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Intelligence and Music: Lower Intelligent Quotient Is Associated With Higher Use of Music for Experiencing Strong Sensations

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Abstract

Intelligence is a key psychological feature associated to emotion and perception. Listening to music is often linked to emotional experience and sensation seeking (SS), traits that have been shown overall negatively correlated with intelligence. In a sample of 53 musicians and 54 non-musicians, we assessed the use of music for experiencing strong emotions through the Music in Mood Regulation (MMR) and the intelligence quotient (IQ) by using the Wechsler Adult Intelligence Scale III (WAIS-III). We found a negative correlation between the full IQ score and the use of music for SS in both musician and non-musician groups. Furthermore, the use of music for SS was negatively correlated with Verbal IQ in musicians, and with Performance IQ in non-musicians. Our findings indicate that less intelligent individuals make a higher use

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of music for experiencing strong sensations than more intelligent ones. Furthermore, this association is modulated by the individual musical expertise.

Keywords
intelligence, high sensation seeking, music usage, Wechsler Adult Intelligence Scale (WAIS), Wechsler Adult Intelligence Scale (WAIS), Music in Mood Regulation (MMR), emotion

Intelligence is a psychological construct that can be defined as the ability to solve problems, perceive information, learn from experience and select adaptive behaviors (Sternberg, 2012). Overall, intelligence has been studied from different perspectives, leading to diverse theories. For example, an important contribution comes from Spearman and Wechsler who proposed intelligence as a quantifiable measure of cognitive processes such as logic reasoning, executive functions, memory and spatial abilities. These processes can be described by general factors named *g* and intelligent quotient (IQ) (Deary et al., 2010) and are usually conveyed into the definition of 'fluid intelligence' (Cattell, 1963), which is the intelligence construct that we considered in our study and measured by the Wechsler Adults Intelligence Scale III (WAIS-III). Another contribution was provided by Gardner, proposing that intelligence is not unitary but rather comprises different categories, such as linguistic, musical and interpersonal (Gardner, 2006). Moreover, Mayer et al. (2008) argue that emotional intelligence has a primary role in the individuals' lives and is defined as the ability to engage in complex information processing about one's own and others' emotions to guide thoughts and behaviours. Previous literature has shown several examples of intelligence affecting and modulating individual behavior, emotion and perception (Barry, 1997; Sternberg, 2000). For example, Sygit-Kowalkowska et al. (2015) show a positive correlation between the level of emotional intelligence and pro-health behaviour such as observance of healthy diet and regular physical exercise in adult participants.

Emotions and their regulation represent another key area in psychological science. Previous research has established several theories and models about emotional functioning, highlighting the emotional sphere as one of the fundamental dimensions in both individual and social lives (Smith-Lovin et al., 1995). Furthermore, Smith-Lovine et al.(1995) underline individual differences in emotional regulation and associated behaviors according to personality traits, cultures and past experience. A further relevant topic connected to emotional experience is the individual inclination towards perceiving strong sensations. Sensation seeking is defined by the search for feelings and experiences considered novel, intense and varied and by the acceptance of potential risks in social, physical, legal and financial domains being necessary for reaching the pursued experience (Leary & Hoyle, 2009). It is measured by evaluating the individual differences in terms of sensory stimulation preferences. A person is defined high sensation seeker when externalizes a great desire for sensations and requires a lot of stimulation to achieve the optimal level of arousal (Zuckerman & Marvin, 2009). A high sensation seeker can be more vulnerable to engage both in adaptive and mal-adaptive behaviors such as gambling or substance abuse (Puente et al., 2008). Moreover, the sensation seeking trait can be also attributed to extrovert and impulsive individuals. Indeed, Eysenck (1990) incorporated sensation seeking as a primary trait inherit to extraversion.

Research into the relationship between intelligence, extraversion and sensation-stimulation seeking has shown controversial results. Cheung et al. (2017) investigated the influence of emotional intelligence on sensation-seeking in university students, highlighting how the use of emotions and emotion regulation techniques induced actions aimed as seeking novel sensations. Moreover, Raine et al. (2002) highlighted a positive correlation between stimulation seeking and intelligence in groups of children aged 3 and 11 years. Starting from the work by Ackerman and Heggestad (1997) that depicted a positive relation between extraversion and intelligence, Wolf and Ackerman (2005) performed an updated meta-analysis, showing that different studies presented different results and highlighting that the overall relation between extraversion and intelligence seemed to be negatively correlated. Indeed, the research by Roberts (2002) shows a fragile connection between extraversion and intelligence test score in a sample of university students. Furthermore, Moutafi et al. (2005) analyzed the association between some personality traits and intelligence, finding the trait of extraversion being a negative predictor of general intelligence (g) and numerical, verbal and abstract reasoning. Other literature indicates that high-sensation seeking can be a risk factor for delinquent impulsive behaviors (Hansen & Breivik, 2001; Zuckerman, 2007) that are usually unrelated or negatively correlated to intelligence (Hirschi & Hindelang, 1977). In conclusion, previous literature suggested that intelligence and sensation-seeking are connected, even if the controversial findings reported so far made difficult to frame that relationship within a clear psychological theory. Therefore, in this study we expected to detect such relationship and we aimed to provide additional evidence on the topic as well as partially clarify the controversial results reported by previous literature.

Due to its complexity and logical structures, music is able to enhance different emotional states (Sloboda & O'Neiil, 2001). This may be specially interesting and useful to deepen the knowledge about the relationship between human cognitive abilities and emotional experience. Music works through several variables along acoustic and semantic domains that, through various combinations, are able to express different emotions and sensations (Gabrielsson, 2011; Juslin & Sloboda, 2013). For instance, previous literature has shown that fast tempo and major musical mode enhance a sense of happiness while slow tempo and minor musical mode express sadness (Bonetti & Costa, 2017a; Brattico et al., 2011; Dalla Bella et al., 2001a; Nieminen et al., 2012; Pallesen et al., 2003). However, it is important to highlight that these results came by using Western music and a Western sample of participants.

People use music for various purposes, such as emotional experience, social engagement and aesthetic pleasure (Rentfrow & Gosling, 2003; Saarikallio et al., 2013). Particularly, previous literature has produced that individual differences are able to drive preferences and uses of music. For example, Rentfrow and Gosling (2003) argue that participants with higher tendency to openness to experience exhibit a preference for a more reflective and aesthetic use of music, while people who report higher level of neuroticism when experiencing negative circumstances tend to utilize sad music for emotional regulation (Van Den Tol & Edwards, 2013). Another study (Taruffi & Koelsch, 2014) shows that listening to sad music evokes four different kinds of reward: reward of imagination, emotion regulation, empathy, and no "real-life" implications. Reward of imagination derives from undertaking imaginative processes. Emotion regulation reward is the attainment of various self-regulatory goals, such as mood enhancement and releasing. Reward of empathy is the pleasurable effects connected with sharing the sadness reflected in the music as expressed by the composer. Finally, the no "real-life" implications lead the listeners to be delighted from sad music and understand its emotional aspects without necessarily feeling negative "real-life" consequences. The authors also suggest that the appreciation of sad music is mood-congruent and stronger among individuals with high empathy and low emotional stability. Summarizing, Taruffi and Koelsch propose that listening to sad music can lead to benefits in terms of negative emotion regulation and consolation. Miranda and Claes (2009) suggest that music listening coping strategies are able to affect depression level of adolescences, describing differences according to the gender of the participants. Another relevant variable affecting the use of music and processing of music-related emotions is the musical expertise of individuals. Kantor-Martynuska and Horabik (2015), for instance, argue that musicians exhibit a higher recognition of emotions induced by music than non-musicians, while Kreutz et al. (2008) propose that individuals with higher musical expertise utilize music for more reflective and aesthetic purposes. Müller et al. (2010) found that, when asked to judge the beauty of unfamiliar musical sequences, musicians' affect-related brain responses were weaker than those of non-musicians. However, another study (Brattico et al., 2015) presented functional differences in the limbic system connected with musical expertise. Specifically, the authors showed enhanced liking-related activity to affective listening for familiar song excerpts in fronto-insular and cingulate areas in musicians as opposed to non-musicians.

Other studies have highlighted the central role of music in emotional regulation and its role as a protector or a risk factor for psychological disorders. For example, Thomson et al. (2014) propose that music-related mood regulation is a predictor of psychopathology, such as depression, anxiety and stress. However, the authors state that, at the same time, the use of music for emotional regulation purposes might also reduce psychopathology symptoms. In another study, Carlson et al. (2015) have shown that some uses of music may not only be affected by psychological individual differences, but also produce negative effects on mental health. In their study, exploring the self-directed use of music for mood regulation, they found that using music to express negative emotions was related to increased anxiety and neuroticism in all participants, particularly in males.

A link between music perception, use of music and intelligence can be deducted from the previous literature. Firstly, Chamorro-Premuzic and Furnham (2007) discovered several connections between individual psychological differences and various uses of music in everyday life. They show that open and more intelligent people were likely to use music in a cognitive way, in terms of rational processing and appreciation of music. Specifically, authors described this usage of music as focusing on the performers, considering the quality of the interpretation and examining the structure of the composition more than simply experience the emotional engagement. On the contrary, people who were introverted, neurotic and non-conscientious tended to use music for emotional regulation and to change or enhance moods. However, in the study by Schäfer and Mehlhorn (2017) is underlined how individual differences, specifically referred to personality traits, do not correlated with music style preferences. Other research also proposes musical training as able to enhance the level of non-music-related cognitive abilities. Schellenberg (2004) and Moreno et al. (2011), for example, demonstrated that exposure to medium- to long-term musical training is able to significantly enhance the IQ level of the participants. Other recent studies highlight a relationship between music perception and cognitive abilities. Bonetti and Costa (2016) propose a link between preference for minor musical mode and level of intelligence, while Bonetti and Costa (2017a) argue that the level of intelligence is a predictor of children's capacity of making visual-auditory cross-modal associations. Furthermore, Bonetti et al. (2018) report associations between working memory, a cognitive ability strongly connected to the general fluid intelligence, and the automatic brain discrimination of auditory deviants inserted in a musical context.

Aims, Research Questions and Hypotheses

The current study aims to explore the relationship between fluid intelligence and strong emotional experience in music usage. Specifically, we focus on the strong emotion-seeking related to music since music is one of the human arts able to convey strong emotions (Gabrielsson, 2011; Juslin & Sloboda, 2013), and it is widely used for emotional regulation, especially by neurotic, stressed individuals and by non-musicians (Chamorro-Premuzic & Furnham, 2007; Getz et al., 2014). Since previous literature that explored the relationship between intelligence and general sensation seeking showed few and controversial results, here we explored that relationship, hypothesizing a lower use of music to achieve strong emotional experience in individuals characterized by a higher level of fluid intelligence as measured by WAIS-III as compared to others with low fluid intelligence. Furthermore, since previous literature showed the role of music expertise in daily music usage and perception, we also contrasted the results obtained for musicians and non-musicians.

Methods and Materials

Ethics

All of the experimental procedures have been approved by the Coordinating Ethics Committee of the Hospital District of Helsinki and Uusimaa (approval number: 315/13/03/00/11, obtained on March the 11th, 2012) and developed in agreement with the ethical principles of Declaration of Helsinki. Moreover, before starting the experiment we collected the signed informed consent for each participant.

Participants

We utilized a subset of data previously collected for the Tunteet protocol, involving a series of paradigms and measures aimed at collecting a multimodal dataset aiming at testing a series of distinct hypotheses (Bonetti et al., 2018; Bonetti, Haumann, Vuust, et al., 2017; Carlson et al., 2015; Criscuolo et al., 2019; Kliuchko et al., 2018). The first findings obtained from this dataset were published in Carlson et al. (2015). The dataset included 107 participants, 46 males (42.99%) and 61 females (57.01%), who were divided into two groups according to their musical expertise, resulting in 53 musicians (both professionals and amateurs) and 54 non-musicians. One-hundred and seven corresponds to the number of participants that were administered the psychological tests used in this study. Musicians had received a thorough musical education focused on learning one or more instruments, while non-musicians had not been exposed to musical training outside the school curriculum. According to the *three components model* of the musician definition by Zhang et al. (2020), a musician can be defined either by musical skills such as engagement in music training or ability to play an instrument, by the self-evaluation of himself/herself as musician or by the predisposition towards musical ability. Coherently with this study, our participants were considered musicians when they followed professional music courses and self-evaluated themselves as musicians. Table 1 shows mean ages and length of musical training for the two groups. The volunteer participants were compensated for the time spent in the experiment with

Table 1. Mean Ages of Participants and Musical Training for Musicians and Non-Musicians.

Group	Mean age of participants (years)	Mean length of musical training (years)	Sex (M/F)	Intelligence Quotient (IQ)
Musicians	28.61 ± 8.15	10.54 ± 7.77	24/29	119.49 ± 7.84
Non-musicians	28.43 ± 8.68	0.62 ± 1.25	22/32	116.69 ± 7.85

vouchers useful for sport and cultural purposes (e.g., museums, swimming pool). All participants declared themselves to be healthy, not under any kind of medication and to have normal hearing. Moreover, participants had no history of neurological or psychiatric disorders.

Music in Mood Regulation (MMR)

In our study, we chose the Music in Mood Regulation (MMR) questionnaire for assessing the role of music for everyday needs of self-regulating transient mood. This questionnaire, created by Saarikallio (2008) on the basis of an earlier study (Saarikallio & Erkkila, 2007), has been found reliable and valid in both its long and short versions (Saarikallio, 2008, 2012; Saarikallio et al., 2013). The MMR consists of a 40-item scale divided into seven different sub-scales (Cronbach's alpha for scale reliability is provided in parenthesis): 1) Entertainment (.96); 2) Revival (.86); 3) Strong Sensation (.86); 4) Diversion (.77); 5) Discharge (.92); 6) Mental Work (.85); 7) Solace (.91). Each item of each subscale consists of a 5-point Likert-scale ranging from *Strongly agree* to *Strongly disagree*. In our study, we focused mainly on the Strong Sensation subscale, which measures the use of music for inducing and strengthening intense emotional experiences, although we also report results for the other subscales of the MMR (Saarikallio, 2008, 2012). The Strong Sensation subscale of MMR consists of seven items (e.g. *Music has offered me magnificent experiences; I want to feel the music in my whole body; I want to listen to music that evokes feelings in me*) which are answered on a Likert scale ranging from *Strongly disagree* to *Strongly agree*.

Wechsler Adult Intelligence Scale III (WAIS-III)

The WAIS-III is one of the most frequently used scales for evaluating general intelligence (Lange et al., 2006; Wechsler, 1997), intended as the set of cognitive abilities needed to solve especially visuo-spatial and logical-mathematical problems. Even though there are currently newer versions of WAIS test, at the time of ideation of the experimental protocol, the WAIS-III represented the best available tool to assess fluid intelligence. Moreover, several studies showed its similarity and consistency with the following version (WAIS IV) (for example see Holdnack et al., 2011). WAIS-III provides scores for full IQ as well as for verbal

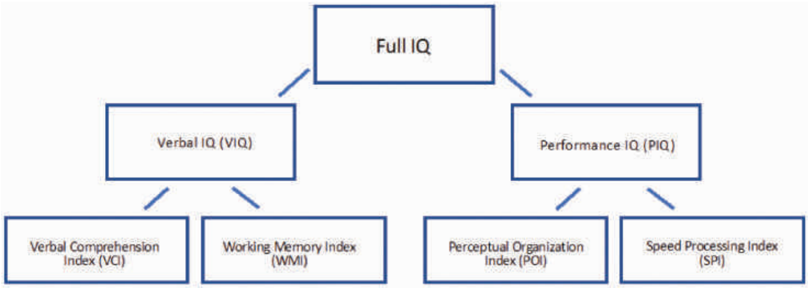

Figure 1. Hierarchical Structure of WAIS-III Principal Subscales and Indices.

and performance IQs (Wechsler, 1997). It also comprises four secondary indices called Verbal Comprehension, Working Memory, Perceptual Organization, Processing Speed and 12 subscales (Vocabulary, Similarities, Information, Comprehension, Arithmetic, Digit Span, Letter-Number Sequencing, Picture Completion, Block Design, Matrix Reasoning, Digit Symbol-Coding, Symbol Search) that have been widely shown reliable, valid and consistent within themselves and with regards to other cognitive tests (Silva, 2008). All subscales and indices are organized in a hierarchical order depicted in Figure 1.

Procedure

Participants filled in the Music in Mood Regulation Test (MMR) and all subscales of the third edition of Wechsler Adult Intelligence Scale (WAIS-III), as well as background questionnaires concerning their socio-economic status and musical training. Since this study was part of the larger Tunteet project involving several neuroscientific and behavioral experimental paradigms, participants also filled in a number of other psychological questionnaires to control for other variables, such as the Montgomery-Åsbert Depression Scale (MADRS), the Hospital Anxiety and Depression Scale (HADS-A) and the Big Five Questionnaires (BFQ) that did not belong to this specific experimental design, but were employed in Carlson et al. (2015) and Bonetti et al. (2017).

Data Analysis

Statistical analyses were performed separately for the two samples of musicians and non-musicians. First, a regression model was used inserting the full IQ score calculated through WAIS-III as the independent variable and the subscale Strong Sensation (SS) as the dependent variable.

Second, to investigate which specific WAIS-III indices were relevant for the relationship between intelligence and MMR, we performed further regressions considering WAIS-III indices as the independent variables and MMR score as the dependent variable.

Finally, the procedure was replicated using the subscales of the indices of WAIS-III that were significant in the previous regressions as the independent variables and MMR score as the dependent variable. Moreover, the assumptions for linear regressions were tested. Specifically, by adopting Durbin-Watson and Kolmogorov-Smirnov tests, we assessed whether the residuals of the regressions were linear, independent, normally distributed and had an equal variance. These conditions must be met to compute proper and reliable linear regressions (Kafadar & Sheskin, 1997). The whole procedure was performed for both musicians and non-musicians.

Additionally, outliers were screened by considering the leverages of each observation in the regression analysis. Leverage is a measure of how far away the independent variable values of an observation are from the ones of the other observations. Usually, the average leverage score is calculated as $(k + 1)/n$ where k is the number of independent variables and n the number of observations. Outliers usually present a leverage of about 2–4 times the average leverage (Kafadar & Sheskin, 1997). In our case, the observations did not present such high leverages and therefore we did not remove any outlier.

Effect sizes (f^2) were calculated according to Selya et al. (2012), as described by Equation 1:

$$f^2 = r^2/(1 - r^2) \tag{1}$$

where r^2 is the goodness-of-fit measure for linear regression models.

Furthermore, following the procedure described by Bruin (2006), we compared the coefficients of the regressions involving musicians and non-musicians in order to determine whether the relationship between IQ and the Sensation Seeking subscale of MMR (MMRSS) was statistically different across the two groups.

Finally, to determine whether the relationship between IQ and use of music for SS was specifically limited to the SS seeking and not to a general higher level of use of music, we carried out similar analyses using the other subscales of the MMR and regressing them with IQ scores.

Results

Descriptive statistics related to the scores obtained by musicians and non-musicians in the WAIS-III and MMR are reported in Table 2.

Musicians

The regression analyses showed significant results for the scores of the different IQ scales and the MMRSS score for musicians:

Table 2. Scores Reported by Musicians and Non-Musicians for the Subscales of WAIS-III and MMR.

	WAIS-III						
	Full IQ	VIQ	PIQ	VCI	WMI	POI	SPI
Musicians	119.49 ± 7.84	116.85 ± 7.90	120.06 ± 9.37	116.43 ± 6.70	108.38 ± 13.52	118.26 ± 10.45	117.38 ± 11.36
Non-musicians	116.69 ± 7.68	113.78 ± 9.13	118.07 ± 8.28	113.93 ± 8.29	103.94 ± 12.52	116.70 ± 8.99	114.72 ± 9.58
	MMR						
	ENT	REV	SS	DIV	DIS	MW	SOL
Musicians	4.03 ± .95	3.47 ± 1.12	4.34 ± .65	3.47 ± .93	2.61 ± 1.17	3.57 ± 1.02	3.59 ± 1.14
Non-musicians	4.15 ± .82	3.28 ± .96	3.81 ± .86	2.78 ± .78	2.48 ± .95	3.00 ± .85	3.25 ± .91

VIQ = Verbal IQ; PIQ = Performance IQ; VCI = Verbal Comprehension IndEx; WMI = Working Memory Index; POI = Perceptual Organization Index; SPI = Speed Processing Index; ENT = Entertainment; REV = Revival; SS = Strong Sensation; DIV = Diversion; DIS = Discharge; MW = Mental Work; SOL = Solace.

- Full IQ:, $\beta = -.29$, $R^2 = .07$, $F(1, 52) = 4.71$, $p = .03$, $f^2 = .008$
- Verbal IQ: $\beta = -.31$, $R^2 = .08$, $F(1, 52) = 5.52$, $p = .02$, $f^2 = .01$
- Verbal Comprehension Index: $\beta = -.34$, $R^2 = .10$, $F(1, 52) = 6.59$, $p = .01$, $f^2 = .013$

There were no significant results between scores representing MMRSS and performance ($p = .23$) and Working Memory Index ($p = .93$) scores.

Durbin-Watson test for independency of the residuals provided coefficients included in the range: 1 – 3, meaning that residuals were independent (Full IQ: 1.86; Verbal IQ: 1.85; Verbal Comprehension Index: 1.97). Kolmogorov-Smirnov test was non-significant for the regressions reported above, meaning that residuals were normally distributed (Full IQ: $p = .20$; Verbal IQ: $p = .05$; Verbal Comprehension Index: $p = .01$). Additionally, residuals of all regressions were linear and had equal variance, according to visual inspection.

Figure 2 shows plots for the significant regressions.

Non-Musicians

The regression analyses showed significant results between the scores of the different IQ scales and the MMRSS score for non-musicians:

- Full IQ: $\beta = -.28$, $R^2 = .06$, $F(1, 53) = 4.56$, $p = .03$, $f^2 = .007$
- Performance IQ: $\beta = -.43$, $R^2 = .17$, $F(1, 53) = 11.71$, $p = .001$, $f^2 = .04$
- Perceptual Organization Index: $\beta = -.40$, $R^2 = .15$, $F(1, 53) = 10.03$, $p = .003$, $f^2 = .03$
- Processing Speed Index: $\beta = -.28$, $R^2 = .06$, $F(1, 53) = 4.26$, $p = .04$, $f^2 = .006$

There were no significant results between scores representing MMRSS and Verbal IQ ($p = .56$).

Durbin-Watson test for independency of the residuals provided coefficients included in the range: 1–3, meaning that residuals were independent (Full IQ: 2.57; Performance IQ: 2.59; Perceptual Organization Index: 2.58; Processing Speed Index: 2.63). Kolmogorov-Smirnov test was non-significant for the regressions reported above, meaning that residuals were normally distributed (Full IQ: $p = .06$; Performance IQ: $p = .20$; Perceptual Organization Index: $p = .05$; Processing Speed Index: $p = .20$). Additionally, residuals of all regressions were linear and had equal variance, according to visual inspection.

Figure 3 shows plots for the significant regressions.

Comparing Regression Coefficients of Musicians and Non-Musicians

We compared the regression coefficients of musicians (βm) and non-musicians (βnm) to test the null hypothesis (H0): $\beta m = \beta nm$. In order to carry out this

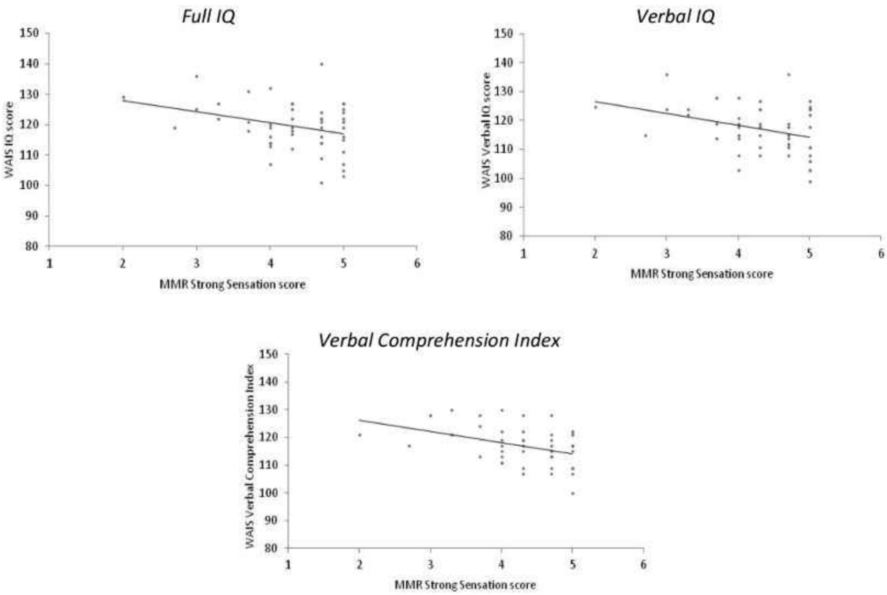

Figure 2. Plots of Significant Regressions Performed Inserting MMR Score as the Dependent Variable and Total IQ, Verbal IQ and Verbal Comprehension Index Scores as the Independent Variables.

analysis, as suggested by Bruin (2006), we first created a dummy variable called MusBinary, coding 1 for musicians and 0 for non-musicians, and a variable IQ_MusBinary that was the product of MusBinary and IQ. Successively, we inserted in the regression equation the variables MusBinary, IQ_MusBinary and IQ as predictors and the MMRSS as the dependent variable. We ran this procedure for all the regressions previously carried out. In Table 3, we report the significance level for the whole model and the t and p values calculated on the IQ_MusBinary (progressively we used Full IQ, Verb IQ, Perf IQ, etc., as reported in Table 3) coefficient(s). A significant result for the IQ_MusBinary coefficient demonstrated that βm was significantly different from βnm.

IQ and Other MMR Subscales

To show that the significant regression between IQ and use of music for strong sensation was specifically limited to strong sensation seeking and not to a general higher level of use of music, we carried out an additional analysis regressing the other subscales of the MMR with the IQ score. As expected, we did not obtain any significant effect for any of the subscales in relation to the IQ score (Entertainment: $p = .38$; Revival: $p = .71$; Diversion: $p = .79$; Discharge: $p = .65$; Mental Work: $p = .43$; Solace: $p = .18$).

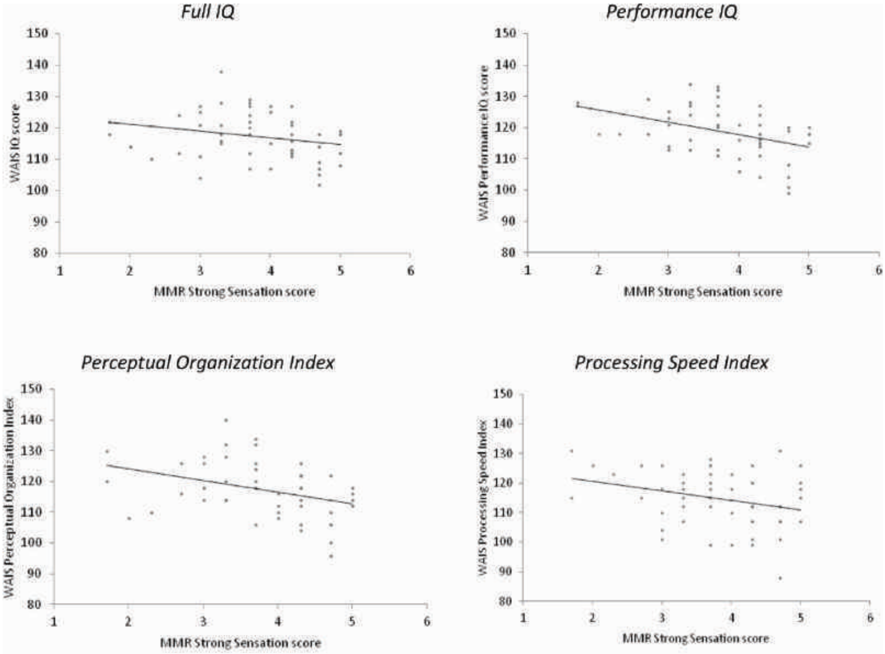

Figure 3. Plots of Significant Regressions Performed Inserting MMR Score as the Dependent Variable and Total IQ, Performance IQ, Perceptual Organization and Processing Speed Indices as the Independent Variables.

Table 3. Regression Models Used for Testing the Difference Between Regression Coefficients Between Musicians and Non-Musicians.

	Whole regression model			Rejection of H0: $\beta m = \beta nm$	
IQ scale	*F*	*p*	R^2	t	*p*
Full IQ	7.72	<.001	.16	.41	.68
Verb IQ	5.85	.001	.12	−1.04	.30
Perf IQ	**9.92**	**<.001**	**.20**	**2.05**	**.04**
VCI	6.87	<.001	.14	−.69	.49
POI	**8.96**	**<.001**	**.18**	**2.11**	**.03**
SPI	6.49	<.001	.14	1.22	.23

The table reports both the parameters for the whole model and the specific parameters for testing the difference between musicians and non-musicians. The model was used for each of the IQ scales considered previously. Verb IQ = Verbal IQ; Perf IQ = Performance IQ; VCI = Verbal Comprehension Index; POI = Perceptual Organization Index; SPI = Speed Processing Index.

Discussion

The aim of the present study was to explore the relationships between intelligence as measured by WAIS-III and strong sensation seeking and to assess whether the musical expertise is able to modulate it. Considering the large diffusion of music as mood regulator, we believe that developing a deep understanding of the relationship between the use of music for experiencing strong sensations and key psychological variables such as fluid intelligence can provide relevant insights for psychological research and thus have an important impact on the society. Here, according to our hypothesis, the results of this study show that both musicians and non-musicians present a negative regression between intelligence and the use of music for experiencing strong sensations, meaning that less intelligent people tend to use music for feeling strong sensations more than individuals that present higher level of intelligence. Moreover, we report negative correlations between musicians' scores on the verbal IQ and Verbal Comprehension Index and sensation seeking, and between non-musicians' scores on the performance IQ, Perceptual Organization and Processing Speed indices and sensation seeking. Even if the regressions that we report do not show a very large effect size, those relationships are clearly statistically significant, suggesting that the level of intelligence modulates the use of music for feeling strong sensations. More specifically, our results show that musicians with lower level of verbal intelligence and non-musicians with lower level of visual-spatial intelligence tend to use music for experiencing strong sensations more than individuals with higher level of intelligence measured with the relevant IQ subscales.

Our results might be consistent with previous studies showing more intelligent people using music for aesthetic purposes, preferring more complex, structured and instrumental music than high-arousal one (Kanazawa & Perina, 2012; Rentfrow & Gosling, 2003). Saarikallio et al. (in press) propose that the daily pleasure of music is constituted of at least two underlying emotional-motivational dimensions: relaxation-sensational and social-contemplative. Our findings might suggest that intelligence can serve as an explanatory factor for individual differences in preferring these different types of musical rewards. Additionally, previous studies on musical pleasure and aesthetic appreciation showed that positive aesthetic responses occur with harmonic surprises and deviations from the predictions and suggest that aesthetic appreciation is not only determined by object characteristics, but also mediated by several extrinsic factors such as psychological traits and individual inclinations (Brattico, 2020; Gold et al., 2019; Skov, 2019; Skov & Nadal, 2019; Skov & Skov, 2019). Future research should link those evidences with individual differences among fluid intelligence, exploring whether intelligence can mediate aesthetical appreciation and musical pleasure.

Previous literature widely showed relevant differences between musicians and non-musicians, both in the neuroscientific field (Bonetti, Haumann, Vuust, et al., 2017; Brattico et al., 2009; Münte et al., 2002; Vuust et al., 2009), and with regard to behavioral results (Brandler & Rammsayer, 2003; Franklin et al., 2008; Patel & Iversen, 2007). Along this line, our results also show some variation depending on the musical expertise of our participants. Specifically, although we revealed the same kind of relationship between intelligence and use of music for strong sensation, this relationship involved different WAIS subscales according to participants' musical expertise. Non-musicians who use music for experiencing strong sensations display a lower level of performance intelligence. Moreover, even though we do not reveal a statistically significant difference when directly testing the coefficients for musicians and non-musicians, we observe that musicians who prefer to use music for experiencing strong sensations report a lower level of verbal intelligence and a normal level of performance IQ. This interesting evidence suggests that the relationship between intelligence and SS seeking shows the same tendency for both musicians and non-musicians, even if it is expressed through different features of intelligence. In this study, we aimed to detect differences between musicians and non-musicians, and future research is called to further explore why these differences exist.

In spite of the relevance of the findings, our study presents some limitations, such as the possible cultural-dependency of the results. In other words, it might be possible that the styles of use of music for experiencing SS would be different in different cultures and that our results are representative only for well-educated individuals currently living in Finland. This limitation calls for a follow-up study involving different cultures and participants from lower socio-economic backgrounds. Another perspective deriving from the present study involves the relevance of cross-modality in music perception and use of music. Since music perception has been shown affected by concurrent presentation of stimuli coming from different sensory modalities (Bonetti & Costa, 2017b; Bragança et al., 2015; Crisinel et al., 2013) and use of music often occurs together with other activities and in environments comprising visual and proprioceptive stimulations (e.g. cinemas, theatres, concert halls) (North et al., 2004; Sloboda et al., 2001), future studies may explore the relationship between intelligence and SS seeking related to other sensory domains, such as visual or tactile ones, taken in consideration alone or together with music. Additionally, future research may explore the relationship that we described in our study taking into account also other measures of intelligence and not focusing only on fluid intelligence as we did. Finally, even if the relationships that we report in this study were statistically significant, the effect sizes were small, suggesting that the observed relationships, even if clear, were not particularly strong. Thus, future research is called to replicate and extend our results.

Notably, we observed our results in the musical domain, detecting the relationship between fluid intelligence and the search for strong sensations elicited by music. Other studies focused on psychological perception of artistic works highlighting a relationship between sensation seeking and preference for abstract art (Furnham & Bunyan, 1988; Zuckerman et al., 1993). However, to our knowledge there are no studies that explicitly explore the relationship between sensation seeking, art appreciation and fluid intelligence. Hence, in order to replicate and extend our findings, we call for future research in which the individual emotional responses to classes of stimuli such as paintings or poems could be analyzed in relation to general intelligence. We would expect to find a modulation of the observed relation between intelligence and high-sensation seeking by domain and style. Additionally, along this line, future studies are called for investigating whether the relationship between fluid intelligence and sensation seeking could be modulated by different kinds of sensation seeking. In other words, the search for strong sensations can involve and refer to different domains (e.g. physical sensation seeking, psychological sensation seeking or aesthetic sensation seeking). Currently, we do not know whether the seeking for strong physical sensations may provide us with a different relationship with intelligence than the searching for more abstract aesthetic feelings and sensations. Future studies should disentangle this potential ambiguity and provide us with additional findings.

In conclusion, according to our hypothesis, the results suggest that less intelligent individuals tend to exhibit higher level of sensation seeking during use of music (with some variations depending on musical expertise), strengthening the idea that high sensation seeking might be negatively correlated with fluid intelligence. These results offer new multi-disciplinary evidence addressing our research question about how intelligence and a long-term experience with music are able to affect and modulate emotional regulation and use of music.

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