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ARTICLE

Does learning to play an instrument have an impact on change in attainment from age 11 to 16?

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Abstract
Much previous international research has demonstrated links between general school attainment and active engagement with music. The research reported here compared the change in examination outcomes in English and mathematics in national examinations at ages 11 and 16 of instrumentalists and non-instrumentalists. Data from 701 pupils showed statistically significant differences in examination outcomes between instrumentalists and non-instrumentalists, which was also related to the duration of learning and the instrument played. Instrumentalists had greater change scores in mathematics, but not English, although instrumentalists of lower socio-economic status showed greater change in both subjects. The implications for music education are discussed.

Keywords: Attainment; instrumental learning; English; mathematics; socio-economic status

Background

There is considerable research exploring whether active engagement with music has an impact on academic attainment (for a review see Hallam & Himonides, 2022). Much of that research, some of which is based on very large samples of thousands of students, has indicated that learning to play a musical instrument can have a positive impact on academic attainment in a range of academic subjects (see Southgate & Roscigno, 2009; Hille & Schupp, 2015; Swaminathan & Gopinath, 2013; Thorton, 2013; Yang et al., 2014; Yang, 2015; Gill, 2020). However, not all the research has shown such benefits, some indicating no benefits (Elpus, 2013; Tai et al., 2018), while reviews and meta-analyses have drawn mixed conclusions or found that there is no benefit (Jaschke et al., 2013; Sala & Gobet, 2017a, 2017b, 2020). This research is based on correlations, so it may be that learning to play a musical instrument attracts those who are already high attainers (Costa-Giomi, 2012; Schellenberg, 2015). There have been relatively few studies that have demonstrated causality. Typically, these are small scale and take place over a relatively short period of time. The findings from these studies are also mixed (Cabanac et al., 2013; Mehr et al., 2013; Haywood et al., 2015; Holochwost et al., 2017). The quality and intensity of the musical experience are rarely considered in the research. An exception is the work of Johnson and Memmott (2006) who studied 4,739 elementary and middle school students and showed that those participating in exemplary, high-quality music education programmes as identified by professors of education scored higher in standardised tests in English and mathematics than those participating in programmes deemed by the same professors of education to be of low quality. Despite this, the students participating in the low-quality programmes scored higher than those who had no music classes or participated in poor quality choral programmes. Some research has focussed on children from economically

deprived areas. For instance, evidence from El Sistema and Sistema-inspired projects has indicated positive outcomes for attainment for some children. In England, Smithurst (2011) reported that after 1 year of participation, children achieved higher scores in mathematics, reading and writing compared with non-participating peers, while in Chile, Egaña de Sol (2008) showed a positive effect on verbal and mathematics skills. In a review of Sistema programmes, Creech and colleagues (2013) concluded that, with some exceptions, there was a significant and steady improvement in academic attainment for participating children.

An alternative approach has been to consider the impact of active engagement with music on attainment over time. For instance, Guhn and colleagues (2020) compared change in the examination grades of 15,483 students who participated in school music courses with 97,433 who did not. Taking previous academic achievement into account, scores were significantly higher for those actively participating in making music. The effect was most pronounced for those who were highly engaged with instrumental music. Academically, they were over 1 year ahead of their peers. Similarly, dos Santos and colleagues (2015) studying 11 to 14 year olds showed better academic performance in those studying music after controlling for prior academic achievement, intelligence, socio-economic status and motivation. In England, Hallam and Rogers (2016) drew on nationally available data on attainment in mathematics and English for 608 students, 115 of whom played a musical instrument. Those participating in musical activities showed greater change over time and overall better academic examination outcomes. The longer that they had been playing the greater the impact. Instrumentalists performed at nearly one standard deviation higher on almost all examination outcomes despite there being negligible differences at age 11. Playing an instrument made a statistically significant contribution to performance at age 16 across all measures.

The research reported here builds on the work of Hallam and Rogers (2016) and explores change in examination performance between age 11 (Standard Assessment Tests, SATs) and 16 (General Certificate of Secondary Education, GCSEs) in national examinations in mathematics and English taken in England, Wales and the Crown Dependencies. Further developing the earlier work by Hallam and Rogers (2016), the research reported here considered whether the instrument played had an impact on attainment. Data from a subsample of those living in relative poverty also enabled an examination of the impact of playing an instrument on this group. The specific research questions were as follows:

- Are there advantages for those learning to play an instrument in national examinations taken at ages 11 and 16?
- Is there a greater change between the scores in these examinations for those playing an instrument?
- Does the length of time playing an instrument have an impact on examination outcomes or change over time?
- Are there differences between those playing different musical instruments?
- Is there a relationship between the length of time learning to play an instrument and instrument played?
- What proportion of participating children eligible to receive free school meals played instruments?
- Are there academic benefits for those eligible to receive free school meals of learning to play a musical instrument?

Methods

Seven hundred and one young people drawn from eight secondary schools in England or the Crown Dependencies participated in the research. Drawing on school records, participating schools provided data from test results in English and mathematics derived from national

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examinations (Standard Assessment Tests, SATs) taken at the end of primary school (Key Stage 2) and the outcomes of the General Certificate of Secondary Education (GCSE) in English and mathematics taken at age 16 (the end of Key Stage 4). In 2020, the year the data were collated, GCSE results were based on Teacher Assessed Grades rather than independent national marking because of the COVID-19 pandemic. There is evidence that the grades in 2020 were more lenient than in 2019 (He & Black, 2020). However, as this leniency was the same for all students participating in the research reported here the findings are not affected.

Participating students completed a questionnaire that asked whether they learned to play an instrument; the name of their main instrument; the length of time that they had been learning; and their eligibility for receiving the Pupil Premium or comparable Crown Dependency funding. The pupil premium is funding to improve education outcomes for disadvantaged pupils in schools in England (DfE, 2022). The questionnaires were completed during class music lessons. The secondary school music teachers were keen for their students to participate as this provided them with additional information about the musical activities of their students some of which they may not have been aware of. The instrumental tuition that the children received was largely through local music service provision, with weekly one-to-one or small-group lessons held within schools provided by visiting, peripatetic teachers. Lessons were typically paid for by parents although in some cases were subsidised through school budgets.

Points scores derived from national tests at ages 11 (SATs) and 16 (GCSE) were used in the analysis. Point scores derived from GCSE scores are used by both local authorities and schools to enable both to monitor their performance against national statistics. SPSS (Statistical Package for the Social Sciences) was used to analyse the data. The SATs and GCSE data provided by the schools were transferred into a database and the data from the questionnaires coded and entered into the same database.

To answer the research questions, a range of statistical analyses were undertaken. Independent 't' tests were used to compare the outcomes for instrumentalists and non-instrumentalists. One-way analysis of variance and regression analyses were used to compare the scores of those playing for different periods of time and those playing different instruments. National test scores at age 11 (SATs) were included in regression analyses to account for prior achievement. Analyses were undertaken to explore if there was a relationship between the instrument played and length of time learning to play. Separate analysis was undertaken for students where schools were in receipt of additional funding (the Pupil Premium or comparable Crown Dependency funding) related to students' parents' socioeconomic status. The findings are reported below with details provided in tables and figures. The probability of each finding having occurred by chance is reported with the smaller the probability the greater the likelihood that the findings did not occur by chance. Findings with a low probability of occurring by chance are described as highly statistically significant ($p = .0001$), while those with a higher p ($p = .001$) are reported as statistically significant. Normally, statistical probability is considered acceptable when p is less than 0.05. The abbreviation df stands for degrees of freedom (the maximum number of logically independent values, which are values that have the freedom to vary, in the data).

Comparisons between instrumentalists with non-instrumentalists

Of the 701 students completing questionnaires, 113 (16.1%) were learning to play an instrument. There were highly statistically significant differences in the point scores for English, reading, writing and mathematics ($p = .0001$) between the instrumentalists and non-instrumentalists at age 11. Table 1 and Figure 1 set out the details. Those playing an instrument had consistently higher scores. At age 16 (GCSE level), there were highly statistically significant differences between test scores for those learning to play instruments and those not receiving tuition. Those playing an instrument had higher mean scores for every examination outcome. The details are set out in Table 2 and Figure 2. Regression analyses were undertaken using scores at age 11 and whether

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Table 1. Comparison of attainment scores for instrumentalists and non-instrumentalists at age 11

Subject	Non- instrumentalists	Instrumentalists	t	Sig
English	28.3 (0.2)	30 (3.1)	4.7	.0001
Reading	27.7 (3.7)	29.7 (3.4)	4.1	.0001
Writing	26.5 (3.7)	28.3 (3.3)	3.8	.0001
Mathematics	28.7 (4.4)	29.9 (3.9)	2.6	.0001

Figures in brackets indicate standard deviations.

Table 2. GCSE outcomes for instrumentalists and non-instrumentalists

Subject	Non-instrumentalists	Instrumentalists	t	Sig
English	42.5 (3.3)	44.0 (3.3)	26.4	.0001
English literature	42.7 (3.05)	44.8 (3.3)	27.1	.0001
Mathematics	41.7 (4.0)	43.4 (3.8)	18.5	.0001

Figures in brackets indicate standard deviations.

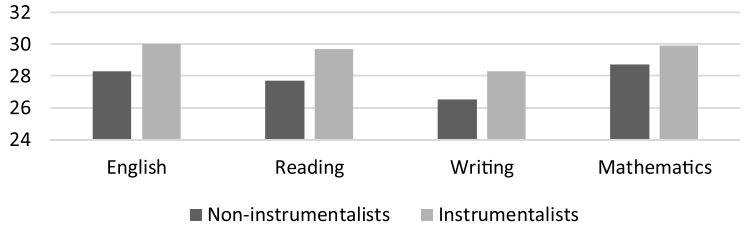

Figure 1. Comparison of attainment scores for instrumentalists and non-instrumentalists at age 11.

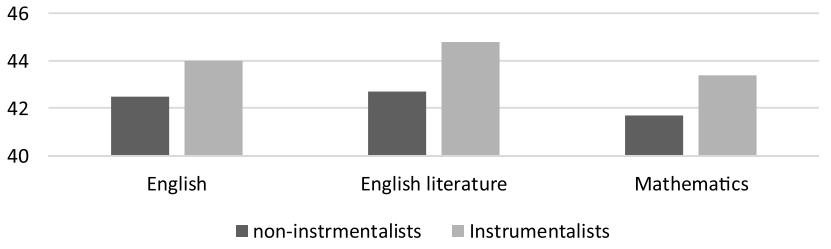

Figure 2. GCSE outcomes for instrumentalists and non-instrumentalists.

an instrument was played as the independent variables. These were highly statistically significant, with the greater proportion of variance accounted for by prior knowledge represented by scores at age 11, although a small contribution was made by playing an instrument. The details are set out in Table 3 and Figure 3.

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Table 3. Regression analysis of GCSE scores at age 16

Subject	R	R^2	Beta weight for outcome at age 11 (English or mathematics)	Beta weight for playing an instrument	F	Sig
English	.61	.37	.61	.1	189.9	.0001
English literature	.53	.28	.57	.15	135.5	.0001
Mathematics	.77	.59	.75	.11	431.4	.0001

Table 4. Length of time learning and attainment outcomes aged 11

Subject	No tuition	Up to 3 years tuition	Over 3 years tuition	F	df	Sig
English	28.3 (3.6)	28.4 (3.3)	31.0 (2.6)	18,43	2,649	.0001
Reading	27.7 (3.7)	28.5 (3.5)	30.9 (2.9)	12.34	2,395	.0001
Writing	26.5 (3.7)	27.1 (3.3)	29.5 (2.8)	11.267	2,395	.0001
Mathematics	28.7 (4.4)	27.8 (3.5)	31.2 (3.8)	11.86	2,649	.0001

Figures in brackets indicate standard deviations, df = degrees of freedom

Table 5. Length of time learning and GCSE outcomes aged 16

Subject	No tuition	Up to 3 years tuition	Over 3 years tuition	F	df	Sig
English	42.2 (3.3)	42.5 (3.2)	45.0 (3.1)	20.86	2,634	.0001
English literature	42.5 (3.4)	43.5 (3.5)	45.3 (3.1)	16.59	2,486	.0001
Mathematics	41.7 (4.0)	41.3 (3.4)	44.8 (3.3)	20.93	2,635	.0001

Figures in brackets indicate standard deviations, df = degrees of freedom

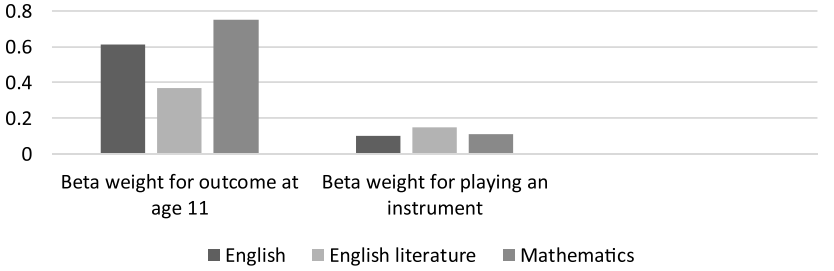

Figure 3. Regression analysis of GCSE scores at age 16.

Length of time learning to play an instrument

Forty-three (38%) of the instrumentalists had been learning to play for up to and including 3 years, 70 (61.9%) for over 3 years. One-way analysis of variance was undertaken in relation to length of time learning for each subject at age 11 and 16 (see Tables 4 and 5 and Figures 4 and 5). At each age, there were highly statistically significant differences with those learning to play an instrument for longer performing better in each subject. Regression analyses were highly statistically significant with the greater proportion of variance accounted for by prior

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Table 6. Regression analysis of GCSE outcomes at age 16 by length of time learning

Subject	R	R^2	Beta weight English or mathematics at age 11	Beta weight length of time learning to play	F	Sig
English	.63	.4	.59	.11	199.9	.0001
English literature	.61	,37	.56	.15	135.1	.0001
Mathematics	.77	.59	.74	.12	434.1	.0001

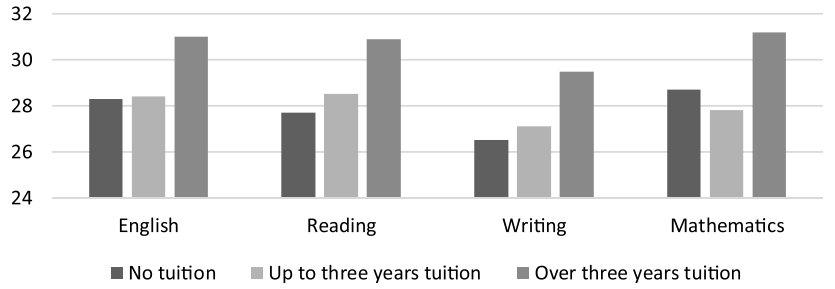

Figure 4. Length of time learning and attainment outcomes aged 11.

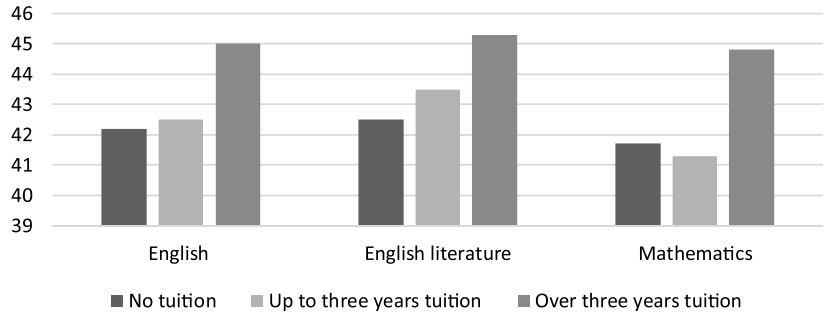

Figure 5. Length of time learning and GCSE outcomes age 16.

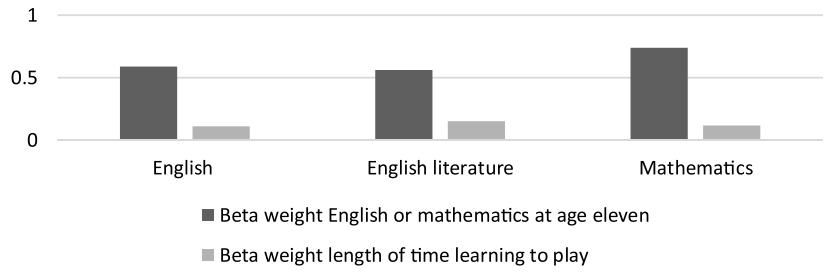

Figure 6. Regression analysis of GCSE outcomes at age 16 by the length of time learning.

knowledge represented by scores at age 11, although a small contribution was made by the length of time learning to play an instrument. The details are set out in Table 6 and Figure 6. There were no statistically significant differences in change scores between ages 11 and 16 in relation to length of time learning.

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Table 7. Instruments played

Instrument group	*Number*	*Percentage*
Woodwind	17	15.0
Piano/keyboard	15	13.3
Stringed instruments	14	12.4
Drums/percussion	11	9.7
Guitar	10	8.8
Brass	8	7.1
Instrument not declared	38	33.7

Table 8. Instrument differences in GCSE outcomes and change scores in English and mathematics

	Strings	Piano/ Keyboard	Brass	Woodwind	Drums/ percussion	Guitar	F	Df	P
English	45.5 (2.8)	41.3 (2.6)	44.3 (209)	44.9 (3.2)	41.3 (2.0)	42.8 (3.3)	5.1	5,66	.001
English literature	46 (2.7)	44 (3.3)	43.7 (2.3)	44.8 (3.5)	42.0 (2.3)	44.0 (3.7)	1.2	5,46	NS
Mathematics	44.3 (3.8)	39.5 (3.4)	44.0 (2.1)	43.2 (2.9)	40.9 (2.4)	42.4 (3.2)	4.8	5,69	.001
Change score English	11.3 (12.4)	14.3 (2.9)	13.5 (2.8)	15.0 (2.6)	6.1 (17.9)	13.4 (1.8)	1.6	5,69	NS
Change score mathematics	13.1 (3.4)	13.1 (2.4)	13.7 (2.8)	14.2 (1.6)	13.0 (3.5)	13.6 (2.1)	.422	5,69	NS

Figures in brackets indicate standard deviations. *NS = not statistically significant*

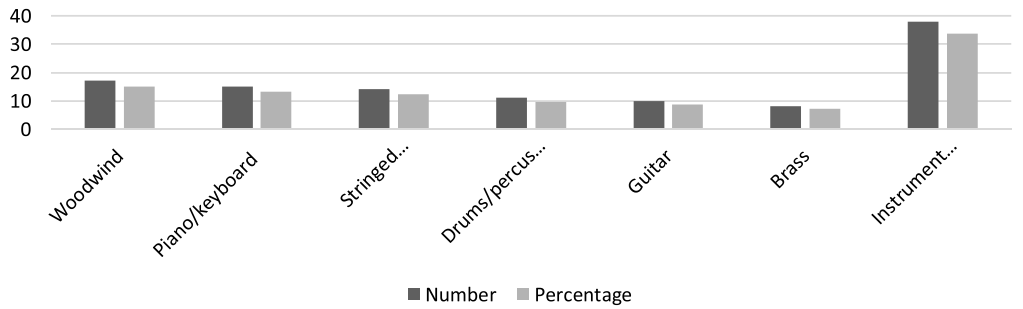

Figure 7. Instruments played.

Comparisons between those playing different instruments

A range of instrument were played by the participating young people. The details are set out in Table 7 and Figure 7. There were too few children playing different instruments at age 11 to enable analysis of instrument differences. However, there were statistically significant differences in performance at age 16 in English and mathematics between those playing different instruments ($p = .001$) but not in relation to English literature (see Table 8 and Figure 8). Regression analyses of outcomes at age 16 in relation to the instrument played showed highly statistically significant differences ($p = .0001$), with the larger portion of the variance accounted for by performance at age 11, although a small proportion was related to the instrument played (see Table 9 and

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Table 9. Regression analysis of outcomes at age 16 by instrument played

	R	R^2	Beta weight English or mathematics at KS2	Instrument played	F	Sig
English GCSE	.63	.39	.61	.1	198.9	.0001
English literature	.61	.37	.56	.15	135.1	.0001
Mathematics	.71	.51	.71	.02	36.9	.0001

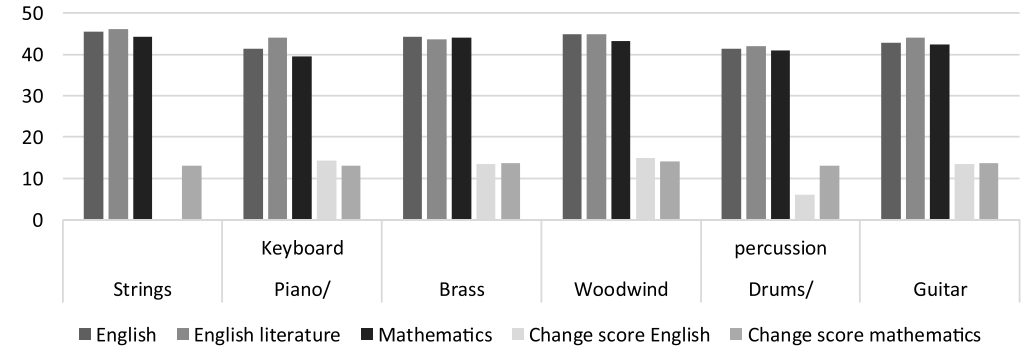

Figure 8. Instrument differences in GCSE outcomes and change scores in English and mathematics.

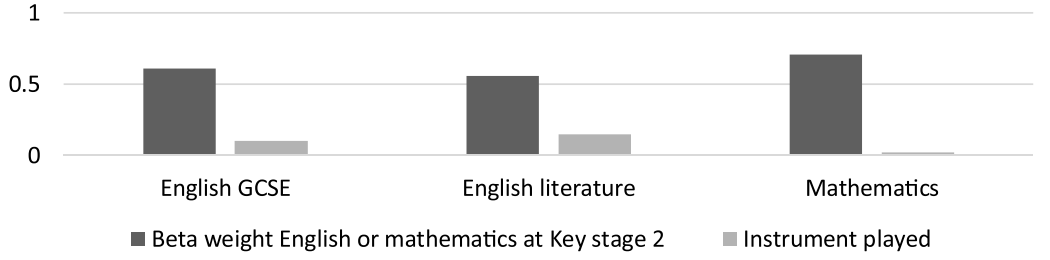

Figure 9. Regression analysis of outcomes at age 16 by instrument played Chart Title.

Figure 9). There were no statistically significant differences in change scores between those playing different instruments (see Table 8 and Figure 8).

A chi-squared test was undertaken to see if there were any relationships between length of time learning and instrument played. Table 10 and Figure 10 set out the details. There were highly significant differences between groups in the length of time they had been learning ($x^2 = 97.7$, df = 35, p = .0001), although no clear patterns emerged. The string players seemed to have been learning for longer than any of the other groups perhaps because tuition of stringed instruments tends to be available more frequently in primary schools, although some woodwind and brass players had also started to learn to play while at primary school.

Change in English and mathematics scores between KS2–KS4

Independent 't' tests were undertaken between the scores of instrumentalists and non-instrumentalists in relation to the change scores between outcomes at ages 11 and 16. There were no statistically significant differences in relation to English but there were highly statistically

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Table 10. Length of time learning by instrument learned

	12 months or less	13 to 24 months	25–36 Months	37–48 Months	49–60 months	61–72 months	73–84 months	85–109 Months
Strings	0	0	0	0	4	3	2	5
Piano/keyboard	6	5	1	3	0	0	0	0
Brass	0	0	1	1	2	1	3	0
Woodwind	1	4	2	1	1	2	6	0
Drums/percussion	4	1	3	3	0	0	0	0
Guitar	0	5	5	0	0	0	0	0

Table 11. Change scores for instrumentalists and non-instrumentalists

Subject	Instrumentalists	Non instrumentalists	T	P
English	12.82 (7.6)	11.89 (13.4)	1.02	NS
Mathematics	13.55 (2.64)	10.89 (13.3)	4.39	.0001

Figures in brackets indicate standard deviations. *NS = not statistically significant*

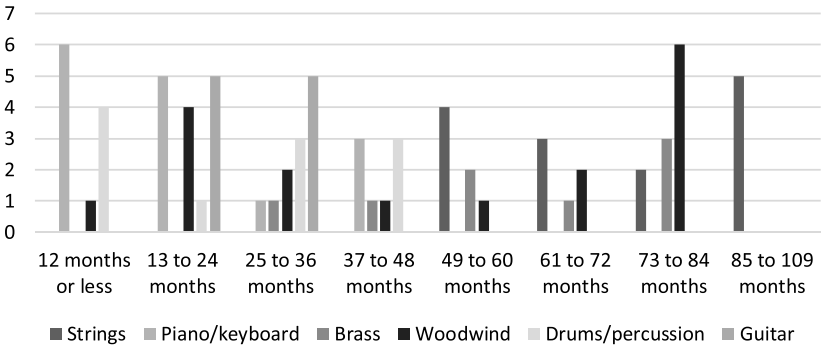

Figure 10. Length of time learning by instrument.

significant differences in relation to mathematics with those learning to play an instrument having larger change scores with smaller standard deviations. The details are set out in Table 11 and Figure 11. There were no statistically significant differences in change scores with regard to the length of time learning or the instrument played.

Analyses of data for children from low socio-economic status households

One hundred and twenty-one (17.3%) children were eligible to receive the Pupil Premium or the Crown Dependency equivalent. Only 14 (12.4%) of these received instrumental tuition. This is in comparison with 16.1% (113) playing instruments of those not eligible for financial support. Of the children receiving financial support, the largest number reported playing keyboard or piano (7), with two playing drums or percussion and only one representing the other instrument groups,

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Table 12. Comparison of test outcomes at age 11 between instrumentalists and non-instrumentalists from low socio-economic status households

Subject	Not playing an instrument	Playing an instrument	T	Df	P
English	26.2 (3.9)	27.9 (2.7)	1.5	117	NS
Reading	25.7 (4.1)	28.3 (2.5)	2.1	78	.038
Writing	24.7 (3.8)	26.6 (2.4)	1.7	78	NS
Mathematics	26.8 (4.3)	27.4 (3.4)	.52	117	NS

Figures in brackets indicate standard deviations. *NS = not statistically significant.*

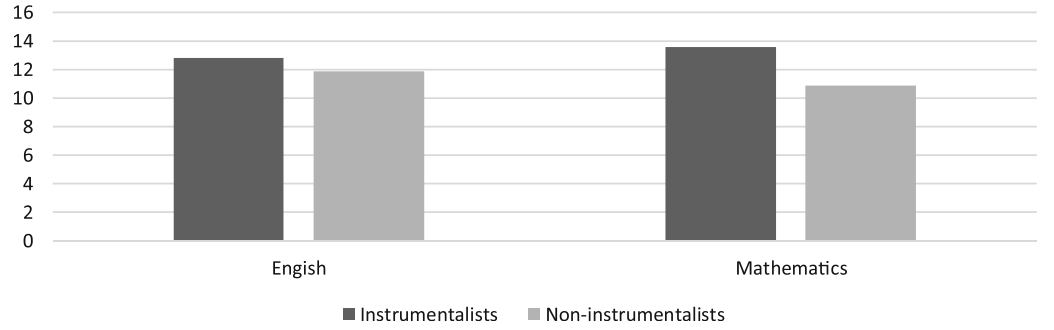

Figure 11. Change scores for instrumentalists and non-instrumentalists.

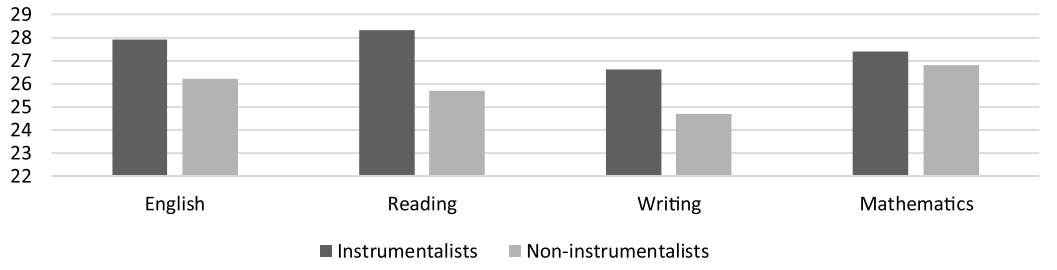

Figure 12. Comparison of test outcomes at age 11 between instrumentalists and non-instrumentalists from low socio-economic status households.

strings, woodwind and guitar. Two participants did not report the instrument that they played. Separate analysis of the data for pupils from low-income households revealed a small statistically significant difference at age 11 between instrumentalists and non-instrumentalists in relation to reading ($t = 2.1$, $df = 78$, $p = .038$) but not writing, an overall English score or mathematics. Table 12 and Figure 12 set out the details. There were no statistically significant differences between the two groups in performance on any measures at age 16. However, those receiving tuition did statistically significantly better in terms of change over time than those not receiving tuition. In English, these differences were statistically significant ($p = .001$) and in mathematics highly statistically significant (p - .0001). The details are set out in Table 13 and Figure 13. These findings need to be interpreted with caution as the sample sizes were very different, and the variation in scores between the groups was large.

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Table 13. Change scores for those from low socio-economic status households

Subject	No instrumental tuition	Instrumental tuition	T	df	p
English	7.7 (13.7)	12.8 (2.4)	3,43	111,969	.001
Mathematics	6.2 (13.7)	13.1 (2.7)	4.63	104,855	.0001

Figures in brackets indicate standard deviations, df = degrees of freedom

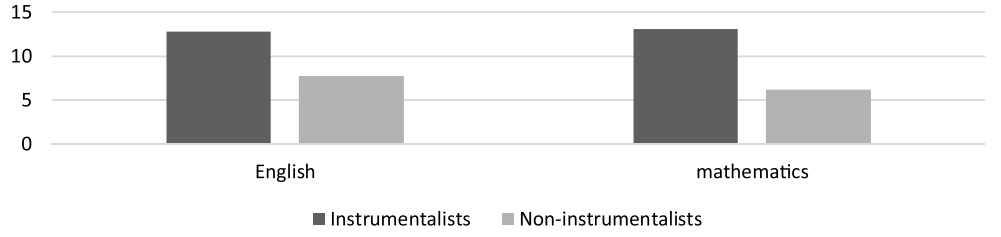

Figure 13. Change scores for those from low socio-economic status households.

Discussion

To summarise, the findings from the whole sample showed that at age 11 students receiving instrumental tuition had significantly higher scores in English, reading, writing and mathematics. This was also the case at age 16 for English, English literature and mathematics. There were also significant differences related to length of time learning to play an instrument at ages 11 and 16 with those learning for longer achieving better results. There were also significant differences for those learning to play different instruments at age 16. However, the change scores between ages 11 and 16 were only statistically significant greater for those playing an instrument in mathematics, not in English. Although, the instrumentalists at ages 11 and 16 performed better than those not playing instruments this does not take account of a wide range of possible confounding factors. The change scores which take account of performance at age 11 only show greater change between ages 11 and 16 in mathematics. Overall, the findings are based on correlational data, which cannot demonstrate causality. Only empirical interventions with appropriate comparison or control groups can demonstrate causality. While the findings tend to suggest that playing a musical instrument may enhance academic performance, it might be that those choosing to play an instrument are already strong performers in these subjects prior to playing an instrument. Certainly, the regression analyses of performance at age 16 showed that the highest proportion of the variance was accounted for by prior performance at age 11, although playing an instrument, the type of instrument played and the length of time learning did make small contributions. The outcomes in relation to change scores in mathematics do not reflect previous findings where, with the exception of the learning of fractions, musical engagement tends not to enhance mathematical performance (Azaryahu et al., 2020; Lim et al., 2018).

The percentage of children from low socio-economic backgrounds who were learning to play an instrument was lower (12.4 %) than children from more affluent households (17.3%). The change in attainment over time for these children in both mathematics and English was statistically significant, suggesting that learning to play an instrument may have greater benefits for children from economically deprived areas. While this supports previous research with participants in El Sistema or Sistema-inspired programmes (Creech et al., 2016), the sample size was very small. The sample sizes of those playing or not playing instruments were also very different. In the year from which the GCSE data were drawn, the marks were awarded by schools themselves based on teacher assessment and existing student work. Although these marks were moderated to ensure

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consistency, they did differ from those in 2019, which were based on examinations alone and marked independently.

Despite these limitations, it is important to consider what might underpin these findings. There is considerable research showing that learning to play a musical instrument brings about changes in the brain which may enhance a range of intellectual skills (Fernandez, 2018; Habibi et al., 2018; Huotilainen & Tervaniemi, 2018). The self-discipline required for sustaining musical practice may enhance executive functions, self-regulation and concentration (Cortés Pascual et al., 2019; Moradzadeh et al., 2015; Zuk et al., 2014). Receiving positive feedback from others during the learning process or following successful performance may also enhance positive self-beliefs which, in turn, can enhance motivation (Diaz, 2010), self-efficacy (Degé et al., 2014) and raise aspirations in relation to performance in subjects other than music (McPherson and O'Neill, 2010).

There are implications for music education. The cost of tuition for a musical instrument is substantial. A report from the Department for Education (2021) showed that the greatest barrier perceived by young people, parents and carers to taking up musical activities was the expense. The research findings also suggest that tuition should start at an early age for the benefits to be maximised, ideally in the early years of primary education reflecting findings from earlier studies (Corrigall & Schellenberg, 2013; Holochwost et al., 2017). Although the research did not address issues of the quality and intensity of the musical experience, it has been shown to be important in prior research (Johnson & Memmott, 2006; Kinney, 2008; Rauscher, 2005). For there to be any additional benefits to those directly linked to music, it is not sufficient to simply provide tuition. It has to be of high quality. There is evidence that this is possible even when teaching takes place in large whole-class groups (Hallam, 2019).

To conclude, despite the limitations outlined above, the research raises important issues relating to inequality of opportunity and the greater benefits of receiving music tuition for those from low-economic status families. This requires further investigation as it has important implications for music education.

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