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Quantitative Method as a Tool in Musicological Interdisciplinary Research of Musical Rhetoric

ABSTRACT: The choice of research method significantly affects the course of research itself. It is becoming increasingly common to see cases of methods from various fields combined to achieve the required results. This is exemplified by the use of a quantitative method in traditional score analysis to verify premises in the field of music psychology. The article addresses the previous views of traditional musicology on the use of natural methods in the field and presents instances of the usefulness of the quantitative method in music research. In the second part, by referring to musical-rhetorical figures, it is shown how this method can deepen the knowledge of both musical-rhetorical figures and have a valuable contribution to the psychology of music.

KEYWORDS: methodology, quantitative method, music psychology, human sound expression, musical-rhetorical figures

Introduction

Research methodology is defined as any scientifically correct way of acquiring the data needed to either confirm or refute a hypothesis (Huron, 1999, p. 2). Consequently, it is a certain set of guidelines, rules and precepts; however it can also simply be a series of guidelines, suggestions or consist of heuristics used to normalise scientific activities and solve the research problem (Huron, 1999, pp. 1–3). The choice of method is one of the mandatory steps in planning one's own research. As it is well known, there are various divisions of research methods in terms of their degree of generality, the purpose they are intended to serve, and by the discipline in which they are used (Sztumski, 2005, pp. 72–76).

It is customary to distinguish the methods used by the humanities from those of science (Sztumski, 2005, p. 75). The first one embraces such research methods as, for example, historiographical, semiotic, deconstructive, hermeneutic and

many other, while in the natural sciences the main approaches include, among others, statistical and quantitative methods, modelling and simulation, analysis by synthesis as well as experimental approaches (Huron, 1999, p. 2). These different modes of inquiry are reflected through philosophical disputes about the nature of scientific research; however it is crucial to realize that disciplines are not defined by the method used, but by the object of study (Huron, 1999, pp. 1–3). It is becoming increasingly common that the same research methods are being used in the natural sciences and humanities, though not to the same extent (Sztumski, 2005, p. 75).

Different research methods are combined and adapted to best explain the research problems. This is because part of the responsibility in scientific work is to refine the methods that are suitable for verifying the theses set within the given scientific disciplines and to search for new solutions to the research goals that have been set (Domanska, 2010, p. 54). These trends, in turn, lead to the emergence of new sub-disciplines. Such phenomenon could be observed in the field of music research. Music philology, biomusicology and cognitive musicology, among others, can be treated as examples of such emerging subdisciplines created by combining different scientific methods.

However, the differences between the educational background and approach to research of a scientist from the field of natural science and a scholar from the humanities can cause considerable discomfort when combining various methods (Huron, 1999, p. 3). The issue could be observed in applying new methods to musicology, and therefore it is important to keep learning about new research procedures and try to use them in practice. The aim of this article is to provide examples of the use of the quantitative method in music research based on existing patterns of research procedure. It also describes the possibilities of applying the quantitative method to the analysis of musical-rhetorical figures in 17th- and 18th-century works based on the assumptions of music psychology.

Quantitative method as a bridge between historical and psychological knowledge

To many humanists, quantifying human experience – especially the one related to human attachment, aesthetic experience, and spiritual life – is automatically associated with the natural sciences, and certainly not art (Huron, 1999, p. 20). Notably, Maciej Jablonski expressed his objections to using a “positivist”¹ approach to musicology (Jablonski, 2002, 2014). In his works he sought to show that the use of methods taken from the natural sciences, especially in the field

¹M. Jablonski refers many times in his article to “positivism”, “scientism” and “scientism” in music research and each time having in mind the use of methods inspired by natural sciences in musicology. He does not mention exactly which methods he specifically refers to, but it can be inferred that the criticism of positivism in methodology presented in Jablonski’s text also applies to the use of various quantitative methods, as they are often used in the natural sciences.

of musical analysis, musicologists mistakenly regard as superior for presenting the results of their studies.

[...] the concept of “analysis” within the dualism of “that which is scientific” – “that which is not scientific” was located without hesitation on the side – “scientific”, and thus “rational” verifiable”, “objective”, “object” (belonging to the object, produced by this object) or “observable”. That’s why I think that musicology, clinging to the idea of grounded and accurate ‘representation,’ as evidenced by many quite recent statements, is stuck in the vice of the positivist cognitive pattern, cultivating it with a conviction worthy of a better cause.² (Jablonski, 2002, p. 76)

Jablonski was not enthusiastic about the use of naturalistic methods for the analysis of music, partly because they do not consider the specific nature of the object of study, which, as he believed, is much more complex. According to him, it would be more appropriate for the methodology of musicology to interpret the art of music using language, which means words, not numbers.

Art evades a scientific approach, because what is most valuable in art is a matter of the future (to which science has no access), and critical glorification about art is always incomplete and inadequate due to the complexity of cognition and the nature of art itself. [...] However, this does not change the fact that there is no turning back from language.³ (Jablonski, 2002, p. 99)

And further:

[...] interpretation [of music, MK] - if we assume that this is only what it is in essence – is that cognitive process which is inevitably to be identified with linguistic cognition and whose results, of course, are expressed in language.⁴ (Jablonski, 2002, p. 100)

According to Jablonski, music, as art, does not subject itself to scientific methods, that is, methods that study it in a way that assumes, for example, a numerical representation of the results. Because of the complexity of music, he believes, only linguistic description can reflect its complex nature on some level. Despite the fact that the author does not directly refer to analysis by quantitative methods, his views seem to present a negative approach to any non-humanistic methods of researching music.

² „[...] pojęcie „analizy” w ramach dualizmu „to, co naukowe” – „to, co nienaukowe” lokowano bez szczególnych wahań po stronie – „naukowe”, a tym samym „racjonalne” weryfikowalne”, „obiektywne”, „przedmiotowe” (należące do przedmiotu, wytwarzane przez ten przedmiot) bądź „obserwowalne”. Dlatego sądzę, że muzykologia, trzymając się kurezowo idei ugruntowanej i trafnej „reprezentacji”, o czym świadczy wiele całkiem niedawno sformułowanych wypowiedzi, utkwiała w imadle pozytywistycznego wzorca poznawczego, kultywując go z przekonaniem godnym lepszej sprawy.” [Translation: author of the article]

³ „Sztuka uchyla się naukowemu ujęciu, gdyż to, co w sztuce najwartościowsze, jest sprawą przyszłości (do niej nauka nie ma dostępu), zaś wysławianie krytyczne o sztuce jest zawsze niepełne i nieadekwatne ze względu na złożoność poznania i naturę samej sztuki. [...] Nie zmienia to jednak faktu, że od języka nie ma odwrotu.” [Translation: author of the article]

⁴ „[...] interpretacja [muzyki, MK] – jeżeli przyjmujemy, że tak tylko jest w istocie – jest tym procesem poznawczym, który nieuchronnie utożsamić należy z poznaniem językowym i którego rezultaty – co oczywiste – w języku zostają wyrażone.” [Translation: author of the article]

A quite contrastive approach to this topic was presented by music psychologist David Huron. He argued that scientific research methodologies should be distinguished from philosophical beliefs about the nature of the world (Huron, 1999, p. 20). In his work, he also presented reasons why the use of quantitative methods in music research is often necessary. One of the examples he gave involved research into the concept of “melodic arch – a presumed general tendency for melodic phrases to ascend and then descend” (Huron, 1999, p. 21). In order to verify this hypothesis, he analyzed 36,000 melodic phrases taken from folk melodies, and through the quantification method, determined the average pitch of the initial, final and middle notes. Then, comparing the results with each other, he concluded that in a significant number of cases the initial and final sounds turned out to be lower than the middle sounds, thus giving credence to the musical arc hypothesis (in terms of European music). Naturally, this is one of many examples of the application of the quantitative method in musicological research. Still, merely from this one, it can be observed that the use of traditional analyses of the note material would not have made it possible to trace pitch trends on so many examples and, consequently, to generalize the conclusions drawn.

As Huron argues: “quantitative methods are important for the same reason that musical notation can be important: like musical notation, quantitative methods allow us to observe patterns of organization that might otherwise be difficult or impossible to decipher” (Huron, 1999, p. 22). Obviously, this thesis does not undermine the fact that musical notation, despite its function of capturing musical patterns that are difficult to convey in the oral tradition, is also a useful tool for scientific research. By converting information from auditory to visual, it overcomes the limitations associated with the processual nature of stimuli transmitted in the auditory modality. In other words, musical notation allows one to simultaneously perceive the music and pay attention to certain phenomena that, without notation, require more time or are impossible to recognize. To illustrate this with an example: using notation, the interval of the fifth of the first bar can be compared with the fifth of the last bar and with all the fifths occurring throughout the composition. This is impossible when listening to the piece alone, without the visualization through the music notation.

Still, despite the undoubted advantages that notation provides in music analysis, some of the information is still not readily available to the observer. Either through listening to music or analysis of its notation it is possible to experience certain structural properties that are easily accessible to consciousness. Those include among others melody or rhythm, as well as the ones not initially accessible to our consciousness such as average pitch, average interval, or trends of change in the pitch range. Studies on the perception of musical stimuli and those created from them show that in a listening, these issues are most likely analyzed subconsciously in the brain (Bowling et al., 2012; Huron, 2006, 2008; Juslin & Västfjäll, 2008; Sloboda & Juslin, 2001). In the case of research on sound material or scores, quantitative methods can be instrumental in gaining insight into the mentioned parameters. In such a situation, they become a tool for capturing not only phenomena available to human consciousness and subject to deductive reasoning from the musical notation, but also those that, despite their availability

to cognitive processes, are not revealed in the mental experience of the music viewer and researcher. Quantifying the musical phenomena of interest enables recognition of the numerical relationships between them and thus comparison of them with the available knowledge of musical experience in humans. As with Huron's research, the quantitative method can be used on extensive research material. After calculating the statistical error and disproving the null hypothesis, the result makes it possible to generalize the observed phenomenon.

Therefore, music research can combine two components. On the one hand, there is the conscious component that is at the centre of the musicologist-historian's thought, and on the other hand, there is the unconscious component, which is of interest to psychology and other natural disciplines. Due to its ability to break under the conscious structure, the quantitative method becomes, in a sense, a bridge between the historical aspects of musicological research and the natural and psychological perspective. Importantly, such a method of research does not exclude the traditional analysis of musical scores, but only deepens it. The quantification of musical phenomena does not rob them of their originality but gives them a new dimension.

Naturally, in order to properly apply any method, one must also have an adequate knowledge of the subject of the research. Thus, if depending on the research goal set, the musicologist's considerations take into account specific theories, simply applying the quantitative method without taking into account the facts about them will not allow a complete understanding of the results. Only correlation of historical phenomena observed through the quantitative method with theories from other sciences, such as music psychology, allows one to broaden the research perspective to include the unconscious component. Noteworthy is that the added value of using quantitative methods is the creation of a field for interdisciplinarity. The results presented clearly in a numerical form facilitate comprehension of musical correlations to those outside the discipline of musicology.

Another definite advantage of using quantitative methods to study aspects of historical music is that the data thus obtained sheds a new light on historical facts and subsequently can contribute to their new interpretations. The usefulness of the quantitative method in the analysis of music of previous centuries is well exemplified in the research of Cameron J. Anderson and Michael Schutz on the historical changes in musical communication and transformations of the relationship between mode and emotionality in well-known prelude cycles (Anderson & Schutz, 2022). The scholars considered how compositional choices made by 17th- and 19th-century composers (in J.S. Bach's and F. Chopin's cycle of *24 Preludes*, respectively) affect the emotional communication of these compositions. Their work initially focused mainly on analyzing the various structural elements of these works' scores through the use of quantitative methods. The goal was to extract "musical cues" that is, musical structural features that can affect the emotional dimension of the composition under study. The next step was to compare the conclusions of the analyses with people's actual impressions derived from individual experience. An experiment was conducted in which the subjects were tasked with listening to designated, pre-translated excerpts from

Bach and Chopin *Preludes*, and then describing their emotional impressions. A comparison of the results of the score analyses with the results of the experiment showed how the different compositional means used by Bach and Chopin changed the emotional reception of the compositions in the same modes. The results also suggest that the “importance” of the mode in the compositions changed in over various historical eras. For example, the mode is responsible for the greatest differences in valence ratings of Chopin’s preludes, while in Bach’s preludes, the mode plays a greater role in the rating combined with the attack tempo (Anderson & Schutz, 2022, pp. 12–14).

As can be observed, research utilizing the appropriate application of quantitative methods in score analysis can yield interesting results and cast a new light even on such undoubtedly well-known and thoroughly studied compositions as the *24 Preludes* of Bach and Chopin. However, the question how else to use such a method of research in the aspect of considering the expression of emotions in music is yet to be considered.

The relevance of using the quantitative method in the study of universal emotional expression in music

The example given above also opens up a very broad topic of musical expression and how the quantitative method can help explore this aspect, as it is assumed that some of the basic emotions are expressed by people in similar ways. Consequently, research methods originating from the psychology of emotions can be instrumental in the exploration of the issue of emotions in music. As in the famous “Ekman faces” experiment, which found that in all communities around the world, the same basic emotions are expressed on people’s faces in the same way (Ekman et al., 1983), similarly, the same emotions can be expressed equally through sound expression. Taking this fact into account, it has been hypothesised that certain features of the musical stimulus are responsible for associations with specific expressions of emotion.

Research into the expression of emotions in music began with trials with the human voice as the most natural musical instrument for humans and also a tool for verbal communication. This was undertaken by Klaus Scherer by conducting an experiment in which he compared the use of the expression of emotions (anger, sadness, joy, fear, among others) by an actor (in speech) and by a singer (in singing) (Scherer, 1995b). The subjects were presented with speech samples expressing the emotions in question, followed by samples expressing neutrality, modified in terms of average pitch, accentuation, rate of speech, contour, and loudness. It was then noted which features of the audio stimulus had the greatest statistical impact on listeners’ interpretations of the emotional message. In the case of singing samples, several opera arias musically depicting the underlying emotion were selected and analyzed for the same features that were found to be statistically significant in the interpretation of emotions expressed through speech. The first interesting finding was that in both cases, speech and singing, the text was of marginal importance in evaluation of the emotional message.

Of greater importance, however, were the acoustic features of the examples presented. It turned out that both the results of the experiment with samples of the presentation of emotions in speech and singing showed similar trends in the expression of particular emotions, e.g. faster tempo in the expression of happiness, lower energy and time of attack in sadness, higher volume in the expression of anger. Scherer concluded that this similarity may indicate a common mechanism for evaluating basic emotions and musical emotions in the brain. He concluded that evolutionarily old, but extremely powerful, low-level emotion detection systems are responsible for this system, so it occurs outside of our consciousness, instinctively (Scherer & Zentner, 2001, p. 367). The research described above also led to another reflection about musical emotional expression; since the characteristics of the acoustic stimuli used to express emotions in speech and singing are similar, could this be a premise that the characteristics of human sound expression may be universal?

Musical expression and its behavioural context in different cultures, on the other hand, were studied by Samuel Mehr with his research group (Mehr et al., 2018, 2019). The main goal of his project was to test whether a person, regardless of the culture in which he or she was raised, is able to recognise the behavioural context of music from another culture. To verify this, traditional vocal forms from around the world were analysed. The pieces were examined in terms of eighteen musical characteristics established by the researchers, including: metrical characteristics (rhythmic and metrical variation, occurrence of small/large rhythmic values, triple metre/double metre), tempo, melodic characteristics (pitch range, average interval, melodic contour, average pitch) and musical tension (Mehr et al., 2019, pp. 9–11). The results showed that music in each society is statistically most often associated with four main behavioural contexts: infant care, healing, dancing and love. Their analyses also prove the existence of universal elements in music. Regardless of musical culture, there is a connection between the characteristics of music and the contexts indicated above. Furthermore, it most probably affects the perception of the emotional dimension.

The tendencies of the musical stimulus in emotional expression have also been studied in instrumental music. The above-mentioned David Huron analyzed nearly 10,000 composition themes to determine whether their tonality could translate into what emotions they represent (Huron, 2008). It turned out that the average pitch for compositions in minor keys is lower in a statistically significant number of cases than for compositions in major keys. According to Huron, this relationship may have to do with the expression of positive emotions by major keys and negative emotions by minor keys. He explained this by similarity with the prosody of spoken language – when expressing sadness, speech shows a lower average pitch than when expressing happiness.

In the examples indicated above, the application of the quantitative method consisted of quantifying the data obtained from the experiments in order to analyse the results based on them. On their basis it was possible to determine which features of the musical stimulus are important in the expression of musical emotions. These were: melodic features (melody contour, average pitch, average interval, pitch range), tempo and rhythm features (accents, metrical and rhythmic

changes), the issue of tension in the piece, and loudness. According to the study, certain emotions can be reproduced sonically (in speech, singing, instrumental music) by specific properties of these parameters, which is an important argument for the existence of universality in people's sound expression.

Since the sound expression of emotions is assumed to be universal, its characteristic elements should also be present in early music. However, as is known in the case of this music, there are no original recordings from the era that could be subjected to spectral analysis to verify whether the same characteristics of the musical stimulus were used to express emotions at the time. Despite the many modern recordings of early music, it still must be remembered that these performances may not reflect the original expression of the piece in its entirety.

However, to test the hypothesis of universality in this music, the score might be more than helpful. Given that most of the universal features indicated above have their reference in musical notation, there are no obstacles that prevent designing a study on the question of the expression of ancient works on the basis of score notation. Musical-rhetorical figures may prove to be a field for such inquiries due to their functions of musically emphasising emotionally coloured words in 17th- and 18th-century compositions.

A new look at musical-rhetorical figures

Musical-rhetorical figures are part of a broader issue embedded in the assumption that music contains certain elements that refer to spiritual aspects of humankind. Even in antiquity, it was assumed that music was linked to the world of ethics, and that the choice of appropriate instruments or scales could influence people's moral attitudes. Views on this subject were presented by such thinkers as Pythagoras, Damon and Plato (Fubini, 2002, pp. 29–39). This thought was continued by Boethius (480–524), who believed that melody can have a positive or negative effect on human beings, depending on the modalities used (Fubini, 2002, p. 79). The subject of the ancients' reflections was also affect, i.e. the emotional state associated with mental reactions to felt emotions. Plato distinguished four basic affects - joy, pain (sadness), fear, hope (desire), and Aristotle deepened the reflection on affects, noting their relation to both the psychological and physiological spheres of mankind (Paczkowski, 1998, pp. 9–26). The ancient *ars oratoria* (rhetoric) among other things, aimed to evoke specific affects in the audience, through which a certain emotional experience affecting moral change could take place.

In the 17th century, the psychological sphere was the subject of lively reflection by European thinkers. Descartes, in his *Passions of the Soul* (1649), presented a rationalist account of the science of affects, which he considered both phenomena arising from human physiology and experiences that stimulate the soul to certain activities (man consisted of a spiritual and a bodily component). He distinguished six basic feelings: joy, sorrow, love, hatred, admiration, desire. The role of the ancient rhetor, who evoked a specific affect in the audience through persuasion, was taken over by art - including music. Therefore, also Descartes in his reflections

took into account this type of artistic activity – he considered whether certain musical solutions applied during the process of composing a work could produce a psychic effect in a person (Paczkowski, 1998, p. 49). The German theorist and composer Athanasius Kircher also treated the physiological effects caused by music in *Musurgia universalis* (1650), noting, among other things, the affective effect of intervals: large ones have a joyful effect, small ones a sad one, as well as of musical figures that represent and express affect in a physiological way (Paczkowski, 1998, pp. 115, 162). Many of the observations about physiological reactions in humans found in his theory are reflected in the insights of empirically oriented modern psychologists.

The musical figures Kircher treated are elements of a musical work that carry rhetorical content. They permeate various spheres of the work, such as melody, harmony, texture or instrumentation. The rhetorical aspect of music composition was particularly adopted in Germany, where the so-called *musica poetica* was developed, i.e. the art of composing a musical work well, adapting to the field of composition the Quintilian principles of classical rhetoric, i.e. *inventio*, *dispositio*, *elocutio*, *memoria*, *actio* (Wilson et al., 2001). Rhetorical figures, which were part of the *musica poetica* described by German theorists, were musical structures intended to evoke an extra-musical association, reinforce a word, affect, or evoke an emotion. To define those, concepts from classical rhetoric were used, which *per analogiam* were recited to describe a musical work. Thus, the *gradatio* (*climax*) occurring in speech “consisting in ranking in a gradational manner, that is, according to the degree of intensification or weakening of some feature, sentences or phrases, behind the preceding word”. (Korolko, 1990, p. 109), in music it manifests itself as, for example, the repetition of a musical thought a second higher, which produces a strengthening (intensifying) effect (Lisecki, 1993, p. 20).

As seventeenth-century thought’s knowledge of figures became more widespread, catalogues of rhetorical and musical-rhetorical figures began to be compiled, providing a definition of a figure, its structure and its use. Authors of such works included Burmeister, Bernhard, Nucius, Thuringus and Mattheson (Bartel, 1997, p. VIII). It is worth noting that their works were not always consistent with each other – occasionally the definition proposed in one lexicon did not coincide with the explanation proposed by another theorist (Bartel, 1997, p. VIII). Today, the most complete and comprehensive compendium on rhetorical-musical figures is the work of Dietrich Bartel (Bartel, 1997), in which the most important German catalogues of musical-rhetorical figures are collected and systematised.

Challenges of quantitative method against the study of musical-rhetorical figures

Since the empirical studies of human vocal expression of emotions cited above indicate that there is a relationship between the expression of the same basic emotions and some acoustic features of these expressions, it is likely that these features are present in musical-rhetorical figures. An artistic product,

which a written composition undoubtedly is, can admittedly bear a number of elements characteristic of the culture of the period, including those derived from the composer's style. However, as is already known, information about the expression of emotions is largely encoded in evolutionarily old areas of the brain (Scherer, 1995b), which makes it possible to perceive certain elements universal to expression in the compositional record. Assuming that composers were subconsciously guided by these cognitive patterns in creating works, this enters the realm of music psychology. Following the example of the cited research on the vocal expression of human emotions, it may be necessary to use a quantitative method when studying these aspects.

The first step in such a research problem is to establish criteria for the selection of repertoire, that is, to prepare the research material. Because of the wide range of available works, it may be helpful to decide whether the study will be limited to instrumental or vocal-instrumental music. This stage depends on the goal set and requires historical knowledge of the types of musical-rhetorical figures, the compositions in which they were used, the composer's style and the convention of the time, in a word, everything described above about musical-rhetorical figures. As is already known, the golden period of their development and use was in the 17th and 18th centuries, so the works must come from this period. Both instrumental and vocal-instrumental music abounded in musical-rhetorical figures, but given the main role of figures, which was to emphasise the meaning of the text, it seems that the first choice that comes to mind would be vocal-instrumental pieces. As also described above, the tenets of *musica poetica* grew out of the tradition of the German school and had a very strong influence on the sacred compositions of North German composers (Board, 2006, p. 12), so this repertoire can be dealt with at the outset. Instrumental music can be analysed in further studies.

Furthermore, to obtain consistent data, it is beneficial to decide what manifestations of the underlying emotions to look for in the selected examples. Thus, in this case, focus on the characteristics of musical stimuli described in other articles (including those mentioned above), is advisable. It is closely related to the fact that the previous findings of researchers on the characteristics of musical stimuli specific to the expression of the emotions in question can be of great support in the interpretation of the results obtained. In the case of studies of vocal and instrumental music, it is also necessary to take into account the text of the work, since, in the case of rhetorical figures, it constitutes an important reference for the use of such musical structures. Ideally, the words should refer to the underlying emotion, for example by directly stating the emotions in question, as it will be easier to distinguish their highlights in the musical structure based on them (Sun & Cuthbert, 2017). Basically, the more emotional the text is, the more likely it is that musical-rhetorical figures have been used in its musical elaboration.

At this stage, one can move on to one of the key issues of the research, which is an analysis of the selected scores in order to extract from them the structures of the musical-rhetorical figures themselves, e.g. *anabasis*, *saltus duriusculus*, *pathopoia*, *epizeuxis*, etc. It is such musical excerpts, in which the occurrence of a given figure is noted, that would have to be analysed using the quantitative

method to identify the features of universal musical expression. The before mentioned catalogues of rhetorical figures provide the necessary knowledge of how in musical-rhetorical figures they present themselves to the musical structure, so the researcher's task will be to recognise them in the musical notation. Subsequently, this part should be quantified to acquire the necessary data on musical structure required for formulating conclusions.

The parameters to be quantified are listed above, those being the musical features that have been recognised as carriers of emotion in speech and at the same time as features of universal sound emotional expression. Naturally, when examining a musical notation from the 17th and 18th centuries, loudness will not be subject to analysis, as not all scores from that period have dynamic markings. This leaves aspects of melodics, i.e. the average pitch of a selected section with a musical-rhetorical figure; outlining the contour of the melody in the section; determining the average interval, the most common interval and ambitus; and issues of tempo and rhythm, i.e. calculating the tempo of the section. Each of these activities will be discussed in more detail later in the article. The calculations, the necessary visualisations and statistical summaries of the results can be done at least in Excel or in another tool that can be programmed according to one's analytical needs, such as Humdrum or Music21 (Ariza & Cuthbert, 2010; Cuthbert et al., 2011; Cuthbert & Ariza, 2010).

1. Analysis of melodic aspects

Following the example of Huron's research (Huron, 2008), the first step when studying the presence of universal expressive qualities in a musical structure is to calculate the average pitch on a selected passage with a musical-rhetorical figure. This parameter will be used to determine whether a section ranks higher or lower than the previous one, which affects the emotional expression of its structure. To obtain the arithmetic average, quantify sequentially each pitch occurring in the selected passage. For instance, all the pitches from the scale of the entire composition can be listed sequentially and assigned with arbitrary numerical values (e.g., from C1 as 1 to c³ as 49), so that in each case a fixed number will be assigned to a given sound and you will get comparable results. After the arithmetic mean value has been calculated (extreme values can be ignored), it is necessary to verify which sound is "pinned" to the obtained result, since this obtained numerical value refers to the average pitch of the sound on the analysed section.

Based on the excerpted sounds, it is also possible to determine the ambitus in the section under study. The size of the ambitus is also taken into account as a feature of universal sound expression (Mehr et al., 2019, p. 9). A small ambitus is associated with emotions of sadness/despair or love/worship, and a large one with expressions of joy or anger (Scherer, 1995a).

The next step is to generate the contour of the melody from the recorded sounds, since, as is known from the studies cited above, the shape of the contour also influences the sensation with which affect the musical utterance is associated

(Scherer, 1995a, pp. 93–94). To create the contour, a chart must be made, utilizing the arbitrary numerical values given to the sounds beforehand.

Another parameter relevant to emotional expression that is present in different cultures is the average interval of a given passage and the most frequent interval. (Bowling et al., 2012; Mehr et al., 2019). These two parameters can be determined by a method analogous to calculating an average pitch - by assigning arbitrary values to intervals. The results obtained will serve to verify whether a given musical structure consists of small or large intervals, which has a bearing on the expression of the musical-rhetorical figure. The conclusion might be that in all passages the main interval is a minor or major second, but by discarding these values, a tendency for certain intervals occurring more or less frequently is obtained.

2. Analysis of rhythmic and tempo aspects

The question of tempo may prove to be the most complicated issue to quantify, but it is essential when studying the characteristics of universal human sound expression. As is well known, a fast tempo is considered characteristic of the expression of anger and happiness, while a slow one distinguishes sad and loving emotions (Schellenberg et al., 2008; Scherer, 1995a; Scherer & Zentner, 2001). However, bar notation, unlike recordings, is relative in terms of tempo and there is no single tempo that can be taken as a reference. In determining the absolute tempo of a section, for example, Mieczyslaw Kolinski's method can be adapted, that was used in his ethnomusicological study of phonograph recordings (Kolinski, 1959). Kolinski studied their tempo by determining the ratio of the number of musical events per unit of time, which, with appropriate modifications, can work well for score analysis. A similar method was used in a study by Anderson and Schutz (Anderson & Schutz, 2022, p. 5).

As a unit of time, one can take the basic rhythmic value determined by the metre. Thus, in a 4/4 metre it would be a quarter note, and in a 3/8 metre, an eighth note. Musical events are understood as all sound events regardless of their rhythmic value. If there are eight eighth notes in a 4/4 bar, then the ratio of an event to a unit of time will be 2 (8/4), and if there is an entire note in such a bar, the ratio will be 0.25 (1/4). Thus, a ratio equal to or greater than 2 indicates a fast tempo, and less than or equal to 1 a slow or moderate tempo.

Consequently, based on a comparison of the ratio of the tempo in the episode with the musical-rhetorical figure and the tempo in the immediately preceding passage without the figure, it can be determined whether the tempo is faster or slower. This is because human perception works relatively. If prior to the part with the figure the rhythmic tempo is based on constant, equal values, and suddenly the values decrease and there is more density, the brain will perceive this as a faster tempo, even though the pulse remains the same. However, the results obtained by this method are only reliable for comparisons of figures within the same section maintained in the same metre, so this method has its limitations.

Conclusions

The method of studying musical-rhetorical figures presented above can shed new light on the hypothesis of the universality of musical features in emotional expression by verifying it in early music. In addition, such analyses can also help enrich the knowledge of differences in the use of musical-rhetorical figures by composers to express emotions. This will enable a comparison of the works with each other and can contribute to the development of existing knowledge of compositional styles.

As can be seen, the use of the quantitative method is applicable to traditional music analysis, adding a new dimension to it. Obviously, the examples give only a partial insight into the possibilities provided using such a method of research. The quantitative method as a tool for music analysis continues to be improved through the development of computer programs based on popular programming languages such as Python. Such software includes the Humdrum or Music21 (Ariza & Cuthbert, 2010; Cuthbert et al., 2011; Cuthbert & Ariza, 2010; Sun & Cuthbert, 2017). These tools are geared to automatically quantify the phenomena under study in a score, and their goal is to give the user the ability to analyse as large a corpus of music as possible and gather as much data as possible.

These new opportunities for conducting music research might be crucial to the development of musicology as a scientific discipline in future years. By adapting methods from other disciplines, not merely the humanities, to musicology, even the best-studied issues can gain new interpretations and be enriched with new facts. This approach also opens musicology to cooperation with other disciplines. Thus, despite the fear of losing their identity, various types of science should not avoid creating bridges between them. While music will still be the centre of interest for the musicologist, musicology will remain musicology no matter what scientific methods it uses.

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