Mozart is still blue: a comparison of sensory and verbal scales to describe qualities in music

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ABSTRACT

An experiment was carried out in order to assess the use of non-verbal sensory scales for evaluating perceived music qualities, by comparing them with the analogous verbal scales. Participants were divided into two groups; one group (SV) completed a set of non-verbal scales responses and then a set of verbal scales responses to short musical extracts. A second group (VS) completed the experiment in the reverse order. Our hypothesis was that the ratings of the SV group can provide information unmediated (or less mediated) by verbal association in a much stronger way than the VS group. Factor analysis performed separately on the SV group, the VS group and for all participants shows a recurring patterning of the majority of sensory scales versus the verbal scales into different factors. Such results suggest that the sensory scale items are indicative of a different semantic structure than the verbal scales in describing music, and so they are indexing different qualities (perhaps ineffable), making them potentially special contributors to understanding musical experience.

1. INTRODUCTION

Traditionally, studies on music qualities such as perceived emotions, performance styles, or timbre nuances are communicated through words. A sophisticated example of how words can be used to generate an understanding of underlying semantic constructs is the semantic differential [1], a tool that allows the measure of the connotative meaning of music through bipolar rating scales. A novel approach, based on non-verbal sensory scales applied to music, was proposed by Murari et al. [2]. Sensory scales were first introduced by [3] with the aim to study perceived qualities of colours by substituting Osgood's verbal scales with sensory ones. This approach makes use of multisensorial scales instead of the corresponding verbal scales: for instance, instead of asking the observer where he/she would place his/her impression about a piece of music along the continuum between "warm" to "cold" expressed by words, the observer immerses his/her hands in cold and warm water, deciding which sensation best "describes" the music. In Murari et al. [2], musically trained and untrained listeners were required to listen to 12 music excerpts (two experiments were carried out, involving 6 excerpts each) and to evaluate each along seven different non-verbal scales (see [2] for a detailed definition of the scales and materials used). The data showed that subjects' ratings on non-verbal sensory scales are consistent, offering interesting possibilities about the relationship between music and other sensorial information. One could speculate that the consistency was due to the direct link between the sensory experience and the verbal analog (or verbal "equivalent"), such as sensorial warmth from warm water, and the word "warm" in describing a section of music. Alternatively, the results may suggest that non-verbal scales convey specific sensations that cannot be described verbally. In other words, asking a subject to evaluate a piece of music according to the sensation of warmth felt by immersing ones hand in water does not give the same results as verbally asking whether that music piece is warm or cold. This explanation assumes that evaluation based on sensorial information is not (or is less) mediated by verbal associations. To better explain this concept, consider the word "blue". This word can mean sadness (I feel blue), a musical style (the blues), a colour etc. Therefore, the subject's evaluation may be influenced by a specific but non-unique association between the word and one of its meanings. On the contrary, if the sensory perception of the colour blue has a more limited number of interpretations/representations, the subject's evaluation may be less influenced than its verbal counterpart. Unfortunately, the results of [2] does not offer evidences supporting one or the other alternative, because the experimental design did not include a comparison between sensory scales and the verbal analogs.

This paper presents the result of a new experiment, designed to better understand the relation between sensory and verbal scales. 25 participants were asked to evaluate six musical excerpts using non-verbal sensory scales (visual, auditory, tactile, haptic and gustative) and the "equivalent" verbal scales. Three additional verbal scales were introduced to reflect Osgood's semantic differential dimensions of evaluation (using a scale with poles pleasant-unpleasant), potency (strong-weak), and activity (active-passive). Moreover, we added another three scales (very familiar-very unfamiliar; I like this piece a lot-I dislike this piece a lot; happy-sad) to see if familiarity has a systematic influence on the responses, and to determine whether a large amount of variance in the verbal and sensory ratings could be accounted for by how much the listener liked or did not like

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the piece and, finally, to cover a contemporary perspective of emotional dimensions [4, 5].

The aims of the paper are: (i) to evaluate the reliability of the non-verbal measures by comparing them with the results reported in [2]; (ii) to evaluate if and which differences can be found between non-verbal sensory scales and the analogous verbal scales.

2. METHOD

2.1 Participants

Twenty-five participants were recruited on a voluntary basis, of whom 13 rated themselves as "musician" (age range 17-49, mean age 32,15; 4 women and 9 men) and 12 as "non-musician" (age range 17-73, mean age 42,7; 6 women and 6 men). The SV group (completing the set of sensory scales before) was made up of 14 participants of whom 4 were musicians (age range 22-36, mean age 26; 4 men) and 10 were non-musicians (age range 17-56, mean age 28,4; 4 women and 6 men). The VS group (completing the set of verbal scales before) was made up of 11 participants of whom 9 were musicians (age range 17-49, mean age 38,3; 4 women and 5 men) and 2 were non-musicians (age range 41-73, mean age 57; 2 women). The SV and VS groups are not balanced in the number of musicians and non-musicians subjects; however, previous experiments [2] didn't show significant differences between musicians and non-musicians during a similar evaluation task. A questionnaire was administered to determine the participants' musical background and experience, including listing the instruments played and number of years trained in each instrument.

2.2 Stimuli

For the present study, six music pieces, representing the three main clusters of Rodà et al. [6], were chosen. Three selected stimuli were in a major tonality, while the other three were in a minor tonality. Each excerpt had a duration of about 30 seconds. A list of the stimuli is reported in Appendix A.

2.3 Materials

We prepared the following material to use for the bipolar sensory scales:

1. maluma - takete [7], two pieces of paper with the two visual forms (cm 4,3 x 4, 3);
2. blue - orange, two cards with the two colours (NCS notation: S 2055-B10G, S 1080-Y70R, cm 4,3 x 4, 3);
3. hard - soft, a piece of wood of cylindrical shape and a cylinder of polystyrene foam;
4. smooth - rough, N 1200 and N 30 sandpapers;
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);
6. heavy - light: a dark plastic bottle full of liquid and the same bottle without liquid;

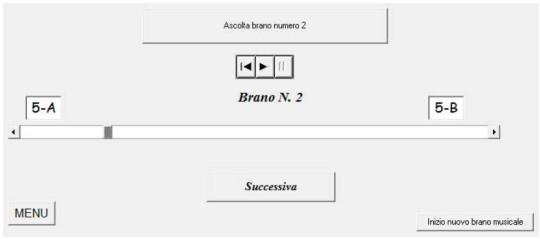

Figure 1. User interface employed in the experiment.

7. cold - warm: one cup of cold water and one cup of warm water;
8. tense - relaxed: iron wire covered with cloth and rubber band covered with cloth.

2.4 Procedure

Some participants were selected at random to complete the set of sensory scales before, and the verbal ones later; the other participants completed the study in the reverse order: verbal first, then sensory. Within the two groups of scales, the order of the scales, the order of the poles of each scale and the order of the stimuli were randomised repeatedly. The participants could listen to the stimulus as frequently as they wished. The verbal scales used had poles for item as follows:

1. maluma-takete
2. blue-orange
3. hard-soft
4. smooth-rough
5. bitter-sweet
6. heavy-light
7. cold-warm
8. tense-relaxed
9. active-passive
10. strong-weak
11. pleasant-unpleasant
12. very familiar-very unfamiliar
13. I like this piece a lot-I dislike this piece a lot
14. happy-sad

Each sound file stimulus was initiated by clicking a button on the computer screen. Each musical excerpt was heard over headphones.

A research assistant ensured that the correct pairs of materials were presented in the given order for each sensory scale item, based on a code displayed on the computer screen. In this way, non-verbal sensory scales were never explicitly associated to verbal descriptors. The procedure consisted of expressing a subjective evaluation on the characteristics of the stimulus heard by placing the indicator inside a slider at the position that was considered representative of the association strength either with the sensations on which the listener was focused (for the sensory items), or with the meaning of the verbal terms proposed (for the verbal items). All 6 excerpts were rated in one block and then again in another block. One block contained the sensory scale items and the other block contained the verbal scale items.

3. RESULTS

A two-way multivariate analysis of variance (MANOVA) was carried out with the six musical excerpts and the two groups (SV and VS) as independent variables and the 22 scales (8 sensory and 14 verbal) as dependent variables. Significant main effects were found for musical excerpt (F(22; 120) = 13.2 $p < .001$) and group (F(22; 116) = 2.92 $p < .001$). Moreover a significant interaction was found between musical excerpts and groups (F(22; 120) = 2.26 $p < .001$).

A post-hoc pairwise comparison was carried out using FDR correction. Table 1 shows the significance levels of the differences between pairs of musical excerpts along the eight sensory scales.

The strongest juxtaposition is represented by the couple Brahms-Chopin which was significantly different along every sensory scale except blue-orange, and by the couple Chopin-Bach, significantly different along every scale except the maluma-takete and blue-orange. Chopin's Prelude is significantly different from all the other five excerpts for hardness, roughness and tension. A similar juxtaposition is also shared by the couples Bizet-Brahms, Bizet-Vivaldi and Bizet-Mozart which are significantly different for hardness and roughness. The most striking similarity is represented by the couple Vivaldi-Bach which doesn't differ significantly in any sensory scale. Inside the cluster represented by the excerpts Brahms, Vivaldi, Mozart and Bach, we notice the strong similarity between the couples Bach-Mozart, Bach-Brahms and Vivaldi-Mozart with a significant difference only in one sensory scale. In particular, the bitterness of Mozart is a quality that significantly differentiates this stimulus from Bach, Vivaldi and Brahms. No significant difference appears for the scale blue-orange.

3.1 Factor analysis

A factor analysis with a four factor solution was conducted and the solution was rotated according to the Varimax method. This was applied three times, once using the whole group of participants and once for each of the separate groups (SV, VS). In the first case, the explained variance is 67,63%. As can be seen from Table 2, seven sensory scales (maluma-takete, hard-soft, smooth-rough, bitter-sweet, heavy-light, cold-warm, tense-relaxed) are better explained by the first factor. The second factor comprises five verbal scales (hard-soft, smooth-rough, bitter-sweet, heavy-light, tense-relaxed) together with the scales pleasant-unpleasant, very familiar-very unfamiliar, I like this piece a lot-I dislike this piece a lot. The third factor comprises the two verbal scales active-passive and strong-weak and the fourth factor comprises the scales blue-orange, both sensory and verbal. The scales maluma-takete (verbal), cold-warm (verbal) and happy-sad are not well aligned with any of the four factors, since they appear with relatively low factor loadings in every factor.

As regards factor analysis performed on separate groups, the explained variance for the SV group is 73,43% (see Table 3). Factor 1 includes eight verbal scales: hard-soft, smooth-rough, bitter-sweet, heavy-light, tense-relaxed, pleasant unpleasant, very familiar-very unfamiliar, I like this piece a lot-I dislike this piece a lot; factor 2 is made up of the sensory scales maluma-takete, hard-soft, smooth-rough, heavy-light, tense-relaxed, and the verbal scale maluma-takete; factor 3 puts together the verbal scales blue-orange, cold-warm, active-passive, strong-weak, happy-sad; factor 4 includes the remaining sensory scales: blue-orange, bitter-sweet and cold-warm.

Regarding the VS group, the explained variance is 66,57% (see Table 4). In this case, sensory scales are less consistently grouped into one factor, since they split between factor one (cold-warm, tense-relaxed), factor two (maluma-takete, blue-orange, hard-soft, bitter-sweet) and factor three (heavy-light). Verbal scales are mainly grouped into the first factor, apart from the scales blue-orange, heavy-light and cold-warm belonging to factor three and the scales active-passive and strong-weak shaping factor four.

	Factor			
	1	2	3	4
mal-tak	**-.675**	-.155	-.150	.337
blu-ora	-.062	.029	-.071	**.836**
har-sof	**.808**	.276	.027	-.188
smo-rou	**-.613**	-.332	-.429	-.172
bit-swe	**.709**	.085	-.042	.352
hea-lig	**.705**	.204	-.030	.126
col-war	**.590**	.319	-.211	.197
ten-rel	**.736**	.269	.166	-.093
mal-tak	-.399	-.439	-.121	.439
blu-ora	.221	.188	-.305	**.707**
har-sof	.529	**.632**	.275	-.045
smo-rou	-.422	**-.688**	-.210	-.018
bit-swe	.407	**.725**	-.086	.051
hea-lig	.494	**.615**	.039	.167
col-war	.379	.417	-.491	.316
ten-rel	.472	**.671**	.223	-.050
act-pas	.070	-.088	**.892**	-.163
str-wea	.229	.118	**.868**	-.129
ple-unp	-.241	**-.837**	.135	-.156
fam-unf	.017	**-.687**	.046	.003
lik-dis	-.149	**-.788**	.194	-.035
hap-sad	-.445	-.382	.457	-.328

Table 2. Scores of the coefficients of the evaluation scales and their assignment to the respective factor. The upper rows refer to non-verbal sensory scales, the lower ones to the verbal scales. All subjects.

Both the analyses on all subjects (Table 2) and on the SV group (Table 3) show a quite clear distinction between sensory and verbal scales, apart from the scale blue-orange in Table 2 and the scale maluma-takete in Table 3. For the VS group (Table 4), the first and third factors are characterized by a less accentuated division between sensory and verbal scales.

In order to determine in which way each musical excerpt is represented by the different factors, factor-based scores were generated (see Fig. 2) for each different factor analysis (all participants, SV group, VS group). An ANOVA was carried out and a graphic representation of the mean

	Mal/Tak	Blu/Ora	Har/Sof	Smo/Rou	Bit/Swe	Hea/Lig	Col/War	Ten/Rel
Bra-Viv				.028				.026
Bra-Biz	.000		.000	.000		.008		.000
Bra-Moz					.000	.013		
Bra-Cho	.000		.000	.000	.000	.000	.000	.000
Bra-Bac	.024							
Viv-Biz	.045		.009	.024		.000		
Viv-Moz					.003			
Viv-Cho			.000	.000	.000	.000		.000
Viv-Bac								
Biz-Moz	.000		.003	.004				.004
Biz-Cho			.047	.038	.006			
Biz-Bac			.006	.003		.017		.004
Moz-Cho	.024		.000	.000		.003		.000
Moz-Bac					.005			
Cho-Bac			.000	.000	.000	.000	.000	.000

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

values of factor scores was created. Analysis on the results deriving from the whole group of participants shows that Chopin is significantly different from Brahms, Vivaldi, Mozart and Bach, but not from Bizet. The order of musical excerpts inside factor 1 from the highest average value to the lowest (see Fig. 2) is Brahms, Vivaldi, Bach, Mozart, Bizet and Chopin, showing that Brahms, Vivaldi and Bach share the qualities maluma, soft, smooth, sweet, light, and relaxed representing a sensation of gracefulness and gentleness as opposed to Bizet and Chopin sharing the sensory qualities takete, hard, rough, bitter, heavy, and tense which express a sensation of harshness and roughness. This fac-

	Factor			
	1	2	3	4
mal-tak	-.184	**-.710**	.239	-.118
blu-ora	.077	-.034	.503	**.686**
har-sof	.209	**.867**	.105	.114
smo-rou	-.479	**-.498**	.231	-.425
bit-swe	.147	.344	.277	**.625**
hea-lig	.140	**.638**	.206	.308
col-war	.270	.214	.155	**.734**
ten-rel	.212	**.796**	-.115	.196
mal-tak	-.317	**-.619**	.053	.374
blu-ora	.348	-.002	**.734**	.322
har-sof	**.659**	.517	-.153	.243
smo-rou	**-.806**	-.398	.029	-.169
bit-swe	**.735**	.381	.255	.162
hea-lig	**.759**	.257	.226	.165
col-war	.351	.212	**.727**	.313
ten-rel	**.757**	.446	-.064	.182
act-pas	.061	.218	**-.868**	-.059
str-wea	.296	.447	**-.722**	-.005
ple-unp	**-.819**	-.200	-.358	-.206
fam-unf	**-.777**	.088	.052	-.002
lik-dis	**-.722**	-.260	-.433	-.025
hap-sad	-.385	-.170	**-.621**	-.369

Table 3. Scores of the coefficients of the evaluation scales and their assignment to the respective factor. The upper rows refer to non-verbal sensory scales, the lower ones to the verbal scales. SV Group.

	Factor			
	1	2	3	4
mal-tak	-.212	**-.748**	-.187	-.040
blu-ora	-.108	**-.894**	.128	.015
har-sof	.551	**.592**	.236	.064
smo-rou	-.471	-.184	-.429	-.439
bit-swe	.144	**.596**	.538	.129
hea-lig	.422	.242	**.655**	.190
col-war	**.622**	.320	.325	-.274
ten-rel	**.633**	.306	.384	.009
mal-tak	**-.564**	-.517	-.065	-.120
blu-ora	-.297	-.106	**.816**	-.100
har-sof	**.631**	.437	.255	.217
smo-rou	**-.640**	-.262	-.122	-.241
bit-swe	**.557**	.377	.260	-.175
hea-lig	.500	.371	**.561**	.133
col-war	.408	.016	**.504**	-.324
ten-rel	**.649**	.310	.212	.183
act-pas	-.064	.020	-.011	**.901**
str-wea	.065	.079	-.016	**.896**
ple-unp	**-.759**	-.167	-.011	.083
fam-unf	**-.598**	.144	-.153	.334
lik-dis	**-.809**	-.057	.282	.065
hap-sad	-.256	-.340	**-.510**	.417

Table 4. Scores of the coefficients of the evaluation scales and their assignment to the respective factor. The upper rows refer to non-verbal sensory scales, the lower ones to the verbal scales. VS Group.

tor appears to be mainly related to aspects connected with arousal. Factor 2 includes 6 of the verbal sensory scales and the verbal scales pleasant-unpleasant, very familiar-very unfamiliar and I like this piece a lot-I dislike this piece a lot. It is best represented by the scales pleasant-unpleasant, and I like this piece a lot-I dislike this piece a lot. Once more it discriminates excerpt 5 as opposed to excerpt 1, 4, and 6 and the order of musical excerpts inside this factor is the same as for factor 1 (Brahms, Vivaldi, Bach, Mozart, Bizet, Chopin). It appears to be related to aspects connected mainly with valence. In particular, the qualities hard, rough, bitter heavy, tense, unpleasant, unfamiliar and "I dislike this piece a lot" convey a sensation of repulsion. On the other hand, the qualities soft, smooth, sweet, light, warm, relaxed, pleasant, familiar and "I like this piece a lot" represent a sensation of attraction. Factor 3 includes the scales active-passive and strong-weak. It discriminates Brahms as opposed to Bizet, Chopin, Mozart and Bach; and Mozart as opposed to Brahms, Bizet, Chopin and Bach. The order of the excerpts inside factor 3 is Mozart, Vivaldi, Brahms, Bach, Chopin and Bizet. This factor is mostly related with aspects connected with potency and activity. If we consider also the happy-sad scale (related to evaluation), which has on this factor the highest factor loading, factor 3 would include all three of Osgood's dimensions [1]. Factor 4 comprises the two scales (both sensory and verbal) connected with colours and the order of the excerpts along this factor is Vivaldi, Bizet, Bach, Chopin, Brahms and Mozart, with Vivaldi the most orange and Mozart the bluest.

Following Fig. 2, the scores along factors 1 and 2 (the first associated to sensory scales, the second to the equivalent verbal ones) are quite correlated even if differences can be found observing the couple of excerpts Brahms-Bach and Vivaldi-Bizet. We need to remember that this analysis includes all subjects and about an half of them evaluated the verbal scales before the sensory ones, with the possibility that the evaluation along the latter could be influenced by an association with the former. This hypothesis is supported by the factorial scores related to the SV group only: Fig. 3 shows that in this case the scores of the factors associated to sensory scales (factor 2 and 4) are quite different from the factors associated to the verbal ones (1 and 3).

4. DISCUSSION

The analysis of variance showed that subjects are able to significantly differentiate musical excerpts by evaluating them along non-verbal sensory scales. As seven of the eight sensory scales were also used in [2] and the six musical excerpts are a subset of the stimuli used in that work, it makes sense to compare the results of our previous and current experiments (subjects were of course different) in order to verify if the associations between musical excerpts and sensory scales are consistent. It is important to be aware that the experimental designs are different because in [2] no equivalent verbal scales were included and no division of groups (SV and VS) was carried out. Tables 5 and 6 show the qualities of the six excerpts based on the subjects' evaluations in the current and previous [2] experiments respectively. In particular, only ratings significantly different (at $p < .05$) from 50 (the mid-point of the evaluation scale) are reported according to t-tests.

It can be noted that the subjects' evaluations are mostly in agreement. In particular, Brahms, Vivaldi, Mozart and Bach are characterized by the qualities soft and smooth, both sensory and verbal (see Table 5). Each of these excerpts received very high scores in the scale "I like this piece a lot", and Bach's Badinerie was the most appreciated piece in this respect according to the mean score for the "liking" rating scale. Brahms and Bach also share the qualities sweet, light, warm and relaxed both from the sensory scales and from the verbal ones. Also in our previous experiment, Brahms' violin concerto and Bach's Badinerie had 6 significant features in common. In the current experiment, Bach's Badinerie is characterized by the orange verbal quality. This outcome differs from our previous study in which Bach was rated highest in "blue" according the evaluation on sensory scales. This same stimulus was analyzed also in a study by Palmer at al. [8], where the Badinerie was associated with a combination of orange and blue colours. The range of results across the studies could be attributed to qualities of the stimulus, together with a difference in liking/familiarity between the participant cohort.

Comparing evaluations on sensory scales and their equivalent verbal scales, we see that Mozart is characterized by the quality bitter only from a sensory point of view. This outcome is probably due to the fact that sensory scales allow a more direct appreciation of the musical excerpt which is not mediated by evaluative thoughts. Distinctive verbal attributes are passive, weak and the apparently incongruent coupling sad and pleasant. As pointed out by Taruffi and Koelsch [9], people appreciate sadness in music, since it seems to have a rewarding effect. Emotional responses to sad music are multifaceted and linked to a multidimensional experience of pleasure. Paradoxically, listening to sad music can lead to beneficial emotional effects since it provides a form of consolation and regulation of negative mood and emotion. Panksepp [10] found that sad music is more effective for arousing "chills" (i.e., intensely pleasurable responses to music) than happy music. Furthermore, Huron [11] proposed that the pleasure experienced through sad music is due to the consoling effects of prolactin, a hormone usually released when people are sad or weeping, and Schubert [12, 13] has argued that absorption with music allows a separation of negative emotions such as sadness from pleasure.

Regarding the factor analysis, interesting similarities can be found with the results of Da Pos and Pietto [3], who carried out an experiment using non-verbal sensory scales applied to evaluation of colours. In particular, sensory scales were grouped into factors different from verbal scales, similarly to what we found in our experiment. Moreover, one factor included all the three verbal scales deriving from the main Osgood's dimensions [1], as did the third factor of Table 3. The two maluma-takete scales (sensory and verbal) in the factor analysis of the VS group were assigned to

Brahms	Vivaldi	Bizet	Mozart	Chopin	Bach
maluma		takete	maluma	takete	
			blue		
soft	soft	hard	soft	hard	soft
smooth	smooth		smooth	rough	smooth
sweet	sweet		bitter	bitter	sweet
light	light			heavy	light
warm		warm		cold	warm
relaxed		tense	relaxed	tense	relaxed
maluma			maluma	takete	
			blue	blue	orange
soft	soft		soft	hard	soft
smooth	smooth		smooth	rough	smooth
sweet	sweet			bitter	sweet
light	light			heavy	light
warm		warm			warm
relaxed	relaxed		relaxed	tense	relaxed
		active	passive	active	active
weak		strong	weak	strong	strong
pleasant	pleasant	pleasant	pleasant		pleasant
			familiar		familiar
I like	I like	I like	I like		I like
	happy	happy	sad	sad	happy

Table 5. The qualities of the six excerpts based on the subjects' evaluation. Blank cells mean that no significant ($p > .05$) trend has been found. The upper rows refer to non-verbal sensory scales, the lower ones to the verbal scales.

Brahms	Vivaldi	Bizet	Mozart	Chopin	Bach
maluma	takete	takete	maluma	takete	maluma
			blue		blue
soft				hard	soft
smooth	smooth		smooth	rough	smooth
sweet				bitter	sweet
light				heavy	light
warm					warm

Table 6. The qualities of the six excerpts as evaluated in the experiments presented in [2]. Blank cells mean that no significant ($p > .05$) trend has been found.

the same factor (the second one in Table 3). The alignment of the verbal scale with the non-verbal sensory scale is indicative of the lack of a semantic association for the words maluma and takete (both "nonsense" words, but with their sound and orthographic shape bearing a resemblance to the shapes they indicate. For more details, see [14]).

5. FUTURE WORK AND CONCLUSIONS

Future work will continue to examine the relationships between sensory and verbal scales in describing musical qualities. The focus of the present research program involves examining semantic relationships, however we acknowledge that different variants for relationships may also exist and interact. For example, cross-modal psychophysical relationships may influence responses. Studies by S. S. Stevens and J. C. Stevens [15, 16] have found relationships between intensity of audio signals with intensity of sensations such as grip strength, redness saturation and so forth. For the current stimuli we did not do a direct comparison of the psychophysical intensity of the complex, realistic musical stimuli with the sensory scales, but some influence may be present and factors such as this may explain some of the less straight forward results we found.

In conclusion, subjects' ratings show notable consistency when compared with the results obtained in previous experiments [2, 3, 17], providing evidence for the reliability of the measurements obtained through sensory scales. Regarding the relation between sensory scales and their verbal equivalent, the order in which the rating task was completed (verbal scale first, versus sensory scale first) impacted on the ratings. Sensory scales appear to have less influence on "equivalent" verbal scales, but verbal scales do not seem to influence sensory scales. This provides weak, but important evidence that sensory scales are not, or need not be mediated by language. And so together, sensory

scales provide new perspectives in rating phenomena such as music, which are also distinct from verbal scales, and made reliably.

From the applicative point of view, such research can foster the development of innovative interfaces to browse audio digital collections. These new devices will allow users to interrelate in a spontaneous and even expressive way with interactive multimedia systems, relying on a set of advanced musical and gestural content processing tools, adopting descriptions of perceived qualities, or making expressive movements.

6. REFERENCES

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Appendix A

Description of the musical excerpts:
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 combining 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, 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.
5 - 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.
6 - 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.

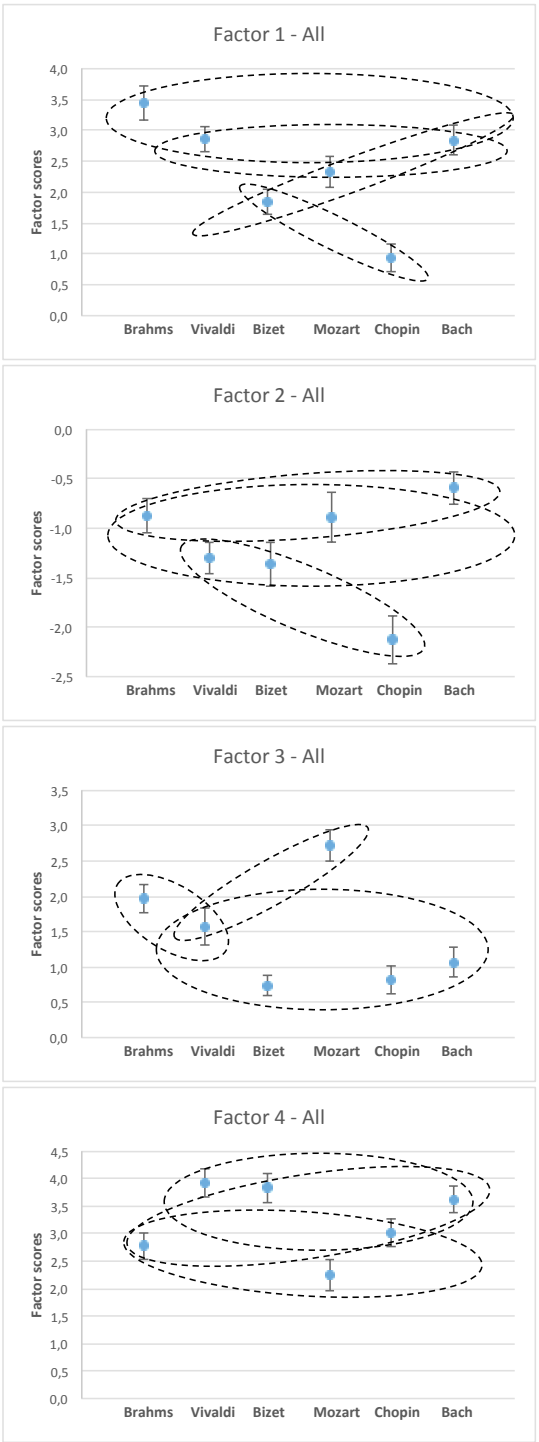

Figure 2. Scores of the music stimuli along the four main factors. Dashed ellipses group together excerpts that are not significantly different according to the ANOVA. All subjects.

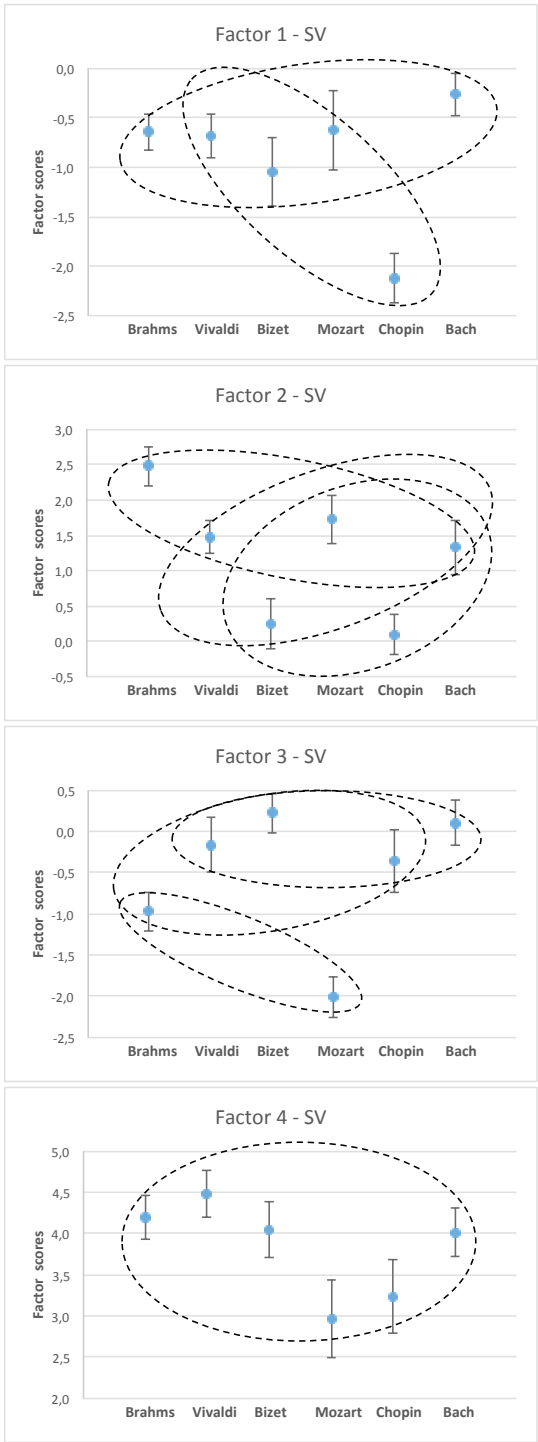

Figure 3. Scores of the music stimuli along the four main factors. Dashed ellipses group together the excerpts that are not significantly different according to the ANOVA. SV Group.