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A Consideration of the Inheritance of Musical Talent on the Occasion of the Mozart Bicentenary

As an introduction to the specific question of the genetics of musical talent and the Mozart family, we should first consider the more general subject of genetic influences on behavior.

Although we now clearly recognize that the brain is essentially responsible for the whole realm of human abilities, including literature, poetry, and all the special abilities—including music—which make humankind more complex, and distinct from other species, there is a reluctance to believe that genetic factors play a principal part in the governance and functioning of this organ. By contrast, there is a relatively easy acceptance of the evidence that other organs such as kidney, heart, or liver, can be strongly influenced in their function by genetic factors. We tend to believe that the acceptance of a similar status for the brain would diminish the possibility of free will, downgrade the importance of an optimal environment and of education, and would promote the importance of fate and determinism as opposed to responsibility and individual choice.

If we take the more objective view that genetic factors influence the growth and development of all physical structures and also the optimum utilization of those structures, it is unreasonable to assume that behavior should be excluded from such genetic influence, or that human behavior should be intrinsically different in this regard from the behavior of other animals.

There is evidence to indicate the genetic influences on human behavior. Examples can be found to illustrate this influence which have no relation whatever to developmental delay or mental handicap, features which are well known to be influenced by genetic factors.

First, there are a number of examples of basic genetic constitutional changes which are clearly associated with behavioral changes. Thus, individuals who have but one X chromosome, and no other sex chromosome, are not mentally handicapped but do show learning/behavioral problems, specifically a relative disability with spatial relationships (Money 820). Females who have an additional X chromosome (XXX females) have a tendency to behavioral changes which shows up as an increased frequency of thought disorder, sometimes identified as schizophrenia (Kidd et al 90; Olanders 1097). The best known (but probably the least understood) of these conditions is that of those males with an extra Y chromosome whose behavioral tendencies are clearly different from those of the general population, such that they are 20 times more likely to spend time in a penal institution (Hook 139), though our attempts to identify the behavioral characteristics which produce this result have thus far been sadly inadequate (Welch 323).

Second, certain specific single major genes are often associated with specific behavioral changes. Thus Huntington Disease is frequently associated with behavioral changes which may variously be interpreted as paranoia, schizophrenia, or depression (Marsden 233). Individuals with the Lesch-Nyhan syndrome often show a specific tendency to self-mutilation; still not fully explained but present in 85% of cases (Lesch & Nyhan 561; Nyhan et al 257). Individuals with porphyria may show periodic outbursts of disturbed irrational behavior which in the absence of the genetic diagnosis may be deemed to be psychiatric (Carter 51; Tishler et al 1430).

It is also clear that there are strong genetic influences behind the occurrence of behavioral problems such as schizophrenia and manic depressive psychosis. The long-standing reluctance of many psychiatrists to accept the major importance of genetic factors in these conditions is finally diminishing in light of the overwhelming scientific evidence to the contrary provided by twin studies and adoption studies (Kinney 457). The importance of genetic factors in alcoholism has also been shown by similar adoption studies (Agarwal and Goedde 481).

More recently, it has been possible to identify the location in the human genome of some specific genes, the presence of which predispose to such behavioral disorders as schizophrenia, manic depression, and dyslexia (McGillivray et al 10; O'Donovan and Owen 171; Sherrington et al 164; Smith et al 1245; Pennington 93).

The reluctance to accept the importance of genetic factors in these situations is of long standing, and is not confined to psychiatrists. Sir Francis Galton, who pioneered the study of genetic factors in human behavior in the latter half of the nineteenth century, and who pioneered the use of twins in studying the importance of genetic factors, included musicians amongst his consideration of *Hereditary Genius* (230) in his own era, with Mozart as one example of hereditary genius. Although Galton also clearly perceived the difficulty of acceptance of genetic factors as influencing human abilities, he felt that the general perception had changed between 1869 and 1892 (Galton vii, viii). In fact, it appears that there has not been much change, at least in the public perception, over the ensuing 120 years or so.

It may be argued that all of these studies are of *abnormal* human behavior but say nothing about the genetic influence on *normal* human behavior. However geneticists have long agreed that genetic factors, acting in consort, strongly influence the overall level of general intellectual ability—and that human tests and scales have been devised to allow us to measure and compare this ability among different persons. Regardless of some reasonable scepticism as to their accuracy in defining and identifying "true ability," we nevertheless continue to rely heavily on tests of this type. It is of interest that we are reluctant to recognize or use such tests in decision-making with regard to elementary and secondary education (rooted in an irrational belief that all persons are of approximately equal ability and must therefore all go through the same rate of progression). This reluctance is swept away in subsequent educational phases where we rely heavily on specialized tests to determine an individual's aptitude for medical school, or for law school. The notion of equality of ability for these specialized opportunities is summarily dismissed.

Whatever it is that we measure by these somewhat despised IQ tests, it is clear that test results are strongly influenced by genetic factors. Comparing the correlation coefficients (a statistical measure of similarity) between twins of the same genetic constitution (monozygotic twins) reared together, and reared apart, Bouchard (147) reported a correlation coefficient for IQ of 0.58 for 29 pairs of MZ twins reared apart, as compared to a correlation coefficient of 0.66 for a similar sample of MZ twins reared together. The closeness of these results indicates the influence of strong genetic factors. A similar finding (with even closer correlation coefficients) was also found by Shields (61).

Note that although the genetic influences are clearly strong, there is also an identifiable environmental influence, implied by the higher correlation coefficient for MZ twins reared together, and as indicated by the finding of a positive correlation of 0.20 to 0.30 between unrelated individuals who are reared together (Bouchard and McGue 1055). The generally accepted belief at this time is that the heritability of I.Q. amounts to about 0.5 (i.e. about half of the observed variability is attributable to genetic factors) (Farber 197; Rose 959).

Is intellectual ability a single entity influenced by a number of genetic factors, each of similar weight, or is there a generalized intellectual ability plus other specific minor abilities? The latter is now generally believed, and although there is some dispute as to the number of major additional factors, there is general recognition that two such factors are mathematical and musical abilities. It is an unresolved debate whether there is a correlation between mathematical and musical abilities. Some anecdotal evidence suggests that the two are correlated. It is of interest in this regard that Mozart is said to have had some early fascination and considerable ability with mathematics and with arithmetic (Davies 3).

The evidence which documents the occurrence and importance of genetic factors in musical ability is admittedly not as clear cut as one might wish. Part of the reason for this deficiency is the difficulty in objectively measuring musical ability. Nevertheless, such measures do exist and some have been around for half a century. I refer to the measures of psycho-physical-auditory perception devised by Seashore (302), tests using musical material such as those devised by Wing (39), and tests which attempt to evaluate musical appreciation and recognition of musical passages such as the Oregon discrimination tests (Hevner and Landsbury; Long). It is also of interest in that although these three types of tests were developed independently and were intended to measure quite different attributes, a comparative review of these studies by MacLeish (1) has shown a strongly positive correlation, suggesting that there is a

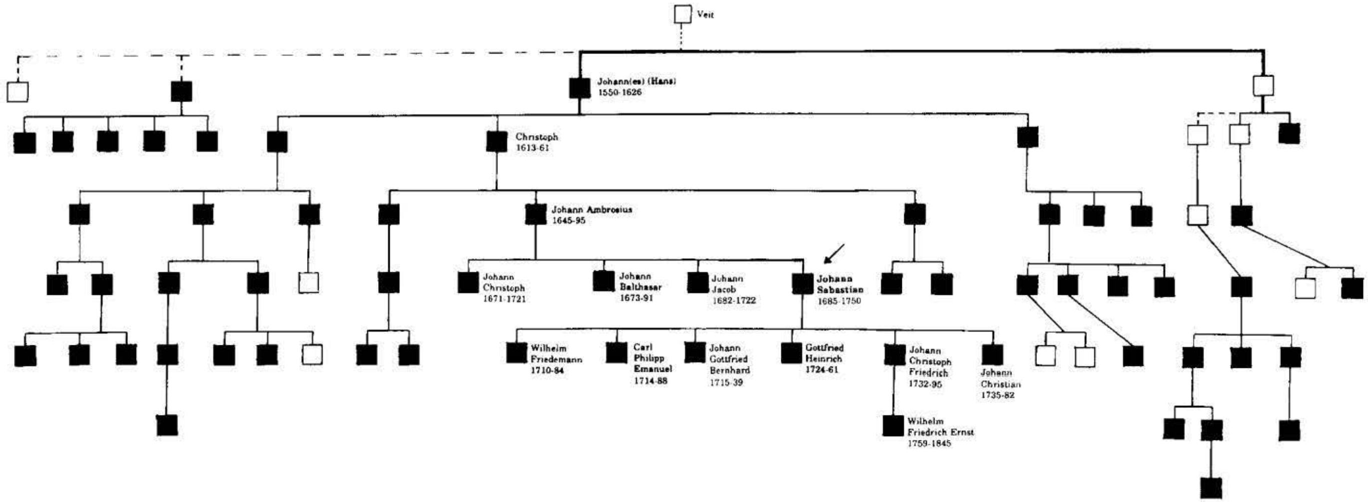

Figure 1. Pedigree of the Bach family (redrawn, with some abbreviations, from Grove 1-776). Solid symbols are those designated as "musicians" in Grove (1-774). For brevity, only those who are direct descendants or forebears of J. S. Bach are named. Information on the other family members, evidence of their musicianship, etc. is contained in Grove (1-774). Interrupted pedigree lines indicate uncertain ancestry. The wives and daughters of the Bachs' are not recorded in Grove (1-774), however there is a general comment that intermarriage between families of musicians was frequent, and some of the family names of musician families are causally mentioned (Grove 1-780). Some further details of the wives and daughters are probably to be found in the *Ursprung* (the family genealogy originally compiled by Johann Sabastian in 1735. The original Bach (Veit) was a baker by trade and may not have had any professional musicians amongst his ancestors (Grove 1-781).

single strong common factor involved in all of them, described by MacLeish as "the ability to recognise and understand the nature of changes in musical and quasi-musical materials." So far as I have been able to determine, no one has used these tests in any meaningful fashion to determine whether the factor measured by them is familial and, if so, what kind of pedigree pattern is associated with it.

This brings us to the analysis of pedigrees, a simple but most useful technique in the elucidation of genetic factors. The pedigree of the Bach family is commonly and deservedly used as evidence for genetic influences on musical ability. (See Figure 1.)

This pedigree of Johann Sebastian Bach's antecedents is of considerable interest from several aspects. First, every individual who is specifically identified by a solid symbol in the pedigree was, at the least, a professional musician whose livelihood was based on this ability. While not all of these individuals are recognized today as composers of outstanding ability, there are several whose names are well known to present-day musicians, in addition to Johann Sebastian; the best known being his sons, Carl Philipp Emanuel and Johann Christian. (Galton [233] considered that there were far more than 20 *eminent* musicians in the Bach family.)

The second point worth noting is the extent of the information available on this family. This is due to the interest and diligence of those family members who researched and documented the family background while the pertinent information was still available, notably Johann Sebastian himself and his son, Carl Philipp Emanuel. The third notable point in this pedigree is the remarkable predominance of males! I doubt that this reflects the number, or non-survival, of females; though I suspect that it does, in one sense, reflect the historical non-musical survival of females, since we may assume that a number of females were born into the Bach family and that the musical talents, which I am sure some of them must have had, were neither nurtured nor recorded with the same care as that of the males. You will also note that the pedigree is strictly patrilineal, thus the accomplishments of the wives are not recorded, certainly not in *The New Grove Dictionary of Music and Musicians*, from which this pedigree information was obtained.

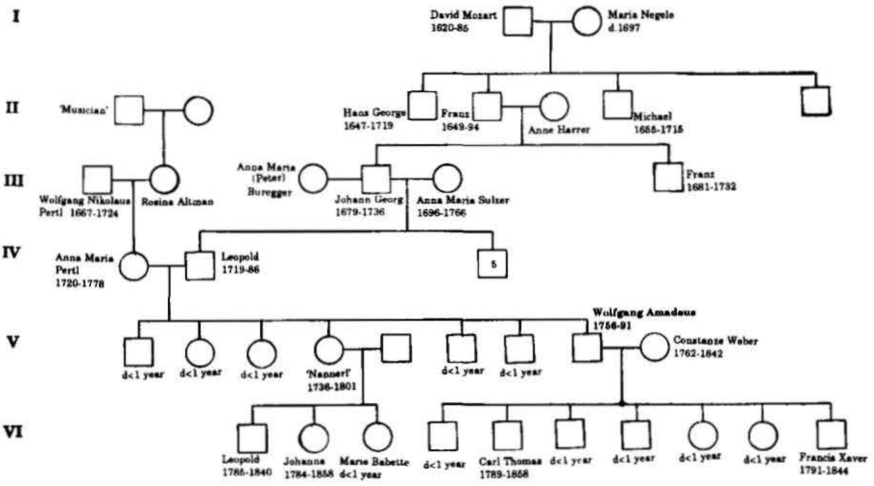

Figure 2. Pedigree of W. A. Mozart. The above pedigree incorporates information obtained from a variety of sources (Boyd 36-37; Fischer and Besch 7-9, 13-14; Davies 3) unfortunately poorly referenced in these sources. The name Mozart was common in the Augsburg area, where the family lived back to the fourteenth century, with various spellings (the marriage documents of Mozart's paternal grandfather variously records the family name as Mozer and Mozarth (Deutsch) however Mozart's great-great-grandfather, David, appears to be the earliest authenticated antecedent.

There is also some inconsistency in the reference material quoted. Thus Davies states that David's son, Michael, was a sculptor; whereas Fischer and Besch state that he was Franciscan Friar. It seems generally agreed that most of these early antecedents were builders and masons, however his great uncle, Franz (generation III) is said to have been a sculptor in Strasbourg (Davies 3).

Despite all the above deficiencies, the Bach pedigree affords strong support for the notion of genetic factors in musical ability. Although it is easy to suppose that a musical environment might make a major contribution to the abilities and creative choice of all the members of a sibship, it is difficult to believe that environmental factors would contribute so forcefully and repeatedly in generation after generation and family after family within the same kindred, extending, as it does, over at least 200 years and spanning at least six generations. Although the best known, the Bach family is by no means the only example of outstanding musical talent passed down over a number of generations. Other well-known family names include Couperin, Lully, Kreutzer and Brandts-Buys (Revesz 192, 194).

Figure 2 shows the pedigree of Mozart, born in 1756. In this case the information is considerably more fragmentary; however, there is information to indicate that a number of Mozart's forebears and relatives possessed significant musical ability. On his father's side, the earliest known relative appears to be his great-great-grandfather, David Mozart (1620-85), who was a master mason. His great-grandfather, Franz (1649-94), is variously said to have been an architect or mason. He was apparently cast out from the masons' guild because he had helped bury the body of an illegitimate man (a reprehensible deed in those days) and at age 33 (when Mozart's grandfather was aged 3) Franz became an inmate of the workhouse and remained a pauper for the rest of his life (Fisher & Besch 7). Mozart's grandfather Johann Georg (1679-1736), was a bookbinder. In those days, a bookbinder was a considerably more artistic pursuit than it generally is today. It is of interest that Johann Georg acquired his credentials by marriage to the widow of a bookbinder, which gave him automatic entry to the guild. Two months after the widow's death, the 39-year-old Johann Georg married Anna Maria Sulzer, the 22-year-old daughter of a weaver. Mozart's father, Leopold, was born to this couple. One of W. A. Mozart's maternal great-grandfathers was a coachman, but, his maternal grandmother, Rosina Altman was the daughter of a musician and his maternal grandfather, Wolfgang Nikolaus Pertl (1667-1724) appears to have been a successful and able bureaucrat. Wolfgang Pertl also had some music training and during his academic training was appointed an instructor in singing.

In Mozart's immediate family, his father Leopold was an accomplished musician. Mozart's older sister, known as Nannerl, appears to have been something of a child prodigy comparable to her brother as a performer. Whether she might have shown similar compositional abilities must remain an open but intriguing question, especially as she did produce some compositions which apparently met with the approval of her brother, but which have not survived. It is clear that in later childhood, her talents were not promoted by Leopold, who concentrated all his attention on Wolfgang. For example, from the age of eighteen Nannerl was permitted to show her talents only at home, while her brother travelled extensively.

Mozart married Constanze Weber, a singer who was first cousin to Carl Maria von Weber. They had two surviving sons, both of whom appear to have had some musical ability. The youngest son Xaver Mozart was a professional musician with some compositions to his credit.

What evidence is there of a genetic influence in the Mozart family? The fact that Mozart's father was an accomplished musician does not constitute proof of genetic influence. Better evidence is provided by the fact that his maternal grandparents clearly had musical ability. It can be argued that some minimal socio-economic status is necessary to provide musical talent with the opportunity to flower. The scanty available evidence suggests that both of Mozart's grandfathers successfully scaled the social ladder, as compared to their own parents and forebears. It has been noted (Davies 3) that Mozart's father, Leopold, and his maternal grandfather, Wolfgang Nikolaus Pertl, were the first in their respective families to receive a tertiary education. It is also worth noting that Mozart's youngest son was only five months of age at Mozart's death and any musical inclination and abilities he subsequently showed are therefore not directly attributable to the influence and instruction of his father.

In addition to the pedigrees of famous musicians, what data do we have on the inheritance of musical talent? As I have indicated, hard data is relatively scanty; the present situation constitutes a golden opportunity for a combined genetics/music investigation to try to elucidate the genetic factors involved.

One feature related to musical talent is "perfect pitch." Obviously the possession of perfect pitch, said to be present in perhaps one in fifteen hundred of the general population (Profita and Bidder 766), does not guarantee or confer musical ability. It is clear, however, that its possession would be of considerable advantage to a musician and is of interest in this regard that Mozart is said to have had perfect pitch and an exceptional musical memory. Obviously the one would complement the other and it is clear that he had exceptional abilities in these areas, even if we discount the anecdote of his identifying a 1/8 tone difference between two violins heard in two different places on two different occasions (John 1: 21). It is also clear that some ability to discriminate pitch is an essential attribute of the practising musician. Healey Willan has stated: "In music, absolute pitch is of relative importance, but relative pitch is of absolute importance."

There is good evidence that perfect pitch may be inherited. This feature was studied in selected musical families by Profita and Bidder

(763). (See Figure 3.)

Some of their pedigrees are shown here. It is clear that if the population prevalence of perfect pitch is only one in fifteen hundred, the likelihood of identifying families with such an aggregate of individuals having perfect pitch on the basis of chance would be exceedingly rare and unlikely. These pedigrees are most consistent with an autosomal dominant mode of inheritance. It must also be admitted, however, that there is probably a strong environmental component in the development of perfect pitch. One study (Sergeant and Roche 39) showed that perfect pitch was present in 95% of musicians who commenced their training prior to four years, but only present in 5% of musicians who commenced their training between 12-14 years of age.

Another music-related factor which has been studied is so-called tone or tune deafness, christened "dysmelodia" by Kalmus and Fry (369). These investigators found that this trait showed a familial aggregation, as illustrated in the following pedigree. (See Figure 4.)

While this finding does not prove the inheritance of musical ability, it at least indicates that a factor influencing and limiting musical ability appears to be inherited.

I have tried to indicate that there are clearly identifiable genetic factors which influence the behavior of persons who possess them. Second, that genetic factors play a major role in determining the degree of general intellectual ability which we all have in various amounts. Third, that there is good circumstantial evidence to indicate that a small number of major factors influence the occurrence of musical ability. In the case of Mozart, in recognizing the genius, we are also forced to recognize that if there are major genetic factors influencing musical ability, that he surely possessed these to an above average extent. While it is obviously impossible to prove the point in the case of Mozart, I believe this to have been the case, and I echo the comment made by Sir Walter Bodmer, Professor of Genetics at Oxford, at the International Genetics Congress in Washington in 1991; namely, that had Mozart been born in a Bedouin tent, it is likely that he might not have produced the wealth and beauty of the compositions which he achieved; however, if Walter Bodmer (or I) had been born the seventh child to Leopold Mozart, the world would have lacked the creative legacy of Wolfgang Amadeus Mozart.

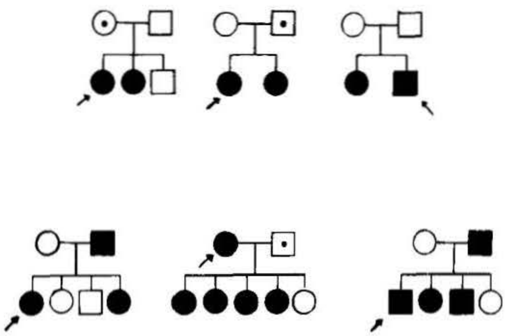

Figure 3. Six of the families identified and studied by Profita and Bidder (767). Potential probands were obtained from the musical communities of several large metropolitan areas. Nineteen of these were considered to have perfect pitch after appropriate testing. The immediate families of these probands were then similarly tested. Solid symbols represent those considered to have perfect pitch. Symbols with dots indicate uncertainty with regard to the subjects' possession of perfect pitch. Open symbols represent those who do not have perfect pitch, despite exposure and training. Arrows indicate probands. (Redrawn form Profita and Bidder 767.)

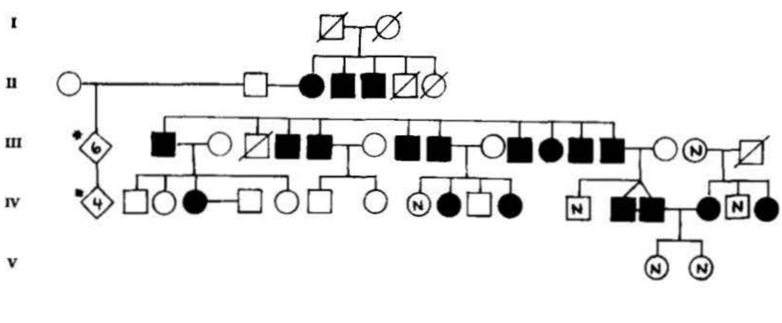

Figure 4. Kindred with dysmelodia, redrawn from pedigree #1 of Kalmus and Fry (369) and slightly adapted.
■ ● considered to have dysmelodia by objective testing, [N] (N) tested and considered normal.

* Indicates individuals said to be a "all musical." (Note the assortative mating illustrated in generation IV, a feature which Kalmus and Fry felt to be non-random in their aggregate of families.)

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