Proceedings of the 3rd International Conference on Music & Emotion (ICME3), Jyväskylä, Finland, 11th - 15th June 2013. Geoff Luck & Olivier Brabant (Eds.)

SPECIFIC EMOTIONAL REACTIONS TO TONAL MUSIC – INDICATION OF THE ADAPTIVE CHARACTER OF TONALITY RECOGNITION

Piotr Podlipniak

Department of Musicology, Adam Mickiewicz University Poznań, Poland
podlip@poczta.onet.pl

Abstract

People report that specific emotional reactions accompany the perception of tonal relations during listening to tonal music. These reactions are not restricted only to people living in the Western culture. Different types of tonality which are observed in all musical cultures seem to evoke similarly strong emotional reactions. The emotional response to a tonal sound sequence has been predominantly explained by fulfilling or not the pitch-related expectations of listeners. However, although this model indicates the general mechanism of prediction as the main source of an emotional reaction, it does not explain why the musical pitch-related expectation causes a stronger emotional reaction than other sound stimuli such as speech. Thus, an adaptive character of a general mechanism of expectation cannot explain specific emotional reactions in response to tonal stimuli. Because a strong emotional reaction accompanying a specific behaviour is usually an indicator of the adaptive value of this behaviour, it is suggested that the ability of tonality recognition has to possess an adaptive character. This view is supported by the fact that tonal music is still the most popular music in the world, although atonal music has been intensively promoted for almost one hundred years. The origin of the ability to recognize tonal hierarchies could be related to the social character of tonal music performance observed among primitive cultures. A better memory for tonal than atonal sequences suggests additionally that the emergence of tonality could have been gradual and based on genetic assimilation.

Keywords: tonality, adaptation, expectation

1. Introduction

Tonality in a broad sense is an arrangement of pitches in which some pitches are more important than others (Snyder, 2001). This feature of music is one of the most salient elements which influence the impression of musical structure. In the case of tonality the structural function of pitches is realized thanks to difference between the emotional assessments of particular scale degrees. These emotions are usually described as the feelings of tension and relaxation or instability and stability (Meyer, 1956) and they depend solely on musical contexts (Krumhansl, 1990; Huron, 2006). The eliciting of tension and relaxation is explained as a result of common psychological principles of expectations (Krumhansl, 2002). More specifically, listeners' emotional reaction to tonal stimuli results from their successful or unsuccessful predictions based on implicitly learned statistical characteristics of pitch occurrence in music, which is specific to their culture (Huron, 2006).

However, it is difficult to explain these emotional reactions by referring to evolution. Because emotions are evolutionarily old mechanisms of evaluating the external world in terms of the potential adaptive or maladaptive value of stimuli (Panksepp & Biven, 2012), emotional reaction to sounds should reflect the assessment of environmental traits connected to these

sounds. But, it seems that there is nothing adaptive in the musical contexts of pitch occurrence which could account for strong emotional reactions observed during listening to tonal music.

Moreover, there is also nothing functionally unchangeable in the extra musical context of tonal music performances which could explain stable emotional assessment of *tonic*. People listen to and perform tonal music in many circumstances and for various purposes, which may or may not be adaptive. Thus, it is extremely difficult to imagine that the Pawlovian conditioning could be responsible for stable emotional reactions to tonal characteristics.

One of the explanations of this problem suggests that specific emotional assessment of tonal features is a result of misattribution (Huron, 2006). According to Huron, the successful or unsuccessful predictions of stimuli generate emotional reactions as a result of the adaptive value of the general ability of prediction. The positive emotional assessment of *tonic* is incorrectly attributed to a particular pitch because our minds learned statistically to expect it and therefore associate a given positive emotion generated by successful prediction with melodic context specific to the appearance of *tonic*. Hence, all tonal predictions are possible thanks to statistically learned characteristics of pitch frequencies observed during our life-long experience of music.

However, because this explanation reduces the emotional assessment of tonal music to principles of general cognition, the same way of reasoning should be applied to predictions of all kinds of stimuli, e.g. pictures, spoken words or elements of other human sound expressions. In other words, according to Huron there is nothing unique about the emotional assessment of tonality. But feelings of tension and relaxation which accompany listening to tonal sound sequences, seem to be qualitatively unique. Insofar as the stronger emotional reaction to sounds in comparison to visual stimuli could be explained by the fact that auditory processing is probably evolutionarily older than visual processing (Panksepp & Biven, 2012, pp. 11-12), it still does not explain why the emotional reactions to well predicted speech or environmental sounds seem to be at best less impressive. Even in the perception of music, accurately predicted timbre does not elicit emotional reaction similar to well predicted pitch.

These observations provoke some important questions. What is the reason for which emotional reaction to pitch statistics differs from the reaction to timber statistics in music and speech perception? Why do children implicitly learn the rules of pitch organization instead of learning some principles of timber or dynamic orders in the same way? Why do people spontaneously organize music using 'pitch syntax' whereas they do not do that by means of 'timbre syntax'? The fact that the former was accidentally invented in the ancient times and has been cultivated from generation to generation through social learning does not seem convincing explanation.

It is suggested in the present paper that these questions can be answered only if it is assumed that the emotional assessment of tonality is an indispensable element of the adaptive human ability which enables perception of tonality. What is here meant as adaptiveness is, for example, that the feeling of relaxation which accompanies the appearance of *tonic* should be understood as a response to the communication of social consolidation rather than mere effect of the prediction of the most probable pitch.

2. The uniqueness of tonality

Tonality seems to be a strange phenomenon. Humans organize pitches in different frequencies and establish their importance depending on some rules. They start to learn them relatively early in childhood (Corrigall & Trainor, 2009) by means of implicit learning (Tillmann et al., 2000). This causes that any conscious knowledge is not needed to predict and comprehend tonal order. In this respect acquisition of tonality resembles the learning of mother tongue (Brandt et al., 2012), but as far as we know there is nothing structurally similar to tonality in any language (Patel, 2008). However, although implicit learning is

not restricted only to development of inborn abilities (Reber et al., 1999), in the case of quick learning of a complex pattern of behaviour on the basis of poor input, one usually assumes some innate basis (Dor & Jablonka, 2001, p. 44). In this respect tonality undoubtedly resembles grammar of language.

Furthermore, the function of emotions in the implicit learning of tonality seems special. Emotions play an important role in this process not only because they motivate children to concentrate their perception on pitch order but also because affective response becomes an inherent part of every experience of tonality. An additional probable advantage of the tight connection between emotions and tonality is the extension of working memory for tonal pitch sequences. People remember tonal melodies better than the atonal ones (Schulze et al., 2012). Similarly the sequences of tonally ordered pitches are better remembered than vocabulary, digits and nonrepresentational figures (Steinke et al., 1997). The memory advantage of tonal sequences can probably be ascribed to the fact that emotions attract attention (Compton, 2003), which in consequence improves working memory (Kensinger & Corkin, 2003). This kind of 'implicit mnemonics' is comparable only to facilitating memory for words sequences by means of rhymes (e.g. assonances) in poetry.

Apart from that, tonality seems to be a universal trait of humanity. It is not only observed in all musical cultures but predominates within them (Bannan, 2012). In many cultures tonality is sustained by means of very popular technique of music composition which is known as *bourdon*. Its popularity and presence in many primitive cultures imply that tonality is one of crucial music features.

Surprisingly, although various musical cultures shape the tonal structure of their music in their own unique ways, people are able to make accurate cross-cultural tonal expectations (Castellano et al., 1984; Kessler et al., 1984; Eerola, 2004; Ambrazevičius & Wiśniewska, 2009; Eerola et al., 2009). This suggests that the ability to recognize tonal organization is sensitive not only to culturally specific tonal hierarchies, stored in long-term memory, but also to basic statistical distributions of tones observed in an individual piece of music written in an unknown style (Krumhansl & Cuddy, 2010). This ability probably influences also the way in which music is composed in every culture.

In fact, tonality is the only way of organizing pitches in music except for the Western twentieth-century's post-tonal music (Scruton, 1999). However, tonal music and atonal music differ significantly from the socio-behavioural perspective. Contrary to popularity of tonal music among almost all contemporary social groups, the popularity of atonal music is restricted to the comparatively small groups of academic elites and the avant-gardes fans (Dutton, 2009). This fact is especially notable if we realize that atonal music has almost a hundred-year old history and has been intensively promoted during the last century. Another reason of grater popularity of tonal music is fact that it is familiarized faster. This is because the structural understanding and emotional responses to the atonal music pieces are weaker than to tonal compositions (Daynes, 2011). All these observations imply that the ability to recognize the tonal order of pitches is a part of human nature.

3. The question of function

The suggested natural character of tonality imposes evolutionary explanation of its origin. Every evolutionary explanation demands pointing out an adaptive function of the evolved trait. Because tonality is a structural feature of music, it is necessary to indicate a relationship between tonal structure and its adaptive function. Even though many theoretical assumptions emphasize the structural specificity of tonality (Lerdahl & Jackendoff, 1983; Krumhansl, 1990; Krumhansl & Cuddy, 2010), they at the same time suggest that these structures are products of some mental capabilities used in other domains of human perception and cognition.

However, as far as there is a structural and behavioural similarity of an observable, unique and universal trait, it is reasonable to suppose that this results from some domain-specific

inborn predisposition (Gazzaniga, 2008). This predisposition could be understood as a specific motivational mechanism which leads to the development of domain-specific ability or functionally connected abilities. Neither does it mean that this ability needs to work independently of abilities specific to other domains. The structurally complex phenomena (e.g. language) are usually a result of the activity of an interdependent set of different mental tools. What is however crucial for evolutionary explanation of the origin of a behavioural trait is its common functional characteristic which became an object of selection during evolution. While in the case of language grammar its most probable adaptive function is communication of particular constrained subset of linguistic meaning (Dor & Jablonka, 2001), the adaptive function of tonality remains unknown.

One of the clues which could help to resolve this puzzle is affective response to tonality. Information about the emotional state of communicating people is poorly transmitted by means of language vocabulary. It is rather a domain of acoustic features of suprasegmental organization of speech phonology which are not specific solely to language. These features – continuous variables such as modulation of tempo and dynamics, stress etc. – are present also in music (Scherer & Zenter, 2001). Moreover, as a part of so called expressive dynamics they seem to be understandable at least among some species of mammals (Merker, 2003). This interspecies recognition indicates that they are evolutionarily older than discrete communicative ingredients of speech and music such as phonemes and pitches.

But the emotional assessment of tonal sequences is opposite in nature. The feelings of tension and relaxation which accompany tonal recognition results from predictions which concern discrete elements – pitches. Hence, emotional communication in music was extended to include a new tool based on perception of structure. Unlike in language, discrete structural ingredients act in music as an additional tool designed to elicit emotions. However, there are some similarities between tonality and language grammar in respect to their inherent peculiarities. As in the case of linguistic grammar in which particular semantic categories determine some universal aspects of grammar (Dor, 2000), it seems that specific emotions correlate with some aspects of tonal organization. The feeling of relaxation which accompanies the recognition of *tonic* is irreplaceable with the feeling of tension. People are completely unaware both why some grammatical patterns are dependent on semantics (Dor & Jablonka, 2001, p. 38) and why some feelings are dependent on pitch order. In this respect the relationship between the semantic categorization and the grammatical rules is similar to the relationship between the emotional assessment and tonal organization. In the same way grammar in language cooperates with different structural features in order to transmit meanings, tonality in music is only one of many other tools eliciting emotions.

However, tonality does not seem to be a mere emotional meanings transmitter. Although emotional meanings are well communicated through facial expressions (Ekmann, 2007), body language, laughter (Provine, 2001), etc. every of them is designed to perform specific adaptive function. The same is perhaps true when we think about a variety of musical tools such as timbre, dynamics, keys, musical mimesis, musical symbolisation, etc. While many of these musical tools transmit emotional information by means of culture-specific associations (Juslin, 2001), a particular emotion elicited by tonality prediction is not arbitrarily chosen by culture. Thus, the stable connection between feeling of relaxation and *tonic* seems to reflect a specific important communicative function.

The feeling of relaxation usually accompanies situations in which people are safe and comfortable. Because music is mainly a social activity (Cross, 2011) it may be suspected that the function of tonality is to provide information about social acceptance and support. Such information is easily associated with feelings of relaxation. The feeling of uncertainty which accompanies the lack of knowledge about social acceptance once this knowledge is gained results in relaxation. This emotional underpinning of the

exchange of mutual acceptance certainly facilitates group integration. Emotional assessment of tonality resembles this scheme. Tonal order is one of the features which enable communal singing. The implicit memory of *tonic* allows singers to intuitively orientate in pitch space. Tonal predictions belong also to important indications of musical closures. Both these elements facilitate integration among performers. Without sustained memory of *tonic*, the consolidating power of music would be definitely less impressive.

Of course, in different cultures both the presence of tonality in music and its elaboration vary drastically. Tonality is present in numerous religious chants without metro-rhythmical order. In the majority of cases tonal order is combined in culturally specific way with other expressive features such as rhythm, stress, dynamics etc. In the history of Western music tonal predictions became a foundation of functional harmony (Dahlhaus, 1968; Thomson, 1999). However, in spite of all these differences the primary emotional meaning of tonal relations remains unchanged.

4. The origin of tonality

The characteristics of tonality suggest that the genesis of the ability to recognize tonal order is connected to interaction between cultural and genetic evolution. As has been recently indicated, the evolution of the human mind is a result of complicated interactions between genetic and epigenetic information as well as the cultural environment (Jablonka & Lamb, 2005). Because the proposed adaptive integrative function of music is related to social life of our ancestors which was based at least on some cultural traditions it is reasonable to suppose that culture became a part of our selective environment.

On the one hand, musical stylistic traditions are transmitted over generations through social learning. Thus, it is easily imaginable that tonal organization of pitches in music could be one of such traditions similar to the invention of some Palaeolithic stone tools. Their appearance and gradual sophistication in our ancestral prehistory is explained solely by means of cultural evolution.

On the other hand, the ability to recognize tonal order is learned implicitly in childhood like language grammar. Additionally, children detect changes in music more easily when the melody contains repeated notes (Schellenberg & Trehub, 1999), which motivates them to develop the implicit knowledge about tonal hierarchies characteristic to their culture. Tonal melodies are better remembered and tonal music predominates in every human culture. The connection between feeling of relaxation and *tonic* as well as spontaneous tonal organization of music are invariant despite the diversity of other musical features. All these observations imply that the origin of tonality has some roots in genetic evolution.

It is however difficult to imagine how accidental mutation which was responsible for proclivity to perceive music in such peculiar way could have proliferated without previous existence of tonality in music. One of the possible solutions of this dilemma is the evolution of tonality recognition by means of genetic assimilation. The process of genetic assimilation, known also as the Baldwin effect (Weber & Depew, 2007), is a process in which natural selection transform learned response of organism into instinctive response (Dor & Jablonka, 2001, p.45). In the case of animals able to socially learn, some adaptive changes, as responses to new challenges, are first socially learned. Then, if the process of learning is strenuous and costly and if the selective pressure is long enough, accidentally emerged instinctive learning is preferred by natural selection (ibid.).

The Baldwinian scenario of tonality evolution starts with the cultural invention of the tonal organization of pitches. It is only a matter of speculation if there was a communal religious ritual or a kind of other group performances in which tonality appeared first. Hominines were able to invent tonal organization because they were endowed with the necessary mental abilities such as pitch categorization, relative pitch, the ability to grouping sound events in linear order. All these skills are observed in non-human listeners too (Trehub & Hannon, 2006), which leads to conclusion that our ancestors definitely used them in cultural contexts.

At this stage however hominines, unlike contemporary humans, had to learn the rules of tonal order by strenuous repetitions similar to the contemporary learning of writing. The emotional component of tonality started to play an important role in this process when tonality became tool of group consolidation. The social context of integrated group during communal singing elicited feeling of relaxation always when singers met together on tonic.

At some point in time, the differences in the speed of learning occurred among people. The accidental mutation predisposed one individual to learn faster than others. It was possible thanks to the instinctive coupling between emotional assessment, implicit knowledge of tonal hierarchy and working memory. Of course, in this scenario the fastest learners were adapted the most successfully, thus they started to dominate among the whole population. What was formerly achieved by means of many repetitions suddenly became an instinctive response to music stimuli.

5. Conclusion

The emotional specificity of music perception is hardly explainable solely by means of social learning. Also the understanding of musical skills and emotional assessment of music as a result of general-purpose mechanisms does not answer to the question why music is so ubiquitous tool applied to eliciting emotions. The proposition of the adaptive character of tonal recognition suggests that the specific emotional reactions to tonal pitch order are music-specific objects of musical communication. Of course, music is complex phenomenon which communicates emotions by means of many mechanisms. Tonality is only one of them. It is probable that also other abilities used in music perception have adaptive character. Another music-specific ability is the synchronisation to musical pulse. Although music is usually composed of both tonality and pulse, these features seem to be separate tools which could act alone.

What is the most important characteristic of tonality recognition is the emotional assessment of the segmental organisation of music. This seems to distinguish music from other forms of human sound communications.

Of course, the presented evolutionary scenario has speculative character. It is only one possible explanation of the potential process which could lead to the emancipation of tonality. Nevertheless, the ubiquity of such peculiar phenomenon as tonality implies that it has to be based on some inborn predisposition.

References

Ambrazevičius, R., & Wiśniewska, I. (2009). Tonal hierarchies in Sutartinės. *Journal of interdisciplinary music studies*, (3/1-2), 45–55.

Bannan, N. (2012). Harmony and its role in human evolution. In N. Bannan (Ed.), *Music, language, and human evolution* (pp. 288–339). Oxford: Oxford University Press.

Brandt, A., Gebrian, M., & Slevc, L. R. (2012). Music and Early Language Acquisition. *Frontiers in Psychology*, *3*. doi:10.3389/fpsyg.2012.00327

Castellano, M. A., Bharucha, J. J., & Krumhansl, C. L. (1984). Tonal hierarchies in the music of north India. *Journal of experimental psychology*, *113*(3), 394–412.

Compton, R. J. (2003). The Interface Between Emotion and Attention: A Review of Evidence from Psychology and Neuroscience. *Behavioral and Cognitive Neuroscience Reviews*, *2*(2), 115–129. doi:10.1177/1534582303002002003

Corrigall, K. A., & Trainor, L. J. (2009). Effects of Musical Training on Key and Harmony Perception. *Annals of the New York Academy of Sciences*, *1169*(1), 164–168. doi:10.1111/j.1749-6632.2009.04769.x

Cross, I. (2011). Music as a social and cognitive process. In P. Rebuschat, M. Rohmeier, J. A. Hawkins, & I. Cross (Eds.), *Language and Music as Cognitive Systems* (pp. 315–328). Oxford University Press.

Daynes, H. (2011). Listeners' perceptual and emotional responses to tonal and atonal music. *Psychology of Music*, *39*(4), 468–502. doi:10.1177/0305735610378182

Dor, D. (2000). From the autonomy of syntax to the autonomy of linguistic semantics. Notes on the correspondence between the transparency problem and the relationship problem. Pragmatics & Cognition, 8(2), 325–356.

Dor, D., & Jablonka, E. (2001). From cultural selection to genetic selection: a framework for the evolution of language. *Selection*, (1-3), 33–57.

Dutton, D. (2009). *The art instinct: Beauty, pleasure, & human evolution* (1st ed.). New York: Bloomsbury Press.

Eerola, T., Louhivuori, J., & Lebaka, E. (2009). Expectancy in North Sami yoiks revisited: the role of data-driven and schema-driven knowledge in the formation of melodic expectations. *Musicae Scientiae*, *13*, 39–70.

Eerola, T. (2004). Data-driven influences on melodic expectancy: Continuations in North Sami Yoiks rated by South African traditional healers. In S. D. Lipscomb, R. Ashley, R. O. Gjerdingen, & P. Webster (Eds.), *Proceedings of the 8th International Conference on Music Perception & Cognition* (pp. 83–87). Evanston, IL: Society for Music Perception & Cognition.

Ekman, P. (2007). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life* (2nd ed.). New York: Henry Holt.

Gazzaniga, M. S. (2008). *Human: The science behind what makes us unique* (1st ed.). New York: Ecco.

Huron, D. B. (2007). *Sweet anticipation: Music and the psychology of expectation* (1st ed.). Cambridge, Mass. ;, London: MIT.

Jablonka, E., & Lamb, M. J. (2005). *Evolution in four dimensions: Genetic, epigenetic, behavioral, and symbolic variation in the history of life*. Cambridge, Mass: MIT Press.

Juslin, P. N. (2001). Communicating emotion in music performance: a review and a theoretical framework. In P. N. Juslin & J. A. Sloboda (Eds.), *Series in affective science. Music and emotion. Theory and research* (pp. 309–337). Oxford, New York: Oxford University Press.

Kensinger, E. A., & Corkin, S. (2003). Effect of negative emotional content on working memory and long-term memory. *Emotion (Washington, D*, *3*(4), 378–393. doi:10.1037/1528-3542.3.4.378

Kessler, E. J., Hansen, C., & Shepard, R. N. (1984). Tonal schemata in the perception of music in Bali and the West. *Music Perception: An Interdisciplinary Journal*, (2), 131–165.

Krumhansl, C. L. (1990). *Cognitive foundations of musical pitch*. New York: Oxford University Press.

Krumhansl, C. L. (2002). Music: A Link between Cognition and Emotion. *Current Directions in Psychological Science*, (11/2), 45–50.

Krumhansl, C. L., & Cuddy, L. L. (2010). A Theory of Tonal Hierarchies in Music. In M. Riess Jones, R. R. Fay, & A. N. Popper (Eds.), *Music Perception* (pp. 51–87). New York, NY: Springer Science+Business Media, LLC.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. Cambridge, Mass: MIT Press.

Merker, B. (2003). Is There a Biology of Music, and Why Does it Matter? In R. Kopiez (Ed.), *Proceedings of the 5th triennial conference of the European Society for the Cognitive Sciences of Music (ESCOM). Hanover University of Music and Drama, September 8 - 13, 2003* (pp. 402–405). Hanover: Inst. for Research in Music Education.

Meyer, L. B. (1956). *Emotion and meaning in music*. [Chicago]: University of Chicago Press.

Panksepp, J., & Biven, L. (2012). *The Archaeology of Mind: Neural Origins of Human Emotion*. New York, NY: W W Norton & Co Inc.

Patel, A. D. (2008). *Music, language, and the brain*. Oxford ;, New York: Oxford University Press.

Provine, R. R. (2001). *Laughter: A scientific investigation*. New York, N.Y: Penguin Books.

Reber, A. S., Allen, R., & Reber, P. J. (1999). Implicit versus Explicit Learning. In R. J. Sternberg (Ed.), *The nature of cognition* (pp. 475–513). Cambridge, Mass: MIT Press.

Schellenberg, E. G., & Trehub, S. E. (1999). Culture-general and culture-specific factors in the discrimination of melodies. *Journal of experimental child psychology*, *74*(2), 107–127. doi:10.1006/jecp.1999.2511

Scherer, K. R., & Zenter, M. R. (2001). Emotional effects of music: production rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Series in affective science. Music and emotion. Theory and research* (pp. 361–392). Oxford, New York: Oxford University Press.

Schulze, K., Dowling, W. J., & Tillmann, B. (2012). Working Memory for Tonal and Atonal Sequences during a Forward and a Backward Recognition Task. *Music Perception: An Interdisciplinary Journal*, *29*(3), 255–267. doi:10.1525/mp.2012.29.3.255

Scruton, R. (1999). *The aesthetics of music*. Oxford [u.a.]: Oxford Univ. Press.

Snyder, B. (2000). *Music and memory: An introduction*. Cambridge, Mass: MIT Press.

Thomson, W. (1999). *Tonality in music: A general theory*. San Marino, CA: Everett Books.

Tillmann, B., Bharucha, J. J., & Bigand, E. (2000). Implicit learning of tonality: a self-organizing approach. *Psychological review*, *107*(4), 885–913.

Trehub, S. E., & Hannon, E. E. (2006). Infant music perception: Domain-general or domain-specific mechanisms? *Cognition*, *100*(1), 73–99. doi:10.1016/j.cognition.2005.11.006

Weber, B. H., & Depew, D. J. (Eds.). (2007). *Life and mind. Philosophical issues in biology and psychology*. *Evolution and learning: The Baldwin effect reconsidered*. Cambridge, Mass, London: MIT.