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The impact of instrumental music learning on attainment at age 16: a pilot study

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There is increasing international evidence that playing a musical instrument has a positive impact on attainment at school but little research has been undertaken in the UK. This study addresses this drawing on data on attainment at age 11 and 16 relating to 608 students, 115 of whom played a musical instrument. The findings showed that the young people playing an instrument showed greater progress and better academic outcomes than those not playing with the greatest impact for those playing the longest. The findings are considered in relation to the possible reasons for this, and the implications for education.

Introduction

There is a growing body of international evidence relating to the impact of active engagement with music on attainment in school. However, there is relatively little evidence from schools in the UK. Much of the existing research is based on correlation analysis which precludes the demonstration of causality, particularly as there are many possible confounding factors including having supportive parents and a home environment conducive to studying. There is also evidence that those who choose to play an instrument are already high attainers which may distort the findings (Harrison, 1990; Klinedinst, 1991) (for reviews see Arnett-Gary, 1998; Shobo, 2001; Yoon, 2000; Hodges & O'Connell, 2007; Costa-Giomi, 2012; Schellenberg, 2014). The testing and examination system in place in the UK at the time of the research meant that it was possible to take prior attainment into account as national tests and examinations were undertaken by the children participating in the research at ages 11 and 16.

The evidence from correlation studies in the USA has shown that students who participate in music education do better than their peers on many measures of academic achievement. For instance, using state-wide data, Abeles (2007) reported that groups of second grade children who participated in a weekly violin programme (three lessons every two weeks) outperformed non-violin group controls in performance on mathematics and language arts tests. Morrison (1994), using data from the National Centre for Educational Statistics representing over 13,000 students, showed that high school students who participated in music reported higher grades in English, mathematics, history, and science than those who did not participate. Similar outcomes have been reported by Trent (1996), Cardarelli (2003) and Fitzpatrick (2006). Johnson and Memmott (2006), in a study in four regions including 4,739 elementary and middle school students, showed a strong

relationship between third- and fourth-grade students' academic achievement and their participation in music programmes. This was moderated by the quality of the programme; the higher the quality of the programme, the higher the academic attainment.

Research based on standardized verbal and mathematics achievement tests in the USA has shown that children who have participated in music courses while in high school perform better with the number of years engaged in music correlated with test performance (Catterall, 1998). Those young musicians who participate in state wide ensembles also have higher SAT scores than state averages (DeCarbo, Fiese & Boyle, 1990; Henry & Braucht, 2007). Schellenberg (2006) also showed that music training was associated positively with children's performance in school and that those who took music lessons over relatively long periods of time tended to be particularly successfully even when intelligence was controlled for. However, not all of the research supports these findings.

Miksza (2007), using data from National Education Longitudinal Study of 1988 with a sample of 5335, created a composite item which assessed student participation in music for the entire duration of the study from eighth to 12th grade and measured academic achievement in mathematics, reading comprehension, science and social studies. There were significant differences for all subtests in the initial testing in favour of those who had participated in band, choir or orchestra, but rates of change in mathematics, science and social studies were no greater for the music participants. Indeed, in reading achievement the music participants increased more slowly than non-participants. In a later study Miszka (2010) using data from the Educational Longitudinal Study of 2002, taking account of a wider range of variables studied the impact of musical engagement on standardized mathematics scores and found that students in high-school music ensembles were more likely to have higher standardised mathematics achievement scores.

Also in the USA, Southgate and Roscigno (2009) – using two national data sets, ECLS-K (20,000 US kindergarten students) and NELS:88 (25,000 adolescents), and three measures of music participation (in school, outside school and parental involvement in the form of concert attendance) – found that music involvement varied systematically by class and gender status. Involvement had implications for both mathematics and reading achievement for young children and adolescents and associations between music and achievement persisted even when prior achievement was taken into account. Musical engagement generally increased achievement levels, although gains were not distributed equally among all students; a white student advantage existed.

A study in Germany by Hille and Schupp (2013) used the German Socio-Economic Panel Study (SOEP) longitudinal data to establish the impact of musical training on attainment. The database includes a detailed assessment of the intensity and duration of music activities for representative youth cohorts, and a variety of outcomes including school results. As it is a household rather than an individual survey it allows consideration of a wide range of parental characteristics. The findings on attainment at age 17, taking account of a wide range of individual and family characteristics, showed that children playing an instrument from age eight to 17 and having taken lessons outside school scored one-sixth of a standard deviation higher than children not playing an instrument.

There is also evidence of the impact of active engagement with music on attainment from El Sistema, and Sistema inspired projects. In a programme in Chile, Egaña de Sol (2008) showed a positive effect on academic attainment in verbal and mathematics

skills. This was attributed in part to participants holding higher expectations of their academic achievements, although evaluations of other programmes in Chile had mixed results, with some programmes having positive results and others no impact (Evaluación de impacto programa orquestas juveniles e infantiles, 2010). Programmes in the USA have indicated increased academic attainment as an outcome of participation with more children achieving roll of honour status particularly where children participated for an extended period of time (Creech *et al.*, 2013).

In the UK, where Sistema-inspired programmes focus on children in primary schools in deprived areas, Smithhurst (2011) reported that after one year of participation in the programme, children in Years 1–4 (aged 5–9) in one school were achieving better scores in mathematics, reading and writing compared with their peers who were not involved. 90 per cent of the children were reaching target grades in mathematics compared with 68 per cent not involved in the programme. Similar trends were evident in reading with 85 per cent of programme children reaching target grades compared with 62 per cent not in the programme, and in writing, 65 per cent compared with 45 per cent. Burns and Bewick (2011) reported that after two years of participating in the programme where children engaged with music for 4.5 hours per week, 43 per cent of the children had progressed more than four levels in mathematics, 53 per cent in reading, and 42 per cent in writing, compared with a national average of three levels, despite the fact that the participants included a high proportion of children with special educational needs. However, the rate of improvement slowed as participation continued.

There have been a small number of experimental studies on the effects of participation in music on general attainment. The findings have been mixed. Hoffman (1995), Wallick (1998), and Barr *et al.* (2002) indicated a positive effect in some subject areas as did Cabanac *et al.* (2013) who compared the performance of students who participated in a music programme in a single school in Canada with those who did not and found that the music students had consistently higher attainment. Hines (2000), studying students with learning difficulties from kindergarten through to ninth grade, found neither reading nor mathematics achievement was affected by type of music instruction, motoric or non-motoric. Legette (1993) also found no effect of music instruction. Schneider and Klotz (2000) compared the impact of enrolment in music performance classes or athletic extracurricular activities on academic achievement and found that all groups were equivalent in the fifth and sixth grade but during the seventh, eighth and ninth grades the musicians achieved significantly higher academic achievement scores than the athletes but not than non-participant controls.

In the UK, national testing of children's attainment at age 11 and national examinations at age 16 provide the opportunity for an objective assessment of the role of playing a musical instrument on progress and final outcomes. The aim of the current study is to explore whether students learning to play a musical instrument have enhanced achievement at age 16 in performance on UK national examinations taking into account their performance on national tests at age 11. The specific research questions are:

1) Does playing a musical instrument enhance performance on examinations at age 16?
2) Does the length of time playing a musical instrument impact on performance on examinations at age 16?

Methodology

This study draws on existing data from three secondary schools in a large English Local Authority. The results of students in the General Certificate of School Education, a national examination taken at age 16, were used to assess attainment. This included the number of subjects taken, the average point score obtained, the total score point obtained, and the capped score obtained when performance in the best eight subjects was taken into account. The children's scores in mathematics and English on national tests taken at age 11 were also collected, and data on whether they played a musical instrument and how long they had been playing for. The latter data were divided into those who had been playing for up to three years and those who had been playing for four or five years. The information on national tests and examinations in English and mathematics was provided by data managers in each school. The information about involvement in instrumental and vocal learning was provided by the head of the music department in each school.

School A, with an intake of about 750 pupils and very low numbers of children eligible for Free School Meals (FSM) and with Special Educational Needs and Disabilities (SEND), was one of the highest performing schools in the Local Authority – within the top quartile for Key Stage 4 (KS4) results. School B was a large school with 1500 pupils, with low numbers of pupils eligible for FSM and low numbers of pupils with SEND. Overall, KS4 results were within the second quartile for the Local Authority (around the average for the whole of England). School C had about 900 pupils on roll with low numbers of FSM pupils and average numbers of SEND pupils, with overall KS4 results within the third quartile for the Local Authority (below the average for the whole of England).

The total number of students in the sample was 608. Of these 493 students (81%) did not learn to play an instrument or have voice tuition in school. 115 students (19%) learnt to play an instrument or had voice tuition in school. Of those who were learning to play an instrument, 60 had been learning for four or five years and 55 had been learning for up to three years.

Findings

The findings are presented in terms of English, mathematics and overall attainment.

English

Analysis of variance showed that there were statistically significant differences in performance between the non-instrumentalists and instrumentalists at Key Stage 2 (age 11) (see Table 1 for details). The non-instrumentalists had an average point score at KS2 in English of 28.39 (SD = 4.15), the instrumentalists 29.89 (SD = 4.75). The minimum score was 0, the maximum 33.

At KS4 (age 16) in English the non-instrumentalists had a mean point score of 41.8 (SD = 6.75; range 16–58), while the instrumentalists had a mean point score of 46.92 (SD = 6.1; range 26–58). These differences were statistically significant (see Table 1).

Data on progress between KS2 and KS4 were also collected. In English the mean progress score from KS2 to KS4 for the non-instrumentalists was 3.03 (SD = .87; range -1

Table 1. *Means and standard deviations for outcome measures by instrumentalists and non-instrumentalists*

	Non-instrumental students		Instrumental students				
	Mean	SD	Mean	SD	F	df	Sig
Total number of KS4 exams taken	10.10	2.19	11.38	1.88	32.35	1.605	.0001
Average points for all KS4 exams	42.93	6.3	48.48	5.37	86.02	1.605	.0001
Total points for all KS4 exams	434.4	131.9	551.6	125.1	74.98	1,605	.0001
Total number of points from student's best eight examination scores	343.05	67.94	400.76	48.46	74.17	1,605	.0001
KS2 English points score	28.39	4.15	29.89	4.75	11.51	1,605	.001
KS2-KS4 English progress (levels)	3.03	.87	3.6	.68	46.61	1,605	.0001
KS4 English points score	41.8	6.75	46.92	6.09	55.51	1,605	.0001
KS2 Mathematics points score	28.04	4.51	29.95	4.48	16.68	1,605	.0001
KS2-KS4 Mathematics progress (levels)	3.0	1.08	3.83	.89	64.96	1,605	.0001
KS4 Mathematics points score	41.39	8.74	48.21	7.36	59.78	1,605	.0001

to 5) and for the instrumentalists 3.63 (SD = .68; range 2 to 5). These differences were statistically significant (see Table 1).

Analyses were also undertaken in relation to the length of time that the students had been learning. There were no statistically significant differences between the two groups at KS2. The mean for the instrumentalists learning for 2/3 years was 29.29 (SD = 4.24) and for those learning 4/5 years 30.45 (SD = 5.15). However, there were statistically significant differences in progress to KS4 and performance at KS4. The mean for progress for those learning 2/3 years was 3.47 (SD = .69) and for those learning for 4/5 years 3.77 (SD = .65) and for performance at KS4 for the those learning 2/3 years 45.09 (SD = 6.37) and those 4/5 years 48.6 (SD = 5.34) (see Table 2 for details).

A series of multiple regressions were undertaken to establish the extent to which playing an instrument impacted on attainment in English, taking account of performance in English at KS2. A multiple R of .68 was obtained with an adjusted R^2 of .46 ($F(2,604) = 259.04$, $p < .0001$). The standardized beta coefficients were .205 for playing an instrument and .62 for KS2 English. Both were highly statistically significant ($p < .0001$) (see Table 3 for details).

An analysis using the data relating to how long the students had been playing revealed a multiple R of .593 with an adjusted R^2 of .34 ($F(2,112) = 30.37$, $p < ,0001$). The

Table 2. *Means and standard deviations for outcome measures by number of years learning*

	Those learning instruments for 2/3 years		Those learning instruments for 4/5 years				
	Mean	SD	Mean	SD	F	df	Sig
No. of KS4 exams taken	11.22	2.16	11.53	1.59	.759	1,113	NS
Average points score for all KS4 exams	46.32	5.53	49.67	4.71	12.28	1,113	.001
Total points score for all KS4 examinations	525.36	135.03	575.75	111.05	4.8	1,113	.03
Total number of points from student's best 8 examination scores at KS4	386.36	52.77	413.95	40.23	10.04	1,113	.002
KS2 English points score	29.29	4.24	30.45	5.15	1.72	1,113	NS
KS2-KS4 English progress (levels)	3.47	.69	3.77	.65	5.55	1,113	.02
KS4 English points score	45.09	6.37	48.60	5.34	10.31	1,113	.002
KS2 Mathematics points score	29.84	3.62	30.05	5.17	.065	1,113	NS
KS2-KS4 Mathematics progress (levels)	3.55	.89	4.10	.79	12.31	1,113	.001
KS4 Mathematics points score	46.04	7.36	50.20	6.84	9.89	1,113	.002

standardized beta weights were .522 for KS2 English score ($p < .0001$) and .225 for how long the students had been playing .225 ($p < .01$) (see Table 3 for details).

Mathematics

There were statistically significant differences between the instrumentalists and non-instrumentalists in their performance in mathematics at KS2 ($F(1,605) = 16.68$, $p < .0001$). The non-instrumentalists had a point score of 28.04 (SD = 4.5), the instrumentalists 29.95 (SD = 4.48). At age 11 those who played instruments were significantly ahead of their non-instrumental playing peers, although the difference was very small (see Table 1 for details).

At KS4 in mathematics the non-instrumentalists had a mean score of 41.39 (SD = 8.74; range 0–58) while the instrumentalists had a mean score of 48.21 (SD = 7.36; range 26–58). These differences were statistically significant (see Table 1 for details). The mean progress score from KS2 to KS4 for the non-instrumentalists was 3.0 (SD 1.08; range -1

Table 3. *Weightings and statistically significance for multiple regression analyses*

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Total number of qualifying examinations taken at the end of KS4					
Key Stage 2 mathematics points score	.081	.023	.169	3.529	.000
Key Stage 2 English points score	.105	.024	.205	4.316	.000
Playing an instrument	.948	.212	.170	4.482	.000
Total number of qualifying examinations taken at the end of KS4					
Key Stage 2 mathematics points score	.161	.054	.383	2.967	.004
Key Stage 2 English points score	− .058	.052	− .146	− 1.121	NS
How long playing	.226	.229	.090	.989	NS
Average points score for all qualifying examinations					
Key Stage 2 mathematics points score	.474	.054	.330	8.796	.000
Key Stage 2 English points score	.523	.057	.344	9.196	.000
Playing an instrument	4.207	.497	.252	8.466	.000
Average points score for all qualifying examinations					
Key Stage 2 mathematics points score	.352	.134	.294	2.636	.010
Key Stage 2 English points score	.252	.127	.223	1.991	.049
How long playing	1.987	.562	.279	3.536	.001
Total points score for all qualifying examinations					
Key Stage 2 mathematics points score	8.025	1.266	.264	6.338	.000
Key Stage 2 English points score	9.613	1.336	.299	7.195	.000
playing an instrument	87.539	11.670	.248	7.501	.000
Total points score for all qualifying examinations					
Key Stage 2 mathematics points score	11.151	3.406	.399	3.274	.001
Key Stage 2 English points score	− .256	3.234	− .010	− .079	.NS
How long playing	32.201	14.331	.194	2.247	.027
Total number of points from student's best 8 examination scores at the end of KS4					
Key Stage 2 mathematics points score	4.334	.601	.289	7.214	.000
Key Stage 2 English points score	5.254	.634	.330	8.286	.000
playing an instrument	41.574	5.538	.238	7.508	.000

Table 3. *Continued*

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Total number of points from student's best 8 examination scores at the end of KS4					
Key Stage 2 mathematics points score	3.201	1.237	.296	2.588	.011
Key Stage 2 English points score	2.034	1.174	.199	1.733	.NS
How long playing	16.363	5.204	.254	3.145	.002

to 6) and for the instrumentalists (3.73 (SD = .89; range 1 to 6). These differences were statistically significant (see Table 1 for details).

Comparisons were also made between those who had been learning for 2/3 years and those who had been learning for 4/5 years. There were no statistically significant differences in KS2 scores but the group who had been learning for longer made greater progress and had higher KS4 scores. The group learning for 2/3 years had a mean of 3.55 (SD = .89) in relation to progress while the group learning for 4/5 years had a mean of 4.1 (SD = 79). In relation to performance at KS4 the young people learning for 2/3 years had a mean of 46.04 (SD = 7.36) while those learning for 4/5 years had a mean of 50.2 (SD = 6.84) (see Table 2 for details).

A multiple regression to establish the extent of the impact of playing an instrument on attainment revealed a multiple R of .71 with an adjusted R^2 of .5 (F (2,599) = 300.93, $p < .0001$). The standardized beta coefficients were .65 for mathematics score at KS2 and .197 for playing an instrument.

A similar analysis using the length of time learning as a predictor along with mathematics score at KS2. A multiple R of .55 was revealed with an adjusted R^2 of .29 ($F(2.112) = 24.27$, $p < .0001$). The standardized beta coefficients were .47 for KS2 mathematics and .27 for length of time playing an instrument (see Table 3 for details).

Overall attainment

The trends observed in relation to English and mathematics was also seen in relation to overall attainment. There was a statistically significant difference between instrumentalists and non-instrumentalists in relation to the number of KS4 examinations taken with the instrumentalists taking 11.38 (SD = 1.88) and the non-instrumentalists 10.1(2.19). The mean for the instrumentalists for the average KS4 points score was 48.48 (SD = 5.37), total points for all KS4 examinations 551.6 (SD = 125.1) and capped score for the best eight examinations 400.76 (SD = 48.46). The mean for the non-instrumentalists for the average KS4 points score was 42.93 (SD = 6.3), total points for all KS4 examinations 434.4 (SD = 131.9) and capped score for the best eight examinations 343.05 (SD = 67.94). In every

case the instrumentalists outperformed the non-instrumentalists. These differences were all highly significant statistically (see Table 1).

A series of multiple regressions were undertaken to establish whether playing an instrument contributed to attainment at KS4. A multiple regression analysis was undertaken on the total number of qualifying examinations taken with KS2 scores in English and mathematics and playing an instrument or not as predictors. The multiple R was .4 with an adjusted R^2 of .157 ($F(3,603) = 38.59$, $p < .0001$). The beta weight for mathematics at KS2 was .169, for English at KS2 .205 and for playing an instrument .17. This suggests that learning to play an instrument is as strong a predictor of the number of examinations taken at KS4 as mathematics level at KS2 and almost as strong a predictor as English level at KS2. Table 2 provides details of the levels of statistical significance for each predictor. A similar analysis was undertaken substituting whether a musical instrument was played with the length of time playing. This revealed a multiple R of .31 with an adjusted R^2 of 0.71 ($F(3,111) = 3.89$, $p < .011$). The beta weight for mathematics was .383, for English −.146 and for length of time learning .09. The beta weights for length of time learning an instrument and attainment at KS2 in English were not statistically significant predictors (see Table 3).

A multiple regression on the average points score for all qualifying examinations taken at KS4 with KS2 mathematics and English scores and playing an instrument or not as the predictors revealed a multiple R of .69 with an adjusted R^2 of .48 ($F(3,603) = 186.99$, $p < .0001$). The beta weight for mathematics at KS2 was .33, for English .344 and for playing an instrument .252. While academic attainment in mathematics and English at KS2 were better predictors than playing an instrument, the latter still made a substantial and statistically significant contribution to explain the variance. Details of the statistical significance for each variable are given in Table 2. When length of time playing replaced learning an instrument or not the multiple R was .57 with an adjusted R^2 of .31 ($F[3,111] = 17.94$, $p < .0001$). The beta weight for mathematics at KS2 was .294, for English .223 and for length of time learning an instrument .279. These findings were highly statistically significant and suggest that length of time learning to play an instrument is a better predictor of average points score at KS4 than English level at KS2 and is almost as good as mathematics at KS2 (for further details see Table 3).

A multiple regression analysis was undertaken on the total points score for all qualifying examinations using KS2 mathematics and English scores and playing an instrument or not as predictors. This revealed a multiple R of .6 with an adjusted R^2 of .36 ($F[3,603] = 113.18$, $p < .0001$). The beta weight for mathematics at KS2 was .264, for English .299 and for being an instrumentalist .248. While KS2 attainment in mathematics and English were slightly better predictors of total points score than playing an instrument, the latter nevertheless made a highly statistically significant contribution (see Table 3 for details). When the length of time playing was substituted for playing or not the multiple R was .44 with an adjusted R^2 of .17 ($F(3,111) = 8.94$, $p < .0001$). The beta weight for attainment in mathematics at KS2 was .399, for English at KS2 -.01 and for length of time playing an instrument .194. While mathematics at KS2 was a better predictor than length of time playing an instrument the latter still made a statistically significant contribution, in contrast to English attainment at KS2 where the contribution was not statistically significant.

A multiple regression was carried out on the total number of points from student's best eight examination scores at the end of KS4 with KS2 mathematics and English and playing an instrument or not as predictors. This revealed a multiple R of .64 with an adjusted R^2 of .41 ($F[3,603] = 140.31$, $p < .0001$). The beta weight for attainment in mathematics at KS2 was .289, for English at KS2 .33 and for playing an instrument .238. While playing an instrument made a lesser contribution than KS2 performance it was still highly statistically significant. When playing an instrument was replaced by length of time learning the multiple R was .54 with an adjusted R^2 of .27 ($F[3,111] = 15.25$, $p < .0001$). The beta weight for attainment at KS2 was .296, for English .199 and for length of time learning .254. The weighting for English was not statistically significant (see Table 3 for details).

Discussion

The evidence presented in this paper provides the first evidence from UK secondary schools that playing a musical instrument enhances performance on national examinations at KS4 and progress between KS2 and KS4 and that the impact is greater the longer a young person has been playing an instrument. The instrumentalists across all three schools, on most measures, performed at nearly one standard deviation better than those not playing an instrument at KS4 despite there being negligible differences at KS2. Those who had been learning for four or five years had the best results. When multiple regression analyses were undertaken, length of time playing an instrument was a better predictor than attainment at KS2 in English in relation to total points score and total number of points from the best eight examinations at KS4. Playing an instrument made a statistically significant contribution to performance at KS4 across all measures.

The findings support the international evidence where correlation studies have suggested that children who experience musical training have advantages across all school subjects except sport even after general intelligence is controlled for (Wetter, Koerner & Schwaninger, 2009). Their performance is better than might be expected based on their scores on intelligence tests (Corrigall, Schellenberg & Misura, 2013; Schellenberg, 2006).

There are many possible reasons for the better progress and performance of the instrumentalists. For this age group (11–16 years) it is not likely that the benefits of active engagement with music seen in relation to language, literacy and spatial reasoning (see Hallam, 2015) are contributory factors, although this cannot be completely ruled out.

Motivation is crucial in how well children perform at school and is closely linked to self-perceptions of ability, self-efficacy and aspirations (Hallam, 2005). If active engagement with music increases positive perceptions of self, this may transfer to other areas of study and increase motivation to persist. Research in Norway supports this showing a relationship between musical competence and high motivation which led to a greater likelihood of success in school (Lillemyr, 1983). There were high correlations between positive self-perception, cognitive competence, self-esteem, and interest and involvement in school music. The confidence and self-beliefs that can accrue from learning to play a musical instrument and performing in public may increase motivation more generally leading to enhanced attainment across the whole curriculum.

Another possible contributory factor may be the impact on learners' aspirations, which in turn affects motivation. There is certainly evidence that participating in musical activities can change aspirations in disadvantaged groups (Devroop, 2009). In the UK, Lewis, Demie and Rogers (2011) reported raised aspirations in pupils participating in a Sistema-inspired programme, in part attributed to contact with inspirational role models. In a review of El Sistema and Sistema inspired projects, Creech *et al*. (2013) concluded that raised aspirations were one of the most frequently cited positive outcomes.

Another possible explanation for the impact of playing an instrument on attainment is that active music making can provide opportunities to develop different aspects of learning. For instance, Burton, Horowitz and Abeles (1999) described a taxonomy of eight general areas which may be relevant, including the opportunity to express ideas and emotions; enhanced and focused perception; the opportunity to make connections and to observe layered and complex relationships between diverse forms of knowledge; and being able to construct and organise new meanings, to perceive and understand various points of view, to imagine new possibilities, and to provide opportunities for sensory learning. The extent to which this might be relevant to enhanced attainment in those playing an instrument requires further research.

Learning to play an instrument may also encourage conscientiousness, resulting from the need to sustain individual practice. There is certainly evidence that music students are more conscientious than non-music students (Corrigall, Schellenberg & Misura, 2013). Of course, it is possible that conscientiousness underpins success in playing an instrument and general attainment and that the relationship is not causal. Longitudinal research which took account of personality variables prior to children beginning to play an instrument could address this issue.

One explanation for the impact of musical activities on attainment has drawn on the possible mediating role of executive functioning and self-regulation. Executive functions are related to working memory and also involve the conscious control of action, thoughts, emotions and general abilities such as planning, and the capacity to ignore irrelevant information, to inhibit incorrect automatic responses and to solve problems. Executive functions also include cognitive flexibility – the ability to adjust to novel or changing task demands (Diamond, 1990, 2002; Lezak, 2004; Zelazo, 2004). Playing a musical instrument, particularly in an ensemble, requires many sub-skills associated with executive functioning including sustained attention, goal-directed behaviour and cognitive flexibility. Formal music practice involves cognitive challenge, controlled attention for long periods of time, keeping musical passages in working memory or encoding them into long-term memory, and decoding musical scores and translating them into motor programmes. These activities draw on complex cognitive functions which have been illustrated in brain-imaging research (Schon *et al*., 2002; Stewart *et al*., 2003). Hannon and Trainor (2007) argue that formal musical instruction seems to train a set of attentional and executive functions, which have domain-specific and domain-general consequences. Correlation studies have explored the relationships between active music making and enhanced executive functioning with largely positive results although there are some exceptions (see Hallam, 2015 for a review). Research with children has had mixed findings. For instance, in a study with children aged 9–12 years Degé, Kubicek & Schwarzer (2011) assessed five different executive functions (set shifting, selective attention, planning, inhibition, and

fluency) and found significant associations between music lessons and all of the measures of executive function – although a similar study by Schellenberg (2011) with musically trained and untrained musicians aged 9–12, assessing five measures of executive function, found no relationship with musical training. Despite the mixed evidence from correlational studies, interventions with young children have demonstrated a positive impact of active music making on some executive functions and self-regulation (Moreno *et al.*, 2011a; Moreno, Friesen & Bialystok, 2011b; Winsler, Ducenne & Koury, 2011). This is a promising line of enquiry for the future.

Whatever the underlying mechanisms there is accruing evidence that playing a musical instrument has a positive impact on attainment in school. The research reported here adds to that evidence, although it is limited in scope and the number of variables which were able to be taken into account. Future research in the UK needs to be able to take account of a wider range of factors relating to children's home background and the nature of their musical engagement. Such research is important in an educational context where schools have greater independence in terms of the curriculum and where many do not have to follow the national curriculum which in some cases has led to music being marginalised. Hard evidence demonstrating that the benefits of music go beyond those of music for its own sake may convince head teachers that it has an important role to play in schools.

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