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Revisiting the association between music lessons and intelligence: Training effects or music aptitude?☆

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ABSTRACT

We examined whether the link between intelligence and musical expertise is better explained by formal music lessons or music aptitude. Musically trained and untrained adults completed tests of nonverbal intelligence (Raven's Advanced Progressive Matrices) and music aptitude (Musical Ear Test). They also provided information about their history of music lessons and socioeconomic status (SES). Duration of music training was associated positively with SES (mother's education), nonverbal intelligence, melody aptitude, and rhythm aptitude. Intelligence and music aptitude were also positively associated. The association between music training and intelligence remained evident after controlling for SES, but it disappeared after controlling for music aptitude. By contrast, music aptitude had a strong correlation with intelligence even after accounting for music training and SES. Thus, the association between music training and intelligence may arise because high-functioning individuals are more likely than other individuals to have good aptitude for music and to take music lessons.

1. Introduction

Musically trained children and adults score higher on intelligence tests than their untrained counterparts (dos Santos-Luiz, Mónico, Almeida, & Coimbra, 2016; Gibson, Folley, & Park, 2009; Gruhn, Galley, & Kluth, 2003; Schellenberg, 2011a, 2011b; Schellenberg & Mankarious, 2012; Trimmer & Cuddy, 2008). Moreover, as duration of training increases, so does intelligence (Corrigall & Schellenberg, 2015; Corrigall, Schellenberg, & Misura, 2013; Degé, Kubicek, & Schwarzer, 2011; Degé, Wehrum, Stark, & Schwarzer, 2014; Schellenberg, 2006). Because intelligence predicts educational achievement, occupational status, and success in dealing with the demands of daily life (e.g., Deary, Strand, Smith, & Fernandes, 2007; Gottfredson, 1997; Judge, Higgins, Thoresen, & Barrick, 1999; Spinath, Spinath, Harlaar, & Plomin, 2006), any experience that could potentially improve intelligence deserves careful study.

At present, however, there is widespread bias to interpret correlational data as evidence that music training *causes* improvements in nonmusical domains (e.g., Bugos & Mostafa, 2011; Kraus & Chandrasekaran, 2010; Skoe & Kraus, 2012; Strait & Kraus, 2011a, 2011b; Strait, Parbery-Clark, Hittner, & Kraus, 2012; Zuk, Benjamin, Kenyon, & Gaab, 2014). In other words, correlations are interpreted as evidence for far-transfer effects, such that music training is said to improve nonmusical cognitive capacities, such as intelligence, speech perception, auditory memory, or brain plasticity more generally (Herholz & Zatorre, 2012; Strait & Kraus, 2011a, 2011b; Wan & Schlaug, 2010). Although such "far-transfer" effects have been studied for over 100 years, it remains unclear whether such effects are actually possible (e.g., Brody, 1992; Jensen, 1969, 1998; Thorndike & Woodworth, 1901a, 1901b). For example, interventions designed specifically to improve working memory (Melby-Lervåg & Hulme, 2013; Rapport, Orban, Kofler, & Friedman, 2013; Shipstead, Hicks, & Engle, 2012; Weicker, Villringer, & Thöne-Otto, 2016) or academic performance (*Head Start*; Love, Chazan-Cohen, Raikes, & Brooks-Gunn, 2013) report variable or inconclusive results. Moreover, evidence that training in working memory has far-transfer effects (i.e., to reading, intelligence, arithmetic, etc.) is mixed (Melby-Lervåg, Reddick, & Hulme, 2016; Weicker et al., 2016). It is premature, then, to posit that music training would have effects on cognitive abilities when it is unclear whether interventions aimed directly at training such abilities are effective. Indeed, high-functioning individuals may be more likely than other individuals to take music lessons, or a third variable (or set of variables) may influence performance on intelligence tests *and* the likelihood of taking music lessons.

In the present correlational study, we sought to determine whether intelligence is better explained by music training or by music aptitude. If music training causes increases in intelligence (or other nonmusical abilities) that are independent of aptitude, such effects (1) should be observable as associations in correlational studies (unless the effect is miniscule and meaningless), and (2) remain evident (as partial

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associations) when music aptitude is held constant. Moreover, if music training *mediates* the association between aptitude and intelligence (aptitude → training → intelligence), neither hypothesis changes. In other words, although correlation does not imply causation, causation definitely implies correlation. Aptitude could also *moderate* the association between training and intelligence. For example, such an association could be stronger or evident only among participants with relatively high levels of music aptitude.

Some experimental evidence corroborates the notion that music lessons *cause* small improvements in IQ scores. For example, when Canadian 6-year-olds were assigned randomly to 1 year of music lessons (keyboard or vocal) or to control conditions (drama lessons or no lessons; Schellenberg, 2004), pre- to post-test improvements in IQ were larger for the music groups than for the control groups. When Iranian preschoolers were assigned to 3 months of weekly music lessons or no lessons (Kaviani, Mirbaha, Pournaseh, & Sagan, 2014), only the children in the music group exhibited pre- to post-test gains in IQ. In a study of at-risk Israeli children, benefits in nonverbal intelligence were greater for children who attended after-school centers with an intensive music intervention, compared to children at a center without the intervention (Portowitz, Lichtenstein, Egorova, & Brand, 2009). Although replication across cultures is reassuring, the use of *passive* control groups (no intervention of any sort) in the Iranian and Israeli studies makes it impossible to attribute group differences to "music" rather than other aspects of the interventions. In short, unequivocal causal evidence comes from a single study. Moreover, the magnitude of the association between music training and IQ tends to be much larger in real-world (correlational) studies (dos Santos-Luiz et al., 2016; Gibson et al., 2009; Hille, Gust, Bitz, & Kammer, 2011; Schellenberg, 2011a), even when the training is only 1 or 2 years in duration (Schellenberg & Mankarious, 2012), which implicates a role for other environmental variables, or for pre-existing differences.

Positive results are further belied by mixed or null findings (e.g., François, Chobert, Besson, & Schön, 2013; Moreno et al., 2009). For example, when preschool children were assigned randomly to 6 weeks of group music lessons or no lessons at all, there was no advantage in cognitive abilities for the music group (Mehr, Schachner, Katz, & Spelke, 2013). Even correlational studies sometimes report null findings, although these could stem from small sample sizes (e.g. Corrigall & Trainor, 2011; Parbery-Clark, Strait, Anderson, Hittner, & Kraus, 2011; Strait et al., 2012). Null findings are particularly likely when real musicians (e.g., graduate students in music, professional musicians) are compared to other groups with a similar amount of formal education in a field other than music (e.g., graduate students in psychology, law, or physics; Brandler & Rammsayer, 2003; Helmbold, Rammsayer, & Altenmüller, 2005; Rammsayer, Buttkus, & Altenmüller, 2012). Thus, music lessons may be a marker of cognitive ability primarily among individuals who do *not* become musicians.

Other findings reveal that genetic factors influence the propensity to practice music, as well as associations between music practice and intelligence (Mosing, Madison, Pedersen, & Ullén, 2016; Mosing, Pedersen, Madison, & Ullén, 2014), music aptitude (Mosing, Madison, Pedersen, Kuja-Halkola, & Ullén, 2014), and personality (Butkovic, Ullén, & Mosing, 2015). Music training is also correlated positively with the personality trait called *openness-to-experience* (Corrigall & Schellenberg, 2015; Corrigall et al., 2013). Individuals who are interested in learning new things (including but not limited to music) may be more likely than other individuals to take music lessons. Openness is also the personality trait that has the strongest association with intelligence (e.g., Chamorro-Premuzic & Furnham, 2008; Harris, 2004).

It is well documented that music aptitude is correlated positively with taking music lessons *and* with intelligence (for review see Schellenberg & Weiss, 2013). Aptitude is typically measured using tests of pitch and rhythm perception that require same/different judgments (Gordon, 1965; Seashore, Lewis, & Saetveit, 1960). On each trial, the listener decides whether a standard sequence (presented first) is the same as a comparison sequence (presented second). On different trials, one event in the sequence (e.g., a tone or a drum beat) is altered in pitch or time. Aptitude is considered to be a measure of natural musical ability, which predicts how successful an individual will be in musical activities. Although associations between music training and music aptitude are used to validate aptitude tests (e.g., Law & Zentner, 2012; Wallentin, Nielsen, Friis-Olivarius, Vuust, & Vuust, 2010), the causal direction is unclear, and music aptitude is also a marker of intelligence in typically developing populations. In sum, associations between music training and general cognitive ability could stem primarily from pre-existing individual differences in musical ability, general cognitive ability, or personality.

In the present study, we predicted that the association between music lessons and intelligence would be explained, at least in part, by music aptitude. The distinction between aptitude and training is inherently problematic, however, because individuals with high levels of aptitude would be likely to seek out music training, which could, in turn, improve their performance on tests of music aptitude—a classic gene-environment interaction (e.g. Hambrick & Tucker-Drob, 2015; Schellenberg, 2015; Ullén, Hambrick, & Mosing, 2015). When music training *and* aptitude are measured, however, the problem is mitigated. For example, when music training is held constant, performance on a test of aptitude becomes a purer measure of pre-existing musical propensities, at least in principle if the measures accurately represent the underlying constructs. With music aptitude held constant, music training is a measure of skills and abilities *other* than basic music perception, which are acquired through training and could lead to enhanced performance in nonmusical domains, including intelligence.

2. Method

2.1. Participants

Participants were 133 undergraduate students (65 women; mean age 19.1 years, $SD = 2.2$) recruited from an introductory psychology course such that they were musically trained or untrained. Trained participants ($n = 62$, 47 women) had at least 5 years ($M = 13.91$, $SD = 7.37$) of formal music lessons taken outside of school, primarily one-on-one lessons that included instrumental training. For participants who reported training on more than one instrument, years of training were summed across instruments. Untrained participants ($n = 71$, 53 women) had *no* music training outside of school. The testing session lasted up to 90 min and participants received either $15 or $5 plus partial course credit.

Although we intended initially to treat music training as a dichotomous variable in the analyses (≥5 years vs no training), we opted to treat music training as a *continuous* variable because this approach maximized the association with nonverbal intelligence, which, in turn, made tests of the partial association between music aptitude and intelligence (i.e., with training held constant) more conservative. Responses patterns were the same, however, when music training was treated as a dichotomous variable, or as the sum of years of private *and* school-based lessons.

2.2. Measures

2.2.1. Socioeconomic status

Socioeconomic status (SES) is often associated positively with duration of music training and intelligence (e.g., Corrigall et al., 2013). Accordingly, participants were asked to provide information about their family income and their parents' education. As in previous research (Corrigall & Schellenberg, 2015; Corrigall et al., 2013; Schellenberg, 2006, 2011a, 2011b), annual family income was measured in increments of $25,000 ranging from 1 (<$25,000) to 9 (>$200,000), whereas both parents' highest level of education was measured on a scale ranging from 1 (did not complete high school) to 8 (graduate degree). The

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