How blue is Mozart? Non verbal sensory scales for describing music qualities

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ABSTRACT

Studies on the perception of musical qualities (such as induced or perceived emotions, performance styles, or timbre nuances) make a large use of verbal descriptors. Although many authors noted that particular musical qualities can hardly be described by means of verbal labels, few studies have tried alternatives. This paper aims at exploring the use of non verbal sensory labels, in order to represent different perceived qualities in Western classical music. Musically trained and untrained listeners were required to listen to 6 musical excerpts in major key and to evaluate them from a sensorial and semantic point of view (Experiment 1). The same experiment (Experiment 2) was proposed to musically trained and untrained listeners who were required to listen to 6 musical excerpts all in minor key. The overall findings indicate that subjects' rates on non verbal sensory scales are throughout consistent and the results support the hypothesis that sensory scales can convey some specific sensations that cannot be described verbally, offering interesting insights to deepen our knowledge on the relationship between music and other sensorial experiences.

1. INTRODUCTION

The study of music is not limited to the artistic field. Indeed, the power of music to arouse in the listener a rich set of sensations, such as images, feelings, or emotions, can have many applications. In the information technology field, a musical signal can contribute to the multimodal/multisensory interaction, communicating events and processes, providing the user with information through sonification, or giving auditory warnings. In this sense, sound design requires great attention and a deep understanding of the influence of musical parameters on the user's experience.

In virtual/augmented reality systems (e.g. immersive videogames, tools for technological augmented learning) music represents a necessary and all-involving media. In this sense, it is essential to match the environment with the feeling communicated by music. In video-games the soundtrack can improve the user involvement only if emotions aroused by the music are suited to the situation of the game. In (mobile) devices dedicated to play music (mp3 players, etc.), the playlist definition is more and more complex with the increasing memory of devices. In this context, access to music content can be more involving if the interaction is based on sensorial images or metaphors.

Many studies investigated the relation between music and emotions, proving that is possible to correlate the listeners' main appraisal categories and the acoustic parameters. A common characteristic of almost all these studies is to investigate the listeners' responses to music by using verbal labels. Although many authors noted that particular musical qualities can hardly be described by means of verbal labels, few studies have tried alternatives. This paper presents two experiments aiming at exploring the use of non verbal sensory labels, in order to represent different perceived qualities in Western classical music.

Music composers know very well that the music mode is related to the affective properties of music. Traditionally, the minor mode has been attributed to feelings of grief and melancholy whereas the major mode has been attributed to feelings of joy and happiness. In order to reduce the relevant influence of modality, we planned two experiments to emphasize other secondary features which characterize the perceived affective qualities of music: the first one with the pieces in major mode and the second one in minor mode.

2. INTERSENSORY SCALES

The use of linguistic labels is one of the most complex problems of the studies investigating the emotional aspects of music. Musical emotions are so undetermined that it is difficult to render them through words, since the determinedness of language causes an inevitable loss in richness of meanings. The use of verbal labels can encourage participants to simplify what they actually experience [1] and it is still uncertain if research based on the recording of electrophysiological responses to musical stimuli [2, 3] can faithfully account for the subtlety of musical emotions. For this reason, we asked our participants to evaluate their musical experience from a subjective sensorial point of view. Seven intersensory scales (visual, auditory, tactile, haptic and gustative) were presented in random sequence in order to stimulate a quasi-synesthesic response. Our participants were confronted with the following scales: maluma/takete, blue/orange, hard/soft, smooth/rough, bitter/sweet, heavy/light, cold/warm previously tested in an experiment on colour perception [4]. In this case the aim of the researchers was the study of different reactions to normal or iridescent colours and it resulted that evaluations in all scales, sensory and

semantic, significantly discriminated normal from changeable colours. Another study [5] on unique hues led to the discrimination of four characteristic factors: one including the three verbal scales typical of Osgood's findings, one including warm/cold scale, one characterized by the sensory opposition of dissonant, aloud, and orange against consonant, faint, and turquoise and the last including the glass sandpaper scale, and the light-heavy scale dealing with the sensation of smoothness given by the light sources. These two studies confirmed the hypothesis that the sensory scales used in the evaluation of light sources can show up relevant qualitative aspects otherwise hidden. According to [6], emotional responses to music depend upon whether the musical pieces fulfill perceptual and cognitive expectancies generated from the opening of the piece. These expectations mirror the relationships of harmonic keys in Western music. Musical expectancies result from processing several features, such as harmony, rhythm, melody, and thematic relationships cognitively. This processing is believed to occur automatically at an implicit level [7]. Peretz et al. [8] have shown that emotional responses seem to rest on a very fast acting mechanism, so that 250 ms of music may suffice to distinguish happy from sad excerpts. We believe that multisensory scale can provide a strong support in capturing this unconscious encoding of the musical experience and provide creative and interesting interaction with semantic categorization. As regards the semantic analysis, we decided to rely upon the semantic differential, a type of rating scale designed to measure the connotative meaning of objects, events, and concepts ideated by Osgood and his colleagues [9]. They performed a factor analysis of large collections of semantic differential scales and found three recurring attitudes that people use to evaluate words and phrases: evaluation, potency, and activity. Evaluation can be matched to the adjective pair desirable-undesirable. The gentle-violent adjective pair defines the potency factor. Adjective pair active-passive defines the activity factor. These three dimensions of affective meaning were found to be cross-cultural universals in a study of dozens of cultures.

3. EXPERIMENT 1

3.1 Participants

Participants, recruited on a voluntary basis, were 20, of which 12 musicians (age range 17-25, mean age 21.4; 8 women and 4 men) and 8 non-musicians (age range 24-68, mean age 42; 4 women and 4 men).

3.2 Stimuli

The musical excerpts were selected from two previous works [10, 11], in which experiments were conducted to study the clustering of the affective qualities of music. For the present study, six songs, representing the main clusters of [11] were chosen. All the selected stimuli are in a major tonality. Each excerpt had a duration of about 30 seconds; a list of the stimuli is reported in AppendixA.

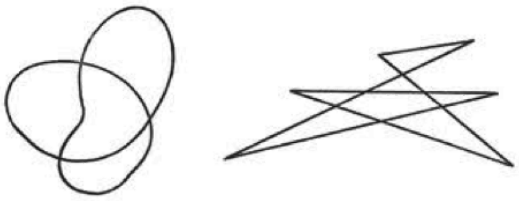

Figure 1. The two forms named maluma (on the left) and takete (on the right) [12].

Figure 2. The two colors that constitute the second sensory scale.

3.3 Materials

Sensory scales were first introduced by Da Pos [5] with the aim of substituting Osgood's verbal scales with really sensory ones. For instance, instead of asking the observer where he/she would have placed his/her light impression in the continuum between 'warm and cold' expressed by words, they made the observer feel his/her hands cool or warm by plunging them in cold and warm water. The results obtained confirmed the hypothesis that multisensory scales greatly improve the efficiency of the semantic differential in enlightening the impact that perceived objects and events determine in the human mind. Specifically we prepared the following material:

- maluma - takete [12], computer visualization of the two visual forms (cm 4,3 x 4, 3);
- blue - orange, the computer display of the two colors (NCS notation: S 2055-B10G, S 1080-Y70R, cm 4,3 x 4, 3);
- hard - soft, a piece of wood of cylindrical shape and a cylinder of polystyrene foam (16x3x3 cm; 16x6x6 cm);
- smooth - rough, N 1200 and N 30 sandpapers (cm 15x10,5);
- bitter - sweet: a bitter substance (Zefirus Calma Plant, 2 drops in a small cup) and water with sugar (1 teaspoon of sugar in a small cup);
- heavy - light: a dark plastic bottle full of liquid (500 ml) and the same bottle without liquid (5 g). The dull color of the bottle didn't allow participants to distinguish the full from the empty bottle;
- cold - warm: one cup of cold water and one cup of warm water (temperature: 5° and 40°).

3.4 Procedure

The sound files were represented on the computer screen by small icons with the number of the musical excerpts. Participants usually listened for one time to the excerpt (30 seconds), but they had the possibility to listen to the songs as many times as they wanted. To avoid repetition, sensory and semantic scales were administered randomly. The experiment consisted in expressing a subjective judgment on the characteristics of the song heard by placing the cursor inside a horizontal bar at the point that was considered more representative of the listeners feelings. Each excerpt was evaluated along the 20 scales (7 sensory and 13 verbal) and each rate for every scale was registered by participants by clicking on a bar put under the cursor. Once the subjective value was registered, the participant could express the following one.

The average duration of the experiment was 20-25 minutes, but, interestingly enough, musicians tended to complete the task in a longer time. Probably they weighed their answers in a more careful way, since the musical excerpts stirred emotions connected to the autobiographical memory, thus activating more complex associations. To evaluate the expressive characteristics of the excerpts, a new version of Osgood semantic differential was used [13]. We used thirteen verbal scales corresponding to Osgood's three main factors: activity (1, 5, 10, 12) evaluation (2, 4, 6, 7, 8, 9), and power (3, 11, 13).

- Active - Passive
- Boring - Interesting
- Slow - Fast
- Superficial - Deep
- Tense - Relaxed
- Masculine - Feminine
- Clear - Confused
- Undesirable - Desirable
- Brilliant - Dark
- Simple - Complex
- Shaken - Calm
- Intimate - Open air
- Gentle - Violent

3.5 Results

Initially, the average scores for the musicians and the non-musicians subjects have been separately calculated. The two set of values present a high correlation value ($r(118) = 0.87$, $p < .001$, where r is the Pearson's correlation coefficient and p-value is computed using algorithm AS 89 [14]), implying a high agreement between musicians and non-musicians. Then, the following results includes the responses of both groups.

The Cronbach's α statistic has been computed to test the inter-subjects reliability. Results show that subjects are able to rate music on the seven non-verbal sensory scales in a highly consistent way ($\alpha = 0.90$), i.e. subjects are able to recognize the sensorial stimuli of the non verbal scales and to associate them with musical stimuli in a meaningful way, although this value is slightly lower than the Cronbach's statistic computed for the verbal scales only ($\alpha = 0.96$) and for all (both verbal and sensory) the scales ($\alpha = 0.94$).

Figure 3 represents the average subjective evaluations on each sensory scale; musical excerpts are reported along the x-axis and are identified with the number listed in Appendix A. In addition, error bars are displayed (standard error of means) for each average value. It can be noted that the musical stimuli are judged very differently on some scales (e.g. maluma-takete), while the differences are less marked on other ones (e.g., hard-soft).

An ANOVA analysis was carried out in order to emphasize the average values that are significantly different. Table 1 shows the significance levels (p-value) of the differences between each pairs of musical excerpts. P-values are corrected by means of False Discovery Rate (FDR) using the Benjamini-Hochberg procedure [15], which relies on the p-values being uniformly distributed under the null hypothesis. Accordingly, the procedure consists of sorting the p-values in ascending order, and then dividing each observed p-value by its percentile rank to get an estimated FDR. Stimuli 1 and 4 share the quality maluma, while 2, 3, 5, 6 belong to the category takete. Brahms' violin concerto (1) and Mozart's flute concerto (4) were judged significantly different from all the other excerpts. It's interesting to notice that the pairs of stimuli discriminated by the scale maluma/takete are the same differentiated by the scale light/ heavy. We can hypothesize that the listening of the stimuli aroused in participants an association between maluma and lightness. The sensory scales blue/orange and soft/hard don't convey any significant result; Mozart and Brahms are considered the bluest and the softest stimuli, but the results don't allow us to discriminate between couples of excerpts. The scale smooth/rough enucleates excerpt 6 as the roughest. Brahms' horn trio (6) significantly differs from excerpts 1, 2, 4, 5. Also Bizet (3) is felt rough enough, since it differs significantly from 1, 2 and 4. The scale sweet/bitter is characterized by results very similar to the previous one. Brahms and Bizet are significantly different from stimuli 1 and 4. The sweetest excerpt is Mozart and it differs significantly from stimuli 2, 3 and 6. Also in the scale warm/cold, Brahms and Mozart are considered the warmest pieces, since they differ significantly from every other excerpt. Other significant results regard stimulus 6, which differs significantly from all the other excerpts, since it is considered the coldest.

4. EXPERIMENT 2

4.1 Participants

Participants, recruited on a voluntary basis, were 25, of which 10 musicians (age range 23-47, mean age 37.2; 3 women and 7 men) and 15 non-musicians (age range 24-77, mean age 56.1; 10 women and 5 men).

4.2 Stimuli

Six stimuli were chosen from the Western classical repertoire. Unlike the first experiment, all the selected stimuli

Table 1. Significance p values with FDR correction of the differences between pairs of excerpts of Experiment 1. Blank cells mean $p > .05$

	Ma/Ta	Bl/Or	Ha/So	Sm/Ro	Bi/Sw	He/Li	Co/Wa
1-2	<.001					.002	.009
1-3	<.001			.005	.029	.001	.018
1-4							.019
1-5	<.001					.010	.072
1-6	<.001			<.001	.003	<.001	<.001
2-3				.013			
2-4	<.001				.032	.001	<.001
2-5							
2-6				<.001	.037		.005
3-4	<.001			.020	.003	.001	<.001
3-5							
3-6					.038		.020
4-5	<.001					.003	.004
4-6	<.001			<.001	<.001	<.001	<.001
5-6				<.001	.023		.016

Table 2. Significance p values with FDR correction of the differences between pairs of excerpts of Experiment 2. Blank cells mean $p > .05$

	Ma/Ta	Bl/Or	Ha/So	Sm/Ro	Bi/Sw	He/Li	Co/Wa
1-2		<.001		<.001	.002	.001	
1-3	.001	<.001	.001	<.001	.015	.001	
1-4		<.001		<.001	.029	.002	
1-5			.016		.001	.004	.013
1-6		.050					
2-3	.047		.020				
2-4							
2-5		.050	<.001	<.001	<.001	<.001	
2-6				.008	<.001	<.001	
3-4			.020	.042			
3-5	<.001	.050	<.001	<.001	<.001	<.001	.013
3-6	.012		.001	<.001	<.001	.002	.024
4-5	.011	.050	<.001	<.001	<.001	<.001	.039
4-6				.042	<.001	.006	
5-6			.007	.008	.002	.006	

are in a minor tonality. The first four musical excerpts were chosen from [10]. The fifth and sixth stimuli were chosen because they were thought not to belong either to the category high arousal-negative valence, either to the category low arousal-negative valence as pointed out by Bigand et al. [10] for minor tonalities. Each excerpt had a duration of about 30 seconds; a list of the stimuli is reported in AppendixA.

4.3 Materials and procedure

Materials and procedure are the same of Experiment 1.

4.4 Results

The average scores separately computed for the musicians and the non-musicians subjects present a high correlation value ($r(118) = 0.86$, $p < .001$, where r is the Pearson's correlation coefficient and p-value is computed using algorithm AS 89 [14]), implying a high agreement between musicians and non-musicians. Then, the following results include the responses of both groups.

The Cronbach's α statistic shows that subjects of Experiment 2 rated the musical excerpts on the seven non-verbal sensory scales in a highly consistent way ($\alpha = 0.90$), as for Experiment 1, a value that is slightly lower than the Cronbach's statistic computed for the verbal scales only ($\alpha = 0.95$) and for all (both verbal and sensory) the scales ($\alpha = 0.93$).

Figure 4 represents the average subjective evaluations on the scale indicated for each musical excerpt examined. In addition, error bars are displayed (standard error of means).

Table 2 shows the significance levels (p) of the differences between pairs of tracks. Two couples of excerpts are significantly differentiated in every sensory scale (3-5; 4-5). This means that Bach's Badinerie (5) is felt as juxtaposed both to Chopin's Prelude (3) and to Liszt's Tasso (4) and these pairs of stimuli are seen as opposites. Another interesting juxtaposition regards excerpts 1 and 3, which significantly differ in almost every sensory scale except the cold/warm scale. The sensory scale maluma/takete significantly differentiates excerpt 3 (Chopin) from 1 (Mozart), 2 (Wagner), 5 (Bach) and 6 (Rossini). This implies that Chopin's Prelude is felt as the sharpest excerpt and this is probably due to the particularly percussive style chosen by the pianist. Also excerpt 4 (Liszt) and 5 (Bach) are significantly differentiated by the sensory scale maluma/takete. As regards the sensory scale blue/orange, it is interesting to notice how Mozart (1) and Bach (5) are considered the bluest excerpts. Mozart significantly differs from stimuli 2, 3, 4 and 6, while Bach significantly differs from 3 and 4. The scale hard/soft particularly discriminates stimulus 5 (Bach). This excerpt is considered the softest one, since it differs significantly from every other stimulus. The same happens for 3 (Chopin), considered the hardest, and significantly differentiated from every other stimulus. As regards the scales smooth/rough, bitter/sweet and heavy/light, significant differences can be seen between excerpts 1, 5, 6 and 2, 3, 4 respectively. This result is particularly relevant for the fact that the group formed by tracks 1, 5, 6 is characterized by smoothness, sweetness and lightness as opposed to the roughness, bitterness and heaviness of the other triad. Inside the scale smooth/rough, even excerpt 3 is differentiated from 4, thus emphasizing the roughness of Chopin's Prelude as opposed to Liszt's symphonic poem. As regards the scale cold/warm, the key excerpt is n. 5, which is felt as the warmest and which is significantly different from stimuli 1, 3 and 4. In this scale we don't find extreme values, since it is characterized by great inter-participants variability, determining similar average values. Strangely enough, Wagner is perceived as warmer than Mozart and this is probably due to the fact that this excerpt is perceived as more violent and the heat was intended as a quality associated with burning.

5. DISCUSSION

In both experiments sensory scales tend to configure according to a similar scheme with great consistency. In particular, it is interesting to notice how the quality maluma always couples with blue, while the quality takete always couples with orange. The only exception regards excerpt 2 in Experiment 2, R. Wagner, Tristan, Act 3, in which the quality orange and maluma are associated, even if with very low values. Besides, in both experiments, Mozart (flute concerto and piano concerto) is evaluated as the bluest and most maluma composer, together with Bach (Badinerie) and Brahms (violin concerto).

As regards the sensory scales, we see how the scales maluma/takete, smooth/rough, sweet/bitter and light/heavy provide significant values; participants labelled the excerpts with great consistency. More problematic are the scales blue/orange and soft/hard; these two scales don't provide significant values, apart from the blue quality of Mozart's piano concerto and Bach's Badinerie and the soft quality of Brahms' violin concerto and Mozart's flute concerto. This result is partially in contrast with research based on the association between music and colours. Researchers of the University of Berkeley found that people tend to pair faster-paced music in a major key with lighter, more vivid, yellow colours, whereas slower-paced music in a minor key is more likely to be teamed up with darker, greyer, bluer colours. US and Mexican participants were asked to choose colours that were most/least consistent with 18 selections of classical orchestral music by Bach, Mozart, and Brahms. In both cultures, faster music in the major mode produced colour choices that were more saturated, lighter, and yellower whereas slower, minor music produced the opposite pattern, characterized by desaturated, darker, and bluer colours [16]. This association of faster-paced music in major key with yellow colours is not confirmed in our study, since none of the excerpts in major key is significantly characterized by the orange quality. On the contrary, it is confirmed the association of blue colours with music in the minor mode.

In order to observe the interaction of the semantic scales with the sensory ones, Table 3 and 4 show the qualities of the six excerpts of Experiment 1 and 2, based on the subjects' evaluation. In particular, only rates significantly different from 50 (the middle point of the evaluation scale) are reported. It's interesting to notice how Bizet (3 Exp 1), Brahms' horn trio (6 Exp 1), Chopin (3 Exp 2) and Liszt (4 Exp 2), described verbally with the same characteristics, (active, interesting, fast, deep, tense, masculine, complex, shaken, open air and violent), receive significantly different sensorial connotations. This makes us suppose that sensory scales can convey some specific sensations that cannot be described verbally. Both Brahms and Chopin are in ternary rhythm with significant changes from ternary to binary subdivision, they share a similar articulation (many notes played marcato) performed by the violin and by the right hand of the pianist and a common accompaniment based on repeated piano octaves. Participants were however able to recognize a slight sensory difference between the two pieces, represented by Chopin's higher hardness, due to the presence of many accents, and by Brahms' higher coldness, due to the obsessiveness of the rhythmic configuration. Another interesting result deriving from sensory scales is represented by the apparent unusual association of the quality takete with the quality smooth applied to Vivaldi (2 Exp 1) and Boccherini (5 Exp 1). Also in this case participants' evaluation seems to recall timbral elements; the staccato and pizzicato generate an idea of sharpness delimiting only the contours of an ideal figure perceived as covered by a smoothly surface. Comparing the two Mozart excerpts (4 Exp 1 and 1 Exp 2) we see that they have 12 features in common. Once more, sensory scales allow us to discriminate between two apparently similar stimuli. The flute concerto differs from the piano concerto in softness, smoothness, sweetness, lightness and warmness, while, from the verbal point of view, we can recognize their diversity only from the higher darkness of the piano concerto. In this case, the qualities underlined by sensory scales offer us some hints about the general mood of the piece, allowing some insights into the depressive and sombre atmosphere of the second excerpt. Also Brahms' violin concerto (1 Exp 1) and Bach's Badinerie (5 Exp 2) have 12 features in common, but in this case, sensory scales report a similarity which is not matched by verbal scales. Verbal scales are crucial in discriminating the swiftness and brilliantness of Bach, but the sensory scales provide useful information about timbral aspects, since both stimuli are played by two wind instruments (oboe and flute) with a particularly warm, soft and rich sound. Further research is needed to confirm our hypothesis on the kind of information provided by sensory scales. In particular, it is interesting to verify which kind of metric relations (if any) can be found between the sensory scales (e.g., see [17]). This step could further the definition of a low-dimensional sensory space, to be used in music information retrieval applications.

Table 3. The qualities of the six excerpts of Experiment 1, based on the subjects' evaluation. Blank cells mean that no significant trend has been found.

1	2	3	4	5	6
maluma	takete	takete	maluma	takete	takete
soft			soft		
smooth	smooth		smooth	smooth	rough
sweet			sweet		bitter
light			light		heavy
warm			warm		cold
	Active	Active	Passive	Active	Active
	Interesting	Interesting	Interesting	Interesting	Interesting
Slow	Fast	Fast	Slow	Fast	Fast
	Superficial	Deep	Deep	Superficial	Deep
Relaxed		Tense	Relaxed		Tense
Feminine		Masculine	Feminine		Masculine
Clear	Clear		Clear	Clear	
Desirable	Desirable	Desirable	Desirable	Desirable	
	Brilliant	Brilliant		Brilliant	
Simple		Complex	Simple	Simple	Complex
Calm	Shaken	Shaken	Calm	Shaken	Shaken
Intimate	Open air	Open air	Intimate	Open air	
Gentle	Gentle		Gentle	Gentle	Violent

Table 4. The qualities of the six excerpts of Experiment 2, based on the subjects' evaluation. Blank cells mean that no significant trend has been found.

1	2	3	4	5	6
maluma		takete		maluma	
blue				blue	
		hard		soft	
smooth	rough	rough		smooth	
	bitter	bitter	bitter	sweet	sweet
	heavy	heavy	heavy	light	
				warm	warm
	Active	Active	Active	Active	Active
Interesting	Interesting	Interesting	Interesting	Interesting	Interesting
Slow	Slow	Fast	Fast	Fast	Fast
Deep	Deep	Deep	Deep	Deep	
Relaxed	Tense	Tense	Tense	Relaxed	Tense
	Masculine	Masculine	Masculine	Feminine	
Clear				Clear	Clear
Desirable				Desirable	Desirable
Dark	Dark			Brilliant	Brilliant
Simple	Complex	Complex	Complex	Simple	
Calm	Shaken	Shaken	Shaken		Shaken
Intimate			Open air		Open air
Gentle		Violent	Violent	Gentle	

6. CONCLUSIONS

Two experiments were carried out in order to test the possibility of describing music through non verbal sensory scales. The overall findings indicate that subjects' rates on sensory scales are consistent and the results support the hypothesis that sensory scales can convey some specific sensations that cannot be described verbally, offering interesting insights to deepen our knowledge on the relationship between music and other sensorial experiences.

Acknowledgments

The authors wish to acknowledge prof. Alessandro Paccagnella, DEI - University of Padova, for helpful discussions and suggestions.

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A. APPENDIX: DESCRIPTION OF THE MUSICAL EXCERPTS

Experiment 1. [18]

1 - J. Brahms - Violin Concert in D major, op. 77, Adagio. Thematic exposition on the oboe of a slow, pure melodic line, built on the tonic major chord, and standing apart above a timbrally rich, sustained orchestra. The doubling of lines serves to reinforce the fullness of sound of the whole.

2 - A. Vivaldi - Trio Sonata in C major, RV82, Allegro. Vigorous and cheerful passage, characterized by a thematic development entrusted to the combination of lute and violin. The violin plays rapid trills, thus complementing the lute's quick, athletic ornaments with its own sharp notes. The ascending tone is emphasized by the intensive use of progressions enriched by the continuous dialogue between lute and violin.

3 - G. Bizet - Symphony no. 1 in C major, Allegro vivo. The work starts with an opening tutti full of strength and force, like a brisk announcement. This bold first idea is answered by a timid pp reply by the winds which are soon harassed again by the tutti repeating the same announcement this time leading to G major.

4 - W. A. Mozart - Flute Concerto G Major, II. Andante non Troppo. Gentle and relaxed theme developed by the flute through an expanse figuration of demisemiquavers. The orchestra accompanies this quiet moment with soft pizzicato and tender eight notes, while the violin answers the flute with responding demisemiquavers figurations.

5 - L. Boccherini - String Quintet in E major, op. 11, no. 5, Minuetto. This popular piece is full of grace and elegance. The dance rhythm is underlined by the upbeat quarter line in the first violin embellished by a characteristic grace note.

6 - J. Brahms - Trio, piano, violin, and horn, mvt 2. Repetition of a thematic rhythmic motif, above major key harmony, punctuated by brass effects, at a rapid tempo and with a very rich sound. The sonority of the French horn enriches the timbral quality of the ensemble, and the structure of the piece is reinforced by the presence of transposed harmonic progressions.

Experiment 2. [18]

1 - W. A. Mozart, Piano concerto Adagio, K 488. Theme in a minor key, played at a very slow tempo. Melancholic trochaic rhythm characterized by a large intervallic distance between sounds grouped by the left hand, and the melody in the high register of the right hand, creating a void in the middle of the range which reinforces the desolate aspect of the theme.

2 - R. Wagner, Tristan, Act 3. Declamation in the low register of the strings of the orchestra. Very strong harmonic tension within a minor key with on the 6th chord against a dissonant second. Slow and dilated tempo. The upper parts ascend in pitch by chromatic movement, with unresolved intervallic tensions. The absence of a bass creates a feeling of vertigo and of ascension into infinity.

3 - F. Chopin, Prelude 22. Motif in the low register of the piano repeated obsessively and characterized by pounding octaves in the left hand, dissonant harmonies, and accompanied in the right hand by a panting rhythm, accentuating the weak part of the beat, and breaking up the violent and hopeless discourse of the left hand.

4 - F. Liszt, Tasso Lamento and Trionfo (from letter A allegro strepitoso). Powerful orchestral line develops tense minor harmonies on a choppy rhythm and at a rapid tempo, supported by the entry of the percussion.

5 - J. S. Bach, Badinerie from Orchestral Suite n. 2 BWV 1067. Exposition of the main theme by the flute in the typical dance rhythm characterized by a joyous and light feeling. The orchestral accompaniment is very simple and elegant.

6 - G. Rossini, La Gazza Ladra (The Thieving Magpie) - Allegro con brio. Particularly fast and tense orchestral passage characterized by frequent accents and chromatic contrasts. Triplets figurations in the violins and violas are punctuated by the other strings playing a very pressing and obstinate rhythm.

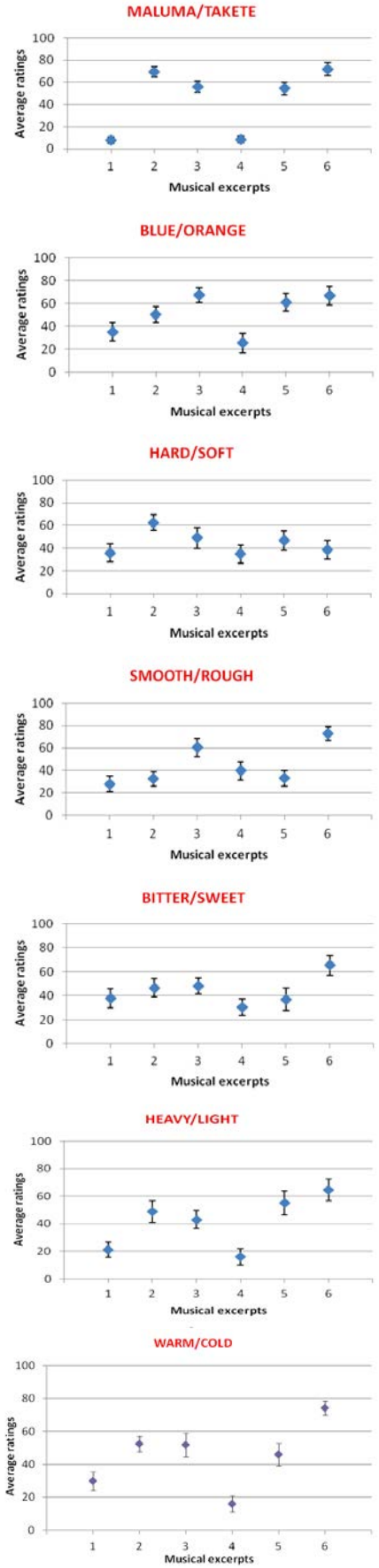

Figure 3. The average scores obtained by the six musical excerpts of Experiment 1 on the seven sensory scales. Bars indicate the standard error.

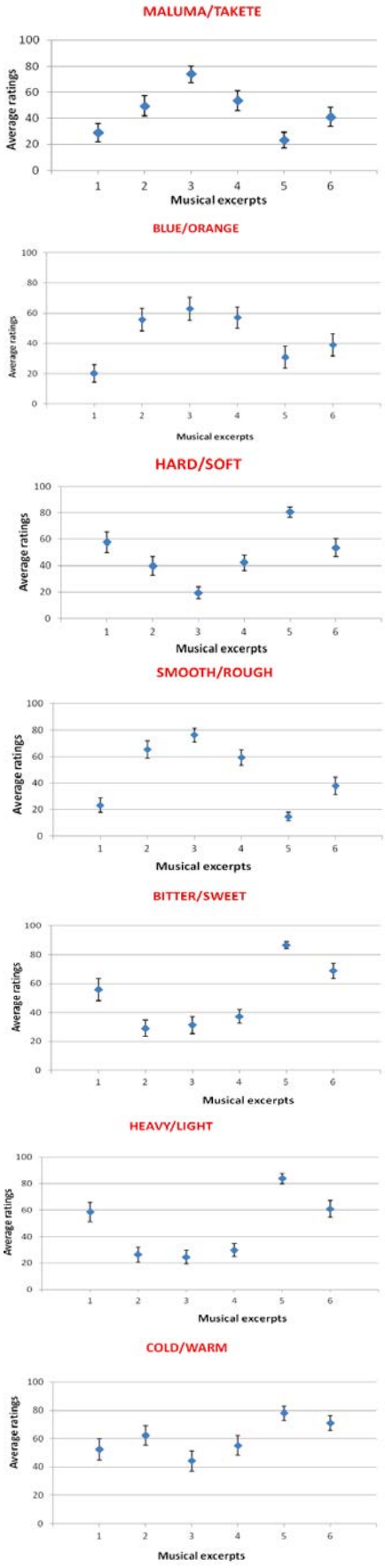

Figure 4. The average scores obtained by the six musical excerpts of Experiment 2 on the seven sensory scales. Bars indicate the standard error.