WHAT IS THE VALUE OF MUSIC EDUCATION?

A summary of preliminary data emerging from 5-years of the LongGold research project

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Contents

About BrainCanDo

BrainCanDo is an educational charity that works with leading neuroscientists, psychologists and educational professionals to bring evidence-informed transformation to educational policy and practice. We do this by sharing best practice through research, training, publications and resources with teachers, school leaders and educational organisations.

Executive Summary

There is a growing body of research showing relationships between participation in music education programmes and improvements in other related cognitive domains. However, the nature of the relationships is not yet fully understood. From the available research it has not been possible to draw the conclusion that music education causes an increase in cognitive and/or academic ability. It is possible that achievements in the areas of music and academic performance may both be linked to other factors such as intelligence and general cognitive capabilities, genetics, favourable environments or personality. Given the existing research, it has not been possible to substantiate claims that musical training has a direct causal impact upon academic achievement in children and young people.

Dr Amy Fancourt, Director of Research for BrainCanDo, has partnered with Professor Daniel Mullensiefen and a team of music psychologists at Goldsmiths University to carry out a longitudinal research project to further understand the nature of the relationship between active musical participation and intelligence, academic achievement and pupil wellbeing over a 5-year period. This research project is called the 'LongGold' project and will follow cohorts of pupils from the time that they begin secondary school (aged approximately 11-years) through to when they are preparing to leave (aged approximately 17-years). Each year pupils in participating schools are asked to complete a battery of tests that measure musical abilities, intelligence, wellbeing and personality.

One of the key questions that we hope to address through such a long-term and naturalistic study design is whether active musical engagement and participation will lead to subsequent gains in academic achievement. In 2015, Müllensiefen et al. published a research paper showing the findings from the initial wave of data collected. These findings revealed that there were associations between musical training, musical listening skills and academic performance in a sample of 312 secondary school children. The continuation of this project over the past 5-years is seeking to address outstanding questions concerning the long-term developmental impact of active musical participation and music education in schools.

From the start of the project in 2015 through to the most recent phase of data collection in 2019, the same cohort of pupils have been tested annually. This has enabled trajectories to be mapped that may begin to shed light on the impact of active musical participation and music education on pupil outcomes over a 5-year period. This report will share some of the preliminary findings from this project and the implications for music education will be discussed.

Introduction

Research has routinely demonstrated that there are positive associations between musical abilities and cognitive abilities such as intelligence, language and memory, thus indicating a valuable role of music education for broader cognitive and emotional development (Hille & Schupp, 2014). Large cross-sectional studies have repeatedly shown greater academic achievements in pupils who receive musical training (Hille & Schuppe, 2014; Guhn, Emerson, & Gouzouasis, 2019) and one of the explanations for these findings is that music education plays a valuable role in shaping important psycho-social variables that are linked to a range of positive life outcomes, including academic achievement (Lipnevich et al., 2016). Indeed Mullensiefen et al (2015) found that musical training was related to beliefs about the nature of intellectual and musical ability which in turn impact upon conscientiousness and academic achievement. In this paper, the authors note that greater engagement in musical activity was associated with a more incremental theory of musicality and intelligence, that is a belief that intelligence is malleable and can be changed, which in turn related to higher overall academic achievement.

Using data from a large panel study, Adrian Hille and Jürgen Schupp (2014) have shown how learning a musical instrument during adolescence is generally associated with higher grades towards the end of students' school careers. Their results have been supported by evidence from a large cohort study with more than 100,000 Canadian secondary school students. In this study Martin Guhn and co-workers (Guhn, Emerson, & Gouzouasis, 2019) show that participation in music courses at school has a positive effect on grades in unrelated subjects (i.e. Maths and English). The effect was strongest for students who were highly engaged with learning an instrument; these students were over 1-year ahead of their peers in terms of their academic progress (Guhn et al., 2019).

In addition to the reported gains in academic achievement, research also demonstrates that active musical engagement and music education are linked to the development of important emotional regulation abilities in children and adolescents. Music provides a mechanism through which young people can begin to employ more effective strategies to regulate their own negative emotions and cope with stressful events (Lonsdale & North, 2011; Miranda & Claes, 2009; Roden et al., 2016). Similarly, pro-social behaviour has been shown to increase with musical engagement (Kirschner & Tomasello, 2010; Williams et al., 2015) and in a comprehensive literature review Miranda (2013) finds that music is closely related to the psycho-social and identity development of adolescents and acts as a protective factor against externalising and internalising problem behaviours. In a large-scale intervention study conducted by Aleman and colleagues (2017), musical opportunities were found to enhance self-control and reduce behavioural problems, specifically in students from disadvantaged backgrounds. In line with these associations between musical activity and psycho-social skills, several studies have also pointed to the positive role can music can play in supporting mental health and well-being (Farahmand et al., 2011; Papinczak et al, 2015; Wang & Peck, 2013), suggesting that music can be particularly "effective for those with more to gain" (Schellenberg, 2016, p. 425).

Alongside the valuable role of music for emotional regulation and psycho-social development there are also many studies showing a connection between music education and the developmental of general cognitive abilities (e.g. intelligence, memory, attention). With research suggesting that music has the potential to be especially beneficial to pupils with special educational needs or disabilities and students from disadvantaged socioeconomic demographics (e.g. Osborne, McPherson, Faulkner, Davidson & Barrett, 2016; Rose, Jones Bartoli & Heaton, 2018; Papinczak et al., 2015; Swaminathan et al. 2017).

Cognitive transfer effects

The idea that playing a musical instrument can lead to improvements in cognitive abilities has received a great deal of interest in the press over recent years. The popularity of the so-called 'Mozart effect' perpetuating the notion that listening to Mozart music will lead to long-term and permanent increases in intellectual ability, is a notable example. Further research has subsequently demonstrated that this apparent Mozart effect has more to do with temporary increases in arousal following music listening than actual changes in intelligence (Thompson et al, 2001). Nonetheless, there is a body of research supporting the notion that music education is related to a range of cognitive abilities including language, memory and attention.

For example, Anvari et al (2002) found a correlation between musical ability and reading skills in 4-5 year old children. Although it is important to interpret these findings carefully and to ensure that causation is not inferred, the results of Anvari's study do support the notion that there may be shared capacities responsible for processing across music and language domains. For example, pitch discrimination ability was found to be a significant predictor of the variance in reading ability, which may indicate that within the auditory system there is some overlap in the mechanisms responsible for pitch discrimination and sound categorisation in language and music.

Further support for the overlap in auditory processing of pitch variations and sound categorisation comes from (Slevc & Miyaki, 2006). They measured the relationship between ability to learn a second language and musical ability in a group of native Japanese speaking adults living in the US. They found that musical ability accounted for a significant amount of the variability in 2nd language skills in this group of adults. Similarly to Anvari et al, the effects were restricted to receptive and productive phonology: those aspects of language that are most related to sound categorisation skills in auditory perception. It may be that musical training facilitates the categorisation of sound within the auditory system and this has positive implications for language learning.

One musical intervention study carried out with children, reported that typical 7-8 year old children who participated in a musical training programme for a period of 18 months showed significantly greater gains in verbal memory than those who participated in a science training programme (Roden, Kreutz & Bongard, 2012). Furthermore, Schellenberg (2004) randomly assigned a relatively large sample of children (N = 144) to two different types of music lessons (keyboard or voice) or to control groups that received drama lessons or no lessons. IQ was measured before and after the lessons and the results showed that children in the music groups exhibited greater increases in full-scale IQ than the control group. The effect was relatively small, but it generalised across IQ subtests, index scores, and a standardized measure of academic achievement. Thus it may be that music education can support the development of more general cognitive abilities that are important for a range of different functions (including language).

The Frequency Following Response (FFR) is a very early evoked brainstem response to the continuous presentation of low frequency tone stimuli. This very early response indicates that when listening to speech, linguistic pitch patterns are tracked by this low-level brain circuitry.

It has been found that musicians have a much stronger and more robust representation and faithful tracking of pitch contours in speech (Wong et al., 2007; Kraus et al., 2017; Kraus, 2011). This more robust tracking of pitch, may be linked to improved acquisition of novel words and reading abilities observed in children who receive music lessons. Nina Kraus has conducted a great deal of research exploring the links between musical abilities and low-level auditory function. She has demonstrated that musicians show a more robust Frequency Following Response (FFR) and more accurate Auditory Brainstem Responses ('ABRs) than non-musicians. Furthermore, these ABR's have been found to predict both reading and music aptitude in typical children those with with poor reading skills and language-based learning impairments (Bonacina et al., 2019; Tierney et al., 2017).

Although there are many studies reporting the existence of transfer effects from music education through to other cognitive domains there are still questions around the strength of such transfer effects. This difficulty in establishing the general effect is reflected in the small effect size (d = 0.17) that Giovanna Sala and Fernand Gobet reported (2017) in their meta-analysis of 38 studies. Although the overall effect size is relatively small, Sala & Gobet (2017) do report that the effects of music training are considerably stronger for certain cognitive domains (e.g. general intelligence and memory) than for others (e.g. spatial processing).

Music Education to Support Learning in Children with Developmental Language Disorders

So we can see that in typically developing children and those with language disorders, music education may be a valuable means through which to support the development of sub-cortical structures implicated in sound categorisation. Alongside this auditory processing, there is research to suggest that rhythmic and sequential processing can also be supported through music education programmes.

The sensorimotor coupling required for rhythmic processing in music is a powerful stimulator of communication and social interactions. This is demonstrated in cases of patients with Parkinson's disease, who have suffered extensive damage to motor control, 'borrowing the will of the music' to regain movement (see Oliver Sacks 'Awakenings' for a more comprehensive account). This has resulted in the hypothesis that investigating the relation between rhythm and speech provides relevant insights into the origins of human communication, as well as perspectives for the rehabilitation of neurological disorders. Children with dyslexia have been found to show impaired rhythm and meter perception important for both music and language processing (Weinert, 1992; Corriveau and Goswami, 2009; Overy et al., 2003; Bedoin et al., 2016; Habib et al., 2016). Through the promotion of rhythm and music stimulation, it may be possible to rehabilitate language and communicative capacities in children with developmental language disorders.

Bedoin et al (2016) compared children with language impairments alongside a group of typically developing matched controls on a task involving grammaticality judgements in spoken sentences. Those children with language difficulties performed more poorly on this task than typically developing controls but performance of both groups improved when they were played a regularly metered piece of music before making a judgement about the sentence. The authors conclude that this regularly metered music acted as a musical prime that facilitated the grammatical processing of the subsequent sentence. An irregularly metered musical prime did not confer this same processing advantage. Thus it seems that the use of rhythmic structures could serve to boost linguistic structural processing in children with developmental language disorders.

A further study conducted by Habib et al., (2016) tested the efficacy of a specially designed 'Cognitive Musical Training (CMT)' programme for children with developmental language disorders. The rationale behind this training was that music and language rely on shared cognitive and neural networks, therefore offering musical training to children with Dyslexia might strengthen brain circuitry that is common to both music and language processing. Habib et al (2016) exposed children with Dyslexia to a three-day intensive musical training and a six-week spaced intervention and found that both types of intervention resulted in improvements on a range of musical and linguistic tasks. Furthermore, these improvements persisted for six-weeks post intervention, indicating that such musical training programmes may confer long-term advantages for language processing in children with Special Educational Needs and Disabilities such as Dyslexia.

Music-induced neuroplasticity

One suggestion as to why music education may have such an impact on a range of other cognitive functions was proposed by Ani Patel (2012). In this paper, Patel suggests that active music participation such playing an instrument or singing, collectively places a greater demand upon the central nervous system and this may confer an advantage for language processing.

The "OPERA" hypothesis proposes that benefits of musical training are driven by adaptive plasticity in auditory-processing networks and that this plasticity occurs when the following five conditions are met:

1. Overlap: there is anatomical overlap in the brain networks that process an acoustic feature that is important in both music and speech (e.g. waveform periodicity, amplitude envelope).
2. Precision: music places higher demands on shared auditory processing networks than speech due to the level of precision needed for musical processing.
3. Emotion: the musical activities that engage this auditory processing network elicit strong positive emotions.
4. Repetition: the musical activities that engage this auditory processing network are frequently repeated.
5. Attention: the musical activities that engage this auditory processing network are associated with focused attention.

According to the OPERA hypothesis, when the above five conditions are met, neural plasticity drives the networks in question to function with higher precision than needed for ordinary speech. Yet since speech shares these networks with music, speech processing benefits from this sharpened acoustic processing. The OPERA hypothesis can offer an account of the observed superior subcortical encoding of speech in musically trained individuals.

It seems then that brain plasticity may be the mechanism through which music learning can effect changes in the brain's anatomy and physiology. These music-induced changes may then serve other cognitive functions leading to so-called transfer effects. Among the changes induced by music training is an increase in grey matter volume in the superior parietal and inferior temporal cortex – areas that are strongly engaged in audio-motor processing during music making (Gaser & Schlaug, 2003). Annemarie Seither-Preisler and colleagues (2014) found in a controlled study with school children that those who take additional music lessons develop a larger Heschl's gyrus over time. Heschl's gyrus is the area in the brain where auditory information arrives from the ears and where it is initially analysed. The effect of music education on the brain is even visible when the genetic make-up of the participants is identical (Manzano and Úllen, 2017).

Rationale for the LongGold project

One of the challenges with the available research to date is that much of it has used a cross-sectional study design (e.g. Asztalos & Csapo, 2016; Müllensiefen et al., 2015) or repeated measurements from very few occasions to assess the effect of specific musical interventions (e.g. Costa-Giomi, 2004; Jaschke et al., 2018). Thus, despite the clear advantages of longitudinal study designs for identifying causal mechanisms, there is a wide gap in the current literature on musical development. There have been some publications from the US and Europe that have sought to employ a longitudinal methodology to assess the impact of music education programmes (Iversen, 2017, Habibi et al., 2016; Kreutz & Feldhaus, 2018; Seither-Preisler et al., 2014). However, these projects do not cover the adolescent period and focus either on neural plasticity in response to musical activity and instruction (Habib et al., 2016; Seither-Preisler et al., 2014) or personality (Kreutz & Feldhaus, 2018) or use a rather qualitative approach (McPherson et al., 2012). Hence, so far there has been no quantitative longitudinal study published on musical development and it's role during adolescence. This means that even from the data of a very large study like Guhn et al. (2019), it is not possible to infer whether additional music education improves other cognitive abilities such as intelligence or whether the more intelligent children opted to take on more music lessons.

The *LongGold* study aims to track the development of musical abilities together with cognitive and socio-emotional skills across adolescence. The longitudinal nature of the study enables us to test the causal directions of hypothetical transfer effects between music and other psychological domains, by examining temporal precedence (e.g. does a major development in cognitive of social skills follow an earlier increase in musical training, or is the reverse true?). Finally, the LongGold study considers musical activity alongside other co-curricular activities such as drama and sport, that serve as control domains. This will help us to address the question of whether music has a special capacity to generate transfer effects, or whether similar effects can also be achieved through analogous training in other domains.

Methodology

In contrast to previous studies, the LongGold study does not employ any specific musical interventions, nor advocate a particular music teaching method. Instead the study aims to capture musical activity and engagement in a realistic way, prescribing neither the type of musical activity nor the musical style or genre to engage with. Instead, the type and intensity of the musical behaviour is observed and recorded at regular intervals and compared to previous and subsequent developmental changes with respect to cognitive and social abilities and well-being. The project is designed as a longitudinal study spanning the secondary school years. During the period of data collection, the development of adolescent participants is tracked by assessing the same pupils in the same secondary schools on the same test battery each year.

The test battery is implemented through a browser-based interface and all data is collected online. The online test battery comprises questionnaires as well as cognitive (intelligence and working memory) and perceptual music tests. All tests are implemented as adaptive tests based on rigorous item response theory models (e.g. Larrouy-Maestri, Harrison & Müllensiefen, 2019; Harrison & Müllensiefen, 2018; Harrison, Collins & Müllensiefen, 2017) which ensure short test durations combined with maximal effectiveness and the comparability of test scores across cohorts. Questionnaires assess musical activity as well as sports and drama activities. Socioemotional development is assessed through established questionnaires on personal strengths and difficulties (Goodman, Meltzer & Bailey, 1998), school engagement (Wang, Willett, & Eccles, 2011), growth mindsets (Dweck, 2000), and social and academic self-concepts (Bracken, 1992).

Children are tested in groups under the supervision of a researcher and teacher in each school. Test sessions take place either in the school's computer classrooms or through tablet computers.

Sample

This report contains the preliminary data from 1732 pupils from across 4 UK secondary schools, aged from 11 to 17 years with an average age of 13.88 years. Data collection took place in 2015, 2016, 2017, 2018 & 2019.

Preliminary results

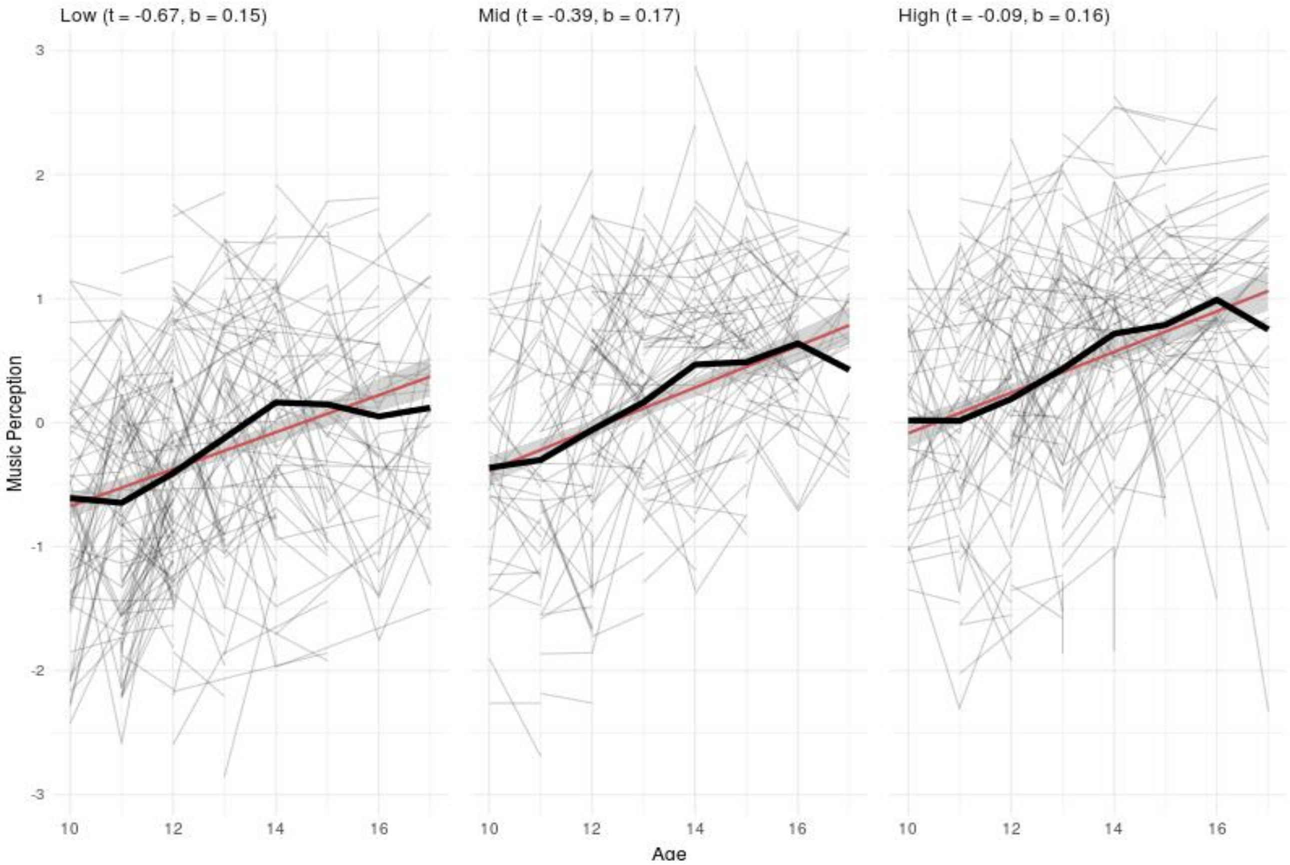
The analyses reflected in graphs 1-5 indicate that opportunities for musical training confer a number of different developmental advantages for pupils throughout the adolescent period. The pattern of relationships between musical training, academic self-concept and incremental theories of intelligence and musicality indicate that the effects of music education may be mediated by important psycho-social variables which play a role in important life outcomes besides academic achievement (Lipnevich et al., 2016)**.**

The following analyses (graphs 1 – 4) represent the findings from cohorts of pupils that have been sub-divided according to the scores achieved on a self-report measure of musical training. The measures of musical training were derived from the Gold-MSI, a very widely used self-report inventory and test battery for individual differences in musical sophistication. It measures the ability to engage with music in a flexible, effective and nuanced way (Mullensiefen et al., 2014).

The musical training scores were calculated from Likert scale responses to 7 questions relating to the perceived musical performance abilities, daily practice, hours practice per day and number of years of formal musical training. Total scores were calculated to give a single 'musical training' score. The overall distribution of musical training scores were divided in three places to enable categorisation of 'low' 'medium' and 'high' levels of musical training in the sample.

The first graph represents the analyses of musical perceptual ability in pupils who expressed low, medium and high levels of musical training. We can see that across all pupils there is a growth in musical perceptual abilities over age and this growth trajectory is slightly greater for pupils who have high levels of musical training.

Levels of Musical Training



Graph 1. The relationship between musical perception and age through adolescence. The black line indicates the average measurements of music perceptual abilities increasing between the ages of 11 – 17-years. The red line represents the ability growth trajectory according to a linear mixed effects model.

Psycho-social skills and growth mindset

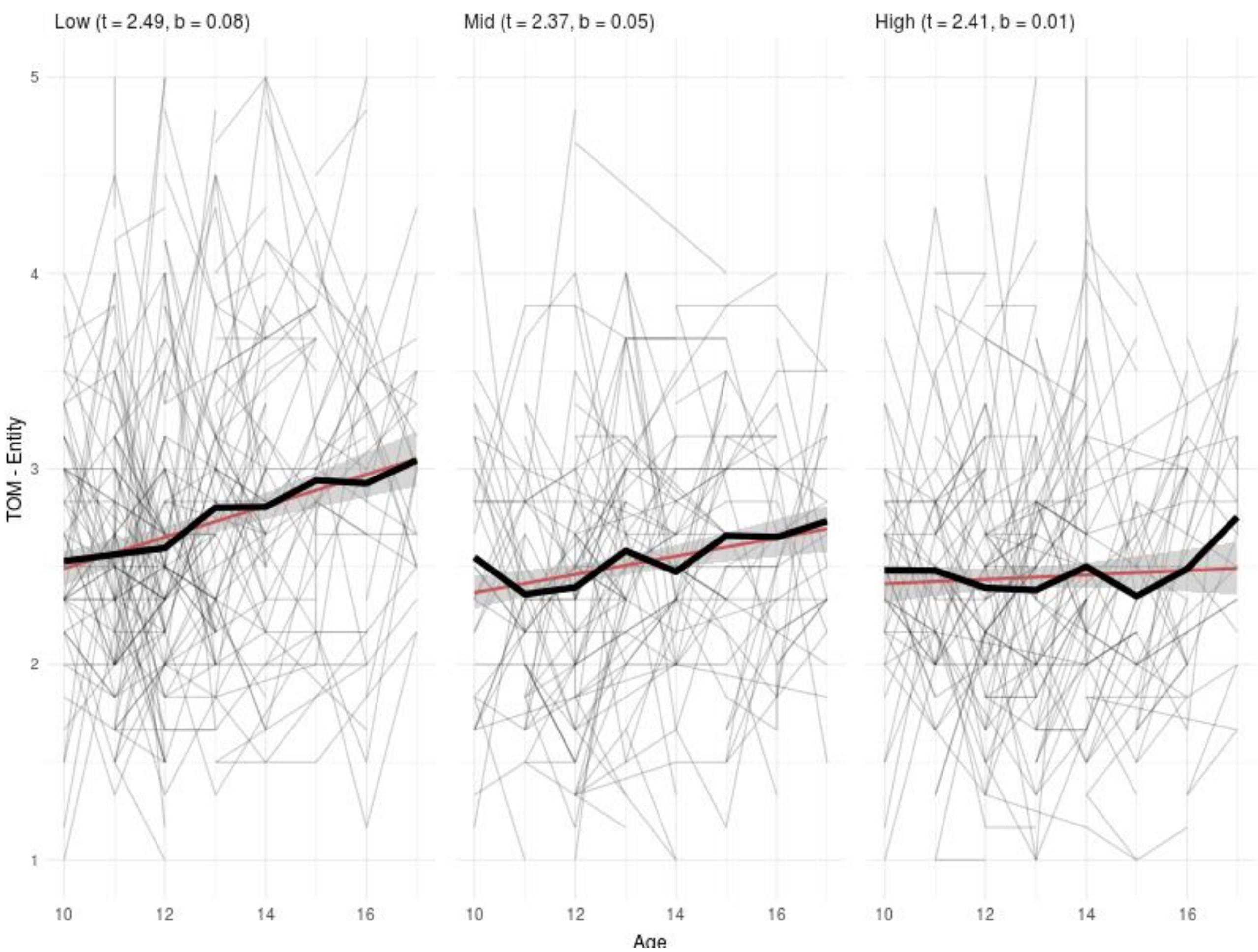
The beliefs that pupils develop about their own abilities can have an impact on their likelihood of achieving academic success. Pupils who grow to believe that intelligence and other abilities are malleable (*'growth mindset'*) are more likely to attribute poor performances to effort rather than ability, and are therefore more likely to take remedial action to improve their performances (Hong et al., 1999). Crucially, pupils with high 'growth mindset' beliefs prioritize their own intellectual development over how intelligent they appear to others (Elliott and Dweck, 1988; Robins and Pals, 2002). On the other hand, those pupils who maintain a belief that intelligence and other abilities are fixed, are more likely to attribute poor performances to a lack of ability, and are therefore less likely to respond to poor performance by increasing effort (Hong et al., 1999).

In the following analyses (graph 2 and 3) we measured the nature of beliefs about intelligence and musicality in pupils who were categorised according to their Musical Training Scores.

In graph 2 we can see that between the ages of 11 – 17-years pupils are more likely to develop a belief that their musical ability is fixed and cannot be changed through practice. When grouped, we can see that those pupils with the highest musical training scores do not show such a steep increase in this belief of fixed musical ability.

Overall we can see from this analysis in graph 2 that music education may help pupils to recognise that musical ability can be improved with focused practice and training and is not a fixed ability.

Levels of Musical Training

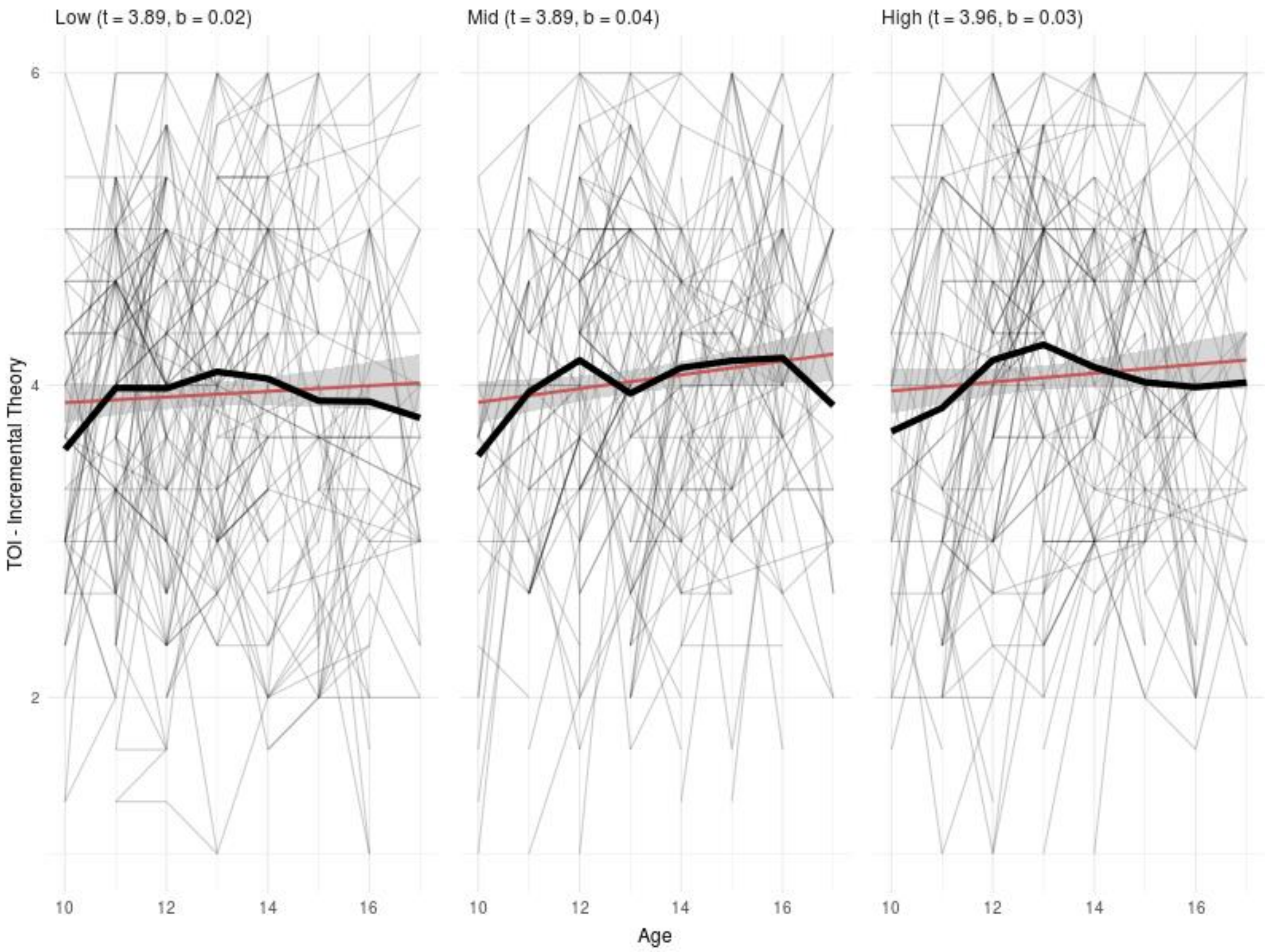


Graph 2. The relationship between subjective theory of musicality and age in pupils who have low, medium and high levels of musical training.

Overall we find that throughout adolescence there is growth in pupils' beliefs that overall intelligence can be changed (graph 3).

We see this most strongly in pupils who have medium to high levels of musical training, thus indicating that music education may be a mechanism through which a more general growth mindset attitude to intelligence may be fostered and developed.

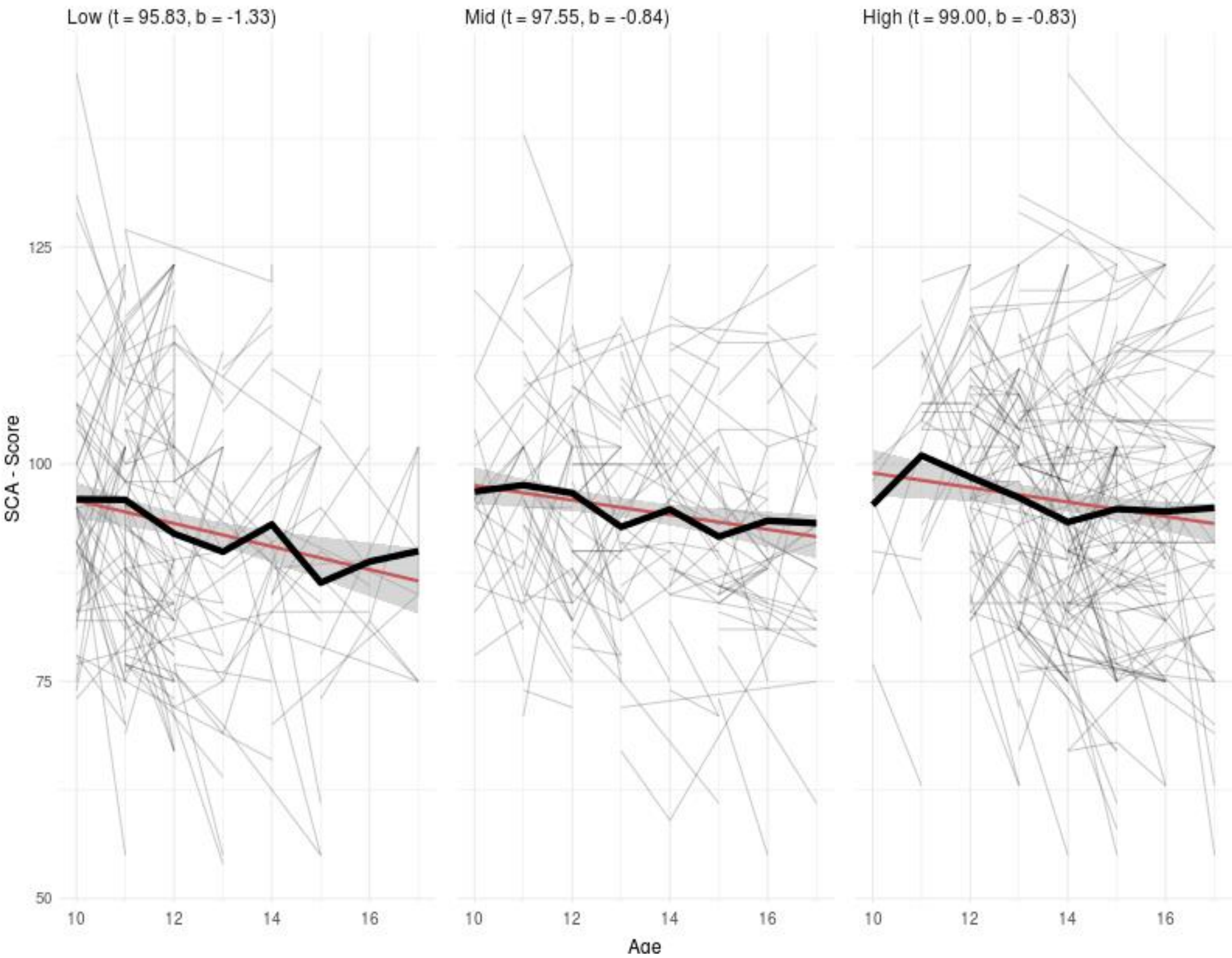
Levels of Musical Training



Graph 3. The relationship between subjective theory of intelligence and age in pupils who have low, medium and high levels of musical training.

Academic self-concept is a measure that reflects how competent pupils feel in their own academic abilities in school. We find that academic self-concept declines with age showing that pupils subjective opinions of their own academic abilities become progressively worse as they move through adolescence. The rate of decline in academic self-concept is less severe in pupils who have high musical training scores when compared with pupils with low or medium musical training scores.

Levels of Musical Training

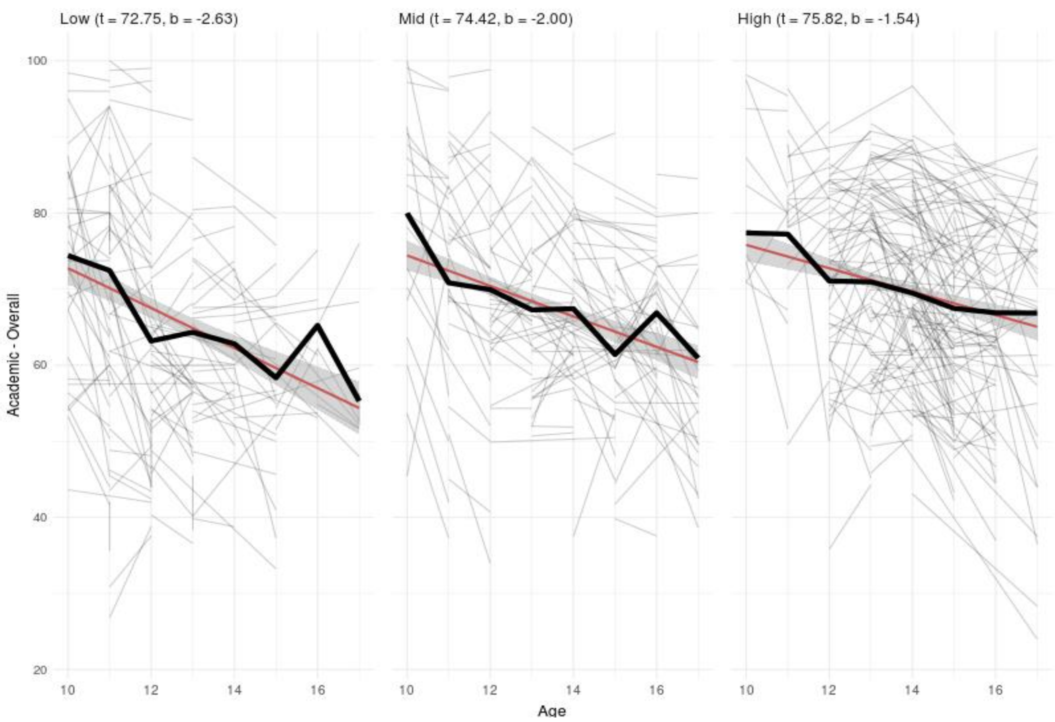


Graph 4. The relationship between academic self-concept and age in pupils who have low, medium and high levels of musical perceptual ability.

The following analyses represent the findings from cohorts of pupils that have been sub-divided according to the scores achieved on measures of musical perceptual ability taken from the Gold-MSI (Mullensiefen et al., 2014). The musical perceptual ability scores are calculated by averaging the scores from across the battery objective musical ability tests assessing different music listening skills (e.g. melodic discrimination, beat perception, intonation perception, musical emotion discrimination, pitch imagery: Harrison, Collins, & Müllensiefen, 1017; Harrison & Müllensiefen, 2018; Larrouy-Maestri, Harison, & Müllensiefen, 2019). The overall distribution of musical perceptual scores were divided in three places to enable categorisation of 'low' 'medium' and 'high' levels of musical perceptual ability in the sample.

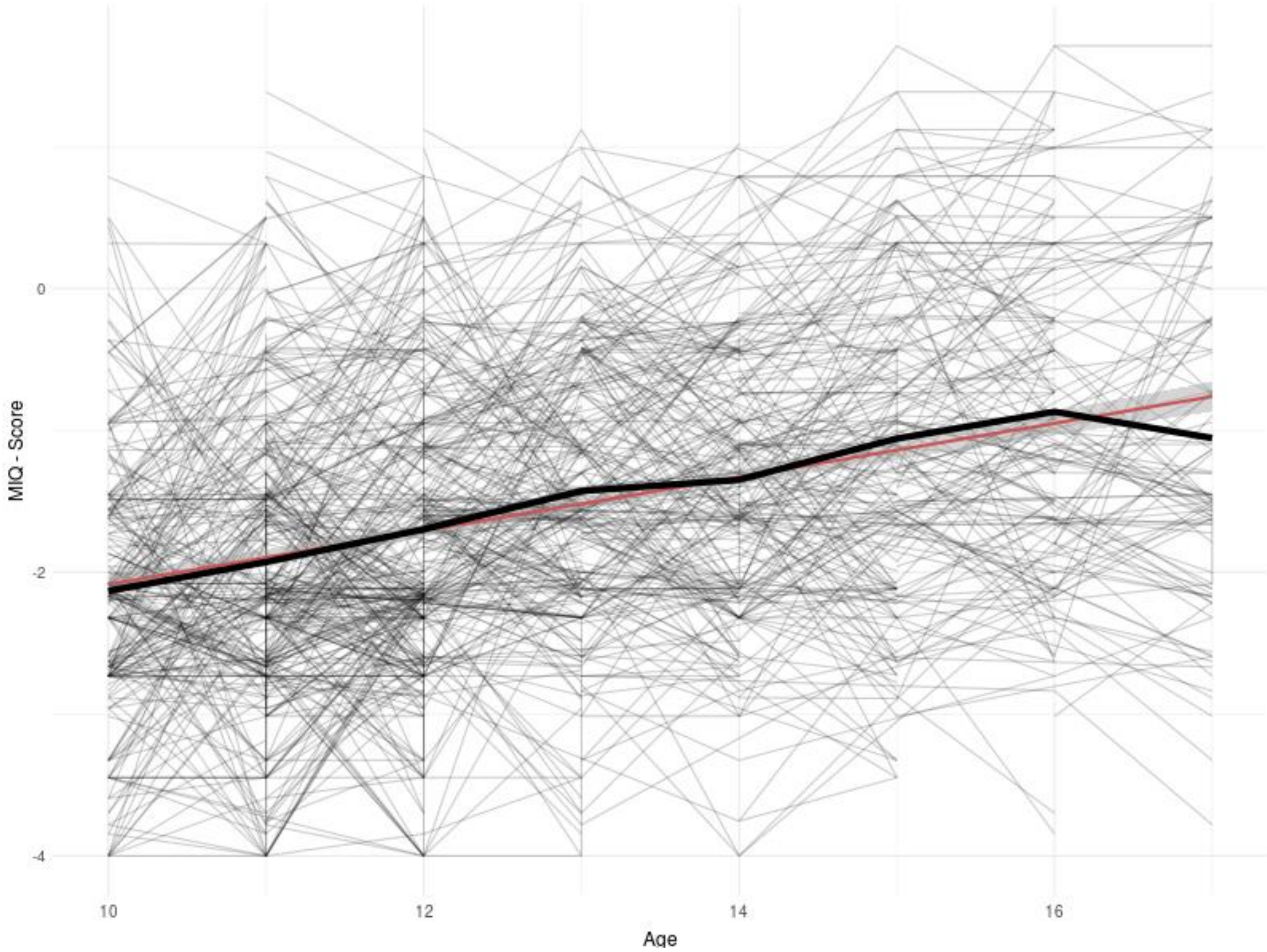
As assessments become more difficult through adolescence, with UK pupils preparing for public examinations such as GCSEs and A-levels, we find that there is an overall decline in academic performance reflected. When the rate of decline is compared across the low, medium and high musical ability groups, this decline in academic performance is far less pronounced in those pupils who have high musical ability scores.

Levels of Music Perception Ability



Graph 5. The relationship between academic performance and age in pupils who have low, medium and high levels of musical perceptual ability.

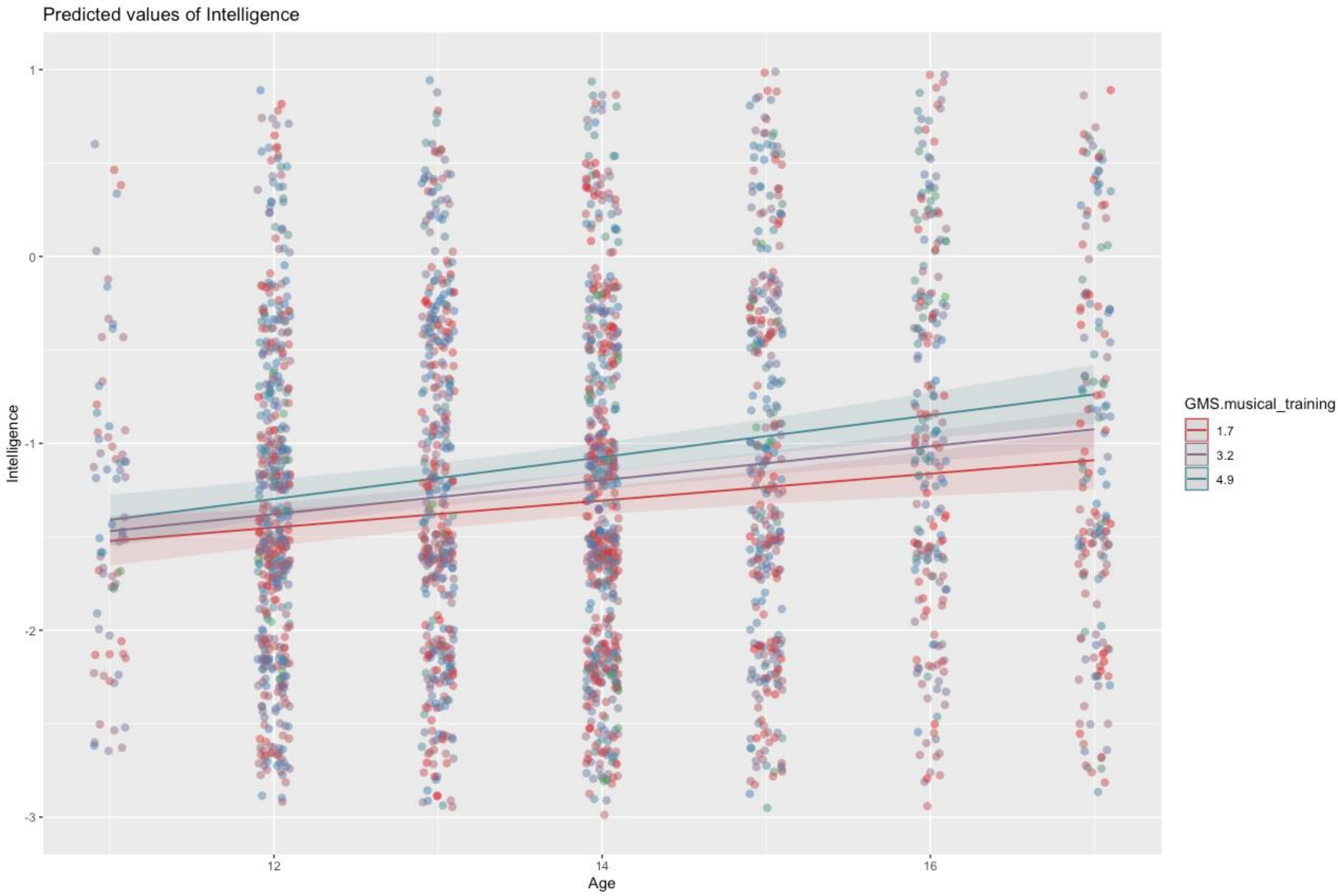
The following analyses include measures of intelligence in pupils grouped according to levels of musical training. Intelligence was measured using the Ravens Progressive Matrices (Ravens, 1981) implemented online using an adaptive tracking procedure constructed and normed by the Cambridge Psychometrics Centre. The scores used are on a standardised z-scale from -4 to +4 with 0 indicating the average from the adult norm sample. The findings reflected in graph 6 demonstrate that, as we would expect, intelligence increases with age.



Graph 6. The relationship between intelligence and age.

In the following analysis (graph 7) we reflect the rate of intelligence growth for those pupils who are among the lowest 10% in terms of musical training (1.7), who are average at 50% (3.2) on musical training, and the top 10% in terms of musical training.

This analysis demonstrates that the rate of intelligence growth is faster in those pupils who have high musical training scores compared to those with low musical training scores.



Graph 7. Relationship between intelligence and age in pupils at the confidence interval bands for those at the 10%, 50%, and 90% of the musical training distribution sample.

Discussion

Overall the preliminary findings from the LongGold project indicate that there are many developmental outcomes that are related to musical training in children aged between 11 – 17-years. When investigating the complex nature of the relationships between age, intelligence and musical ability, the preliminary findings indicate that intelligence increases over age in all pupils, but does so at a faster rate in pupils who have high musical training scores.

When considering the impact of musical training on music perception the findings demonstrate that the rate at which musical perceptual abilities grow over age is stronger in those pupils who score highly on measures of musical training. Thus it seems that, as indicated in the earlier work of Nina Kraus and others, engaging in musical activities may serve to enhance the auditory perceptual abilities that are important for overall music perception (Wong et al., 2007; Kraus et al., 2017). Furthermore, it may be that this growth in music perceptual ability could also confer some advantages in terms of academic progress. Analyses of academic progress over age revealed that as assessments become more difficult throughout the secondary school years with pupils approach public examinations, we see a decline in academic performance. Interestingly, the rate of decline in much less steep in those pupils who have higher music perceptual ability scores. Although the preliminary data reflects this decline across all pupils, it also shows that the rate of academic decline is far less pronounced in those pupils who have high musical ability scores compared to those with low or medium musical scores. Given what the literature shows regarding the relationship between auditory processing and more general music and linguistic abilities (Wong et al., 2007; Kraus, 2011 Bonacina et al., 2019; Tierney et al., 2017), it may be that these more advanced music perceptual abilities could help to support continued language functions in pupils as they age and so confer an ongoing academic advantage for these students.

When it comes to beliefs and values we find that there is a change in pupils incremental theories of musicality and intelligence over age. The findings from the LongGold project show that as pupils age they are more likely to develop a belief that musical ability is fixed and cannot be changed through practice. However, when grouped according to musical training scores we can see that those pupils with the highest musical training scores do not show such a steep increase in the belief that musical ability is fixed. Interestingly, when looking at pupils incremental theories of intelligence we find that with age there is a growth in pupils' beliefs that intelligence can be modified through focused effort and practice. This growth is most pronounced in pupils with medium to high musical training scores, perhaps indicating that music education may have a role to play in helping to foster and develop a more 'growth mindset' oriented approach to cognitive ability. The literature demonstrates that the more growth oriented a person's beliefs, the more likely they are to attribute failures to a lack of effort rather than ability and as such are more likely to strive to improve their performance (Elliott & Dweck, 1988; Robins & Pals, 2002).

Music education may provide the continued reinforcement needed to remind pupils that ability can be improved with focused and determined practice thus building a more resilient approach to work. With reference to earlier findings from the project reported in Mullensiefen et al (2015), it may be that music education has a valuable role to play in the development, beliefs, psycho-social skills and personality traits that are important for future success both academically and in other walks of life (Lipnevich et al, 2016). It may be that through learning to play a musical instrument, or in perfecting a musical skill, students are recognising that achievement is linked to focused and determined practice. Music is a good model for the plasticity of the teenage brain. Learning to play a musical instrument, or to sing in a choir, places very specific and unique demands on the human nervous system and through neuroimaging we can demonstrate the structural and functional changes that take place in the brain as a result of this kind of skill practice (De Manzano and Úllen, 2017; Gaser & Schlaug, 2003; Patel, 2011; Seither-Preisler et al, 2014). If students can understand the dynamic nature of their developing brains, we can foster a positive approach to learning a musical instrument and also help them to recognise that musicians are not born brilliant but achieve brilliance through effort, hard work, and practice.

When it comes to pupils' beliefs about their own academic competencies we find that the measure of academic self-concept declines with age, indicating that pupils subjective opinions of their own academic abilities become progressively worse as they move through secondary school. This measure of academic self-competency has been closely linked to self-esteem and self-efficacy in pupils and the decline is a concerning trend given the role of self-concept in overall self-esteem mental wellbeing and academic performance (Grotan et al., 2019). The preliminary findings from the LongGold project indicate that the rate of decline in academic self-concept is less severe in pupils who have high musical training scores compared to pupils with low or medium musical training scores. Thus it may be that music participation in adolescence can serve as an important protective factor helping to build the resilience and emotional regulation skills needed to maintain a positive state of mental health and wellbeing (Farahmand et al., 2011; Miranda, 2013; Papinczak et al, 2015; Schellenberg, 2016; Wang & Peck, 2013).

In sum, the preliminary findings from the first 5-years of the LongGold project indicate that music education is related to the development of a number of key competencies, beliefs and cognitive abilities throughout the adolescent period of development. Music education has a valuable role to play at all stages of a child's development and a more comprehensive music education programme in secondary schools has the potential to support the development of key psycho-social and cognitive abilities that are important for future life success.

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