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The biological function of musical performance features

Abstract: In the world of Western musicology music is regarded as possessing two main divisions. The first being performance features which consist of traits such as dynamics, and tempo, and a second known as structural features such as the arrangement of notes in time. The main differences between these divisions is that performance features are evolutionarily ancient, indiscrete and present in many sound expressions, whereas structural features are evolutionarily younger, discrete and music-specific. Performance features are tightly connected with motor activity and emotional processing. Despite the fact that performance features carry information about emotional states, they can also be used as tools of manipulation. It has been proposed that one biological function of these tools is to affect the minds of other animals in order to arouse the need for cooperation in them. It has also been suggested that music performance features are homologous with some prosodic features of speech which evolved as a communicative tool before language and music.

Key words: music performance features, adaptation, biological function, cooperation, evolution, emotions

Introduction

The manipulation of sound intensity, intonation, timing, dynamics, articulation and timbre that do not disturb musical structure are often called the 'performance features' of music by musicologists [cf. Czekanowska 1975; Scherer, Coutinho 2013]. These manipulations seem indispensable for every musical performance, since without them music can sound flat and boring. However, because these same sound manipulations are used by speakers in order to make their speech more persuasive and emotional, the function of 'performance features' in music seems to be non music-specific. Nonetheless, if music is a biological adaptation unique to *Homo sapiens* [Fitch 2006; Miller 2000; Mithen 2006; Peretz 2006; Storr 1993] then the importance of performance features as a part of music suggests that these features could have gained a new adaptive function in the course of human evolution which is related to the adaptive function of music. It has been proposed that performance features became an auxiliary musical tool designed to affect the minds of conspecifics in order to persuade them to cooperate. Additionally, it has been suggested that the Western division of performance and structural features reflects the intrinsic difference between the evolutionarily ancient ability to vocally express emotions [Juslin, Scherer 2005] and the more recent evolutionarily ability to organize pitches according to generative rules [Merker 2002].

The Western tradition versus the universal components of music

In Western artistic musical tradition participants have been divided into composers, performers and listeners [Stockmann 1982]. Although there are some exceptions to this rule, it seems that the majority of compositions and performances represent this model. Composers write notes, performers read and interpret them and listeners hear the results. Although this model is obvious there are some important questions concerning such a division. First of all, as composers usually want to instruct performers how to play as accurately as possible, we need to address the question of the difference between the composer's scope of creation (hence the structure of musical work), and the performer's task which always has a motor nature. Is there any clear border between these two areas? If it exists, then is it just the result of tradition, or is it rather an effect of certain human cognitive specificities that influence the processing of sound and music? This question may seem trivial. It not only concerns our cultural decision as to who is responsible for what, but it also pertains to the structure of a musical piece and its interpretation. Moreover, from a musicological point of view there is also the question about what is sufficient to constitute musical work. From a psychological perspective, this question concerns the basic ingredients of the mental prototypes of musical works. For example, why is 'Twinkle, twinkle little star' recognized as the same piece either when it is played fast and quietly on the flute or when it is played slowly and loudly on the trumpet?

Of course, when we speak about human cultural inventions and achievements, no matter if it is the wheel, a particular language or money, our understanding of these is always, at least partly, the result of sociocultural influences [Gauvain 1995], a kind of social agreement on how to understand them. However, some of these phenomena have features which do not depend entirely on culture, such as language grammar [Dor, Jablonka 2001]. While every language has its own specific grammatical rules, all languages have nouns and verbs and probably other grammatical universals [Baker 2009; Croft 2009; Harbour 2009]. In fact, particular grammars can to some extent influence our understanding of the relationship between words [Wierzbicka 1999], but it seems that the division of things and activities represents the human-specific characteristic of mental categorization. Similarly, people use numbers in order to understand significant information about the natural relationships existing within the physical world [Cipora 2013], but the numerical system or even forms of notation (Roman versus Arabic numerals) can drastically impact our counting abilities [Gigerenzer 2009: 168–169].

By the same token music notation can affect how people hear music [Sloboda 2002] yet perhaps the invention of notes may have reflected something more fundamental and specific to human sound perception? In the history of Western musical notation the first challenges were pitch category and sound duration [Apel 1962;

Strayer 2013]. The category of pitch is observed in all musical cultures [Bannan 2012]. In music expression these categories are always arranged in time [London 2004]. Sometimes, sounds which are impossible to perceive as a particular pitch suffice to build a musical expression. With or without pitch, successions of pitches seem to be the main prototypes of musical pieces. They build a structure of music. In the West, we are used to thinking about the composer as a specialist whose job is to put pitches together. But their formula for music does not usually contain the information about the arrangement of pitches in time. In general, the later in history of Western music, the more elements were described by composers including tempo, instrumentation, dynamics, articulation and even some general descriptions of moods to express [cf. Kivy 2006; Strayer 2013]. This proves that the structure of music – hence the meaning of the term 'music-work' – is significantly affected by culture and historical conditions [Huron 2006]. On the other hand, the universality of pitches as building blocks of music indicates that our tendency to communicate by the means of pitches can be specific to all people.

The next question concerns the role of the performer. Apparently, the scope of the performer's interpretation depends solely on the composer's decisions and it has been changing throughout the history of Western music. Therefore, in extreme cases composers specify almost every detail of a musical work. As a result, the performer is like a well-programed computer designed to play Midi format but can never be as perfect as a computer. This suggests that we need the 'imperfection' of human performance. From a historical point of view, the task of the performer was different during different periods. In addition, there is no agreement among historians about what the performer was allowed to do exactly. Also the profession of composing is definitely an invention of only a few cultures. Therefore, the division of the music features needs to be based on other criteria and to be historically and culturally independent. For this purpose, the psychological description of performance features seems to be the most useful approach. This approach consists of contrasting 'performance features' with 'structural features'. Structural features are the arrangements of pitch classes in time. In contrast, 'performance expression' is understood as phrasing and articulation and consists of the manipulation of timing, loudness, and stressing etc. [Thompson 2009: 188]. Therefore, the so called 'performance features' are in fact all sound manipulations which do not change the mental representations of pitches in time. All these manipulations are perceived in a linear, non-categorical fashion whereas structural features are represented as discrete forms. It seems that this division has its grounds in and it is connected to a generic way of music processing. Therefore, independent of whether there is a division between composers and performers in a particular culture or not, music consists of two kinds of components – discrete and indiscrete.

Human evolution and the processing of music

The way in which a human processes music is influenced by their cultural background and individual experiences, even though the influence of culture and experience is restricted by human evolutionary history [Tooby, Cosmides 1992; Gazzaniga

2008]. The functioning of human perception, including sound and music processing, is hierarchical and reflects the evolution of perception in the lineage of *Homo sapiens*. The evolution of perception is closely linked to the development of the nervous system, especially to the evolution of the brain. As the brain has evolved, evolutionarily younger structures have been built onto existing, evolutionarily older, structures [Striedter 2005: 65–70]. As a result, many perceptual and cognitive mechanisms of adaptational significance that were present in lower animals in the evolutionary line of *Homo sapiens* have also been preserved in modern people [Roederer 2003: 10]. This indicates that the human perception of sound and music, as well as music itself, must consist of features which are universal and that occur in various phenomena.

The psychological differentiation between 'performance features' and 'structural features' seems to reflect a distinction between evolutionarily older and younger elements of human vocal/sound communication. Elements such as the manipulation of timing, loudness, stressing etc. are not specific only to music but are present for instance in speech. Moreover, some of the features which are present in phrasing and articulation, for example crescendo and timbre modulation are useful communication tools in mammals [Merker 2003: 405]. Because of this, music performance features should be understood as the features of vocal communication rather than elements solely specific to music. However, it does not mean that performance features cannot fulfil a music specific function when they are used in music.

Of course, some 'performance features' differ in terms of their evolutionary age. To illustrate this point, one may suppose that a sudden loud sound will act more effectively and universally than subtle changes of articulation. Nevertheless, it seems that in opposition to 'structural features', all 'performance features' have a pre-conceptual character strictly related to motor activity and emotional processing. Hence, this trait is the common denominator of all 'performance features'. Similarly, it seems impossible to use 'performance features' as the 'building blocks' of generative systems. For example, we can manipulate pitches and time proportions of sounds to fulfill or break syntactic rules. Yet, this is impossible by the means of dynamics and tempo and even timbre [Patel 2008]. As far as we know, this rule is true for all known music cultures. This suggests that some specific cognitive mechanisms enable the use of 'structural features' in syntactic operations. These mechanisms are separate from the processing of information which is transmitted by 'performance features'.

Biological functions

In general, the biological function of a 'feature of an organism' is often defined as the role of this feature in genetic success and the evolution of this organism [Lewens 2007]. Of course, the term a 'feature of an organism' is understood here not only as a physical trait but also as a pattern of behavior or even as an 'extended phenotype' (in the Dawkinsian sense [2003]). Although there is an unceasing debate about the actual unit of evolution (if it is one gene, or clusters of genes, or gene pools, or species) [cf. Wilson 2012], a 'biological function' always has to bring benefits to this unit.

The question about the actual biological function of music has been crucial for everyone who has been engaged in the debate about music adaptability. Amongst the various answers to this question one in particular dates back to the nineteenth century and is owed to Darwin. Although Darwin wrote about man's musical abilities as being '[…] the most mysterious with which he is endowed' [1871: 333], he was in fact already seeking an explanation for human musicality in the action of sexual selection. The pressure of selection, which according to Darwin and his followers, led to the emergence of musical aptitudes in man, is linked to the key role of music in the evaluation and selection of sexual partners. Another popular answer is linked to the evolution of humans as social animals and concerns the benefits of musical skills which are gained by individuals who live in a group and who use such skills to establish and consolidate a group [Storr 1993] or to provide information about its cohesion [Hagen, Bryant 2003; Hagen, Hammerstein 2009]. Also, music's function in strengthening parental bonds and in a mother's pre-linguistic communication with her children is not without biological significance [Dissanayake 2000; Falk 2009]. However, this hypothesis does not account for the universality of collective vocal activity among adults.

According to the popular evolutionary psychologist Steven Pinker [2002], in contrast to these adaptive understandings of music, music is an example of 'pure pleasure technology' – a popular human invention. From this point of view any biological function which is fulfilled by music is not music-specific. This means that music is composed of other human adaptive abilities which for example evolved separately from certain linguistic abilities or 'auditory scene analysis.' Although this hypothesis does not explain the existence of music-specific traits such as tonality or musical pulse, Pinker emphasizes the relation between particular biological functions and separate single abilities which are collectively used by humans to perform and listen to music. However, if we admit that music as a general phenomenon is a biological adaptation, then we have to identify at least one biological function which is only fulfilled by all music abilities working together.

Biological functions of 'performance features'

By moving away from the biological functions of 'performance features' in music one can begin to speculate about the potential benefits which could be connected to these features. The first and probably the most obvious beneficial function of the manipulation of timing, dynamics etc. is communication. The communicational character of these elements is unquestionably present in every human sound expression. It seems, however, that the communicative role of these elements is especially important in both musical expression and in speech. In the first place, 'performance features' that are the main ingredients of prosodic contour and rhythmic grouping in speech [London 2012] (which are homologues of melodic contour and rhythmic phrasing in music), deliver information about the emotional states of the speaker. The emotional power of these features seems to be strictly connected with their embodied character. Information about a human emotional state is often fundamental for survival. Because of this, the ability to 'read' emotions from prosody is undoubtedly beneficial. The knowledge of a person's attraction or aversion can help us to behave appropriately – in an optimal way – both in individual and social tasks. Recognition of an opponent's anger can help to avoid conflict. The identification of sympathy and attraction in the opposite sex can facilitate mating and reproduction as a result.

On the other hand, this communicative property of 'performance features' can serve as a tool of manipulation. A good speaker or musician is able to evoke a particular mood in an audience independently of the content of the speech or the structure of the musical piece that is performed. The strategy of manipulation and cheating in the animal world is very popular and beneficial. Although it is difficult to be insincere by using 'performance features' [Cross and Woodruff 2009] people often try to delude others by the means of dynamics and articulation. In some circumstances humans speak louder and more emphatically in order to show courage and bravery whereas in reality they are scared and shy. Similarly, to gain somebody's trust cheaters can use smooth and descending phrases although they are emotionally cold and calculating. All these characteristics of sound are translatable into spatial expressions such as width and levels of gesticulation [Clynes 1977]. Of course, the most effective way to control the communication of emotions by the means of 'performance features' is to arouse in oneself the emotion which one wants to express. This strategy is very popular among some actors but it is also advisable for all music performers.

All of these aforementioned functions of 'performance features' are presumably the consequence of the likely existence of some pre-linguistic vocal communication used by our ancestors [Mithen 2006]. The form of vocal communication that preceded speech and music is often regarded as a kind of 'protomusic' [Fitch 2006; 2013] or 'musilanguage' [Brown 2000] since many elements of emotional expression are shared by music and speech. Because old and well-tried traits have been preserved in the course of evolution, the presence of these functions in music is not surprising. It also suggests that all of these functions can be attained without music.

Another kind of function that is achieved by 'performance features' but which is absent in music is to emphasize and convey various kinds of meanings. For example, in many languages 'performance features' serve to deliver information about whether a particular sentence is interrogative, indicative or imperative [Ladd 2008]. Also, some habits of stressing and dynamics are important in semantics and pragmatics. Although there is no agreement about the actual biological function of natural language, the majority of scholars admit that language must be adaptive [Pinker 1994; Jablonka, Ginsburg, Dor 2012]. As the communication of referential meaning seems to be the main function of language, one can assume that the 'meaning function' of 'performance features' in speech is adaptive too. One can imagine a lot of scenarios in which information transmitted or obtained by the means of language can bring advantage to the speaker.

From this point of view, the biological function of 'performance features' in speech is obvious. 'Performance features' facilitate pragmatics, semantics and even syntax [Gordon et al. 2015] which seem to be specific to language. These traits probably play adaptive functions. Therefore, 'performance features' in speech must be adaptive too. But why are 'performance features' in music so important? If music is not an adaptation, then why does it additionally consist of structure? Why does music affect human emotion so strongly? 'Performance features' alone or in speech are not so effective in arousing emotions as they are in music. Additionally, the components of musical structure are music-specific and universal but without 'performance features' music seems to be dull or boring. It seems however that the function of music is something more or different than the simple triggering of emotion. Even if we admit that the expressive and impressive usefulness of music is its main power, it doesn't explain the actual biological function of music. Pleasure by itself is not a biological benefit.

From the perspective of Western musical tradition, we usually treat music exclusively as a work of art – an art which involves the juxtaposing (composing) of tones, in a way that is arbitrarily accepted by a given social group, in order to obtain an artistic and aesthetic effect. There are many contemporary theories which hypothesize that art is a biological adaptation [Dissanayake 1995]. However, by observing people produce music in various situations – not only within our own culture – we need to admit that the communication of artistic or aesthetic content through music does not always take place as in the case of football chanting or singing happy birthday during family gatherings. Therefore, it is untenable to claim that the adaptive value of art equals the basic function of music. So it is useless to explain the biological function of music solely in reference to the adaptive theories of art as long as art is defined by the means of artistic and aesthetic experiences. Music acts more powerfully and in a more direct way on the subcortical emotional systems than any other visual art [Panksepp, Bernatzky 2002], and links connecting music and emotions also appear to be exceptional in comparison to other forms of human sound expression. Although the arousal of emotion cannot be treated as a biological function, this indicates that the stimulus is connected with one such function. Given that emotions are a basic mechanism of evaluation [Scherer 2013] and motivation [Mortillaro, Mehu, Scherer 2013], it may be presumed that they will always accompany us whenever the information that reaches our nervous system is of crucial importance for survival.

Music-specific biological functions of 'performance features'

In order to answer the question regarding the music-specific biological functions of 'performance features', we should concentrate on music-specific structural features and their relation to 'performance features'. First of all, we ought to investigate the probable functions of tonality and musical pulse – features which are ubiquitous features of music [Podlipniak 2007]. So, what kind of biological advantage does the ability of tonality processing provide? Tonality understood in a broad sense is 'the arrangement of pitches in a piece of music so that one pitch predominates, usually accomplished by repeating the pitch and placing it in important locations, such as the downbeat of the metrical cycle' [Snyder 2001, s. 265]. The feelings of expectation, suspension and completion which accompany listening to different 'tonality relations' cause tonality to appear as a natural and intrinsic part of music [Huron 2006]. These feelings are not only collective and similar for musicians, but they can arouse a sense of cohesion for many of us [Podlipniak 2015]. Additionally, the strongest emotional reaction connected to tonality occurs in the participants of collective performances. The feelings triggered by changing tonality relations during a musical performance can give musicians great satisfaction which is often reported by choir singers [Sandgren 2009]. This indicates that tonality is a musical feature which plays an important role in group performances and thus could facilitate group cohesion [Podlipniak 2011].

Being well-consolidated within a group of individuals usually gives each individual an advantage [Ridley 2000]. Whether it is hunting, foraging, working, or deterring predators all of these are activities are usually more effective when done in a group. Therefore, the more cohesive the group, the safer and better fed each group member will be. Vocal group performances are especially popular with the members of hunter-gatherer tribes [Morley 2013]. Their music is structurally simple but tonal. Because singing is one of their daily activities [Blacking 1973], the processing of tonal relations is a frequent cognitive task of an average tribe member. These tribes probably resemble the first stage of the *Homo sapiens* way of living [Morley 2013]. Thus, the popularity of group singing among primitive tribes indicates the biological importance of this behavior. Hence, our proclivity to look for tonal order in music – tonal instinct – is probably the legacy of our ancestral history, a part of our social nature [Podlipniak 2013; 2015]. Is there any role of 'performance features' in processing tonal relations?

It seems that, similarly to 'meaning function' in language, 'performance features' in music were included to establish tonality. It is easier to assure oneself that co-performers are going to reach an important tone in the scale if we apply crescendo or decrescendo to our performance. Also, articulation as well as manipulation of timing can serve to emphasize the importance of the scale degree. This is a music-specific function of 'performance features' and because it facilitates establishing tonality, it serves also as a group cohesion device.

Apart from that, 'performance features' play another music-specific role. This role is connected to the mysterious human ability of motor synchronizing with music [Large 2000]. This is possible thanks to musical pulse which gives listeners a time reference [London 2012]. The periodicity of musical pulse allows the anticipation of a time order of the musical piece. This is the reason why we can dance to music. Motor synchronization with music often leads to a so-called 'musical rhythmic entrainment' [Becker 2004]. In this phenomenon, people dance, sing or listen to music together. During this action their gestures, muscle action, brainwaves and breathing become synchronized, which often leads to altered states of awareness, revitalization and a feeling of well-being. The experience of musical pulse is motor in its nature. Rhythm and beat perception are probably the main reasons why we often move spontaneously to music [Grahn, Brett 2007]. The feeling of well-being as a result of motor activity combined with music seems to serve as a reward for the hard and time-consuming practice of consolidation. But even without this entrainment people are usually satisfied with a well-synchronized performance both when they are either performers or listeners. In fact, listening to high-groove music activates the motor system [Stupacher et al. 2013] which often leads to the synchronized movements of people. Such an interpersonal synchrony increases prosocial behavior [Cirelli, Einarson, Trainor 2014]. Additionally, interpersonal synchrony indicates social helpfulness [Cirelli, Wan, Trainor 2014].

All these observations suggest that synchronization with musical pulse facilitates group cohesion and social bonding between group members [Mithen 2006]. The consolidating function of the motor synchronization with music is observed among many contemporary tribal communities [Becker 2004]. Similarly to tonality, the popularity of group dancing among primitive tribes suggests that musical pulse can be biologically important and that this importance is related to consolidation. Also in this case, 'performance features' (e.g. by the means of accents associated with small changes in intensity, intonation, duration, and/or timbre) serve as a good indicator of the time order of music. Although metrical accents are claimed to be endogenous in nature [London 2012] the appearance of acoustical cues emphasizing metrical stress helps to recognize a particular metrical pattern. Therefore, small changes in intensity, intonation, duration, and/or timbre enhance the recognition of metric structure [Tomic, Janata 2008] and because of that facilitate synchronization. In other words, stressing particular tones in equal distances of time and regular phrasing causes the periodicity of music course to be easily recognizable and causes people to synchronize faster and more effectively.

Conclusion

All forms of sound expressions which are meant as 'performance features' are not music-specific. From an evolutionary point of view they are older than speech and music and thus their main biological functions are not related to music. Nevertheless, it seems that these features gain a new function in music. The tight connection of 'performance features' with tonality and the time organization of music suggests that their function is to some extent common. If tonality and musical pulse served as consolidation tools, then 'performance features' would also support consolidation. This is indicated by the fact that the satisfactions gained from rhythmic synchronization or the maintenance of tonal relations are emphasized and intensified by the means of 'performance features'. All functions of 'performance features' are possible thanks to their tight connection with motor activity and emotional processing.

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