Postgraduate Certificate in Education
Child Psychology Elective

An Investigation into Musical Ability and Ability in Mathematics and Foreign Languages

By

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May 1971

Contents

I Introduction and Aims

The idea for this small piece of research was not the sudden impulse of a frustrated student faced with the task of submitting an original dissertation broadly connected with some aspect of Child Psychology; the thoughts contained herein have long intrigued the writer, and the opportunity of perhaps substantiating original and necessarily tentative conclusions was not unwelcome. The first contacts made with the biographies of the great composers revealed that, in many cases, obvious musical precocity co-existed with ability in mathematics, or in languages. This fact did not strike the writer as being particularly startling until, during his own later schooling, he began to witness the above connection amongst many of his musical contemporaries. Indeed, he himself' was faced with the difficult decision of whether to aim for a career in music, or for a career utilizing his proven skill in foreign languages. The writer acknowledges that, while there were exceptions, the degree of correlation was significant enough to arouse curiosity.

Immediately it can be argued that musical ability is related to general intellectual ability; the 'A' stream of a school is usually better at music than the 'C' stream. Yet many highly intelligent people do not seem to be able to hear the difference between *God Save the Queen* and *The Star-Spangled Banner*, while some mental defectives can play by ear. Wing (1948) observed that there was good agreement between low intelligence and low scores on his tests of musical ability, but that disagreement occurred where a high I.Q. was accompanied by a low score. Edmunds (1960) also found that low intelligence and low musical ability appear to be closely related. When a certain level of general ability is reached, approximately I.Q. 90 for children of secondary school age, intelligence no longer plays a significant part, i.e. children may be musical or unmusical. That the musically great men of history did possess far better than average intelligence is well established. In her meticulous studies of the biographies of great men, Cox (1926) included eleven musicians. Their intelligence was estimated from evidence of the activities of which they were capable at various ages. Bach's I.Q. was thought to lie between 125 and 140; Beethoven's between 135 and 140 and Mozart's between 150 and 155. Taken as a group, however, the musicians were among the lowest in I.Q. of all the eminent men studied. A later study White (1931) also showed that they were among the least versatile. It may also be argued that some aspects of musical ability are more closely related to general intelligence than others. However, research has shown that this, too is by no means consistent; Burt (1909) did find sizeable correlations between intelligence and pitch discrimination, as tested with tuning forks; he thought a possible explanation might be that the development of intelligence in man depended upon the power of speech which in turn partly depended on auditory discrimination.

In the light of the above the apparent connection between musical ability and ability in mathematics and foreign languages, as observed by the writer, would not have been significantly influenced by intelligence, as the upper limit of effective agreement (I.Q. 90) would have excluded the vast majority of the writer's contemporaries. As far as more specific research goes, only oral French shows any marked correlation with musical ability. The results of the experiments by Coulthard (1952) do, however, confirm the popular view that musical children have an advantage when it comes to learning to speak a foreign language. Traditionally a connection between mathematical aptitude and musical ability is said to exist. In the words of Frank Howes (1958):

The analogy between mathematics and music has been recognised from antiquity, and though all attempts to press the analogy, or even to define it, soon break down, it is still recognised by musicians and mathematicians and the rest of us who are neither as a way of thinking in relationships, abstractions there is an obvious similarity.

Thinking-cum-feeling in formal patterns of measurable units and relations, he goes on to say, appears to be a good description of a sonata movement as of mathematicizing. One difficulty which arises in trying to investigate the connection between the two abilities by testing is due to the very different treatment mathematics receives as a school subject. Considerable attention is given to arithmetic and other branches of mathematics and its utilitarian value as an examination subject is made apparent. Music, except for the very talented, may seem to have much less importance, except as a hobby. For the very talented, music requires a considerable amount of time - sometimes at the expense of other studies. Even if they had much aptitude for mathematics, many musicians may have had little time or opportunity to develop it. The results of correlating music and mathematics tests certainly do not reveal any close connection apart from the correlation of .41 between the Seashore Memory test (30 pairs of tonal sequences, 10 items each of three, four, and five tones, the testee to decide which note is different) and a Number Series test (e.g. complete the following: 1 2 4 7 11...). However, as Frank Howes said, the analogy between mathematics and music has been recognised from antiquity.

It must therefore be concluded that the evidence so far available suggests that musical ability is largely specific. There is a fairly well established connection between general intelligence and musical ability in the case of younger and less intelligent children. It seems reasonable to interpret such a correlation in terms of some common ability, such as powers of attending, concentrating or following instructions. For the more intelligent the musical ability of the child depends more on the specific musical factors than it does on his intelligence. Positive correlations are nearly always found between measures of musical ability and other cognitive aptitudes. However, except in the case of an oral test in French, the coefficients are low. Further research is needed before any connection with aesthetic ability in the other arts or with mathematical or linguistic ability could be accepted as established. Faced with this apparent lack of specific research, the writer, by means of this short and perhaps sketchy dissertation all within the confines of a School Teaching-Practice, has attempted to investigate a. further two of the above fields; namely, any possible correlation between musical ability and ability in mathematics and foreign languages.

N.B. The original text has been used unaltered, but where further explanation is now needed, to take account of the fact that it was written in 1970, this has been added in [gray].

MARCH 2007

II PROCEDURE

A) Subjects

A standardized test in musical ability was applied to a sample of children. The 41 children who were tested were all pupils at a recently-instituted comprehensive school situated in East Cornwall, near the border with Devon. The age range of the subjects was from 13.5 - 18.0 years and included 26 girls and 15 boys. These had been 'recruited' to participate in the testing mostly on the basis of showing some recognizable musical prowess either by playing in the school orchestra or by studying music as an academic subject in its own right. Other children, who had some avowed interest in music volunteered their participation and the writer was lucky enough to enlist the aid of a class of leavers (some of whom were in remedial sets) who had heard of the testing sessions and wanted to be included. This afforded the opportunity of conducting a test which would include, at one end of the scale the prospective Oxbridge candidate, and the remedial child at the other. All children, with the exception of Sixth Formers following specialist courses, were studying mathematics and many received lessons in French and Latin in addition; only one child took German, but, as he showed some considerable musical aptitude, was included in the sample. Music, on the other hand, was studied in general terms for the first three years, with the option of continuing studies in the fourth year, eventually leading to CSE and GCE *[today's GCSE emerged as a combination of these two examinations]* and 'A' level examinations in the subject. Some of the children, in addition, were taught privately, either by peripatetic string and wind teachers or by local piano teachers.

Before talking in detail about the testing itself, a few words need to be said concerning external influences which might have had some bearing on the results obtained. Racial differences do not enter into this sample, except if one considers the Cornish as a nation unto themselves! However, Wing (1936, 1948) found little difference between the average scores made by English subjects on a musical ability test and those of Jewish, Welsh and German groups. How far does the socio-economic status of the home affect the children's musical ability? To answer this question the positive relationship between socio-economic status and intelligence must be taken into account. The correlation of father's occupational level with child's I.Q. has been consistently found to be about .35 (Vernon, 1960). If the higher class child does better at a musical test, it may be partly because he is more intelligent. However, the reader will recall that a significant correlation between intelligence and musical ability reaches its ceiling at I.Q. 90, and so results will not greatly be affected by the socio-economic status of the parental home. Research by Wing, Horbulewicz, and others, shows (a) that many students with no formal musical training make higher scores on musical ability tests than do some subjects with considerable training, but (b) subjects who have had music lessons do tend to make superior scores. Yet here again, as far as can be judged on present evidence the above increase is not likely to be large enough to invalidate the test result, and in this present test sample only 17% received separate instruction and were, judged subjectively, those children expected to obtain a higher result on the musical ability test. Finally, in all testing no adjustment of sex differences was seen to be required to the norms of the particular test battery in question, for, only in appreciation tests (which do not figure in the musical ability test used for this piece of research) did girls seem to fare rather better the boys after the age of 14. Therefore it can be concluded that in this sample of 41 children the effects of (a) racial differences, (b) socio-economic status of the parental home, (c) extra-curricular musical instruction and (d) sex differences, are minimal and need not be taken into account in interpreting the data.

B) The Method of Testing

The test of Musical Ability used in this research will be described in detail in the next sub-heading. Information as to the ability in mathematics and foreign languages was required from the 41 children sampled; there being no standardized tests on a par with the music tests, it was decided to obtain, for each child an assessed ability grade on a 15-point scale from the subject teachers concerned in the mathematics and foreign languages departments. This involved subjective judgements on the part of' these teachers, but, as all those children sampled had been at the school for at least two years, records of previous attainments could be consulted. Indeed, some children had also been examined externally (CSE and/or GCE) in Mathematics, French and Latin.

Three testing sessions were scheduled which involved much liaison between departments in order that lunchtimes could be set aside for the 30 minutes needed for testing and administration. The writer must here thank the headmaster and those teachers who kindly assisted by giving the relevant data needed, and especially the head of the Music Department without whose cooperation this research could not have been made. The testing took place in the well-equipped music room where the children were assembled and each given an answer sheet (see appendix) on which (a) they were to record their answers to the test and (b) put the names of their subject teachers in Mathematics, French, Latin and German (where applicable). Though it does not appear on the form, for the sake of clarity, those who had studied any of the above subjects either to CSE or GCE, but who now no longer received instruction in these areas, were requested to fill in their grades (pass or fail) so that numerical assessment could still be made. (This involved

some 35% of the children). The testing environment was excellent, and the 33⅓ rpm record) *[a medium-sized vinyl disc]* for the test was played on a stereophonic record player of quite ample specification (i.e. no significant 'wow' or 'flutter' nor tonal distortion.) Constant supervision took place and the test was run under ideal conditions. No papers were either intentionally or accidentally spoiled even by the less-able children tested, thus dispelling any doubts as to the clarity of the writer's written instructions or the verbal ones from the test record. When all the papers had been collected, appropriate lists for each subject teacher concerned were given out, asking for a 15-point assessment, after which the test results and assessed abilities in mathematics and foreign languages could be examined in great detail.

C) The *Bentley Test* of Musical Ability

The test used was the *BENTLEY MEASURES OF MUSICAL ABILITY*. This is recorded complete on a 10-inch *[approximately 254 cm]* record, playing at 33⅓ rpm, and all instructions are given by Bentley himself; about 25 minutes are required for the test itself, with another few minutes for the extra administration involved with this research. As has been previously noted, each child was given an answer sheet enabling him or her to respond to each question exactly as requested by Bentley, but also allowing for the extra information to be noted thereon. For the test Bentley found that the note(s) produced by a pure tone generator suffered least from harmonic distortions and proved to be the most readily acceptable to children in previous researches. The responses required are simple enough as to allow testing from the age of 7 or 8.

These are the test's specifications in detail:-

It comprises four tests which set about to investigate broadly the two main areas of aptitudes essential to aspiring musicians. These can be best denoted as pitch discrimination and musical memory. The former is, of course, of especial importance for string players who can control the pitch exactly of any note they produce and depend upon their pitch discrimination for correct intonation. Much the same is true of woodwind and brass players, though to a lesser degree. Musical memory is a vital asset in sight-reading because of the constant need always to be one bar ahead of what one is actually producing in sound; it is especially vital for keyboard players, for whom, by the sheer complexity of the written music, much has to be committed to memory, in both its musical and tactile aspects. Pitch discrimination is subdivided, for the purposes of the test, into two parts, pitch discrimination and chord analysis, investigating the listener's ability (a) to discriminate between two sounds heard in succession and (b) to analyse a compound sound into its constituents. Musical memory, too, is investigated in two parts, tonal memory, and rhythmic memory, both essential requirements for the musician. For the purposes of conforming with the amounts of playing-time on each side of the record, the test is laid out in as follows:

1) Pitch Discrimination This test consists of 20 items in which two sounds are heard successively. The preamble explains, with examples, that in each of the items, the second sound heard will be either the same as the first, or higher or lower than it. If it is the same, the response S (same) will be required; if it is higher, it has moved up, and U (up) will be the correct response - likewise with those sounds which are lower, and have thus moved down, D (down) will be correct. As Bentley shows, some sounds can be closer together than the semitone interval which is the smallest used in conventional Western Music. The two sounds in each item range from being the same, to showing a difference of between 3 and 26 cycles per second [*Hz*] in either direction.

2) Tonal Memory The preamble demonstrates that a short, 5- note tune can still be musically acceptable if, on replay, one of the five notes is altered in pitch. During the prefatory examples the subjects are requested to count the five notes of each tune as it is played twice, to facilitate spotting which of the five notes, if any, has been altered. For each of the 10 pairs the subject will write S for same, or the number of the note which has been altered in the second of the pair (i.e. 1 – 5).

3) Chord Analysis Bentley first demonstrates that when 2, or more notes are played simultaneously, the resulting sound can, musically speaking, be called a chord. He analyses chords of 2, 3 and 4 notes into their constituent members, and requests that in the following 20 items the subject will indicate whether the chord heard consists of 2, 3 or 4 notes, by the use of the appropriate figure. The chords have been produced by recording each note separately on a magnetic tape and playing them back simultaneously. This obviates such features as difference tones which occur when the chord is played intact on a pipe organ, where it is far more difficult to analyse into the number of constituents, because of the interaction of harmonics and the synthetic tones thereby created.

4) Rhythmic Memory The accompanying explanation reveals this test to be closely allied with test 2 above. Instead of five-note tunes being used, four-beat rhythmic patterns (given on a monotone) are played in pairs and the subjects are required to indicate, using 1, 2, 3 or 4 the number of the beat which is changed in the second of the pair. As before, counting of beats is advised, and S for same is to be used where occasion demands. There are 10 such pairs in this test.

The norms have been based on testing some 2,000 children. The reliability of each of the four subdivisions is as follows:-

1.	Pitch Discrimination	.74
2.	Tonal Memory	.53
3.	Chord Analysis	.71
4.	Rhythmic Memory	.57
	TOTAL	.84

As regards validity, significant associations between test scores and teachers' estimates for the musical ability of three groups of children studied were found. Four groups of musicians and music students all made high scores. There now follows an analysis of all data received for this research.

III TEST RESULTS AND ABILITY ASSESSMENTS

A) Grades in Mathematics, French, German and Latin.

An assessed grade was received from subject teachers for the 41 children sampled in the Bentley test, in as many subjects as applicable in each case. A grading from E- to A+ was given and converted into a numerical score on a 15-point scale. Thus a C+ in French signified a score of 9 and an A+ in Mathematics a score of 15. Where a child no longer took one of the above subjects, but had obtained a CSE or GCE grade in that subject, assessment was made on the basis of the exam result. Assessments were given by five Mathematicians, one Latin, one German and two French specialists. As only one subject took German, this will not be recorded for the purposes of this research.

B) Bentley Test Results

The marking for the test was as follows:-

1.	Pitch Discrimination	20
2.	Tonal Memory	10
3.	Chord Analysis	20
4.	Rhythmic Memory	10
	TOTAL	60

The mark obtained in each of the four sections was converted to a percentage, as was, too, the total for the test. By employing the formula: *Score (out of 60) ÷3 = Musical Age*, each subject's musical quotient was calculated, enabling correlations between these results and the ability assessments to be made, which now follow.

Table 1: Musical Quotient and Mathematical Ability

Musical Quotient	Mathematical Ability	Musical Quotient	Mathematical Ability
98	14	80	9
108	8	101	14
118	8	98	15
128	14	86	9
88	14	95	5
81	13	89	12
81	8	107	14
89	7	87	8
93	9	86	5

64	6	87	10
82	9	101	9
62	5	92	11
89	8	94	11
121	9	120	14
101	8	133	12
120	8	64	2
95	9	123	5
128	14	121	14
112	11	97	11
127	10	89	15
125	10		

A cursory examination of the figures above shows that, as has been noted earlier, the analogy between mathematics and music, though recognised from antiquity is difficult to press conclusively. Whilst some subjects with high musical quotients receive high mathematics scores, and, conversely some with low musical quotients reveal lesser aptitude at mathematics, there are exceptions to both camps, and there was found to be a high negative correlation of -.8584 between the Musical Quotient and Mathematical Ability of those sampled for this research. However, as Seashore found, there may be a closer correlation between a specific facet of musical ability, and mathematical ability, and each part of the *Bentley Test* will be examined in this connection. The same high negative correlation is also evident when French ability is compared with musical ability as a whole, rather than as four individual facets.

Table 1(a): Pitch Discrimination and Mathematical Ability

Pitch Discrimination	Mathematical Ability	Pitch Discrimination	Mathematical Ability
95	14	95	10
100	8	80	9
100	8	90	14
95	14	80	15
75	14	75	9
60	13	80	5
75	8	80	12
75	7	75	14
70	9	70	8
40	6	75	5
55	9	75	10
55	5	95	9
70	8	90	11

100	9	95	11
90	8	80	14
90	8	100	12
85	9	65	2
100	14	90	5
90	11	95	14
100	10	80	11
90	15		

In this specific field of musical ability there seems little connection with mathematical ability. This is not altogether unexpected because the thought processes in these areas are not related. Pitch discrimination is not far removed from the recognition of speech inflexions and may be thought more closely to correlate with linguistic aptitude. The correlation between Pitch Discrimination and Mathematical Ability was found to be a low positive of .1367.

Table 1(b): Tonal Memory and Mathematical Ability

Tonal Memory	Mathematical Ability	Pitch Discrimination	Mathematical Ability
80	14	100	9
60	8	80	14
100	8	80	15
90	14	100	9
70	14	90	5
70	13	70	12
90	8	90	14
80	7	100	8
80	9	90	5
50	6	70	10
60	9	80	9
60	5	100	11
80	8	80	11
100	9	100	14
100	8	90	12
90	8	70	2
100	9	100	5
100	14	100	14
100	11	90	11
90	10	55	15
100	10		

There would appear to be a lesser connection between these two areas than the previous two. If a specific Number Series Test (see earlier) had been used, a more significant correlation might have resulted. The ability numerically to compare two 5-note tunes must ally itself with the formal concepts involved in mathematical thinking though perhaps not to such a degree as in pure rhythmic memory which is completely free from the necessity to discriminate pitch-wise, being on a monotone. It might thus be expected to obtain a higher correlation between rhythmic memory and mathematical ability than the .0573 correlation found in the case of tonal memory.

Table 1(c): Chord Analysis and Mathematical Ability

Chord Analysis	Mathematical Ability	Chord Analysis	Mathematical Ability
75	14	80	9
45	8	70	14
70	8	55	11
75	14	80	10
60	14	75	10
60	13	35	9
60	8	80	14
65	7	65	15
65	9	45	9
55	6	55	5
65	9	65	12
50	5	80	14
65	8	55	8
100	8	50	5
75	9	60	10
70	8	65	9
65	11	85	5
60	11	80	14
100	14	80	11
85	12	65	15
5	2		

The most apparent fact about this set of figures is the general low marks obtained on the *Bentley Test*, and their extreme range from 5 - 100. All those who had participated in the test agreed that this was the hardest part, and in 70% of the subjects accounted for the lowest mark. An interesting point reveals itself in the case of the 30% for whom chord analysis did not appear the most difficult task, as seen by the results. These children all scored their lowest marks on Test 4, Rhythmic Memory. All those from the class of leavers mentioned before, some of whom were in remedial groups, scored higher in chord analysis than in rhythmic memory. This may, to some degree, corroborate the findings of some tentative research into the relationship between backwardness in reading and lack of rhythmic response, already carried out by Parker and Tansley. There would appear to be a moderately significant connection between the abilities used in analysing a complex sound into the number of constituent parts and in mathematical procedure as witnessed by the test results obtained. A correlation of .4922 was found, which was the highest obtained in this section of the test.

Table 1(d): Rhythmic Memory and Mathematical Ability

Rhythmic Memory	Mathematical Ability	Rhythmic Memory	Mathematical Ability
100	14	80	9
90	8	70	14
70	8	55	11
80	14	80	10
40	14	75	10
40	13	35	9
70	8	80	14
30	7	65	15
70	9	45	9
10	6	55	5
50	9	65	12
100	5	80	14
90	8	55	8
80	8	50	5
80	9	60	10
100	8	65	9
70	11	85	5
90	11	80	14
90	14	80	11
100	12	65	15
100	2		

There would also seem to be a stronger connection between this aspect of musical ability and mathematical ability. This would bear out the findings of Seashore, but again could not be more than mildly significant in attesting to the extremely elusively proven connection between mathematical and musical ability. Although falling outside the realms of this research, an investigation into reading ability, in the light of Parker and Tansley's work, might have shown that the poorest readers sampled received their lowest mark in this section of the *Bentley Test*. It was discovered, from the class teacher concerned, that this was the case with the class of leavers, and a correlation between reading ability and rhythmic perception would certainly be a necessary future objective. In this case the correlation between mathematical ability and rhythmic memory was found to be .4287

When dealing with foreign languages, because the grades received in French, German and Latin showed only minimal deviations for each child, correlations will only be examined in detail between French and Musical Ability to avoid unnecessary statistical duplication. In the two 'living' languages cited, the assessment grade takes into consideration both written and oral ability which, under a more ideal situation, would have been examined as two separate entities. This would be necessary in the case of those children for whom the complexities of grammatical necessities required in the writing down of a language, unfavourably bias that same child's oral ability, as shown by a combined grade assessment. Out of the 41 children, 19 received French grades, 12 Latin, and only 1 a German grade.

Table 2: Musical Quotient and Ability in French

Musical Quotient	French Ability	Musical Quotient	French Ability
98	11	101	11
128	8	98	11
121	11	89	8
101	8	87	5
95	11	101	9
128	8	92	10
112	11	120	13
127	8	121	11
125	8	89	11
80	9		

First glance will reveal, as in the case of the musical quotient and mathematical ability that, on the results of this research, the connection between the musical quotient and ability in foreign languages is again extremely tenuous; the correlation was again found to be a high negative one of -.9628.

Table 2(a): Pitch Recognition and Ability in French

Pitch Recognition	French Ability	Pitch Recognition	French Ability
95	11	80	9
95	8	90	11

100	11	80	11
90	8	75	5
85	11	95	9
100	8	90	10
90	11	80	13
100	8	95	11
95	8	90	11
80	8		

Here the correlation was .0492. This low correlation, though positive, was not totally unexpected because, here again, previous research (Coulthard, q.v.) has only been able to confirm a popular view that there may be some connection between musical ability and the ability more quickly to master a foreign language, orally that is.

Table 2(b): Tonal Memory and Ability in French

Tonal Memory	French Ability	Tonal Memory	French Ability
80	11	90	8
90	8	100	11
100	11	100	8
100	11	90	8
100	8	100	9
80	11	80	11
70	8	70	5
80	9	100	10
100	13	100	11
50	11		

A closer connection in these above two areas is to be seen. Four subjects scored 100 and 11, three 90 and 8 and three 80 and 11, with the remainder falling, for the most part, close within these figures; the correlation between tonal memory and ability in French was found to be .1799. In the early acquisition of a language, whether one's own or a non-indigenous tongue, the ability to differentiate, by inflection, is a vital one. As can be seen in a simple sentence like: "This cat is ours," a multiplicity of meanings can be implied by different stress. For example the listener will have to distinguish between: "*This* cat is ours!" and "This *cat* is ours?" It may be arguable that this is allied to pitch discrimination, as much as to tonal memory, but it is suggested that the former is more akin simply to taking our word 'cat' in the two sentences above, and comparing, extra-contextually, its two different speech pitches, than the latter which concerns itself with combinations of sounds and pitches, or letters and words. With the present showing of goodwill from the leaders of the Chinese nation, it might be possible to sample some Chinese children by way of the *Bentley Test*, as results may prove that their language (largely monosyllabic and depending greatly on pitch inflexions) has provided them with greater acuity of hearing for the tests of pitch discrimination and tonal memory than a comparative sample of Danes, whose language essentially lacks musical pitch.

Table 2(c): Chord Identification and Ability in French

Chord Identification	French Ability	Chord Identification	French Ability
75	11	80	11
75	8	65	11
100	11	65	8
75	8	60	5
80	11	65	9
70	8	65	10
55	11	100	13
80	8	80	11
75	8	65	11
35	9		

The correlation between these two sets of figures is .3874, which, as in the case of mathematical ability, proved to be the highest obtained in this section. A possible reason could be that, as was previously stated, this part of the *Bentley Test*, being the most searching, as seen by the results, demanded, on the part of those non-musically trained subjects, the greatest degree of intellectual involvement. It can be stated, with some certainty, that those children with the highest I.Q. received better grade assessments in mathematics and foreign languages, than did their inferiors. Therefore a moderate positive correlation would not appear unexpected on paper. Immediately a very interesting problem then comes to light - the results obtained by the group of ‘leavers’ cannot be reconciled with the view that, in a broad generalization, the higher the I.Q., the higher the grades in mathematics and foreign languages, and, because of the former, the higher the mark obtained in the Chord Analysis test. Whilst no specific information as to the intellectual abilities of these ‘leavers’ is at hand, at least a significant number of the children had been in remedial groups during their prior school career. It may well be that the apparent facility for these children to analyse a complex stationary sound into its constituents, to the detriment of their ability to recognize, commit inwardly, and repeat a rhythm or rhythmic phrase, accounts for some of their difficulties encountered in reading fluently. This unconscious and perhaps too analytical approach might produce, from these children, an illuminating result on Rohrschach's 'Ink Blot' test, and further research into a possible positive relationship between chord analysis and backwardness in reading, in the light of Parker and Tansley's work with rhythmic perception, would seem to be a potential future objective.

Table 2(d): Rhythmic Memory and Ability in French

Rhythmic Memory	French Ability	Rhythmic Memory	French Ability
100	11	100	11
90	8	100	11
100	11	90	8
90	8	90	5
80	11	100	9
100	8	90	10
70	11	100	13
90	8	50	11
90	8	90	11
100	9		

The apparent non-relationship between rhythmic memory and ability in French is witnessed by the low negative correlation of -.0825 obtained. The dissimilarity between the correlation in this section, and its counterpart in the section concerned with mathematical ability [Table 1(d)], may well attest to the specific different thought process involved in the disciplines of mathematical procedure, and studying a foreign language, for on this section do the correlations differ widely. This can be seen from the following complete table of correlations obtained.

				Correlation
Table 1	**Mathematics**	&	Music Quotient	-.8584
Table 1(a)	"	"	Pitch Recognition	.1367
Table 1(b)	"	"	Tonal Memory	.0573
Table 1(c)	"	"	Chord Analysis	.4922
Table 1(d)	"	"	Rhythmic Memory	.4287
Table 2	**French**	&	Music Quotient	-.9628
Table 2(a)	"	"	Pitch Recognition	.0492

Table 2(b)	"	"	Tonal Memory	.1799
Table 2(c)	"	"	Chord Analysis	.3874
Table 2(d)	"	"	Rhythmic Memory	-.0825

A comparison between Table 1, 1(a), (b), (c) and 2, 2(a), (b) and (c) shows that correlations for mathematics and French with musical ability, in its various facets, are within a small range from .09 to .12 of each other. However a far greater disparity occurs between Table 1(d) and 2(d) and it may well be in this isolated musical facet that the mathematically trained mind veers further away from its linguist partner. It would seem strange that lack of rhythmic perception may reflect reading difficulties, when the mathematician, who, of necessity, is barely concerned with language *per se*, is seen to do better on a test of rhythmic memory than his linguistic partner, for whom the science of numbers probably has no more significance than in the numbering of persons in verbal conjugations, or in identifying Latin noun declensions! This would, however, tend to confirm the findings of this research with regard to the performance, on the chord analysis test, for those subjects with a reading difficulty, and who receive a lower mark on the rhythmic memory test, corroborating Parker and Tansley's findings; further reference will be made to this in the conclusion which follows.

Correlations were also made between the academic subjects investigated – Mathematics, French and Latin – as well as between Latin and musical ability, using the musical quotient. These were found to be:

		Correlation
i)	Mathematical & French Ability	.3922
ii)	Mathematical & Latin Ability	.7849
iii)	French & Latin Ability	.8235
iv)	Musical & Latin Ability	.0711

In (iv) above there would appear to be a somewhat more significant correlation between musical and Latin ability, than with French and Mathematics as in Tables 1 and 2 above. However, this is still a very low positive correlation. A knowledge of semantics would easily justify the high correlation between French and Latin ability, and the difference between (i) and (ii) could account for the place of Latin in the school curriculum as much as a discipline, not unlike the rigours of mathematical thinking, at least at examination level, as a foundation for further linguistic pursuits.

Finally, in looking at the results of the *Bentley Test*, it would be interesting to note the performance of those children for whom music was an academic subject studied either to CSE, or GCE, ('O' & 'A') level, and for those who had opted at the end of their third school-year *[end of Year 9, in modern parlance]* to take music as an examination subject in the forthcoming session. Musical Quotients were as follows:

121	127	101	101	86	120
120	95	133	112	89	123

The mean musical quotient for these prospective examinees is 110, which, as would be expected, is higher than that for non-examinees in music, which is 94. This too, would confirm the findings of validity tests for the *Bentley Test* where significant associations between high scores and the musical ability of music students and musicians studied were observed.

IV Conclusions

Prior to embarking on this research, the writer had investigated previous similar projects, all of which were unable to corroborate the popular notion that musicians may have an advantage when studying mathematics, or a foreign language. Therefore, that this present research should follow in the footsteps of its predecessors, whilst disappointing in that no earth-shattering discovery was made, was not a severe mortal blow. Before summarizing all results, it would be appropriate, at this juncture, to discuss, briefly, ways in which the testing situation could be improved for further research.

It is still thought that the *Bentley Test* used on this research yields the most faithful representation, numerically, of musical ability, both from previous researches, and from the scores obtained by children taught by the writer in this project. Whilst a fairly representative cross-section of children, both age and ability-wise was sampled, it was unfortunate that children from the first and second year *[Years 7 & 8 in modern parlance]* could not have been more strongly represented; this was partly from purely practical reasons, and also because an assessed grade in mathematics or foreign languages would have, of necessity, been a somewhat unreal when teachers had, in some cases, only known children for just over one school term. It was stated that the equipment used for reproducing the test was satisfactory, which indeed it was, but in the ideal situation, a high-quality transcription unit, amplifier, speakers etc., are recommended by Bentley himself. Indeed, in a paper which he read at Dijon, he discusses reproduction of the record in connection with an apparent phenomenon of the human auditory system. The pitch discrimination test, described earlier as consisting of pairs of tones, the second of which was often fractionally higher or lower than its partner, brought this strange fact to light. In the test, number sixteen consists of two sounds which have exactly the same frequency, but so great was the dissention amongst those subjects confident that the second paired sound was, in fact, lower than the first, that intensive investigation was made. When a high quality sound-reproduction system was available, subjects were in the most favourable position for making an accurate assessment; however, as was more often the case, medium quality ‘household’ reproduction led to certain interesting and significant anomalies in test scores. Bentley observed that there is a strong tendency for the listener, when confronted with two identical sounds, which, for some reason such as unfaithful reproduction, cause a measure of uncertainty on the part of that listener, to judge the second as being lower in pitch; that is, the ear listens subjectively, rather than objectively, as it does when it supplies by difference tones, missing harmonics to sounds, or chords heard. Responses on this present research to number sixteen of the pitch discrimination test were:

Correct: 24 Up: 4 Down: 13

It was also interesting to note that, when asked, children replied that it was easier to recognize a downward step of 5 cps ***[Hz]*** rather than one in an upward direction. However, again it must be concluded that the equipment used above, was, at least, satisfactory, and would not have significantly affected findings.

Perhaps the most questionable procedure in this research would be the method used to obtain grades and hence figures for abilities in Mathematics, French and Latin. Whilst all teachers specified the relationship between the grades given and an average ability grade throughout the various year structures, to obviate gross discrepancies between one teacher's conception of 'average' and that of one of his colleagues, the writer feels that, at least in the case of mathematics, use should have been made of standardized tests. However, this would have proved difficult to liaise and arrange, and was, as such, discounted. In French, too, at least a means of differentiation ought to have been made between the subject's oral and written capacity in the language. Again this would have proven impractical, and the further loading of a subjective assessment from the French department for oral ability was deemed to be non-contributive. However, as has been stated, some of the assessments in the academic subjects had been made on the basis of performance in external examinations, and as such seemed not to be totally subjective.

None of the above can successfully be turned to explaining the high negative correlations between mathematics and music, and French and music.. The writer, at first, hopefully looked for a mistake in the programming of the desk computer used for the calculations; this search was, however, fruitless. *[The 'desk computer' used, was indeed a massive beast, by today's standards, and it needed to be set up by a member of the mathematics faculty. It has been suggested that, in fact, it might have been having a 'bad day', as some of the correlations obtained indeed do appear at odds with a cursory glance at the constituent figures. It would be a sensible option to re-check the computations, and this would, of course, be most straightforward, using the statistical analysis tools in Microsoft® Excel]* Whilst still subscribing to the popular notion of a link between mathematics and music, and French and music, the writer is now more firmly convinced that this 'link' reveals itself in only two limited facets of musical ability, and because the musical quotient reflects a much wider and less specific ability, the high negative correlations were not too surprising. Indeed, there are many concert pianists whose repertoire is enormous, but who would simply lack the specific area of' ability to sit down and play *Baa, baa, black sheep* with the correct underlying harmonies, whilst many non-trained pianists, who are said to play 'by ear', do have specific aptitude in this area, but can barely read music. The possession of absolute pitch too, comes under this area of specific abilities, being limited, as it were, to an 'exclusive' club. This form of musical memory enables those who possess it to identify the pitch of all sounds heard, and to reproduce any pitch as required – invaluable for sight-singing, or harmonic analysis 'on the fly', but of significant inconvenience in transposing at sight or playing any transposing instrument like a clarinet.

The two areas in which there would appear to be this elusive link are tonal memory, and rhythmic memory. Whilst in the first case the correlations are positive, yet low, (.0573 for mathematics and tonal memory and .1799 for French with the same), the difference of .1226 would seem to be significant when contrasted with the correlations with rhythmic memory (mathematics .4287 and French - .0825), a difference, this time in the other direction of .5112. It would seem to be that the musician who has greater aptitude for mathematics than for a foreign language scores more highly in tests of a rhythmic, rather than tonal nature, whereas the linguist displays the converse. The statement could be enormously simplified by stating that the linguist recognizes changes in a pattern of different sounds by listening to their inflexions, when the mathematician recognizes rhythmic changes in a pattern of monotones by counting the sounds heard as they pass. Further research would, of course, be required in support of this statement, but in the writer's personal experience he has noted that musicians with strong linguistic aptitude tend to make errors often of a rhythmic nature, whilst their more mathematically-gifted colleagues sometimes fall short when attempting to reproduce, on their own instrument, a tune which has been memorized by them. While this is the very broadest of generalizations, it certainly warrants further investigation. As was said earlier, rhythmic memory and backwardness in reading show an interrelation, as, it would appear, do mathematics and French; the deciding factor in analyzing a subject's performance if he scores more on the tonal memory test, than on that of rhythmic memory, is the performance on the chord analysis, which, in this research only revealed a higher score than rhythmic memory for those children in remedial groups with a reading difficulty. A possible reason for this has been given earlier, but it becomes more apparent that tests of a musical nature can be of more import than in simply assessing a child's expectations in an external music examination; they have obvious diagnostic and prognostic values far beyond the confines of the music department.

To conclude, it appears that the popular notion, often referred to in this research and elsewhere, that musical ability is, in some way, related to mathematical ability, and the ability involved in mastering a foreign language, is only accurate if amended to a specific musical ability. This must be seen to be true if the narrow field of ability exploited by the linguist be compared to that far vaster complex which is music. Specifically, for the musical child of average intelligence and reading quotient, mathematical aptitude would reveal itself more markedly in that child's possible greater command over rhythmic requirements and demands, in contrast with the linguistically-gifted child's greater capacity for playing 'by ear'. For the child of' lesser intelligence and lower reading quotient, (often, as found by Wing, accompanied by low musical ability), who shows little mathematical or linguistic aptitude, a poor score on a rhythmic memory test with a higher one on that of chord analysis, may point to some psychological imbalance which could perhaps be treated as much in the music room as in the educational psychologist's study. It is a great pity that music lessons for children such as those with a 'leavers' syndrome should, in many schools, consist of a 'pop' session with the teacher playing the role of resident DJ. Much beneficial work could be accomplished, but not without equipment which can be costly, and which, it would appear, would be better spent supplying the needs of the very small percentage of children for whom music is not the lesson where nothing seems to be done, or which, to the laymen, consists of making as much noise as is humanly possible with whatever equipment, musical or otherwise, as may be at hand!

However, the remit of this research is not, of course, to criticize the organization of Music in the Secondary School, but, as is often the way with a small project which seeks to investigate a vast field, many smaller and more specific areas reveal themselves, and lead the way for further, ever-refining researches. The field of research into musical abilities and other possible associations is by no means extensive, and is that much more challenging and inviting, when, despite the cold statistics obtained, quotidian experience would have it that, somewhere, and indeed somehow, musical ability is not an only child in the family of abilities.

V APPENDIX

[The test sheet used by the 41 subjects in this research is shown below. The original was produced by hand, and sufficient copies made using a 'spirit duplicator'. This was a low-volume printing method used mainly by schools and churches in the early 1970s, and was also referred to as a 'Ditto' or 'Banda' machine. The layout was exactly the same, though, unfortunately, less neat!]

<u>Please fill in where possible:</u>

NAME: ____________________________ AGE: ________

My MATHS teacher is: ___________________________

My FRENCH teacher is: ___________________________

My GERMAN teacher is: ___________________________

My LATIN teacher is: ___________________________

[Only fill in the teacher's name of the subject(s) which you study. Otherwise leave blank]

I Pitch

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

II Tunes

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

III Chords

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

IV Rhythm

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

<u>*Please leave this section blank*</u>

Maths: __________ *French:* ___________ *German:* __________ *Latin:* ____________

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