Neuropsychological Bases for the Development of Musical Talent

Hester van der Male[1]
Utrecht University

Elizabeth Batista Pinto Wiese[2]
Utrecht University

Abstract: This literature review aims to explain the neuropsychological base of the development of outstanding musical ability. In a discussion on the notion of talent, relevant research is linked to respectively the biological base of talent, early signs, talent identification, key factors in successful musicianship, and the domain specific character of talent. The main finding is that musical talent, which seems to be partly innate, must be nurtured. This process is reflected by the neural correlates underlying high musical ability.

Resumo: Esta revisão de literatura visa explicar a base neuropsicológica do desenvolvimento proeminente da habilidade musical. Em uma discussão sobre a noção de talento, a pesquisa relevante é associada a, respectivamente, a base biológica do talento, sinais precoces, identificação do talento, fatores chave na musicalidade bem sucedida e o caráter específico do domínio do talento. O principal achado é que o talento musical, que parenta ser parcialmente inato, deve ser nutrido. Esse processo é refletido pelos correlatos neurais subjacentes à elevada habilidade musical.

Music is a strong human expression. Although ways of expression differ from culture to culture, every human reacts to music. Musicality seems to be a universal human. With regard to making music in particular, however, there are many individual

1. Student of Roosevelt Academy, International Honors College of Utrecht University, Middelburg, The Netherlands.
2. Professor of Psychology of the Roosevelt Academy, International Honors College of Utrecht University, Middelburg, The Netherlands. Retired professor of IPUSP/PSC. email: *ebatista@usp.br* or *e.wiese@roac.nl*

differences. What makes that a child will become a famous musician in later life? Certain children seem to be born as musician, like Mozart, whereas others do not show any interest in playing a musical instrument.

Professional musicians with a successful career are said to be musically gifted or talented, and regarded to be born with it. For some people, high musical achievement is explained only by practice. Most people agree with the idea that musical talent must be nurtured. How the term *talent* is conceived, has consequences for the development of musical ability, and is therefore relevant for musicians, educators, parents and children.

Talent can be described as an "outstanding performance in a specific field" (Berk, 2008, p. 322), which only takes into account the level of achievement. The idea of potential can be found in the following description of talent, namely "the ability to perform at an elite level" (MacNamara, Holmes, & Collins, 2006, p. 335). Howe, Davidson, and Sloboda (1998, p. 399-400) have proposed a working definition of talent that includes five characteristics:

(1) It originates in genetically transmitted structures and hence is at least partly innate;

(2) Its full effects may not be evident at an early stage, but there will be some advance indications, allowing trained people to identify the presence of talent before exceptional levels of mature performance have been demonstrated;

(3) These early indications of talent provide a basis for predicting who is likely to excel;

(4) Only a minority are talented, for if all children were, there would be no way to predict or explain differential success;

(5) Finally, talents are relatively domain-specific.

With regard to high-level musical expertise, the concept of talent plays a central role. This concept has received most attention in the nature-nurture debate. The main idea is that musical talent seems to be partly innate, but must be nurtured (Howe et al.,

1998). This means, what is already present by birth will become apparent through learning. However, what should be considered as nature and what as nurture is not as clear as what it might look like.

The aspect of nature can be approached from a cognitive neuroscientific point of view. Investigation on neural correlates of high musical ability has contributed to a better understanding of expertise by putting neurobiological principles, for instance connected to learning, in scene (Gaser & Schlaug, 2003). In addition, psychological evaluation of musical talent has shown that environmental factors such as social influences (Moore, Burland, & Davidson, 2003), personality characteristics (MacNamara et al., 2006, 2008), and the amount of practising (Ericsson & Ward, 2007) play a role in musical learning. What follows from this that nature is closely intertwined with nurture.

In the light of these findings from both the fields of neuroscience and psychology, the next question regarding the origin and development of musical talent turns up: what are the neuropsychological bases for high musical achievement? In other words, what contributes inside and what contributes outside the brain to outstanding musical ability? To find an answer to this question, the five properties of talent as proposed by Howe and colleagues (1998) will be discussed. Additionally, relevant and recent experimental studies will be linked to those.

Biological bases of musical talent

Interest in music is presented very early in life, and babies show capacities of music processing similar to adults, which supports the idea that musicality is an innate capacity (Trehub, 2003). Whether differences in musical abilities, or musical talent, are rooted in the genes is less clear.

Studies in twins, which point out some aspects of musical-

ity, present a great hereditary component for the individual variation, as musical capability (hereditability of 44% to 90%; Coon & Carey, 1989), sound discrimination of tunes (hereditability of 71% to 80%; Drayna et al, 2001). Nevertheless, Howe and colleagues (1998) pointed out that little is known about genetic correlates and specific abilities.

Some research has been carried out on abilities, not specifically innate, that are associated with musical excellence. Ruthsatz, Detterman, Griscom, and Cirullo (2008) found a correlation between high-level achievement and aspects such as general intelligence and music aptitude.

Further, Baharloo, Johnston, Service, Gitschier, and Freimer (1998) found that the perfect pitch ability in musicians has a genetic component, since it runs in families, and that early musical training is necessary in order to develop this capacity. It should be noticed that the latter is not evidence for an innate capability. Additionally, Howe and colleagues (1998) pointed out that absolute pitch is not a crucial condition for becoming a professional musician.

If musical talent is partly innate, then the question raises what the role of brain structures is. Gaser and Schlaug (2003) focussed on structural brain differences in musicians and nonmusicians adults. They found that brain regions underlying visual-spatial, auditory, and motor processing, which are involved in music performance, show enlargements in grey matter in professional pianists. These areas are found in the primary motor cortex, the premotor and parietal cortex, the inferior frontal gyrus, and temporal lobe, the Heschl's gyrus (primary auditory cortex), and the cerebellum, reflecting brain plasticity dependent on learning. In addition, Oztürk, Tascioglu, Aktekin, Kurtoglu and Erden (2002) have reported white matter differences: the size of the corpus callosum is different in musicians and non-musicians.

Norton, Winner, Cronin, Overy, Lee, and Schlaug (2005)

did not find any of these differences in five- to seven-year-old children that planned to start playing a musical instrument and ones that did not. They also could not report enhanced performance on cognitive domains, such as visual-spatial and verbal abilities, which are associated with musical training. Generally, a correlation was found between musical perception skills and verbal reasoning and phonemic awareness, but this could reflect the shared neural base of music and language. Thus the neural base for musical ability is already present in childhood, but it seems that these structures develop after environmental stimulation.

Elaborating on those studies, Schlaug, Norton, Overy, and Winner (2005) reported that five- to seven-year-old children, after one year of musical training, showed improved fine motor abilities and auditory discrimination, and some slightly structural brain differences, compared to controls. In addition, behavioural and brain imaging tests with nine- to eleven-year-olds, playing a musical instrument for four years on average, showed more grey matter volume and better performance on several cognitive tasks than control age mates. In addition, the results pointed out to increased activation in frontal brain regions during rhythmic or melodic discrimination tasks, which could reflect that mirror neurons are active during musical training. Learning to play a musical instrument involves listening and watching others, activities in which mirror neurons have proven to be important. The role of these neurons has been confirmed recently by Overy and Molnar-Szakacs (2009).

So, there is support for a strong relationship between performance on cognitive tasks, structural brain differences, and duration and intensity of musical practice. This implicates that atypical brain structures associated with high musical ability are more likely due to exercise than to genetic predisposition. Neuroplasticity is the keyword in this process.

Early signs of musical talent

Children start their acquaintance with music before birth and acquire naturally basic musical skills, for instance producing melodies, during the first years of life, with strong linkages with language development (Trehub, 2003). The first signs of potential talent can be mostly detected by parents from the age of two, or at least from age five during the primary school years (Haroutounian, 2000a). Among these early signs are: a high interest in music and a sensitive response to the character of music, discriminates rhythms correctly, sings in tune and on the same pitch. Furthermore, the child is able to identify identical rhythms or melodies, and higher or lower pitch. Karnes (cited by Richardson, 1990) stated that a child showing all these characteristics could be regarded as musically gifted. In addition, Haroutounian (2000a) has formulated some general criteria for musical talent:

1. Music awareness and discrimination (characteristics of music aptitude):
    - Perceptual awareness of sound (it includes to sense the sounds internally and to listen to sounds discriminately);
    - Rhythmic sense (related to a fluid response to rhythm and to the maintenance of a steady pulse);
    - Sense of pitch (refers to the discrimination of pitches, the remembrance and repetition of melodies).

2. Creative Interpretation:
    - Experimentation and manipulation of sound;
    - Performance and reaction to music with personal expression, involvement;
    - Awareness of aesthetic qualities of sound.

3. Commitment:
   - Perseverance in musical activities;
   - Work that demonstrates focused concentration and internal motivation;
   - Refining of ideas and constructively criticizing musical work of others and self.

Besides this, exceptional ability at young age or without much practice, such as prodigies (Mozart for instance, and some idiot savants), demonstrate that early skills could predict a successful career. However, according to Howe and colleagues (1998), these can only be regarded as an early sign of innate talent if there were no special opportunities for learning or encouragement. Another aspect to be taken into account is the ability of perfect pitch, but we know that musicians with perfect pitch are not necessarily better musicians than others, and this skill can possibly be learned (Howe et al., 1998).

Moreover, one could wonder whether high performance scores on certain cognitive abilities could be seen as early signs. Norton and colleagues (2005) have not found differences in performance on verbal, visual-spatial, and fine motor skills, or music perception in children that started musical training and ones that did not. Furthermore, musical perception and performance on visual-spatial tasks did not correlate. Only language related skills did, but this is because of the common neural basis. Despite this, there is a certain agreement about some abilities that seem to be associated with musical potential. Methods for the identification of talented children will be discussed in the next section.

Identification of musical talent

Whereas some children clearly demonstrate early signs of

musical excellence, children that perform less well could have potential talent, but this could be easily overlooked. Therefore, several behavioural methods have been developed for the identification of musical potential, based on different kinds of information about the child.

Haroutounian (2000b) has interviewed musicians about talent identification and proposed that identification procedures should focus on a couple of aspects. Firstly, perceptual awareness and discrimination should be addressed, which includes perceptual awareness of sound, rhythmic sense, and sense of pitch. The second aspect is meta-perception, the cognitive process in which sound is imagined, remembered, creatively manipulated, and communicated to the audience. Thirdly, creative interpretation, the creative and expressive involvement in musical activities, shall be regarded. Furthermore, behaviour, and whether performance looks natural, shall be taken into account. Lastly, motivation and commitment are important aspects to consider.

Selection methods shall include both music listening and performance so that musical intelligence can be addressed (Haroutounian, 2000b). Identification involves both assessment and observation, preferably over a period of time. Furthermore, Haroutounian (2000b) recommended the use of classical tests, for instance one of Gordon's Measurements of Music Audiation, for activities during music listening, for musical aptitude, and musical creativity. Finally, depending on the context in which selection takes place, for instance if in a primary school, or a music institution, which of the proposed criteria and procedures will receive the most attention (Haroutounian, 2000b). Thus, identification of musical talent in early life gives some idea about the outcome of music education, but many factors are of influence on the child's musical development.

Factors explaining musical success

Even though innate aspects of talent are hard to isolate, there are a couple factors that explain why some children become successful musicians and others drop out. Firstly, a very strong claim is that deliberate practice is the most important factor leading to success, if not the only one (Ericsson, Krampe, & Tesch-Römer, 1993). Deliberate practice differs from common playing in that it includes setting goals, problem solving and feedback used for specifically improving performance. It was found that the level of musical expertise correlates strongly with the amount of deliberate practice, and that high-level expertise takes more than 10,000 hours of studying (Ericsson & Ward, 2007). Intriguingly, Levetin (2006) points out that this also could have been the case for the young Mozart, who wrote his first symphony when he was eight years old. If he started to studying at two and studied for thirty-two hours a week, he could have made the 10,000 at the age of eight.

Furthermore, the social context in which practice takes place seems to be highly influential on the musical development. Moore and colleagues (2003) have found that starting at early age, high parental support, stimulating teachers that do not ask too much, but also are not too relaxed, and sufficient practice, were crucial factors for children to continue with music lessons for eight years. Additional results were that concert activities, improvisation and mothers being home in childhood were significant for the development of adult musicians.

Also personal characteristics play a critical role in whether a musician will be successful or not. MacNamara and colleagues (2006) interviewed world top musicians, to identify challenges of different stages of development, and found that Psychological Characteristics of Developing Excellence (PCDEs), for instance, dedication, planning, commitment, interpersonal skills, confidence, were of crucial importance to face these challenges. Oth-

ers, who dropped their career, did not show these PCDEs. They were also shown to be highly significant in overcoming the transitions between different stages of development (MacNamara et al., 2008). In turn, commitment and planning could facilitate deliberate practice, and social skills to begin the career. So, the amount of deliberate practice, social support and certain personality traits seems to be responsible for successful musicianship.

Domain-specific character of musical talent

Related to talent is the question whether it is domain-specific or domain-general. Ruthsatz and colleagues (2008) have found evidence for the Summation Theory stating that general intelligence, domain specific skills for music, and deliberate practice are correlated with respect to musical achievement. It was found that expert musicians had high scores for those three variables. This suggests that potential for high musical ability and general intelligence are correlated.

Interestingly, there have been reported several transfer effects of musical training. Forgeard, Winner, Norton, and Schlaug (2008) found that learning to play a musical instrument for at least three years improved several cognitive abilities in children, as auditory discrimination, fine motor skills, vocabulary, and nonverbal reasoning. This could be explained by the enhancement of related cognitive abilities or general IQ due to musical education. Whereas there are indications for talent in a broader sense than only for music, it has been proven that music has positive effects on cognitive functioning.

Conclusion

With respect to high musical achievement, the present dis-

cussion shows that the concept of talent (Howe et al., 1998, p. 399-400), as they support that 'it originates in genetically transmitted structures and hence is at least partly innate' and that 'only a minority are talented, for if all children were, there would be no way to predict or explain differential success' is not completely correct. Concretely, musical potential seems to be partly rooted in the genes, but neither research on the neural correlates of music nor any other form of research could specify this. When talent is identified, it must be nurtured in a sensitive way. However, the environment is most responsible for musical excellence. High diversity in paths of development results in different levels of achievement. In turn, innate characteristics will be of influence on these routes.

To balance this, the contribution of biology to high-level performance remains hard to identify, on both the level of heredity and neural correlates. However there are lists of early signs that predict high musical ability, future studies should focus on empirical evidence supporting the innate talent account. The research on psychological characteristics could add to that. Moreover, this knowledge may provide better strategies for talent development. Early identification of potential for musical excellence will increase the chance for a successful career in music, since practicing, guidance, and encouragement can be suited to the student's specific needs.

In conclusion, the neuropsychological basis for high musical ability in the sense of talent remains unclear. However, it origins in heredity, and some of it is expressed in the brain's anatomy after training. It is developed by practice, environmental support, and influenced by personality traits. However, the fact that the most beautiful performances are associated with high musical ability retrieved after many years of practicing should not restrain anyone from making music and enjoying this as much as possible.

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