IDENTIFYING GENETIC FACTORS AFFECTING MUSIC ABILITY

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To what extent is music ability inherited? It is common knowledge that music ability clusters within families. Unusual ability in multiple successive generations suggests an inherited genetic element. Quantitative assessment has required standardized testing. Quantitative studies have shown that music ability is not a monolithic trait but is composed of discrete abilities which show different degrees of heritability. Comparisons of identical and non-identical twins provide evidence for a large inherited component. Identification of specific genes is needed. A specific example is that of tune deafness, inherited as a single dominant gene. Studies recommended for the future include further fragmentation of music ability into discrete components, devising tests minimally influenced by experience, application to unselected populations, selecting individuals who score both very high and very low in ability, and conducting family studies on those individuals. Such studies would benefit from the collaboration of the musicologist, the audiologist, the neurophysiologist, and the geneticist.

The Issue

The family tree of Johann Sebastian Bach is a striking testament to the clustering of music ability within a family. According to Shull (1948), of the 55 male Bachs in six generations, 48 were musicians and only seven had no known music gifts. To what extent is music ability inherited?

This question has important implications, both theoretical and practical. Regarding the theoretical, clearly music is appreciated in a manner distinct from verbal communication. The factors involved in its appreciation are poorly understood and deserve elucidation.

Regarding the practical implications, as Shuter (1969) remarked:

> Music educators may be 'aristocrats' or 'democrats'. Even a democrat who believes that every child can profit from instruction in music has to admit that pupils vary markedly in motivation and capacity to learn. If musical aptitude is largely innate, ought the schools spend too much time on the unmusical? So long as the supply of good music teachers remains inadequate, shouldn't their efforts be mainly directed towards discovering and fostering the talents of the gifted? (p. 90).

In this paper have two goals. The first is to review selected studies on genetic factors determining music ability. The second is to make suggestions for future studies.

Historical Review

In 1865, Gregor Mendel, an Austrian monk, proposed that inheritance was determined by discrete units called genes. Man possesses genes in pairs, one inherited from each parent. An individual transmits only one of each pair to any given child.

In 1912, Hurst seemed to have been the first person to apply Mendel's laws to the study of music ability in an unselected population. He studied parents and children in an English industrial village and concluded that music ability was a recessive trait. A recessive trait is one which, to be manifested, has to be present in the subject in double dose, one dose having been inherited from each parent. Hurst may have been led to this conclusion by the finding of a highly musical child in an entirely unmusical family. Toscanini is said to have been such an individual. One interpretation of this inheritance pattern is that the gene involved determines an inhibitor of music ability and the musical person is one who lacks both copies of the inhibiting gene. From a different viewpoint this theory postulates that everyone has talent bursting to be expressed. What an encouraging thought for the music educator!

In 1939, Scheinfeld studied the families of professional musicians and of music students at the Juilliard Graduate School of Music. He studied virtuosi, opera singers, and music students and found that, of their parents and siblings, 40-70% had "some degree of music talent." Where both parents had music talent, more than 70% of the brothers and sisters also had talent. Where only one parent was talented, there was talent in 60% of the siblings. Where neither parent was talented, only 15% of the brothers and sisters had talent.

In 1926, Mjoen rated individuals for music ability on the basis of a questionnaire. From the questionnaire scores, he grouped subjects into "P" for poor, "M" for intermediate talent, and "S" for superior. Mjoen found that, if both parents were superior, or one was superior and one was intermediate, the largest percentage of children were also superior. If one parent was superior and the other poor, or both were intermediate, the largest fraction of children were intermediate. If one was intermediate and one was poor, or both were poor, the largest fraction of children were poor. Mjoen also noted that the proportion of children correlated with the numbers of gifted grandparents suggesting that music ability could be traced through multiple generations.

The first standardized tests for music talent were the *Seashore Measures of Musical Talent* published in 1919. In 1930, the *Wing Tests of Musical Intelligence* were published. The first of the seven Wing tests, chord analysis, consists of 20 tones, intervals, or chords. The subject is required to check the number corresponding to that of the tone present in each item. The second test, pitch change, consists of pairs of chords. In some items, both chords in the pair are identical, but in others one of the tones in the second chord is higher or lower than the corresponding tone in the first chord and subjects are asked to check which tone is higher or lower. The third test consists of a model music phrase followed by an answering phrase. Subjects are required to note the position of the one altered tone in each answering phrase. Test four is a test of rhythm; test five, of harmony; test six, of dynamics; and test seven, of phrasing. These latter tests measure appreciation or taste in addition to music perception. A more recent test battery is Gordon's *Primary Measures of Music Audiation* (1979).

Twins are a favorite object of study for geneticists. Identical and non-identical twins are commonly compared. The degree to which the similarity among identical twins exceeds similarity among non-identical twins is considered to be a measure of "heritability." Heritability can be calculated as a number ranging from 0-1. A score of 1 indicates complete determination by genes; a score of 0, complete determination by environment. In the case of music ability, neither extreme score is anticipated.

In 1962, Vanderberg studied twins using three Seashore tests and two Wing tests. A surprisingly low heritability score for pitch was obtained using either the Seashore or Wing scale. The heritability scores of 0.42 to 0.52 shown for loudness, rhythm, and music memory provide evidence that scores on these two are determined to a significant degree by heredity.

A criticism of twin studies of the conventional type is that twins are commonly reared together, and therefore the full range of environmental effects are not measured. Hence twins reared separately are a valuable resource for analysis. Only a small number of such twin pairs have been studied with regard to music aptitude. Shuter (1966) studied five pairs of identical twins raised separately. Their scores in the Wing test were very similar even though they had very different levels of music training. For example, one twin had played the cornet in a band for 24 years whereas her twin sister had only started to play an instrument two months before testing at the age of 38. Yet their scores were very similar on the Wing tests. Such data, sparse as they are, may suggest that the Wing tests are little influenced by training.

Shuter (1966) published a study of grammar-school-aged children and their parents using the Wing test. The correlation between a child and the average of the child's parents was close to 0.5. This is suggestive of a strong genetic contribution. A sibling pair also has half their genes in common; the correlation coefficient was close to 0.5 for them as well. An interesting feature of the correlation data is the higher correlation between father and child (0.627) than between mother and child (0.258). However, Shuter comments that fewer fathers than mothers were tested and that perhaps fathers submitted to testing only if they suspected that their offspring resembled them. Shuter concluded that music ability, as scored by the Wing test, is largely determined by inheritance. However few scholars of the subject attribute music ability entirely to heredity.

Vanderberg, whom we previously mentioned in connection with twin studies, commented that analysis of music abilities might be more successful if one studied, not specific music abilities, but specific music defects. Hans Kalmus has extensively studied "tune deafness," defined as the ability to spot the wrong note in a well known melody and more commonly, but less accurately, called "tone deafness." He also offers the term "dysmelodia." Tune deafness differs from inability to carry a tune because the latter involves a certain motor component.

To measure tune deafness, Kalmus and Fry (1980) constructed the *Distorted Tunes Test*. Twenty-six tunes are played in succession, seventeen of which contain mistakes. In each of the seventeen, one or more notes are raised or lowered without change in rhythm.

Kalmus gave the *Distorted Tunes Test* to two contrasting groups of adults, those who considered themselves as having music ability, namely, the music listening panel for the British Broadcasting Company, and individuals who considered themselves tune deaf. To a first approximation, the number of distorted tunes missed ("m" score) represented nonoverlapping distributions for the two groups. On this basis, Kalmus defined individuals who score two or less as normal and those with a score of three or higher as tune deaf. In the British population at large, he found tune deafness in 3.6% of males and in 4.5% of females. Naturally, tune deafness cannot be distinguished at birth. A child must learn the tunes before he or she can recognize mistakes in them. Scores for British children fall up to the age of 16.

Kalmus devised this test in order to study the genetics of tune deafness. He tested families known to contain a tune deaf individual. Many of these families contained multiple such individuals. Their pedigrees could be accounted for by a single gene determining tune deafness. Kalmus concluded that the affected individual passes his tune deaf gene or his normal gene to any given child; the chance of transmission of the tune deaf gene is approximately 50% at each conception. Some affected males transmitted the trait to a son. This observation rules out an X chromosomal location for such a gene because a man transmits his X chromosome only to his daughters.

One problem of tests for tune deafness is the need to have prior exposure and memory for the tunes used. As expected, there were differences in the *Distorted Tunes Test* among people of different nationalities. Whereas only 4% of Englishman were tune deaf, European populations ranged from 25-54% tune deaf and Indians and Pakistani were 82% tune deaf, using English tunes.

Some people familiar with Western music traditions, but unfamiliar with British melodies which formed the basis of this test, got perfect scores. These individuals must have acquired an unconscious set of rules for judging the acceptability of a melody in the Western tradition. Kalmus suggests that this indicates the existence of some deep tonal structure comparable to Noam Chomsky's deep language structure.

In summary, our review of abnormalities of the genetic basis of music ability shows that our knowledge is meager. Tune deafness as defined by Kalmus may be inherited as a single dominant gene. Many other music abilities cluster in families but the dissection of music ability into components is still a subject of controversy and the tests now available for them are probably unlikely to identify individual genes. A plausible explanation may be that a large number of genes are involved. No doubt also, performance in any given test is inescapably influenced by environment, whether by informal exposure to music or by formal music training.

Suggestion for Further Studies

I would like to propose a sequence of steps which might advance our knowledge of the genetic basis of music ability.

1. Research in this area would benefit from the collaboration of a team of professionals. The team should include at least a music educator, a psychologist, a human geneticist, and a neurophysiologist.
2. This team should construct a list of skills required for music performance. Such a list should be more comprehensive and less overlapping than the test batteries of Seashore and of Wing.
3. For each requisite skill, an innate component should be hypothesized.
4. A test should be devised to quantitatively measure this hypothetical innate portion of this requisite skill. Ideally, these tests should be applicable to children as well as to adults.
5. Each such test should be applied to a sizeable group of unselected individuals in the hope of finding, not the usual unimodal distribution, but two or three modes or peaks suggesting that people cluster into identifiable types.
6. One would investigate whether these types had a genetic basis. One would administer the tests to couples, classify the couples by type on the basis of those test results, predict the types of their children on the basis of the simplest genetic hypotheses, and compare prediction with their children's actual test results.

Of course this sequence is very easy to formulate but very difficult to perform. However, today we have a much better chance of succeeding than those performing the studies in the first half of the century. Consider the advanced state of knowledge of hearing and its neural basis. This detailed knowledge of auditory pathways may suggest more specific types of tests than those previously used, such as the ability to monitor two unrelated melodies played simultaneously. Computers may aid in constructing tests which require a subject to make, not a single decision, but a sequence of interdependent decisions.

One promising approach may be to recognize that the right brain is postulated to have a special role in music appreciation (cf. Ehrenwald, 1981). Kellar and Bever (1980) found that, when subjects are asked to distinguish music intervals presented to the right ear and left ear separately, musicians do better with the left ear and nonmusicians do better with the right ear. Further, a family history of lefthandedness significantly affects which ear performs better.

Finally, as Vanderberg suggested, it may be more constructive to analyze defects than to analyze abilities. The best established genetic difference affecting vision is color blindness. Various types are known and their physiological basis now understood. In music, are there a number of types of music distinctions which people are genetically unable to make? Is each such inability inherited in a straightforward manner, as suggested by the one example of tune deafness? Is it conceivable that there is a single gene product which is necessary for each critical step in the neural mechanism necessary for a given type of discrimination so that, when it is genetically deficient, the result is a specific music defect?

I shall close with an anecdote suggesting that appreciation of music may after all be connected to appreciation of words. Hans Kalmus, who was a teacher of mine, began his paper on tune deafness with an English rhyme which acknowledges a possible connection between tune deafness and errors in word order:

There was an old fellow of Sheen
Whose musical sense was not keen.
He said "It is odd,
I can never tell 'God
Save the weasel' from 'Pop goes the Queen.'"

References

Chomsky, N. (1972). *Language and Mind.* New York: Harcourt Brace Jovanovitch.

Ehrenwald, J. (1981). *Anatomy of genius: Split brains and global minds.* New York: Human Sciences Press.

Gordon, E.E. (1979). Primary measures of music audiation. Chicago: G.I.A. Publications.

Hurst, C.C. (1912). Mendelian heredity in man. *Eugenics Review, 4,* 20-21.

Kalmus, H., & Fry, D.B. (1980). On tune deafness (dysmelodia): Frequency development, genetics, and musical background. *Annals of Human Genetics, 43,* 369-382.

Kellar, L.A., & Bever, T.G. (1980). Hemispheric asymmetries in the perception of musical intervals as a function of musical experience and family handedness background. *Brain and Language, 10,* 24-38.

Mjoen, J. (1926). Genius as a biological problem. *Eugenics Review, 17,* 242-257.

Scheinfeld, A. (1939). *You and heredity.* New York: Stokes.

Seashore, C.E., Lewis, D., & Saetweit, J.G. (1946). *Seashore measures of musical talent.* Camden, NJ: Victor Records.

Shull, A.F. (1948). *Heredity.* New York: McGraw-Hill.

Shuter, R. (1966). Hereditary and environmental factors in musical ability. *Eugenics Review, 58,* 149-156.

Shuter, R. (1969). Some problems in psychology of musical ability. *Journal of Research in Music Education, 17,* 90-93.

Vanderberg, S.G. (1962). The hereditary abilities studies: Hereditary components in a psychological test battery. *American Journal of Human Genetics, 14,* 220-237.

Wing, H.D. (1948). Tests of musical ability and appreciation. *British Journal of Psychology, Monograph Supplement, 27,* 88.

Author Notes

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