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The Influence of Musical Style in Perceived Emotion

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Abstract. In this work we address the problem of understanding how musical style influences perceived emotion as well as their pedagogical consequences. The first problem arises when considering the very definition of style. The definition of musical style and how to apply it is thoroughly discussed. Several experiments were carried out in order to gain understanding about the emotional response to musical style. Six styles (Baroque, Classicism, Romanticism, pandiatonicism, twelve-tone serialism, and Phrygian mode) were selected and pieces were composed in those styles to be later played to both musicians and novices. Their perceived emotional response was measured and the results were analyzed thereafter. Differences were found across styles, mode and musical background, including complex patterns in valence and arousal. Last but not least, the knowledge acquired from this research can be incorporated a corpus for application and future study and use in music conservatories and centers for higher education and research.
Keywords: musical style; emotions; cognition, musical composition.

[es] La influencia del estilo musical en la emoción percibida

Resumen. En este trabajo se aborda la cuestión de cómo el estilo musical influye en la emoción percibida y sus consecuencias pedagógicas. El primer problema lo encontramos en la propia definición de estilo. En este trabajo proponemos una definición del estilo y una aplicación del mismo. *A posteriori*, llevamos a cabo experimentos a sujetos para entender las respuestas emocionales al propio estilo. Escogimos seis estilos o "técnicas" (Barroco, Clasicismo, Romanticismo, pandiatonismo, dodecafonismo serial y modo frigio). Se mide la respuesta emocional y se analizan los resultados (los cuales se miden en músicos y no músicos). Encontramos diferencias en los estilos, tanto en el modo (mayor-menor) como en la experiencia (músicos-no músicos), incluyendo patrones complejos en la valencia y activación. Por último, proponemos que todo el conocimiento derivado de este trabajo sea incorporado a los temarios de los conservatorios y facultades de música.
Palabras clave: estilo musical; emociones; cognición; composición musical

Sumario. 1. Introduction 2. Perceived emotion 3. What is musical style? 4. The chosen styles 5. Measurement of emotional response to musical style. 6. Results and discussion. 7. Pedagogical applications 8. Conclusions. 9. Future work. 10. Appendix 1 11. Appendix 2. 12. Appendix 3. 13. References.

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1. Introduction

Among the many parameters in music, musical style concerning its effects on emotion has been the least studied. This paper aims to contribute to fill this gap and initiate a systematic study of musical style from an emotional standpoint. Musical style is the most abstract element, being the combination of all other musical elements (rhythm, pitch, harmony, etc.). If each element of style on its own already influences the musical emotion, how does style as a whole affect the musical emotion? This is the main research question of this paper. To answer it, we conducted experiments consisting of exposing subjects to musical pieces carefully composed in certain musical styles. Those styles were Ba-

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roque, Classicism, Romanticism, to which we added pandiatonicism, twelve-tone serialism, and the Phrygian mode. We analyzed their responses and arrived at some thought-provoking conclusions.

The structure of this paper is as follows. In the first section, models of musical emotion and the main factors that control emotions are discussed. In the third section the factors that shape musical style, including its conceptual formulation are considered. How the pieces were composed is explained in the fourth section. The fifth section fully describes the experiments. In the sixth section, we set forth the results and their validity and scope are discussed. Pedagogical applications of this research are addressed in Section 7. The paper comes to a close with two sections drawing conclusions and discussing possible future work and extensions of these concepts.

2. Perceived emotion

One important conceptual distinction in the research on emotion is the difference between real emotion and perceived emotion. Real emotion is any conscious experience identified by a certain intense mental activity and a certain degree of pleasure or displeasure (Panksepp, 2005). Perceived emotion is the emotion expressed by a person feeling a given emotion. In this case, culture and in particular language mediates between the real emotion and the emotion being expressed. It is a well-known fact that both may not coincide. In this paper we study the influence of musical style on perceived emotion. To measure real emotion, electrophysiological methods are usually used, such as EEG (electroencephalography); see Salimpoor et al. (2011) and the references therein for more information.

In our research we used Russell's (1980) model to register the response to emotion in the subjects. Based upon the eight-circular series of Ross (1938), he proposes two dimensions to measure the emotional response: arousal and valence. Arousal is the intensity of the emotion and it is related to physiological and psychological phenomena. Valence is defined as intrinsic attractiveness or how positive or negative the experience feels. In Figure 1, the x-coordinate corresponds to valence while the y-coordinate is arousal, where a few emotions are shown. Valence and arousal define four quadrants, Q1 to Q4, which will be referred to later on.

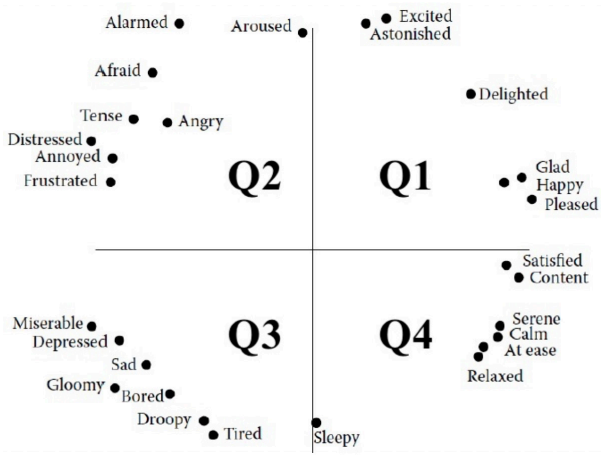

Figure 1: Measuring emotion as a combination of valence and arousal (Russell, 1980)

The main factors that influence the perceived emotion will now be briefly reviewed. When composing the pieces for our experiments, these factors were taken into consideration, as they have a significant effect on the perceived emotion.

Expertise. Morreale, Masu, Angeli, and Fava (2013) distinctly provide evidence that valence differs between musicians and non-musicians (also called novices). They assert that musicians use their expertise to recognize what they feel. Many of their conclusions were confirmed in our own work, as will be shown later. The emotional response elicited from musicians in our experiments differed from the one elicited by novices in most cases, especially before non-tonal styles. This situation led us to analyzing musicians' and novices' emotional response separately.

Tempo. Tempo has a profound effect on the emotional response. Many experiments have confirmed that, as tempo increases, so do arousal and valence. For instance, Chordia and Rae (2008) demonstrate that both arousal and valence are affected by tempo. Taking into account the above, we designed our experiments so that the subjects had to listen to the same piece played at different tempi.

Harmony. Harmony is indeed another important emotional modulator. The extended idea that major mode elicits happiness and minor sadness has been demonstrated on many occasions; see (Parncutt, 1989). As for modality, Ramos, Bueno, and Bigand (2011) carried out a study where the subjects had to rate melodies written in different modes specially composed for the experiment. Their results can be seen in Figure 2. Nodes in each polygonal line represent the average emotional response, which was measured for three tempi (slow, medium, and fast). Notice that arousal

increases as tempo increases. There are more studies related to mode, such as those of Oliveira and Ramos (2007), Tizón, Gómez, and Oramas (2014), or Straehley and Loebach (2014). In our experiments the armony was determined by the particular styles in which we composed the pieces. To account for the effect of mode, some pieces were composed both in major and minor mode.

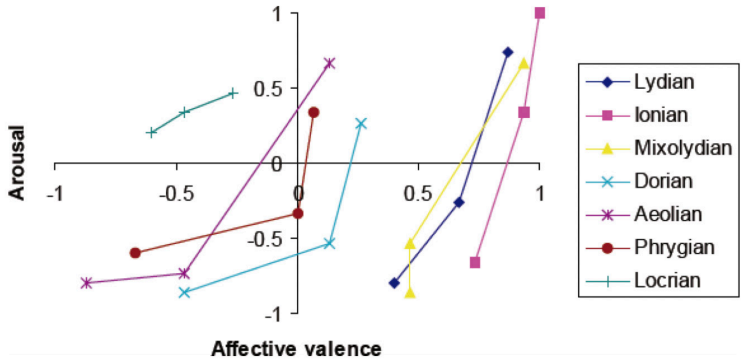

Figure 2: Emotions in modes (novices) (Ramos et al., 2011, p. 169)

Rhythm. For this parameter, there is a clear pattern, which is associated to rhythmic complexity. The more complex a rhythm is, the more associated to high arousal it appears. See, for example, the work of Thompson and Robitaille (2010).

Melody. The melody's nature includes several characteristics, namely melodic contour, pitch range, propinquity, interval distribution, and pitch level (Radocy and Boyle, 2006). Melodic contour is one of the main variables affecting perceived emotion in melody (Scherer and Oshinsky, 1977). Interval distribution (the predominance of some intervals) (Costa, Fine, and Ricci, 2004) or pitch level (Ilie and Thompson, 2006; Watson, 1942; Gundlach, 1935) also affect the emotional response. Section 4 provides details on how the melodies in the pieces were composed.

Timbre. The number of harmonics bear on the emotional response, as proved by Scherer and Oshinsky (1977). The particular instrument's timbre is another factor that shapes the perceived emotion; see Wu, Horner, and Lee (2014) and Eerola, Ferrer, and Alluri (2011). The timbre in our compositions were determined by the styles themselves; refer to Section 4.

3. What is musical style?

Musical style is an extremely difficult concept to capture. No broad and clear consensus exists on a definition of this concept. A few definitions found in the literature that are relevant to musical style and our research are reviewed. Here is an abstract yet intuitive definition of musical style by Dickinson (1965, p. 3).

> Musical style is the individual essence of a work of art which gives it its identity. This identity is the result of a distinctive conjunction of components, coupled with distinctive emphasis among the components.

Dickinson's definition points to two important ideas that recurrently appear in the definitions of musical style: identity and emphasis. However, for this definition to be applicable to our research question, the development of its terms requires further development. Meyer (1997, p. 3), in his book *Style and Music: Theory, History and Ideology*, provides another concise and abstract definition:

> Style is a replication of patterning, whether it be in human behavior or in the artifacts produced by human behavior, that results from a series of choices made with some set of constraints.

In his book, Meyer highly elaborates upon the concept of constraint, the cornerstone of his definition of style. He considers that style is governed by a hierarchy of constraints at several levels. In fact, he attributes the confusion in the discussion of the nature of musical style to the difficulty in correctly identifying this grid of constraints. Music can be thought of as a continuum of phenomena ranging from the most specific entities, such as frequency or pitch, to highly complex entities, such as style or genre. Meyer's definition of style consists of identifying a set of constraints that determine the permissible material and their functions in this continuum. According to Meyer's theory, there are constraints of a culture (style in the anthropological sense), constraints of an epoch (style as art music movement; for instance, the Classicism), and constraints of a work by a given composer (Mozart's style). Meyer thus establishes a hierarchy of constraints, which in decreasing order of abstraction are: laws, rules, and strategies.

Laws can be thought of as cognitive universals and therefore are transcultural. Brown and Jordania (2011) identified and classified several of these universals (discrete pitches, octave equivalence, transposability of music, among others). These laws are present in all musical styles.

Rules, however, are intracultural and "constitute the highest, most encompassing level of stylistic constraints" (Meyer, 1997, p. 17). Indeed, rules allow us to distinguish between musical eras, as well as discovering shared features among them. Meyer suggests that the definition of musical style should be strongly based on a precise account of those rules. Examples of those rules could be harmony rules, dissonance treatment, chord formation, or voice leading rules. Furthermore, rules fall into three categories: syntactic rules, contextual rules, and dependency rules. These rules describe the level of syntactification of the music. Notice that Meyer's definition is based on constraints, which in turn create a syntax upon the musical material. Syntactic rules establish the order and the possible (natural) functional relationships between the musical parameters (e.g., laws of harmony in tonal music). Musical parameters governed by syntactic rules are called primary parameters and they are normally high-level parameters such as antecedent-consequent melody, form, or cadences. The rest of the musical parameters are termed secondary parameters; for example, accents, dynamic marks, and articulations are secondary parameters. Syntactic rules are responsible for the structure of the music. Contextual rules represent a lower level of structure; they are non-syntactical rules and appear as a function of the context without a structuring function (for instance, certain cadences in later Middle Ages music or secondary dominants in tonal music). Normally, contextual rules control secondary parameters. Dependency rules are those that depend on more general rules, normally on syntactic ones, to operate; for example, the rules for melodic embellishment in the Baroque era, where an upper trill was mandatory in the presence of a perfect cadence.

As for strategies, in the succinct words of Meyer (page 20), "strategies are compositional choices made within the possibilities established by the rules of style." It seems that the true complexity of the definition of musical style resides in pinning down the relationships between rules and strategies, especially when influenced by external factors such as culture or ideology.

Out of this conceptual framework, Meyer defines three important concepts: sub-styles, which are characterized by those composers using similar rules or strategies; idiom, or how individual composers prefer certain constraints over others; and intraopus style, which is the style of a single work.

In Meyer's definition given above, we also encounter the phrase replication of patterning, which means that patterns are also involved in the definition of style. Indeed, apart from the constraints, musical style can be accurately defined as a combination of certain repeated patterns in the syntax given by the constraints.

Some authors have put greater emphasis on patterns than on syntax. Cope (1991) describes an automatic system to compose works in a given style. His system analyzes a corpus in a given style and looks for characteristic patterns (by using Markov chains). Once those patterns are retrieved, the system composes a piece by stitching them together. The manner in which they are stitched together follows a grammar, also extracted from the corpus.

On the other hand, there is some criticism in the literature regarding Meyer's definition of style. Deliège and Wiggins (2007, p. 78) described his definition as "very synthetic and rather problematic and in need of clarification." The main problem appears to be the precise definition of the constraints, as well as the identification of the characteristic patterns. Meyer spent the rest of his book defining and giving examples of those constraints. Be as it may, it seems that a combination of rules and patterns may lead to a reasonable, functional definition of musical style.

In our work several well established styles as such are studied. These styles are the Baroque, Classicism, and Romanticism, whose constraints and characteristic patterns are well known. Moreover, we added some sub-styles, namely, pandiatonicism, twelve-note serialism, and the Phrygian mode. In the next section the reasons for including those sub-styles are explained.

4. The chosen styles

As mentioned above, the following musical styles and sub-styles are studied: Baroque, Classicism, Romanticism, pandiatonicism, twelve-note serialism, and Phrygian modality. On this list we find styles such as art music movements as well as sub-styles (twelve-tone serialism and pandiatonicism). Perhaps there are some objections to including the Phrygian modality. However, the Phrygian modality here refers to a sub-style in flamenco and Spanish music that is strongly based on the use of that mode. The inclusion of this sub-style in our study is justified for several reasons, there being a greater variety of styles in our selection, with different rules and strategies in the selected styles, and more variety of stimuli in the experiments. As for twelve-tone serialism and pandiatonicism, it could also be argued that they are not true styles but compositional techniques. They may be not considered as musical styles in the sense of art music movements. Still, when applying Meyer's definition of style discussed above, those compositional techniques can indeed be considered as musical styles. In those compositional techniques, there are syntactic, contextual and dependency rules that impose a high degree of structure and processive relationships. We also find highly elaborated, meaningful strategies within the possibilities allowed by those rules. Furthermore, characteristic patterns can be found for those sub-styles.

In order to carry out experiments to observe the effect of musical style on the perceived emotion, what particular pieces in a given style should the subjects listen to? Those pieces should contain the main features of the style and

in some sense should be standard. If we want to use pieces written by the great composers of a given style, we may encounter the problem of episodic memory. The episodic memory occurs when a piece is associated with a particular event (Juslin and Västfjäll, 2008), and the piece provokes emotions linked to that event instead of the music itself. To deal with these two issues, we made the decision to compose music written in the chosen styles and specially designed for our experiments.

How should the pieces in each style be composed? To answer this question, we turned to the concept of exemplary works, a term coined by Meyer to refer to works that have had a "compositional/cultural impact and resonance that is widespread and inescapable" Meyer (1997, p. 151). Although this concept is perfectly understandable, we must admit that it could be arguable. What mechanisms decide when a work is an exemplary work? Even though the concept of exemplary work is somewhat elusive, it cannot be denied that the works of certain composers are beyond doubt. W. A. Mozart is an excellent example of referential composer in Classicism and J. S. Bach in the Baroque.

In the chosen styles, melody is important (although the case of twelve-tone serialism is treated somewhat differently). Since we had to homogenize the compositions, melody turned out to be a good common element. Figure 3 shows our melody which will serve as the basis for our compositions. This melody exhibits a balance between jumps and steps, the chord being used as a basic element, since the most styles depend on tonality rules.

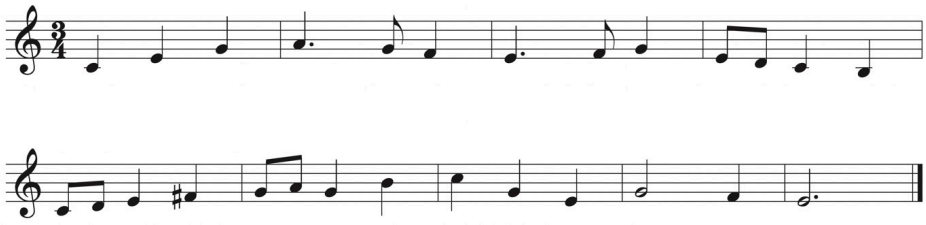

Figure 3: Prototypical melody in major mode

For the minor mode we made the appropriate changes. Figure 4 shows the use of the melodic scale; particular care was taken to prevent augmented intervals. Another important parameter is the direction of the melody. Some research studies have shown the emotional implications of this feature, thereby striking a balance between ascendant and descendent intervals (14 and 12 intervals of each class, respectively). The melody is divided into two phrases. We next proceed to explain how we adjusted these melodies to each style. This adjustment was made on the basis of the concept of exemplary work.

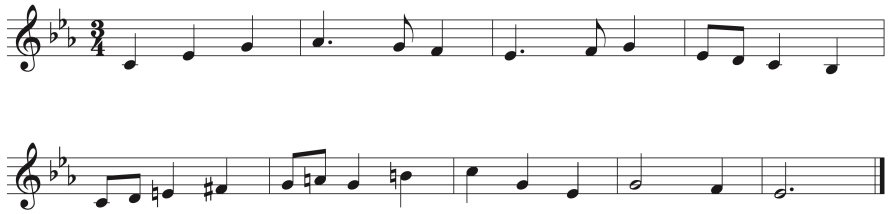

Figure 4: Prototypical melody in minor mode

4.1. The composition in the Baroque style

Following Meyer's concept of exemplary work, we felt obliged to choose one period or sub-style from the Baroque era. Bukofzer (1947) describes the rich diversity of this period: early, middle and late Baroque, Italian, French or northern Baroque are notable examples of this music. We inclined towards the 'fusion of national styles', that is, Bach as the principal example. In our case, the Brandenburg Concertos were chosen from his Köthen period and our piece was composed in this style; the first page of our score is shown in Figure 11 in Appendix 1. A balance can be observed between counterpoint and homophony with mainly contrapuntal textures. There is a melody accompanied by other three voices with an independent contrapuntal approach.

4.2. The composition in the Classical style

Although there are many Classical composers, Mozart was as the 'exemplary composer' for the same reasons Bach was chosen previously (see Figure 12 in Appendix 1). For the orchestration, the main melody was assigned to the woodwinds and the accompaniment to the strings, being a typical arrangement in Classicism. There is counterpoint,

but in this case, it is subordinated to the main melody. The harmony is characteristic from the Classical period, with highly functional chords.

4.3. The composition in the Romantic style

Composers in the Romantic period eagerly sought diversity, individualism, and fantasy. Erpf (2010) asserts that the Romantic orchestra searches for the exotic, the rare, or the singular in an attempt to stimulate the fantasy of the listener. Once again it was considered relevant to apply again the concept of exemplary work; no one can deny the repercussion of Beethoven's works. Thus, this reference was taken to create the orchestral concept. In the score (see Figure 13 in Appendix 1), several typical features of Romantic orchestral music can be observed: the unison between violas and cellos, the independence between cellos and double basses and the inclusion of wind instruments with deep sound (trombones, tubas), among others. The piece also contains chromaticism and harmonic progressions typical of Romanticism (see bar 2, for example).

4.4. The pandiatonic composition

We have already mentioned that this musical technique is not a style strictly speaking in the sense of Dickinson's definition (1965). However, it can be considered as such under Meyer's definition (1997), as in this technique there is a hierarchy of constraints given by laws, rules, and strategies, similar to the ones encountered in tonal music, as well as a higher degree of syntactification in the music. Pandiatonicism can be thought of as tonal music where some constraints have been relaxed. But what is exactly this technique like? According to the principles of pandiatonicism, any chord can link with another without further justification. In this sense, chords are disabled of tonal function. The chord's essence is now its color rather than its function. Therefore, in our score (Figure 14, Appendix 1), we paid more attention to the chord's color than to its function (we used sixth chords, ninth chords, diminished chords, among others).

4.5. The twelve-tone composition

Again, in order to consider the twelve-tone compositional technique as a style Meyer's definition was used. The arguments are the same as in the case of the pandiatonic technique. If we want to compose a twelve- note technique work, it is mandatory to consider influential figures such as Schönberg and Webern. In this case, Schönberg was chosen as a reference (exemplary work) in our composition. This technique is based on assigning the same hierarchy to every note of the chromatic scale. In this system, all 12 notes must sound as often as the others. Furthermore, the music is bare of any tonal center. Since we used a melody (tonal or triad-based) as a unifying feature, we had to change its nature in order to be able to compose in this style. First of all, we thought of keeping both musical phrases. In the original melody, there are 27 notes. However, if two dodecaphonic series were to be taken, there would then be 24 notes. For that reason, the last two were discarded. Figure 5 shows the analogy between both melodies (the atonal is below).

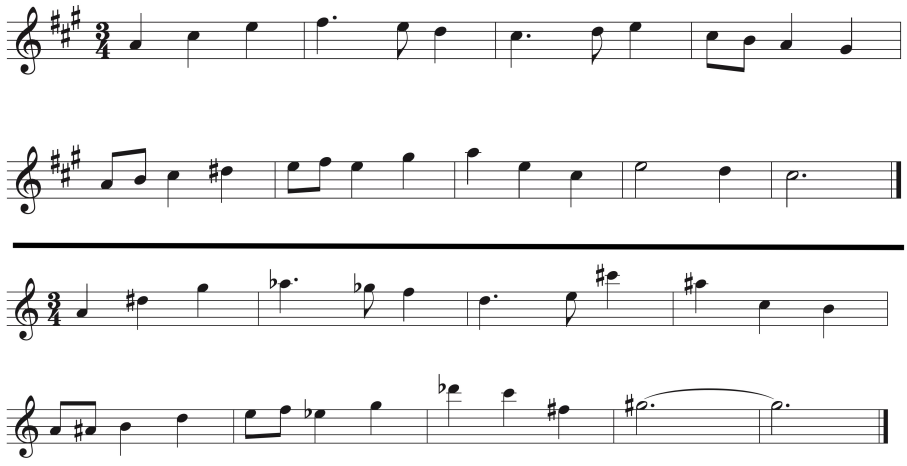

Figure 5: Analogy between the tonal melody (major) and the atonal one

With respect to the series, we organized the material with two dodecaphonic series, namely: one tone row, one phrase. The melodic contour, the ascendant and descendent intervallic, were respected. Figure 15 in Appendix 1shows that every melodic direction has been respected. A slight crescendo was applied to the horns. We are perfectly aware that we were not going to employ dynamics, but it is important to point out that we have used phenotypic elements in every style (in other words, the rules and strategies inherent to the style).

4.6. The Phrygian composition

The last musical technique is the Phrygian mode. This mode is very emblematic in Spanish music, including but not limited to flamenco music. Composers such as Granados, Albéniz, Turina, or Falla prolifically used this mode. Once more, in a broad sense the Phrygian mode is not a style, but when associated to nationalism it can be thought of as such, again according to Meyer's definition. Spanish nationalism is essentially post-romantic music in terms of style. For our composition, the rules and strategies from Spanish post-Romanticism have been borrowed as can be seen in see Figure 16 (Appendix 1).

4.7. Validation of the chosen styles

As stated earlier, we composed the pieces in order to homogenize the excerpts, as well as to avoid the use of pieces familiar to the listeners. However, we wanted to be certain that the pieces are representative enough of the styles. To that end, a validation of the styles was carried out through an experiment. Eleven music teachers and professors currently working in music schools and conservatories were asked to determine the style of each piece. The average number of years as active musician was 28.72, with a standard error of 6.43, the minimum number of years being 20 and the maximum 42. The pieces were presented to them in random order and without any hint of the style. All the participants correctly determined the styles. It was therefore considered that the styles were validated by external experts.

Audios can be listened to in:

https://soundcloud.com/suri-suki-479252739/sets/grabaciones-estilo-y-emociones

5. Measurement of emotional response to musical style

5.1. Experiment design

As stated above, for our experiments the six given styles were chosen and their emotional response studied in terms of valence and arousal. Knowing the effect of tempo on the emotional response three versions of each piece were produced at different tempi, namely, 72, 104, and 132 beats per minute. Mode was also taken into consideration and for the Baroque, Classical, Romanticism, and pandiatonic styles and two versions were written, one in major mode and the other in minor mode. The final total number of pieces was 30. To avoid presentation biases, the order of presentation was randomized across the experiments. Furthermore, volume was normalized, and the pieces were presented to the subjects in a range of 55 to 60 decibels, depending on the acoustical conditions of the room. The excerpts were in AIFF format and were played on a MacBook Pro with external speakers. The design of this experiment is quite standard in the field.

5.2 The entire population

In our experiments, 153 subjects listened to the pieces and filled out the questionnaires. Of these, 28 were discarded because they lacked consistency in their responses. Therefore, we ended up with 125 valid questionnaires. Moreover, there were 32 pieces for which the subjects did not register any emotional response. The experiment population had the following characteristics:

1. Musical background. There were 69 musicians and 56 novices (55.5% and 44.5%, respectively).
2. Age and gender. The population is composed of 46 females and 79 males. The minimum age was 12 and the maximum 68, with an average of 26.5 years and standard deviation of 0.16 years and coefficient of variation of 0.61%.
3. Origin of the population. The subjects were chosen from the city of Madrid and in the region of Galicia, both in Spain. The musicians were selected from conservatories in Galicia and students and teachers from Almudena Cano Municipal School of Music in the city of Madrid. The group of novices has different origins.

5.3. Analysis of the emotional response by style

The amount of results obtained from the experiments was copious. A detailed account of all of them would be impossible to carry out here due to space limitations. We will detail the main analyses and summarize the rest in tables shown in the Appendices. In our analyses, the following features were extracted:

1. The most frequent emotions (displayed in decreasing order in the tables), including peaks in the frequency;
2. The tendencies described as those quadrants where most emotions appear for a given sub-population;

3. Whether there is correlation between the whole population and some sub-population (either musicians or novices);
4. The behavior of the emotional response in terms of patterns of increase/decrease frequencies of emotions.

Tables 1–3 in Appendix 2 presents a summary of the emotional response to each style for the entire population, musicians, and novices. The most frequent emotions associated to the style and population are listed, showing in which quadrants those emotions lie (tendencies), whether there is correlation between some sub-population and the entire population, and additional information. For example, Table 1 shows that for the Baroque piece in minor mode, the most frequent emotions are tense, afraid, alarmed, and frustrated, all lying in Q4 (positive valence and negative arousal), with a decreasing sequence in it, as shown in Figure 6. This is the kind of information summarized in Tables 1-3, and are referred to for a summary of the analyses.

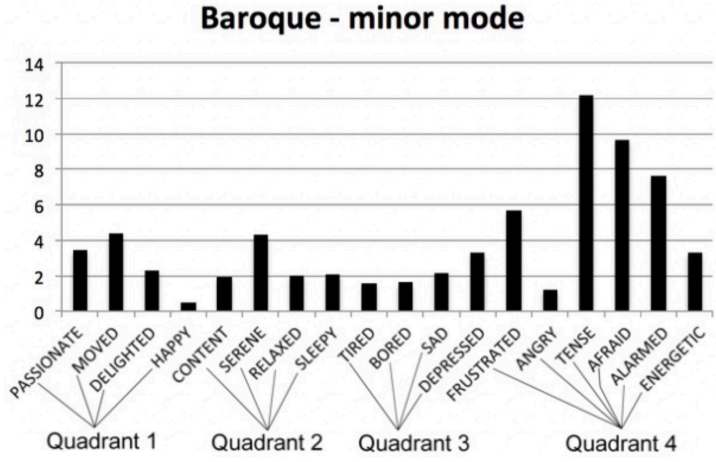

Figure 6: Frequency histogram of the emotional response to Baroque in minor mode for the whole population

6. Results and discussion

6.1 Analysis of the emotional response

This Section analyzes the emotional response as a function of tempo. Here the problem is how to retrieve the valence and arousal values from the subjects' responses. This problem was already looked into by Ramos, Bueno, and Bigand (2011), Tizón, Gómez, and Oramas (2014) y Tizón, Gómez, and Oramas (2013). Since the emotions are points on the plane, it is possible to compute their exact Cartesian coordinates from the emotion model. The *x*-coordinate is valence and the *y*-coordinate is arousal. Once the valence and arousal coordinates are available, the average is computed as a function of tempo. This provides each style with three points on the emotion plane, each one corresponding to a different tempo; the arrows indicate the emotional response as tempo increases (72, 104, and 132 bpm). Figures 7 and 8 display the plot of the emotional response for musicians and novices.

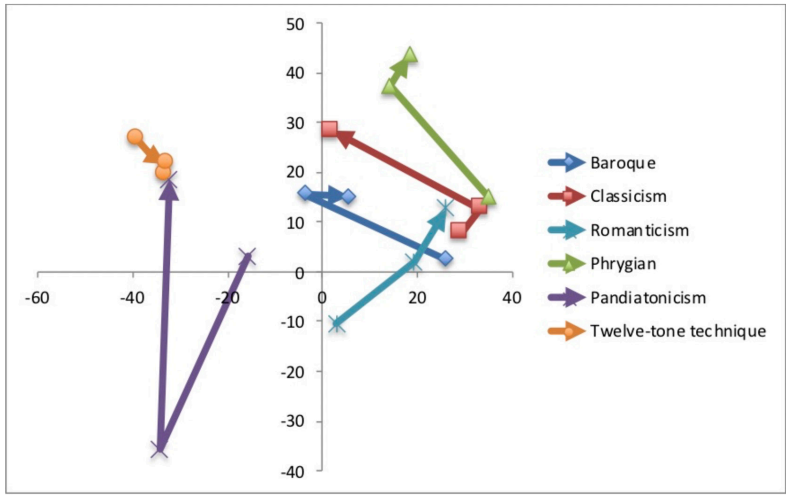

Figure 7: Emotional response to musical style for musicians

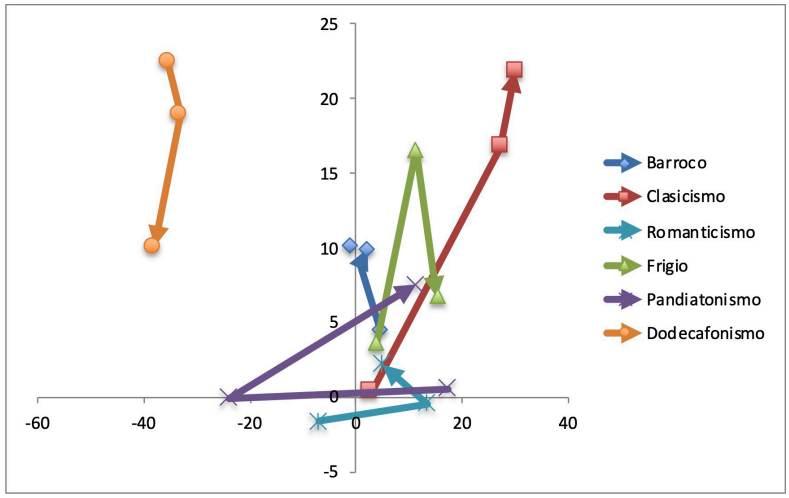

Figure 8: Emotional response to musical style for novices

Expectedly enough, the emotional response showed some variability, both in arousal and valence. In the graphs displayed above the average of the valence and arousal as a function of tempo and style was computed. It is then of interest to know how homogeneous the population is so that the measures of central tendency are representative, and hence the above graphs are meaningful. It is relatively frequent to find outliers in an experiment as complex as the ones described in this paper. For this reason, it is better to measure the dispersion of the data by using order statistics rather than value statistics. Table 6 contains the coefficient of variation for the median of the emotional response (valence and arousal), called *c*. This coefficient *c* is the mean absolute deviation around the median divided by the median itself, expressed as a percentage. It has been proved that *c* is a robust measure of the dispersion of the data (Hoaglin, Mosteller, and Tukey, 1983).

Several observations can be made out of the data in Table 6. In general, and for musicians, most of the coefficients are low in value, the arousal in the Baroque style at tempo 72 being the highest (144.45) and the valence in the Classical style at tempo 132 the lowest (1.56). With some exceptions, the data suggest that there is more dispersion in valence than in arousal for musicians. Values of the coefficients are acceptable for most of the emotional response. As for novices, the values of *c* for both valence and arousal are similar in those of musicians, being the lowest value 1.49 and the highest 110.55. There is no noticeable pattern in the dispersion behavior as a function of tempo. In general, it can be accepted that the population and sub-populations are homogeneous enough for our study of the emotional response to be valid.

	BAROQUE	***Tempo* 72**	***Tempo* 104**	***Tempo* 132**
MUSICIANS	Valence	32.63	2.17	81.47
	Arousal	144.45	4.04	26.04
	CLASSICISM			
	Valence	25.81	13.29	1.56
	Arousal	46.16	15.60	18.82
	PHRYGIAN MODE			
	Valence	12.25	51.38	37.20
	Arousal	3.48	19.62	19.95
	PANDIATONICISM			
	Valence	46.49	23.89	22.50
	Arousal	78.82	108.40	8.79
	ROMANTICISM			
	Valence	2.46	42.35	27.69
	Arousal	47.76	3.12	13.16
	TWELVE-TONE TECHNIQUE			
	Valence	5.99	20.19	14.68
	Arousal	31.95	3.33	6.61

	BAROQUE	***Tempo* 72**	***Tempo* 104**	***Tempo* 132**
NOVICES	Valence	1.49	89.12	2.24
	Arousal	82.26	30.10	38.70
	CLASSICISM			
	Valence	1.56	25.76	10.63
	Arousal	110.55	15.26	15.20
	PHRYGIAN MODE			
	Valence	87.52	61.69	54.73
	Arousal	18.21	13.88	53.73
	PANDIATONICISM			
	Valence	55.30	19.86	64.74
	Arousal	109.99	99.49	61.39
	ROMANTICISM			
	Valence	5.38	60.16	1.15
	Arousal	5.59	92.46	114.32
	TWELVE-TONE TECHNIQUE			
	Valence	15.33	20.79	8.67
	Arousal	10.07	7.25	33.76

Table 6: Coefficient of variation for the median for musicians and novices

These graphs are further discussed in the conclusions section.

Again, due to lack of space, we chose to summarize the results in tables. Tables 4–5 in Appendix 3 contain a description of the behavior of the valence and arousal by style and musical background. The patterns of valence and arousal increase and decrease were studied as a function of tempo, using the following symbols to describe those patterns:

- ⇗ indicates a high increase; analogously, ⇘ means a high decrease.
- ↗ indicates a moderate increase; analogously, ↘means a moderate decrease.
- →indicates that the value is approximately constant.
- For example, a sequence V=⇗⇗ indicates that the valence is increasing high as tempo increases, both for slow-to-medium and medium-to-fast tempi. A = →→ shows that the arousal remains constant. The other patterns are interpreted analogously.

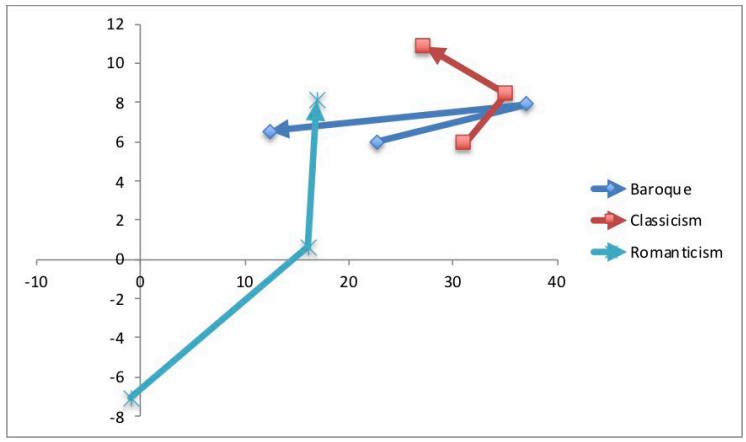

Figure 9: Emotional response as a function of tempo in major mode

6.1.1. Analysis of tempo and mode

The relationship between tempo and mode is of paramount importance and therefore the Baroque, Classic, and Romantic styles were studied separately. Figures 9 and 10 display the emotional response for those styles by mode.

In the Baroque style, in major mode the valence increases and later decreases. The variation in arousal is relatively low. In Classical style, in major mode the same pattern was found in the valence (an increasing-decreasing sequence), but now the arousal always increases. In Romantic style, in major mode there is a high rise in both valence and arousal, from tempo 72 to 104, and then only a rise in arousal (valence is almost constant).

Let's now examine the minor mode; refer to Figure 10. For Baroque, there is a jump from tempo 72 to 104 from the second quadrant (with relatively low valence and arousal) to the fourth quadrant, now with high negative valence and high positive arousal. From that point, valence decreases noticeably, and the arousal hardly changes. In the case of Classicism, arousal keeps increasing all the time, but valence follows the pattern increasing/decreasing with a positive total variation. Lastly, the Romantic style presents an increase in both valence and arousal starting from the third quadrant.

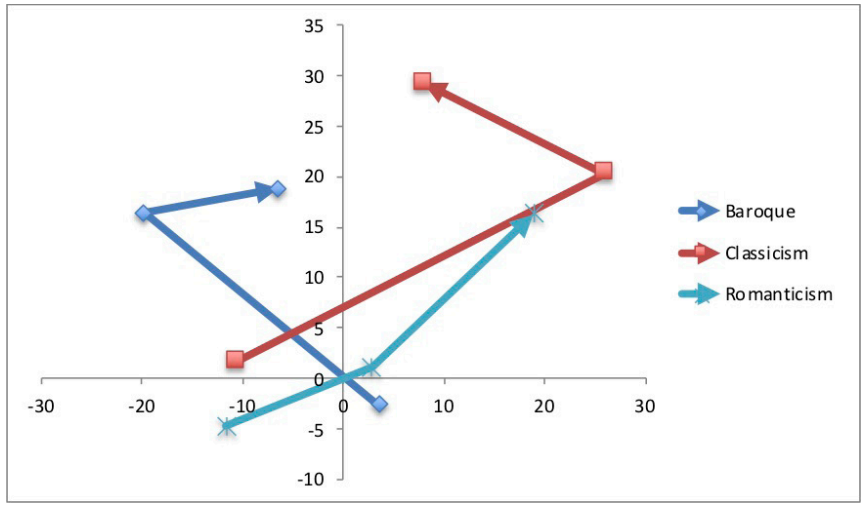

Figure 10: Emotional response as a function of tempo in minor mode

6.1.2. Analysis of variance for the emotional response

For the sake of completeness, an ANOVA analyses of the emotional response were carried out. The goal is to examine what factors affect the emotional response to musical style. All computations were done with Statgraphics Centurion XVII, with a level of significance of 5% throughout all the ANOVA analyses.

Our first step was to run an ANOVA analysis with style, tempo, and musician as factors and with valence as the dependent variable (notice that valence is a continuous variable). Style and all the interactions had effect on the valence (style: *p*-value below 0.001, *F*-ratio: 69.88; style×tempo: style×tempo: *p*-value below 0.001, *F*-ratio: 10.68; style×musician: *p*-value below 0.001, *F*-ratio: 11.79; tempo×musician: *p*-value below 0.001, *F*-ratio: 3.82; style×-tempo×musician: *p*-value below 0.001, *F*-ratio: 5.09).

The ANOVA analysis was then repeated with the same factors, now setting arousal as the dependent variable (arousal also being a continuous variable). This resulted in style, tempo, musician, and the interactions style×tempo and style×musician having influence on arousal (style: *p*-value below 0.001, *F*-ratio: 9.79; tempo: *p*-value below 0.001, *F*-ratio: 17.98; musician: *p*-value: 0.0021, *F* -ratio: 8.89; style×tempo: *p*-value: 0.0003, *F*-ratio: 2.57; style×musician: *p*-value: 0.008, *F* -ratio: 2.49). Table 7 sums up the results obtained from the ANOVA analyses. 'Yes' indicates that the factor in the column affects the variable in the row (either valence or arousal).

	Style	Tempo	Musician	Style× Tempo	Style× Musician	Tempo× Musician	Style×Tempo× Musician
Valence	Yes			Yes	Yes	Yes	Yes
Arousal	Yes	Yes	Yes	Yes	Yes		

Table 7: Summary of conclusions: ANOVA with style, tempo, and musician as factors

In general, it could be noticed that style had an effect both on valence and arousal. The effect of style, tempo, and musical background is discussed in the conclusions section.

7. Pedagogical applications

The pedagogical applications of the research carried out here speak for themselves. First and foremost, this research provides a deeper understanding of emotion in music. Most textbooks on musical emotions do not address the emotional response to musical style; they rather focus on less abstract musical parameters (melody, timbre, rhythm, harmony). Furthermore, the manner in which musical emotion is examined, does not cover the level of detail presented here, where complex and finer behaviors can be observed in valence and arousal across different sub-populations and musical styles. Secondly, this work, when applied to teaching, entails a richer concept of musical style. Not only the concept of style is understood from a purely musical standpoint, but also from an emotional one. Thirdly, since we used an overarching range of musical styles (from Baroque to 12-tone serialism), it is possible to teach and integrate many subjects by taking sections from this work. For example, there are college courses where this material could be used: music cognition, history of musical style, orchestration, composition, music education, or musicology, among others. This material could naturally be adapted to high school teaching. In the official high school curriculum, the teaching of musical emotion is absent. A few teachers teach it out of their own initiative; a good account of recent projects on this teaching can be found in the excellent monograph edited by Martí (2017). The material presented here can provide with content and methodology to undertake such an endeavor.

8. Conclusions

This study confirms previous results from other authors, i.e., that there are considerable differences in the way musicians and novices perceive music and the associated emotions. Generally speaking, musicians provide more consistent and subtler responses and furthermore, gave significantly different responses to certain styles (Baroque, pandiatonicism, and the Phrygian mode; see Tables 1-3) than those of novices.

The emotional response is extremely sensitive to minimal variations and, in general, sub-populations (musicians and novices), modes, *tempi* and style show great heterogeneity. There are different behaviors according to the particular style. In the Baroque style, the major mode presents high variation in valence and almost none in arousal, whereas the minor mode presents variation in both parameters. In the Classical style, the major mode presents less variation than the minor mode, although the patterns of change are similar. In the Romantic style, the behavior of both valence and arousal is quite similar, having an increase in both valence and arousal as tempo increases; see Figures 9 and 10.

The emotional response to mode is in many cases decisive. There is a strong correlation between mode and the general emotional response, both in the whole population and sub-populations; see Tables 1-3. Generally speaking, minor mode exhibits a wider range of responses, especially in novices. For example, the results of the Phrygian mode corroborate this point; see Table 5.

Emotional response changes as a function of tempo, but in our studies, we observe more complex patterns than in other studies. In some studies, both valence and arousal increase as tempo increases, but in those studies the authors were measuring the effect of some less abstract musical parameters on the perceived emotion. However, in our experiments it was not the case. Therefore, the effect of style on the perceived emotion is more powerful and may lead to more complex behaviors in the emotional response. For instance, in the twelve-tone technique, neither valence nor arousal increase, for musicians or novices. For pandiatonicism, valence show increase/decrease patterns as tempo increases. Similar situations can be found in the Baroque and Classical styles. The style that most follows the pattern of constant increase of valence and arousal is Romanticism; see Tables 4-5 and Figures 8 and 9.

In many cases, the general emotional response is split up between the musicians' and novices', where the variation of valence is accounted for by one population and the arousal by the other, or vice versa. To the best of our knowledge, no study has observed and reported on this fact beforehand.

Valence is more influenced by interactions, especially when musical background is present, than by single factors. However, arousal is more sensitive to single factors; see Table 7. Style and tempo and style and background have the greatest influence on the emotional response, as both act upon valence and arousal at the same time.

Conclusions by style:

1. Tonal styles (Baroque, Classicism, and Romanticism). In Baroque and Classicism styles in major mode, the emotional response lies on the first quadrant for all tempi. Romanticism starts on the second quadrant and finishes on the first one, with a high increase of arousal. In minor mode, tonal styles present differences in behavior and emotions can be observed in all quadrants; see Figure 10. However, the common feature here is in all cases a high increase of arousal. Valence exhibits a more complex behavior, with various patterns of increase/decrease and decrease/increase; see Tables 4-5.
2. Pandiatonicism. In musicians, this style elicits high levels of frustration (an emotion of negative valence). In novices, the main two emotions are content and serene.
3. Twelve-tone technique. This style causes unanimity as it provokes the emotions of feeling afraid and alarmed both in musicians and novices.
4. The Phrygian mode. The differences between musicians and novices are very marked. For musicians, this style is energetic and passionate, whereas for novices it is happy and moving.

9. Future work

This work opens up multiple possibilities for further research. Firstly, to investigate what emotions are elicited by other styles or sub-styles (other kinds of Baroque, Renaissance music, pop music, or jazz). Moreover, it is possible to research the evoked emotions in different compositional contexts, that is to say, in different music techniques, such as polytonality, micropolyphony, expanded harmony, among others. Furthermore, it would be fascinating to repeat this work but studying real emotion instead of perceived emotion (EGG helmets should be used instead of questionnaires). Another extension possibility would be to consider more complex models of emotions (3D models, for instance).

Lastly, we believe that the concept of style must be reviewed and extended. We apply Meyer's concept of style to our research, but the conceptual issue is not settled yet. Certainly, we need concepts and models with a greater explanatory power.

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11. Appendix 1

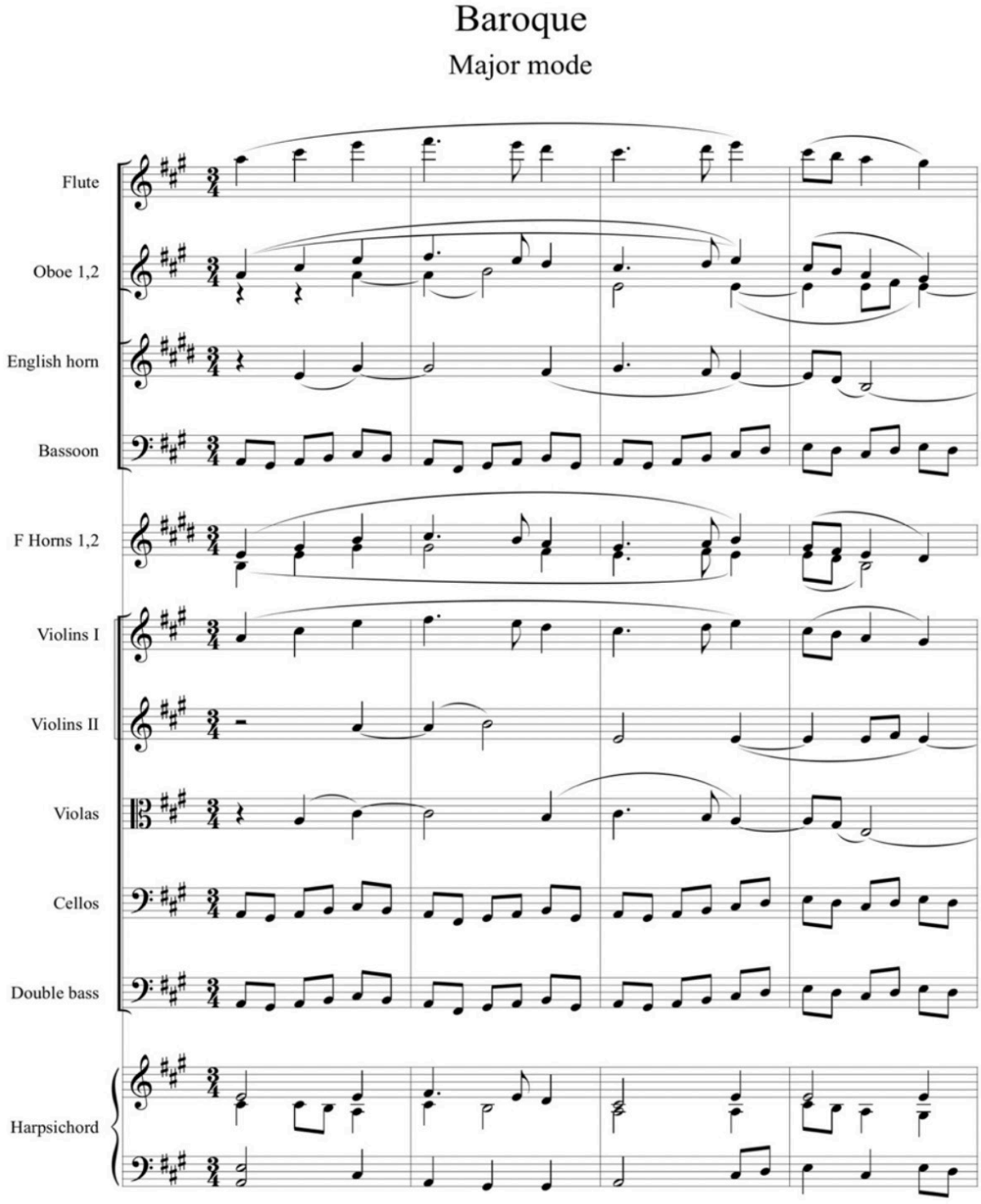

Figure 11: First page of the baroque composition

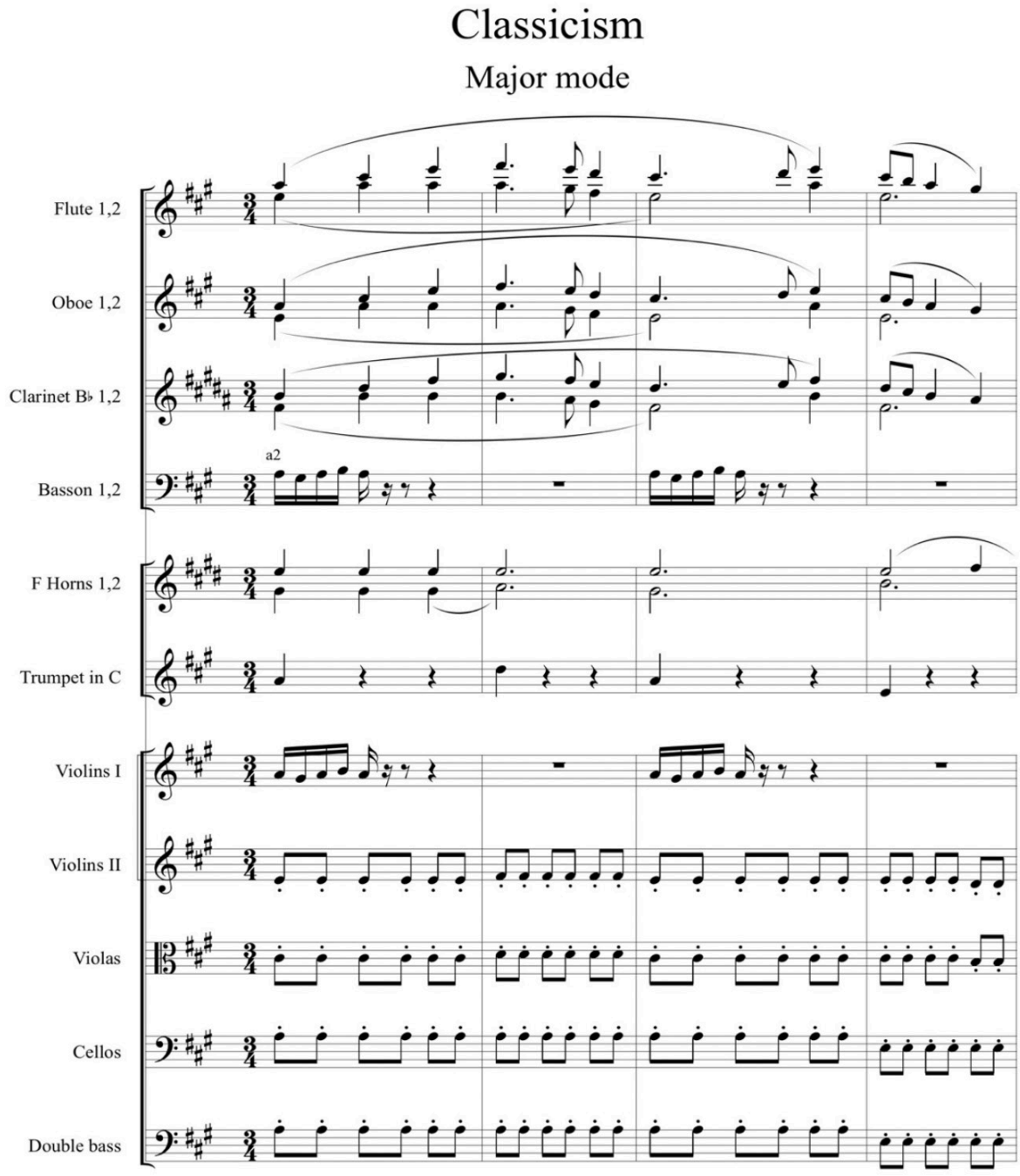

Figure 12: First page of the classic composition

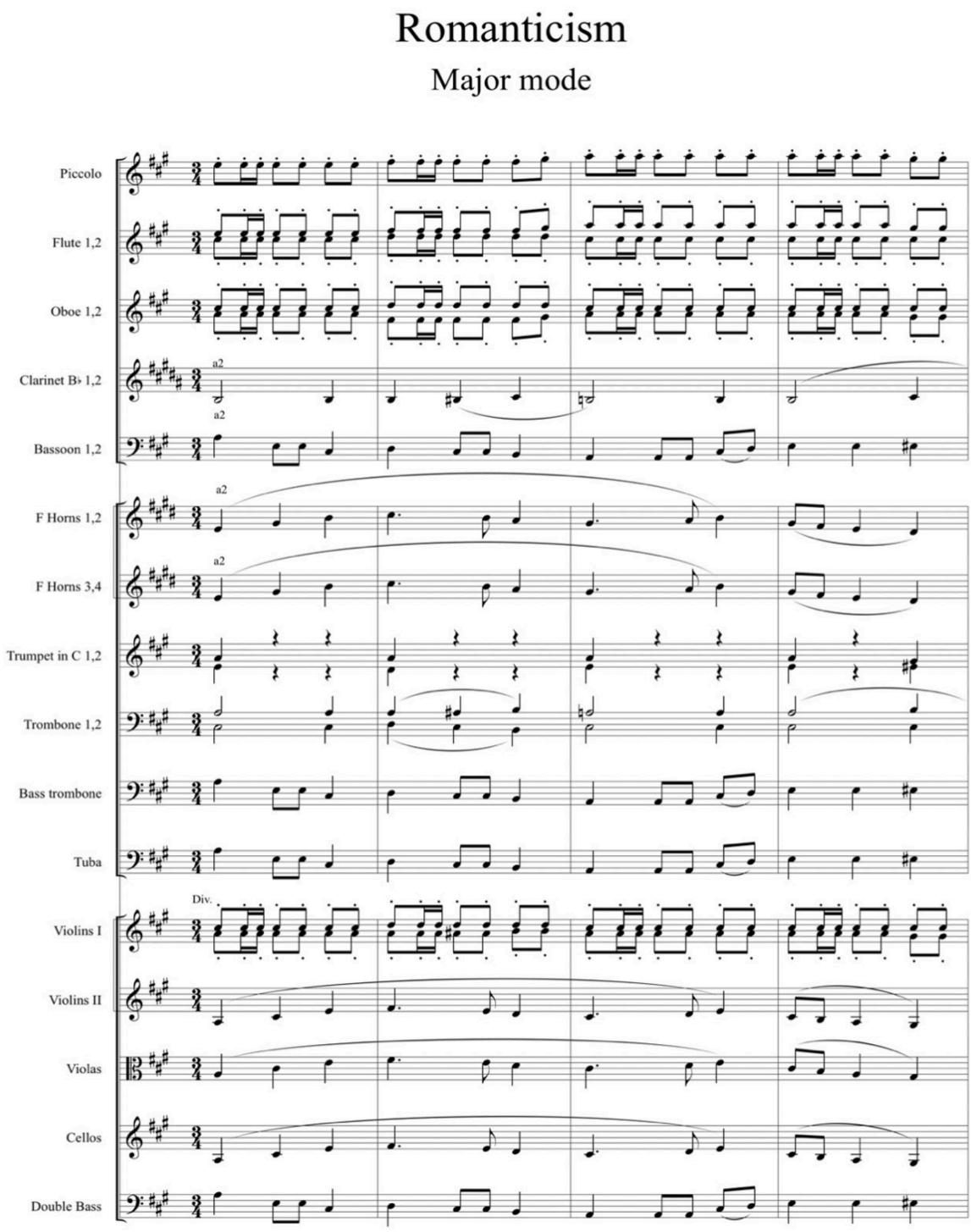

Figure 13: First page of the romantic composition

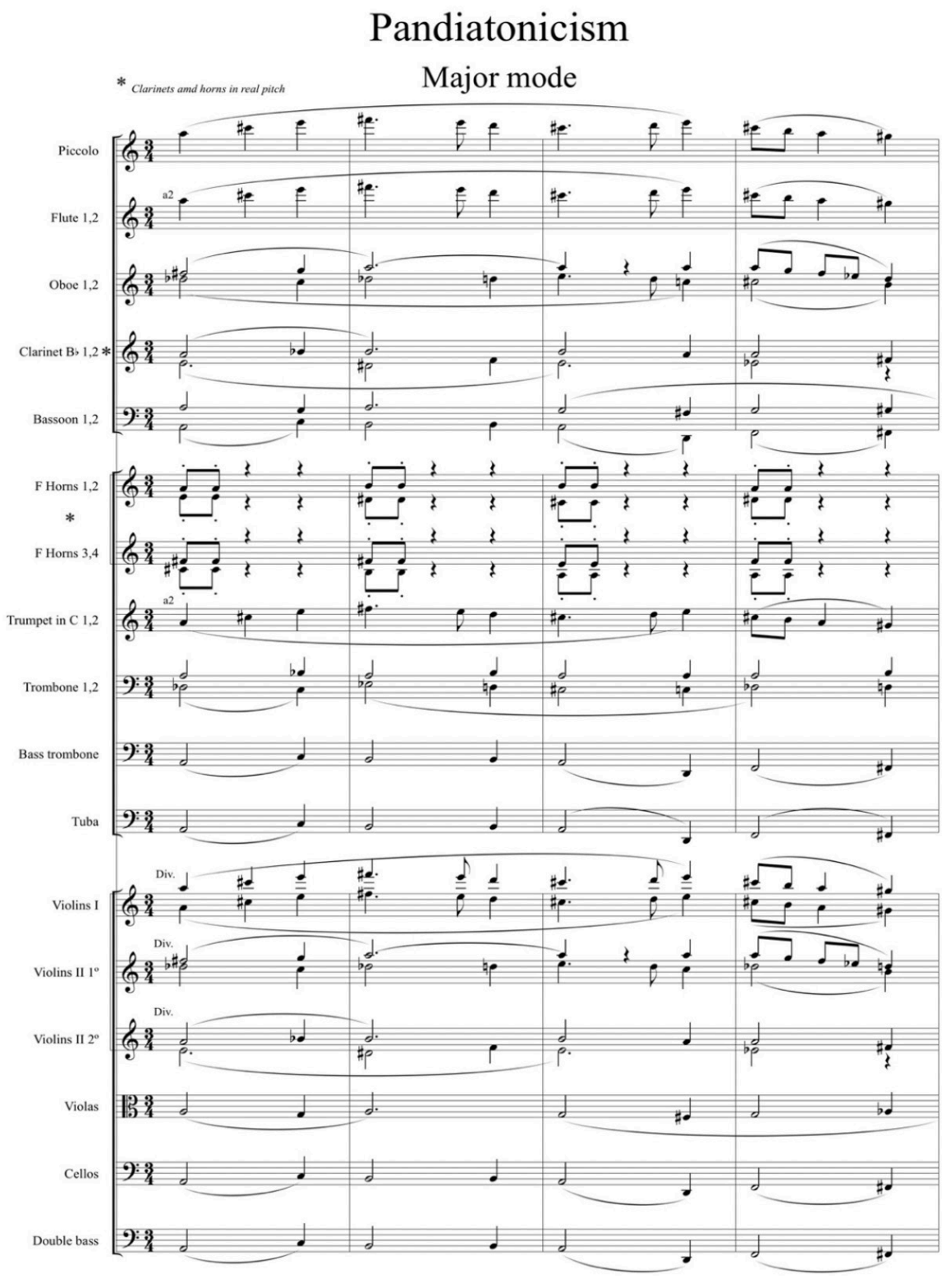

Figure 14: First page of the pandiatonic composition (major tune)

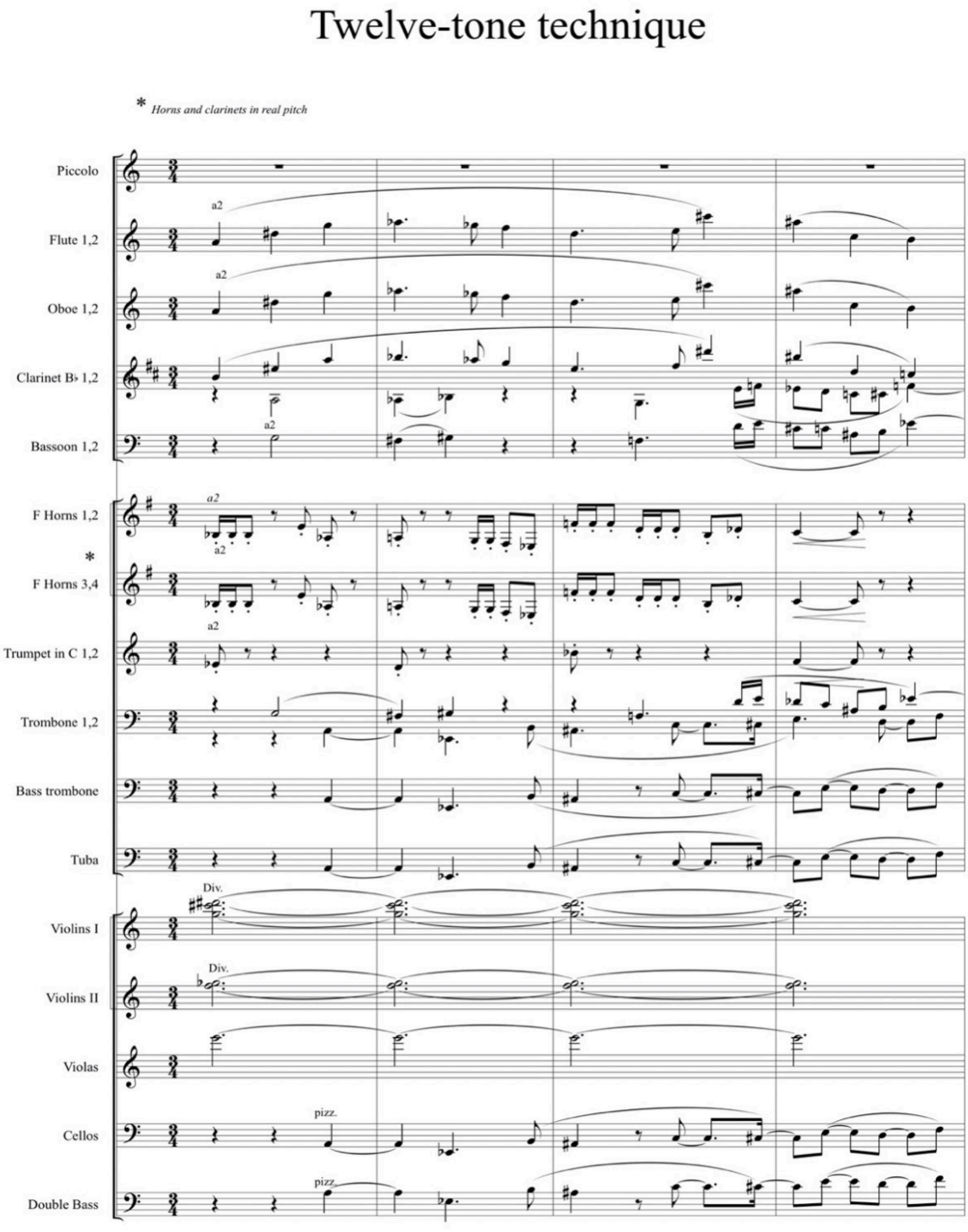

Figure15: First page of the dodecaphonic composition

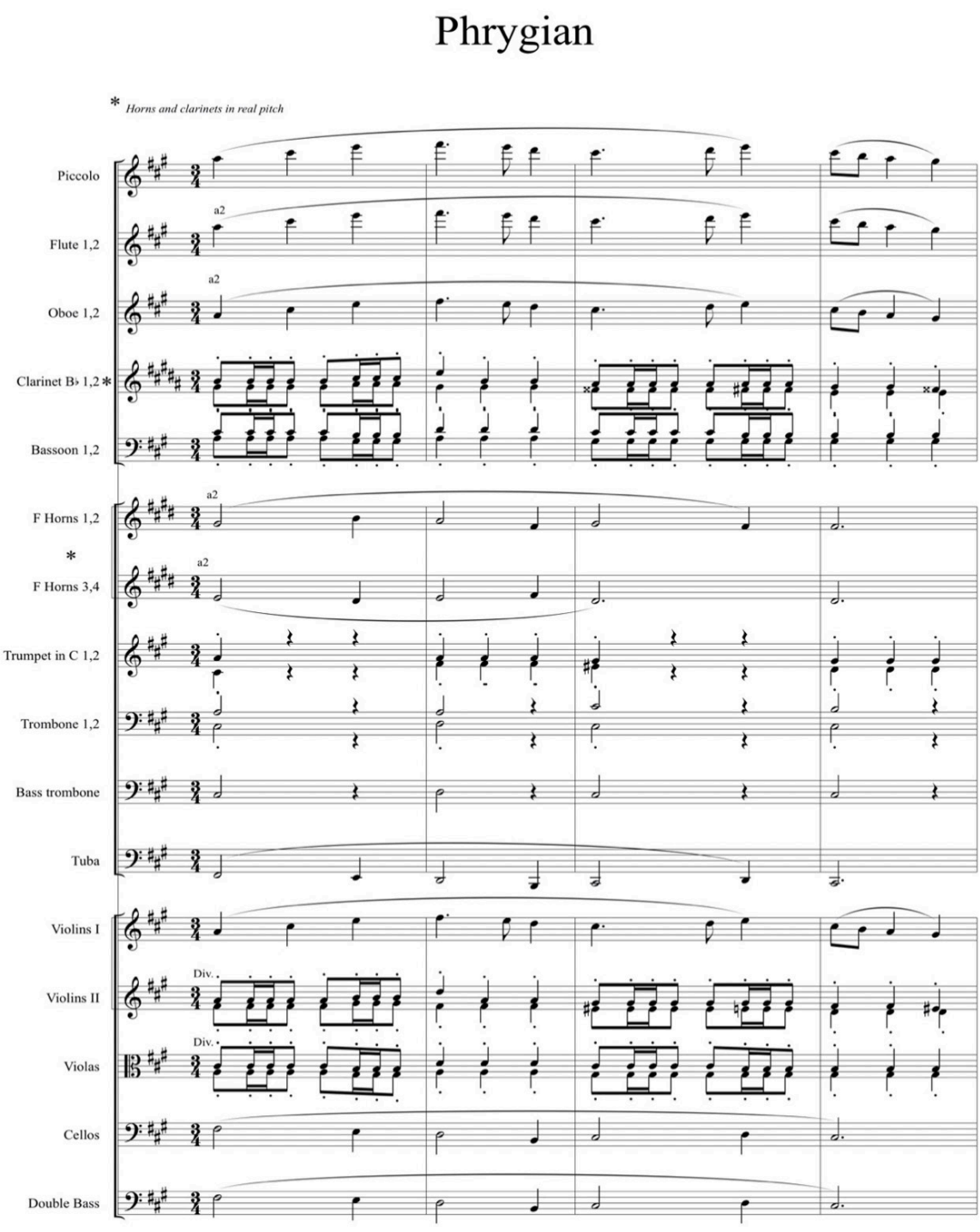

Figure 16: First page of the Phrygian composition

12. Appendix 2

	Populations	Most frequent emotions (Decreasing order)	Tendencies	Correlation	Comments
Entire population	All subjects	Tense, content, moved, frustrated, serene	Q1, Q4		
	Musicians	Tense, content, frustrated, energetic	Q1, Q2		
	Novices	Moved, tense, content, serene	Q1, Q2		Frequencies are mainly distributed across quadrants
Baroque	All subjects	Happy, delighted, tense, moved, serene	Q1, Q2		
	Major mode	Happy, content, delighted, passionate	Q1, Q2		Tense has zero frequency
	Minor mode	Tense, frustrated, afraid, alarmed	Q4		Decreasing sequence in Q4; more emotional variety
	Musicians	Content, tense, serene, delighted	Q1, Q2, Q3	Entire population, R = 82.69%	Low emotional response in Q3
	Novices	Afraid, tense, frustrated, happy, passionate	Q1, Q2, Q4		
Classicism	All subjects	Content, delighted, happy, energetic, moved, passionate	Q1, Q2		Isolated peak at energetic; very low response in Q3 and Q4; increasing sequence in Q1-Q2
	Major mode	Content, happy, delighted, serene, moved	Q1, Q2	Entire population, R = 81.53%	Increasing sequence in Q1- Q2
	Minor mode	Energetic, passionate, content, delighted, moved	Q4, Q1, Q2		Isolated peakat energetic; very low response in Q3 and Q4
	Musicians	Content, energetic, happy, delighted	Q1, Q2, Q4	Entire population, R = 93.91%	Isolated peakat energetic; very low response in Q3 and Q4
	Novices	Content, moved, delighted, happy, passionate	Q1, Q2		

Table 1: Summary of analyses (1): The entire population, Baroque, and Classicism

	Populations	Most frequent emotions (Decreasing order)	Tendencies	Correlation	Comments
Romanticism	All subjects	Serene, moved, relaxed, sad, passionate	Q2, Q1		Sad appears in fourth place
	Major mode	Serene, relaxed, happy, sad	Q2, Q1	Entire population, R = 82.9%	Sad appears in fourth place
	Minor mode	Moved, depressed, passionate, serene, sad	Q1, Q3, Q2		
	Musicians	Serene, passionate, moved, happy	Q1, Q2, Q3	Entire population, R = 90.01%	Almost null response in Q4
	Novices	Serene, relaxed, bored, frustrated, sad, energetic	Q2, Q3, Q1		Less concentrated emotional response across quadrants

Pandiatonicism	All subjects	Frustrated, tense, afraid, tired, bored	Q3, Q4		Decreasing sequence in Q4; high isolated-response in Q2
	Major melody	Frustrated, tired, tense, bored, serene	Q3, Q2, Q4		
	Minor melody	Frustrated, tense, afraid, content, depressed	Q3, Q2, Q4	Entire population, R = 83.4%	Decreasing sequence in Q4; high isolated response in Q2
	Musicians	Frustrated, tense, afraid, alarmed			All emotions are in Q4; decreasing sequence in Q4
	Novices	Content, serene, happy, bored, frustrated, tense			High frequencies emotions are found in all quadrants
Twelve-tone serialism	All subjects	Tense, afraid, alarmed, frustrated	Q4		High peak at tense
	Musicians	Tense, afraid, alarmed, frustrated	Q4	Entire population, R = 99.12%	High peak at tense
	Novices	Tense, frustrated, afraid, alarmed	Q4	Entire population, R = 98.36%	High peak at tense

Table 2: Summary of analyses: Romanticism, pandiatonicism, and twelve-tone serialism

	Populations	**Most frequent emotions (Decreasing order)**	**Tendencies**	**Correlation**	**Comments**
Phrygian mode	All subjects	Energetic, moved, passionate, delighted, content	Q4 and Q1		High peak at energetic
	Musicians	Energetic, passionate, delighted, moved			High peak at energetic
	Novices	Moved, content, frustrated, delighted, relaxed, alarmed, energetic	Q1, Q2, Q3 and Q4		

Table 3: Summary of analyses: The Phrygian mode

10. Appendix 3

	Populations	**Valence**	**Arousal**	**Patterns**	**Comments**
Baroque	All subjects	Highly decreasing; then increasing very little	Highly increasing; then decreasing very little	$V=\searrow\nearrow$, $A=\Uparrow\searrow$	Global response is split up between musicians (valence) and novices (arousal)
	Musicians	Highly decreasing; then in- creasing very little	Very little variation	$V=\searrow\rightarrow$, $A=\nearrow\rightarrow$	It accounts for most of variation in valence in the entire population
	Novices	Very little variation	Highly increasing; then decreasing very little	$V=\searrow\rightarrow$, $A=\Uparrow\searrow$	It accounts for most of variation in arousal in the entire population
Classicism	All subjects	Increases and then decreases by the same amount more or less	Increases through- out	$V=\searrow\Uparrow$, $A=\Uparrow\Uparrow$	Global response is split up between musicians (valence) and novices (arousal)
	Musicians	Increasing very little; then highly decreasing	Constant increasing	$V=\rightarrow\searrow$, $A=\nearrow\Uparrow$	It accounts for the variation in valence in the entire population
	Novices	Increasing throughout	Highly increasing throughout	$V=\Uparrow\rightarrow$, $A=\Uparrow\nearrow$	It accounts for the variation in arousal in the entire population
Romanticism	All subjects	Increasing and then constant	Increasing throughout	$V=\Uparrow\rightarrow$, $A=\Uparrow\Uparrow$	
	Musicians	Highly increasing throughout	Highly increasing throughout	$V=\Uparrow\Uparrow$, $A=\Uparrow\Uparrow$	Musicians' response explains the variation in arousal
	Novices	Increasing and then decreasing very little	Very little variation	$V=\rightarrow\rightarrow$, $A=\searrow\nearrow$	

Table 4: Summary of results: Emotional response to Baroque, Classicism, and Romanticism

	Populations	Valence	Arousal	Patterns	Comments
Pandiatonicism	All subjects	Highly decreases and then increases a little	Decreases very little and then highly increases	$V = \searrow\nearrow$, $A = \searrow\nearrow$	Global response is split up between musicians (arousal)and novices (valence)
	Musicians	Decreases and then stays constant	Highly decreases and then highly increases	$V = \searrow\rightarrow$, $A = \searrow\nearrow$	The response is found in Q3 and Q4. It accounts for the variation in arousal in the entire population
	Novices	Highly decreasing and then highly increasing	Stays constant and then increases	$V = \searrow\nearrow$, $A = \rightarrow\nearrow$	The response is found in Q1 and Q4. It accounts for the variation in valence in the entire population
Twelve-tone serialism	All subjects	Stays almost constant throughout	Decreases very little and stays constant	$V = \rightarrow\rightarrow$, $A = \searrow\rightarrow$	The response is in Q4
	Musicians	Stays almost constant throughout	Decreases very little and stays constant	$V = \rightarrow, \rightarrow$ $A = \searrow\rightarrow$	The response is similar to that of the entire population
	Novices	Stays almost constant throughout	Decreases a little and then highly de- creases	$V = \rightarrow\rightarrow$, $A = \searrow\searrow$	The arousal decreases as tempo increases
The Phrygian mode	All subjects	Constant valence	Highly increases and then decreases	$V = \rightarrow\rightarrow$, $A = \nearrow\searrow$	The response is in Q1
	Musicians	Decreases and Increases very little	Highly increases and increases very little	$V = \searrow\rightarrow$, $A = \nearrow\nearrow$	The response is in Q1
	Novices	Decreases little throughout	Highly increases and highly decreases	$V = \searrow\searrow$, $A = \nearrow\searrow$	The response is in Q1

Table 5: Summary of results: Emotional response to pandiatonicism, twelve-tone serialism, and the Phrygian mode