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Does listening to music increase your ability to discriminate musical sounds?

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ABSTRACT

Music listening plays an important role in the daily lives of many. It remains unclear what explains variation in how much time people spend listening to music and whether music listening improves musical auditory discrimination skills. In 10,780 Swedish twin individuals, data were available on hours of music listening, musical engagement and musical auditory discrimination. Genetic and shared environmental factors together explain half of the variation in music listening in both sexes. Hours of music listening was positively associated with musical auditory discrimination in both sexes and this effect was independent of whether individuals played a musical instrument. However, the effect disappeared when applying a co-twin control analysis to control for genetic and shared environmental confounding. These findings suggest that music listening may not causally improve musical auditory discrimination skills, but rather that the association is likely due to shared familial factors.

1. Introduction

There is large variation in how much time people spend listening to music. While some listen to music daily (e.g., while commuting, exercising or even during work), others easily get through the day without listening to music. Research shows that while the intensity of music listening increases with age up to adolescence and then decreases in later adulthood (Schäfer & Sedlmeier, 2010), personality and sex have little effect on the amount people listen to music, although small differences in genre preferences between the sexes have been reported (North & Hargreaves, 2008; Schäfer & Mehlhorn, 2017). In a recent meta-analysis, Schäfer and Mehlhorn (2017) proposed that underlying reasons for why individuals listen to music explain individual differences in listening to music, namely 1) to regulate arousal and mood, 2) to achieve self-awareness and/or 3) as an expression of social relatedness.

Although many studies investigated the effect of music listening on behavioral outcomes, such as stress, anxiety or pain (see for review: Kim & Stegemann, 2016) and cognitive abilities and IQ (Jaschke, Honing, & Scherder, 2018; Schellenberg & Weiss, 2013), little is known about whether there is a beneficial influence of music listening on musical auditory discrimination skills, possibly caused by implicit learning processes (Frensch & Rünger, 2003). To our knowledge, only one study investigated effects of exposure to music on musical competence, finding that expressive timing judgments are more likely to be enhanced by active listening than by formal musical training (Honing & Ladinig, 2009). However, this study was based on non-genetically informative data and another explanation for the finding could be that individuals with higher musical competence may enjoy listening to music more.

In this study, we examine in a large cohort of Swedish twins, using classical twin modelling, the relative importance of genetic and environmental influence on the hours individuals listen to music (Verweij, Mosing, Zietsch, & Medland, 2012). Secondly, we test whether music listening has an effect on musical auditory discrimination, and, if so, whether this effect remains significant while adjusting for genetic and shared familial confounding (co-twin control modelling (McGue, Osler, & Christensen, 2010)), in line with a causal hypothesis (e.g., an implicit learning effect).

2. Methods

2.1. Participants

Data on music listening and musical auditory discrimination were collected in 11,543 twin individuals in the Study of Twin Adults: Genes

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and Environment (STAGE) cohort of the Swedish Twin Registry (STR) in 2012–2013 (Lichtenstein et al., 2002; Lichtenstein et al., 2006). Of those, 10,780 individuals reported on hours of music listening, of which 6700 also completed the musical auditory discrimination test. Furthermore, of the 10,780 individuals that reported on their music listening behavior, 7784 reported to have played music at some point in their life, while 2990 were never involved in music. For the genetic analyses we had data on music listening available for 2571 complete twin pairs: 430 monozygotic male (MZm), 781 monozygotic female (MZf), 280 dizygotic male (DZm), 440 dizygotic female (DZf) and 640 dizygotic opposite-sex (DOS) pairs and 5299 single twins without the co-twin participating. Data from singletons contribute to the estimation of means, variances and covariances. The participants were aged between 27 and 54 years (M = 40.7, SD = 7.7). See Mosing, Madison, Pedersen, Kuja-Halkola, and Ullen (2014) for a more detailed description of the data collection. The study "Den musicerande människan - kultur och arv i samspel" was approved by the Regional Ethics Review Board in Stockholm (Dnr 2011/570-31/5, with Dnr 2012/1107/32 being an amendment to that project).

2.2. Measures

Hours of music listening. Individuals were asked how many hours per week they listened to music on average during four age intervals (ages 0–5, 6–11, 12–17 and 18 years until time of measurement). We calculated the mean of these answers representing a proxy of the number of hours people listened to music weekly throughout their life.

Musical engagement. Participants were asked whether they ever played an instrument (or sang) to differentiate between those individuals who (ever) actively engaged with music versus those who only engaged passively (i.e. listening only).

Musical auditory discrimination. Musical auditory discrimination was measured using the Swedish Musical Discrimination Test (SMDT) (Ullén, Mosing, Holm, Eriksson, & Madison, 2014). The SMDT measures three components of musical auditory discrimination, namely pitch, melody and rhythm discrimination. A mean score of the three standardized subtest scores was calculated. The overall musical auditory discrimination score was normally distributed without outliers. For a more detailed description and psychometric validation of the SMDT see Ullén et al. (2014).

All measures were standardized.

2.3. Statistical analyses

Classical twin modelling was performed using structural equation modelling in OpenMx in R (Boker et al., 2011). First, we fitted a saturated model to estimate sex and zygosity specific means and correlations. We proceeded with a genetic structural equation model, in which we can partition the variation in the hours of music listening into additive genetic (A), familial common environmental (C), and non-shared environmental (E) components. Since MZ twins share ~100% of their segregating genes, while DZ twins share on average 50% of their genes, one can conclude that genetic factors are relevant when the within twin-pair correlations are higher in MZ than in DZ twins. If the DZ correlations are more than half of the MZ twin correlations it is implied that common environmental influences are of importance. The remaining part of the variance is attributed to unique environmental influences and includes idiosyncratic effects and measurement error. We fitted a sex-specific ACE model to estimate genetic and environmental effects on variation in music listening while allowing for qualitative sex differences (i.e. different genes operating in males and females) due to the large difference observed between the dizygotic opposite-sex and dizygotic same-sex twin correlations.

Regression analyses were performed to estimate the effect of hours of music listening on musical auditory discrimination, while adjusting for sex and age. Additionally, we performed linear regression analyses on the three subtests of the musical auditory discrimination test, i.e. the rhythm, melody and pitch discrimination scores. Lastly, we repeated all analyses separately in individuals who were never involved in music, to make sure that the music listening measure is truly passive and not confounded with music making (e.g. active listening to a piece with the intention to play it later). To correct for relatedness of the twins, we used the robust standard error estimator for clustered observations in STATA.

Co-twin control analyses in identical twins were conducted to follow-up on the regression analyses and to explore whether the association between hours of music listening and musical auditory discrimination remains significant when controlling for shared genetic and shared environmental factors (e.g., a musically enriched childhood environment). Monozygotic twins are genetically identical and share their family environment, therefore, exploring within-pair effects in identical twins shows the association free from familial confounding (McGue et al., 2010). If more hours of music listening would cause higher levels of musical auditory discrimination, we would expect the MZ twin that listened more hours to music to score significantly higher on musical auditory discrimination. Within-pair linear regression analyses, allowing us to adjust for all factors shared within identical twins (genetics and shared common environment), with hours of music listening as independent and musical auditory discrimination as dependent variable were conducted using the *xtreg fe* statement in STATA, a function that offers the possibility to stratify by twin pair. Only complete MZ twin pairs discordant in hours of music listening and their level of musical auditory discrimination contribute to these within-pair analyses (McGue et al., 2010). Correcting for sex and age is not necessary as each MZ twin is matched to his or her co-twin who shares the same sex and age.

3. Results

3.1. Genetic and environmental influences

Average hours of music listening per week was 4.87 ± 1.56 (mean ± SD) for males, and 5.25 ± 1.62 for females. Raw correlations between music listening and musical auditory discrimination were $r = 0.14$ for males, and $r = 0.08$ for females (both $p < .001$, the difference between the sexes was non-significant, χ^2 0.23 (2), $p = .89$). Within twin-pair correlations in male and female MZ, DZ and DOS twins as well as genetic and environmental influences on music listening for males and females obtained from the ACE model are presented in Table 1.

Table 1
Twin modelling results for hours of music listening. Twin correlations and the sex-specific genetic and environmental estimates from the ACE model are shown with 95% confidence intervals in parentheses.

	Hours of music listening
Twin correlations	
Monozygotic males	0.49 (0.41–0.55)
Dizygotic males	0.26 (0.13–0.37)
Monozygotic females	0.39 (0.33–0.44)
Dizygotic females	0.31(0.22–0.38)
Dizygotic opposite-sex	0.12 (0.04–0.20)

Genetic and environmental factors		
	Males	Females
A	46% (20–55%)	16% (0–36%)
C	3% (0–26%)	23% (1–39%)
E	51% (45–59%)	61% (55–67%)

3.2. The association between listening to music and musical auditory discrimination

While correcting for sex and age, the number of hours individuals listen to music significantly predicted the level of musical auditory discrimination ($\beta = 0.10$, $p < .001$). Further analyses showed that hours of music listening correlated with all SMDT subscales, i.e. pitch ($\beta = 0.07, p < .001$), melody ($\beta = 0.09$, $p < .001$) as well as rhythm discrimination ($\beta = 0.07$, $p < .001$).

When exploring the effect of music listening further, we found that the significant effect of hours of music listening on musical ability holds for both individuals that played music ($\beta = 0.07$, $p < .001$), as for individuals that never played ($\beta = 0.05, p < .01$).

The within-pair linear regression analyses within MZ twins showed no significant effects of hours of music listening on overall musical auditory discrimination, with a smaller beta value ($\beta = 0.01, p = .79$). The same holds for the effect within MZ twins of music listening on the individual subscales, i.e. pitch ($\beta = 0.02, p = .50$), melody ($\beta = -0.03, p = .33$), or rhythm discrimination ($\beta = 0.02, p = .51$).

4. Discussion

We aimed to study to what extent genetic and environmental influences explain why people differ in music listening, whether there is a potential beneficial effect of music listening on musical auditory discrimination, and whether this association could be causal.

We found genetic influences to be important for music listening behavior in both sexes, which would be in line with the hypothesis by Schäfer and Mehlhorn (2017) that underlying physiological processes regulating arousal and mood (possibly modulated by dopaminergic pathways) can explain individual differences in music listening. Furthermore, shared environmental influences, e.g. a musically enriched childhood environment, are also important for individual differences in music listening, particularly in females. A possible explanation for these sex differences in the effect of the shared environment on music listening could be that girls are more often than boys encouraged to engage in arts and music (including music listening) by their family environment.

In both sexes, music listening was significantly associated with musical auditory discrimination, as well as with the separate pitch, melody and rhythm discrimination components. Interestingly, the effect of music listening on musical auditory discrimination is also present in individuals who never played a musical instrument, suggesting that the association is not driven by presumably more active listening (e.g. with the intention to learn a piece to perform), that one would expect in active performers, but rather by music listening in general. However, we found that when controlling for familial liability (shared genetics or shared common environment) the effect disappeared. Therefore, the observed association between music listening and auditory discrimination is likely not explained by implicit learning effects, but rather by shared familial effects explaining both, individual differences in music listening and auditory discrimination.

This study has some limitations. First, hours of listening to music was based on self-report data. Although this could introduce a bias, it is unlikely that this would affect the association with musical auditory discrimination as measured here (i.e. using an objective aptitude test). Second, although the association between music listening and musical auditory discrimination was significant, it was rather small (correlation of 0.14 for males and 0.08 for females). Therefore, we were unable to disentangle the shared familial effects (shared genetics or shared common environment) further and derive estimates of the effects of genetic and shared-environmental influences on the association between music listening and musical auditory discrimination. Furthermore, we would like to emphasize that we used a musical discrimination test, in which participants could adjust the volume of the presented stimuli to a comfortable level before testing, to make sure that the test measured tone discrimination, and not the ability to hear. Lastly, we studied voluntarily internally motivated music listening as opposed to imposed music listening based on some sort of music interventions, which could have a differential effect on musical aptitude. Future research could investigate the association between music interventions and musical auditory discrimination. The strength of this study is that the large population-based twin sample allowed us to not only investigate the phenotypic association between listening and auditory discrimination, but also to estimate genetic and environmental influences on music listening behavior, and to explore the associations between music listening and musical auditory discrimination when taking genetic and familial confounding into account to test whether this association could be causal.

In conclusion, half of the variation on hours of music listening is explained by familial factors in both sexes. Although, music listening predicts higher musical auditory discrimination, the effect is likely due to familial factors rather than to a causal effect of music listening. Future research should investigate whether musical auditory discrimination is reflected in genre preferences, e.g. with those with higher musical competence listening to more structurally complex and demanding pieces of music.

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CRediT authorship contribution statement

Laura W. Wesseldijk: Conceptualization, Investigation, Formal analysis, Writing - original draft. **Fredrik Ullén:** Conceptualization, Supervision, Writing - review & editing. **Miriam A. Mosing:** Conceptualization, Investigation, Writing - original draft.

Declaration of competing interest

The authors declare no conflicts of interest with respect to the authorship or the publication of this article.

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The datasets generated and/or analyzed in the current study are not publicly available as nationwide registry data were used, but are available from the respective registries on request.

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