects of diverse types of musical experience. This state of affairs also limits our understanding about which aspects of music training are necessary and sufficient to see training-related changes. Thus, it is worthwhile to examine whether advantages in musical listening

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skills can also be observed among individuals engaged in nontraditional musical activities.

One activity that has not been studied but is now very common is the playing of music video games. People who play music video games represent a natural population to examine potential associations between music aptitude and nontraditional types of musical engagement, given that games are readily accessible but entail extensive and focused attention to music without the need to learn real musical instruments or to be formally taught by an instructor. Video game players also represent a population with cognitive and personality traits that may contrast with typical musicians. We therefore asked whether or not individuals who play music video games might also have enhanced musical skills, despite their lack of traditional, formal instruction. We recruited three groups of participants—a group of music video game players (or *gamers*), a group of trained *musicians*, and a group of nonmusician *controls*—and we tested them on a battery of music listening tasks and on how well they played a music video game (Rock Band 2).

Method

Participants

Three groups of participants were recruited from the University of Nevada, Las Vegas, participant pool and the surrounding community via an online questionnaire. The 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. Specific questions focused on formal music training duration and age of onset, and on how many and what kinds of instruments participants had played. We also asked participants which genres of video games they played, what types of consoles they used, and the duration, frequency, and age of onset of game playing. Participants were asked whether they played music games like Guitar Hero or Rock Band, what instruments they played on those games, and at what level of difficulty they were comfortable playing.

The inclusion criteria were that healthy adults be 18–65 years of age, with self-reported 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 6 years and had played within the last 5 years), a group of music video gamers (who were able to play on the hard or the expert level of Rock Band with at least 80 % accuracy on the hard level), and a group of nongamer, nonmusician controls. The gamer group consisted of participants with experience using Rock Band's guitar or bass settings, but no formal musical training or current practicing of music. The trained musician and nonmusician groups did not have any experience playing video games, other than occasional experience with smart phones or casual games.

Each group contained 15 participants, who were given course credit or a small payment for their participation. Given the lack of prior studies on music video game players, this number was chosen on the basis of the typical sample sizes that are sufficient to show reliable differences between musicians and nonmusicians (e.g., Schneider et al., 2002). The gamer group contained a higher proportion of males than did the other two groups (Rock Band, 11 male, four female; musicians, two male, 13 female; and controls, three male, 12 female). No gender differences were found, but we report all analyses of gender differences in the supplementary information, reporting in the main text only when main effects of group became nonsignificant after including gender as a covariate. The average ages of participants (overall range = 18–41 years) were 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 differences between the three groups regarding age, $F(2, 42) = 1.31$, $p > .250$, $\eta_p^2 = .059$. A nonparametric independent-samples median test showed no significant differences between the three groups with regard to socio-economic status (as measured using parents' highest category of education, where 1 = *no high school diploma*, 2 = *high school diploma*, 3 = *some college*, 4 = *college degree*, and 5 = *graduate degree*), $p = .087$.

Musicians All musicians had been playing their instrument for at least 6 years (cf. Zendel & Alain, 2012), and on average had 12.6 years of experience ($SD = 7.19$). The musicians reported playing between one and four different instruments ($M = 2.16$, $SD = 1.19$), with 60 % playing more than one instrument. Musicians' primary instruments were strings (violin or guitar, $N = 5$), wind instruments (including flute, oboe, piccolo, trumpet, and saxophone, $N = 9$), and voice ($N = 1$). 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 most 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). Three musicians were currently taking private music lessons at the time of the study, and eight 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, for an hour a week.

Gamers Only three of the gamers had any musical training, with two participants having 1 year of formal instruction in middle school, and one playing in middle school and high school bands. None of the participants had practiced any

music for at least 5 years. All gamers reported playing on at least three different types of gaming consoles or smart phones (M = 4.8, SD = 2.9), and ten reported playing video games on a regular basis, for an average of 12 h per week (SD = 12.19). These games were from the puzzle, music, fighting, role-playing, strategy, sports, first-person shooter, side-scroller, and action genres. On average, music video gamers had generally started playing video games at age 7.55 (SD = 4.82) and had been playing for 19.55 years (SD = 5.61).

Eight of the 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 two participants played music games regularly (more than 1–2 h 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 gamers informally reported that they had not played for a few years, giving an approximate range of play from 1 to 7 years. All gamers reported playing the Rock Band game guitar, plus 12 reported playing using the bass, five reported playing on the drums, and five reported being able to play using vocals. According to their questionnaire responses, six participants reported being comfortable playing on the hard setting, and nine reported being comfortable on expert.

Controls The nonmusician, nongamer 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 h per week. Two participants reported having experience playing musical instruments for less than 3 years; neither was practicing regularly (more than an hour a week) at the time of the study, nor had they played within the past 5 years.

Stimuli and procedure

The following tests were performed in a fixed order, described below. An additional visual–spatial processing measure is described in the supplementary information. No other measures besides these were collected. Sound levels were adjusted individually to be at a comfortable level.

Rock band Rock Band 2 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 (see the supplementary information for more details). 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 sequencing skills to master. To establish the level of expertise and to measure differences between our music video gamers and the two other groups, all participants used the simplified practice mode to play 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"). This allowed us to obtain an accuracy score for each participant's performance on each song. In order to verify that the music video gamers weren't overstating their ability on the questionnaire, they had to reach accuracy on the "hard" song of 80 % to be included in the study.

Profile of music perception skills Each group was tested on a musical perception battery over Sennheiser EH2270 headphones. The Profile of Music Perception Skills (PROMS) task is a musical perception battery that objectively tests for musical skill and can be administered to individuals with or without music training (Law & Zentner, 2012). The brief PROMS consists of four subtasks (tuning, tempo, melody, and rhythm; see the supplementary information) in which participants make "same"-versus-"different" judgments between standard and comparison stimuli using the following response categories: *definitely same*, *probably same*, *probably different*, *definitely different*, and *I don't know*. The PROMS provides instructions and practice before presenting 18 trials of each subtask. The scores are recorded as total points out of 36.

Big five inventory All groups took a digitally administered Big Five Inventory (BFI; John, Naumann, & Soto, 2008) to determine whether people with certain personalities were more likely to be music video game players. The BFI scores participants on the Big 5 (or five-factor model) personality dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. The 44-item BFI presents prototypical components of the Big 5 dimensions, which were selected on the basis of large-sample factor analyses of junior college and public university students. Participants responded to items on a 1-to-5 (*strongly disagree* to *strongly agree*, respectively) Likert scale.

Results

Profile of music perception skills task

Figure 1 shows performance on the PROMS subtasks for each group of participants. To determine whether there were group differences in overall PROMS performance, a one-way ANOVA was conducted to compare the three groups (control, Rock Band gamer, and musician) on total PROMS scores. We found a significant main effect of group on total PROMS scores, $F(2, 42) = 6.92$, $p = .003$, $\eta_p^2 = .248$. Tukey's honestly significant difference comparison was performed to compare the differences between groups on total PROMS scores. As is shown in Fig. 1, both music video gamers and trained

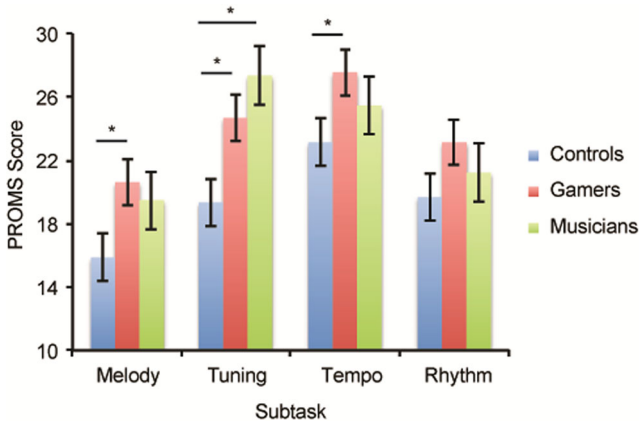

Fig. 1 Profile of Music Perception Skills (PROMS) scores for each group. Means (± *SE*s) are shown for each subtask. Asterisks signify differences between the groups spanned by horizontal lines, using Tukey's honestly significant difference comparisons

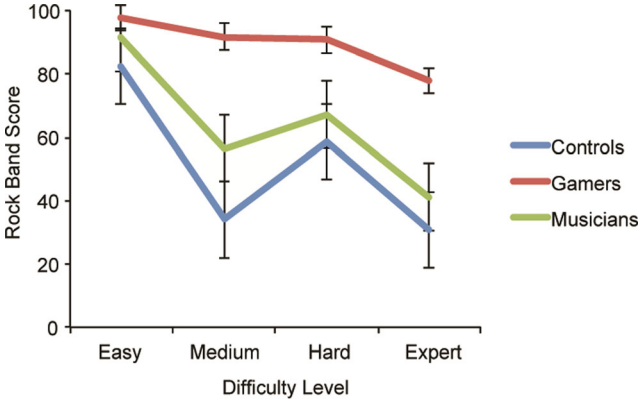

Fig. 2 Rock Band scores for each group. Means (± *SE*s) are shown for each difficulty level

musicians scored significantly higher than controls, but they did not differ from each other.

To determine whether group differences existed on any of the PROMS subtasks, four separate one-way ANOVAs were conducted (one for each PROMS subtask), using group as a between-subjects variable. Significant differences emerged between the groups across three of the PROMS subtasks: Melody, $F(2, 42) = 3.84$, $p = .029$ ($p = .066$ with gender as a covariate), $\eta_p^2 = .155$; Tuning, $F(2, 42) = 11.36$, $p < .001$, $\eta_p^2 = .351$; Tempo, $F(2, 42) = 3.97$, $p = .026$, $\eta_p^2 = .159$. As is shown in Fig. 1, for the Tuning task, both music video gamers and trained musicians scored significantly higher than controls but were not different from each other. In the Melody and Tempo subtasks, music video gamers scored significantly higher than controls, whereas trained musicians did not differ from either group. There were no significant differences between groups in the Rhythm subtask, $F(2, 42) = 2.54$, $p = .091$, $\eta_p^2 = .108$.

Rock band

Although we had verified that our gamer group could reach at least 80 % accuracy on the hard level, we also wanted to verify that music video gamers could outperform the other groups on this game. Figure 2 shows Rock Band scores for each of the difficulty levels. When Rock Band accuracy scores were collapsed across difficulty levels, a one-way ANOVA with group as a between-subjects variable revealed a main effect of group on accuracy scores, $F(2, 42) = 30.79$, $p < .001$. Tukey's honestly significant difference comparisons showed that the gamer group scored significantly higher than the musician group, who scored significantly higher than controls.

Big five inventory

A separate one-way ANOVA was conducted for each factor of the BFI (openness, conscientiousness, extraversion, agreeableness, and neuroticism). There were significant differences between groups for the factors of Neuroticism, $F(2, 42) = 5.01$, $p = .011$ ($p = .449$ with gender as a covariate), $\eta_p^2 = .192$, and Conscientiousness, $F(2, 42) = 3.78$, $p < .031$ ($p = .107$ with gender as a covariate), $\eta_p^2 = .153$ (see Fig. 3). Tukey's honestly significant difference comparisons indicated that music video gamers scored significantly lower on neuroticism than did the trained musicians, and that the controls were not significantly different from either group. Tukey's honestly significant difference comparisons indicated that music video gamers scored significantly lower on conscientiousness than did the trained musicians, and that the controls were not statistically significantly different from either group.

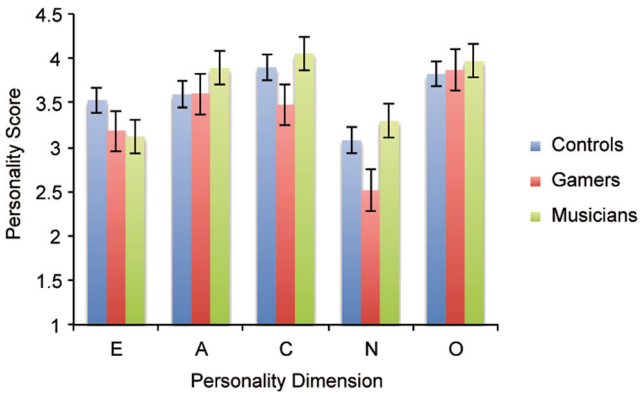

Fig. 3 Big Five Inventory dimension (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness) scores for each group. Means (± *SE*s) are shown for each dimension

Discussion

The present study is the first to our knowledge to show that—like musicians (Law & Zentner, 2012; Schneider et al., 2002)—people with experience playing music video games have better music listening skills than do people who do not play music video games or a musical instrument. There are at least four potential explanations for this result: (1) Playing music video games and taking music lessons causes enhanced musical aptitude; (2) musical aptitude causes individuals to take music lessons and to play video games; (3) a third, unrelated factor (such as personality) drives both music aptitude and choice of hobbies; or (4) differences in musical aptitude or auditory processing skills drive some individuals to select environments that promote better listening skills, creating a circular, cascading interaction between aptitude and experience.

To address the question of whether or not playing music video games causes enhancements in musical skills, or vice versa, future studies would need to randomly assign nonmusician, nongamer participants to practice music video games for a period of time. However, even if preexisting factors influence who chooses to play music video games, if music games can provide advantages comparable to those of formal musical training, this would have important implications. For example, music video games might provide an opportunity for enhancing listening skills among those who do not have the time, money, motivation, or discipline to learn to play a musical instrument.

Future studies should test individuals with a wider range of engagement with musical activities. In the present study, the gamers were only casually engaged in music video game playing, and for this reason we felt that nonprofessional, amateur musicians were the most appropriate comparison group (rather than professional musicians). Nevertheless, it is possible that at higher levels of engagement, these two groups might show larger differences in performance. Although we are not aware of any systematic comparisons of musical instrument training with video game playing, these two activities may entail different demands, with musical instrument expertise possibly requiring a greater amount of practice or finer sensory discriminations and motoric actions that are more challenging to master than music video games (cf. Hochstein & Ahissar, 2002). Given that practice may be related to the degree of expertise in domains such as music (Howe, Davidson, & Sloboda, 1998), it is possible that professionally trained musicians would show better listening skills than even the most ardent music video game players. Testing gamers with more intense music game experience could help establish the extent to which music-listening skills can be enhanced in the absence of formal music training.

It is also possible that unrelated factors lead some individuals to pursue experiences that influence musical aptitude. Individual differences in personality or motivation to practice may influence who chooses to engage in music training and who plays video games (Corrigall et al., 2013; Mosing et al., 2014). In our case, the gamers had personalities that contrasted with the typical personality profile for musicians, although this could be the result of gender differences between our groups. Relative to the general population, musicians tend to have higher openness to experience (Corrigall et al., 2013), whereas in the present study the gamers were less conscientious and less neurotic than musicians and controls. This finding is consistent with averages from a previous study of people who play World of Warcraft (3.46 for conscientiousness, 2.59 for neuroticism; cf. Fig. 3 of Graham & Gosling, 2013), a multiplayer role-playing fantasy game. Personality may also be related to music preference, which could influence who chooses music video games versus classical instrumental music. For example, one study showed that listening to classical music predicted higher levels of neuroticism (Dunn, de Ruyter, & Bouwhuis, 2012), whereas another study showed that higher levels of conscientiousness were related to music preferences for songs that were upbeat and conventional (Rentfrow & Gosling, 2003). Our findings may have implications for understanding how personality interacts with music training effects, because we observed similar enhancements of musical listening skills for musicians and gamers, despite their contrasting personality profiles.

Although preexisting differences can influence musical activity and abilities, it is also clear that auditory abilities and their underlying neural substrates are highly malleable due to experience (e.g., Alain et al., 2007; Lappe et al., 2008). Thus, it is likely that although differences in personality or preexisting perceptual abilities might lead some individuals to choose to learn a musical instrument or play music video games, the actual experience of practicing these activities is what leads to differences in music aptitude. Assuming that musical experiences such as learning an instrument or playing music video games directly enhance musical aptitude, our findings raise the question of what specific activities enhance music abilities. Controlled studies that randomly assign participants to engage in simpler forms of music-related training can help address this question, but such studies sacrifice ecological validity. A complementary approach would be to study an even wider range of populations with music-related expertise, including those who may have superior music-related skills despite not engaging in music-specific activities, such as people who speak tone languages (Bidelman, Hutka, & Moreno, 2013).

Our study is the first to suggest that music aptitude is higher among individuals who engage in informal music activities that do not involve playing a musical instrument, supporting the notion that such listening advantages are not limited to musicians who have the time and resources to pursue formal instruction. Although it is not clear which specific aspects of music video games might promote listening skills, both

musicians and gamers engage in extensive practice on auditory–motor tasks, and there is evidence that active motor engagement might be necessary for auditory neuroplasticity (Lappe et al., 2008). Thus, testing individuals who acquire musical expertise with different levels of intensive motor training (e.g., conductors, composers, audio engineers, or social dancers) would help determine which aspects of training, if any, are associated with an enhancement of music aptitude as a result of real-world musical experience. Another possibility is that attention and other aspects of executive function are related to musical listening expertise in both musicians and gamers, possibly as a consequence of training general cognitive skills (Dye, Green, & Bavelier, 2009; Pallesen et al., 2010). The present study raises many questions, but it marks a crucial first step toward developing a more nuanced understanding of how different types of engagement with music are related to perceptual and cognitive skills.

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