Investigating English Violin Timbre Descriptors

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ABSTRACT

Performers often discuss the sound quality of a violin or the sound obtained by particular playing techniques, calling upon a diverse vocabulary. But how do those words relate to each other? How consistent are they between players? How reliably can they be used by teachers, or performers explaining to violin makers what they want? This study explores the verbal description of the distinctive timbres of different violins: what descriptors are used by performers to characterise violins? 61 common descriptors were collected and then arranged by violinists on a map, so that words with similar meanings lay close together, and different meanings far apart. The results of multidimensional scaling demonstrate consistent use among violinists of a previously informal vocabulary and highlight which words are used for similar purposes. These terms and their relations will be useful for violin makers and luthiers, especially specialists in setting up and adjusting instruments during discussions with performers. They provide a tool for acoustical research into the quality of instrumental sound. Furthermore, identifying word consistency between players can contribute to development of pedagogical and directorial methods, as well as ways of annotating music scores for composers and arrangers.

I. INTRODUCTION

Empirical studies of violin timbre have, until now, been conducted in most depth by Stepanek and Otcenasek (2002, 2004). In that research, participants listened to carefully selected pairs of violin tones and were asked spontaneously to describe (in Czech) the differences in timbre that they perceived between the tones. Subsequent to that experiment, only four words, reported in English publications as *sharp*, *dark*, *clear* and *narrow*, were used for further investigation. The objective of the subsequent research was to correlate acoustical properties with qualitatively identified timbral features (Stepanek and Otcenasek, 2005).

This prior research has some limitations resulting from the fact that the study was conducted in Czech. As it concerns subtle interpretive judgements of verbal classifications, extending the conclusions to translated descriptors may not be fully accurate. Furthermore, the descriptors were obtained by listening to only a selection of violin sounds, and it is hard to be sure that either this sample, or participant reports, covered the whole timbre space.

In other studies investigating correlation between physical measures and/or acoustical properties by comparison to timbral qualities, Dünnwald (1991) used the four words *dark*, *nasal*, *brilliant* and *sharp*. However the basis on which these particular words were generated and selected is not reported.

We therefore decided to explore the verbal description of violin timbre in English in a way that is complementary to these previous studies, by providing an empirically based descriptive vocabulary. We are ultimately concerned with two different contexts in which a descriptive vocabulary might be applied. The first is the timbre that can be achieved on a given violin with different playing techniques. As shown by Bellemare and Traube (2006), the link between playing techniques and timbre is indeed necessary to ensure consistency between players. The second context is the distinctive timbres of different violins: what descriptors are used by performers to characterise violins? Although we consider that both these contexts are important, in this paper, we focus specifically on the second context.

First, the collection of the words will be described. In a second section, we will explain how the words were then arranged by the violinists, applying to two different descriptive situations. Finally, the results derived from multidimensional scaling analyses will be presented and discussed.

II. COLLECTION OF THE DESCRIPTORS

19 violinists (English native speakers) were asked to supply between 5 and 10 words that they would use to describe violin timbre generally. We also collected terms from descriptions of violins in articles published in *The Strad* magazine between 1996 and 2007, dealing with the description of famous violins across the world. As we are interested in descriptors which are meaningful for the whole violinist community, we decided to remove the descriptors which were quoted less than three times (for instance silvery, golden or woody). The final list included the following 61 descriptors (in alphabetical order):

alive	balanced	brash
bright	brilliant	clean
clear	closed	complex
dark	dead	deep
dull	even	free
full	hard	harsh
heavy	interesting	light
lively	loud	mellow
metallic	muffled	muted
nasal	not penetrating	open
penetrating	piercing	powerful
pure	quiet	raspy
resonant	responsive	rich
ringing	rough	round
sharp	shrill	singing
smooth	soft	sonorous
steely	strident	strong
sweet	thin	tinny
tiny	unbalanced	uneven
unresponsive	warm	weak

Table 1. Full set of descriptors

III. TWO-DIMENSIONAL SPATIAL ARRANGEMENT OF THE DESCRIPTORS

14 experienced violinists (English native speakers) were then asked to arrange these 61 words, on two-dimensional maps in a way that indicates which words are similar in meaning, and which have very different meanings. They had to make two different arrangements, each relating to a different context in which the words might be used to describe timbre. The two descriptive contexts are describing overall sound quality of a violin and ease of playing of an instrument.

The experimental setup is shown in Figure 1. Participants were presented with an Excel spreadsheet, at the left of which the list of descriptors had been arranged. The main part of the screen was occupied by a blank field, within which participants were instructed to arrange words from the list. They were asked to construct this arrangement in such a way that words with similar meanings were close together in the spatial arrangement, and words with different meanings were further apart. They were told that the overall arrangement should be such that the distance between any two words indicated how similar the meanings of those two words would be, when used in this particular descriptive context.

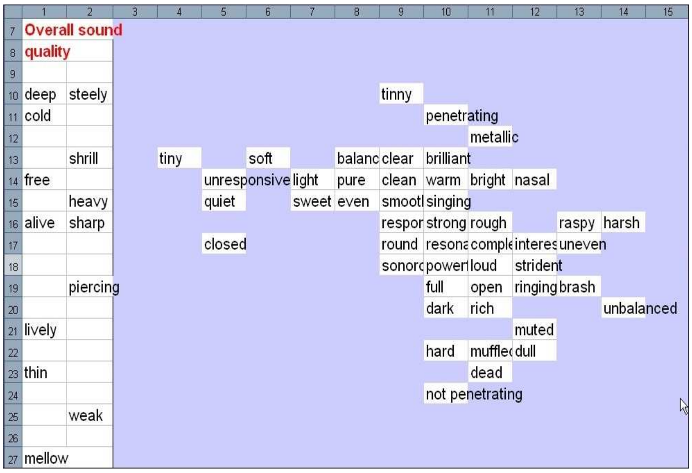

Figure 1. Experimental setup for timbre grouping within a spreadsheet field.

Apart from these instructions, participants were free to choose any principles of arrangement that allowed them to achieve the similarity constraints as well as possible. They were allowed to leave out the words which were not relevant to that descriptive context at all for them. They were also allowed to move descriptors if necessary.

IV. STATISTICAL ANALYSES

The maps made by each participant were converted into distance matrices using an Excel macro that constructed all possible pairs of words that had been placed within the arrangement field. For any pair of words, the distance between them was calculated as Euclidean distance between those two cells in the Excel grid. However, two corrections were applied in the distance calculation.

The first distance correction took account of the aspect ratio of an Excel spreadsheet. Because each cell is wider than it is high, neighbouring cells within a row appear visually farther apart than neighbouring cells within a column. Verbal reports from participants indicated that they took this into account, placing the most closely related words above each other, rather than beside each other. We applied a logical “aspect ratio” of 1.5, so that horizontal separation between cells was weighted 1.5 times that of vertical separation.

The second correction took account of the fact that many participants attempted to “cluster” words that they considered to be extremely close in meaning. They reported that, if they had been able, they would have put some words into the same cell. In order to account for this, our distance metric therefore gave greater weight to cells within a row or column that were separated by intervening empty cells. Where two descriptors were in the same column, with no intervening empty cells, this distance was "discounted" by a factor of 0.5.

Distance data for the words that had been left out were considered to be missing. However, as our planned statistical analyses could not be performed reliably if too many data points from specific participants were missing, any words which had been left out by more than half of the participants were removed for analysis of that context.

The original descriptor list was still complete for the "overall sound quality context" but the following words were removed for the "ease of playing" context: brash, bright, brilliant, cold, complex, dark, deep, hard, harsh, light, mellow, metallic, muffled, muted, nasal, not penetrating, penetrating, piercing, powerful, pure, quiet, raspy, ringing, rough, round, sharp, shrill, singing, smooth, soft, steely, strident, strong, sweet, thin, tinny, tiny.

Multi-dimensional scaling (MDS) analyses were then performed using the option ALSCAL in SPSS. Rather than attempt to reconstruct a canonical two-dimensional space that "averaged" the two dimensional arrangements made by each participant, it is important to note that we did not consider the arrangements made by each participant to be representative of the timbre space eventually constructed using MDS. We recognised that each participant would make more or less arbitrary compromises, in attempting to arrange descriptors in a way that satisfied the similarity constraints that we gave them. We also made it clear to participants that we were interested in the distance between cells, and that they should construct any arrangement that would make those distances most accurate with respect to each other. It is therefore the distances between individual descriptors, as averaged across multiple arrangement strategies, that form the basis for the MDS analysis, rather than consideration of the individual spatial arrangements.

As there are a large number of words and the data are intervals, the S-stress for each context is expected to be relatively large, and possibly even above the common limit of 0.15 below which the MDS analysis is often considered to be unacceptable. We therefore used scree plots (i.e. graphs plotting the value of the stress as a function of the number dimensions used in the MDS) to determine the number of dimensions at the elbow of the curves (Borg and Groenen, 2005).

From Figure 2, combining the "rule of the scree plot" and the rule of thumb of 0.15, the optimal number of dimensions is 3 for the "overall sound quality" and 2 for "ease of playing".

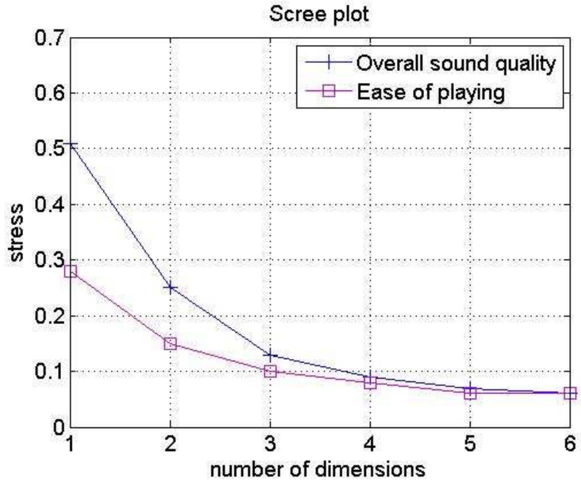

Figure 2. Value of the stress in function of the number of dimensions used in the MDS, for each of the four contexts.

V. RESULTS AND INTERPRETATION

A. Overall sound quality

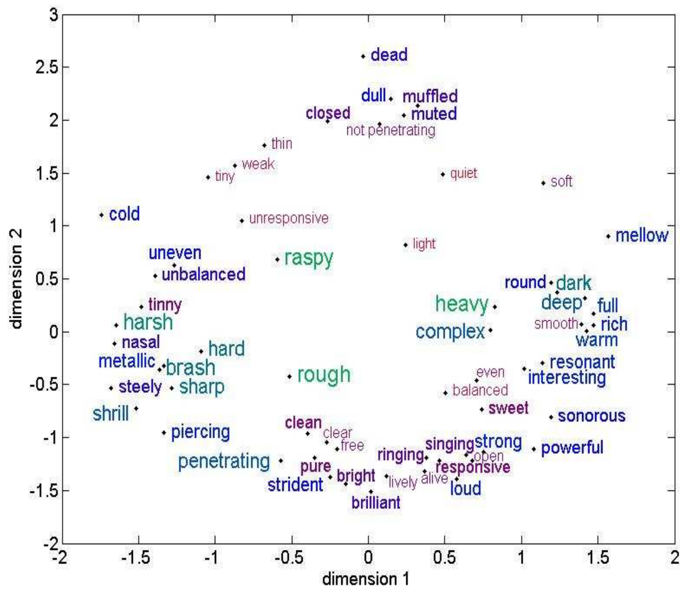

Figure 3. MDS map obtained for "overall sound quality". The third dimension is represented by a change in the font and the color: from large and light green to small and red, going through medium and blue.

At a first glance, we can see that all adjectives describing good qualities are below the diagonal crossing the map from the bottom left corner to the top right corner. We need a closer look to understand the different dimensions. On the first dimension, words go from metallic/harsh/unbalanced on the left to mellow/warm/balanced on the right so this dimension seems to be related to the balance of the instrument as well as the noisiness and the high frequency content. On the second dimension, words are spread between dull/muted on the top and bright/responsive on the bottom. This dimension is therefore related to brightness and responsiveness. The third dimension is harder to interpret. It seems to be related to the depth of the sound: words lay indeed between thin, weak, clear, and light, and harsh, heavy and dark.

B. Ease of playing

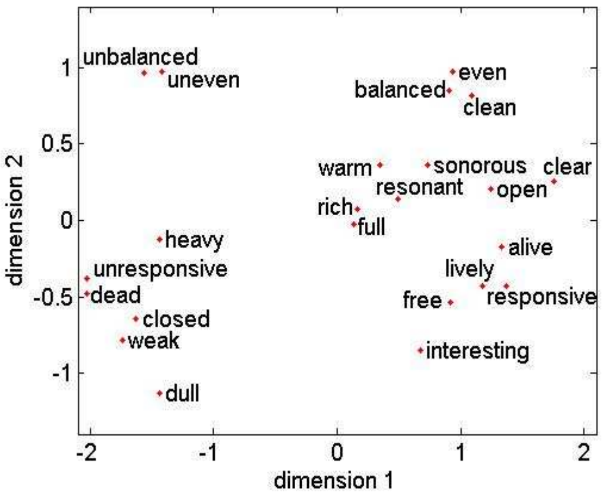

Figure 4. MDS map obtained for "ease of playing"

In Figure 4 the first dimension corresponds to how easy it is to play a violin with certain characteristics: hard on the left hand side of the graph and easy on the right hand side. The second dimension refers to why the violin is easy or hard to play. The top part of the graph corresponds to violins which are easy/hard because they are even and balanced / uneven and unbalanced. At the other end, a violin can be easy / hard to play, because it is lively and free / dead and closed. It is interesting to remark that some words which are semantically antonyms are perceived as such as they lay opposite on the graph, like even/uneven, balanced/unbalanced, lively/dead, responsive/ unresponsive. On the other side, open and closed are not opposite, but rather free and closed. Moreover, words like heavy and weak have been used but not light and strong. This shows that when working with semantic scales, if such a study has not been performed, one should use monopolar scale (like open – not open) rather than dipolar scales (like open – closed) as the words at both ends of the scale may not be relevant antonyms for judging violins. This value - indeed, necessity - of using monopolar scales, by opposition to the bipolar scales traditionally used in differential semantic scaling, has already been demonstrated by Kendall & Carterette (1992a ; 1992b) in their study of verbal timbre attributes of wind instruments.

VI. CONCLUSION

This semantic study on the verbal attributes used by English speaking violinists to describe the timbre of violins shows how these different attributes relate to each other, depending on the context. Two contexts were presented here: the first one is related to the overall sound quality, the second one to the ease of playing. It is not necessarily the case that the same words are used in the two contexts, and where they are used, they may relate differently to other words.

The results of multidimensional scaling demonstrate coherent use among violinists. They also highlight synonyms and antonyms, which are not necessarily intuitive on purely semantical considerations, and which can be different depending on the context.

This study provides a tool that we intend to apply in future acoustical research into the quality of instrumental sound. Our work investigating the perceptual effect of acoustical modifications on violins often presumes knowledge of the relationships between descriptors. We can indeed select some words on the basis of their distribution in the MDS spaces, to be used in monopolar scales for the assessment of the modifications by violinists. This should provide both researchers and luthiers with some input on what is necessary to adjust on a violin to make it brighter or cleaner, with some more evidenced basis than prior suggestions by Dünnwald (1991).

We expect that these terms and their relations will also be useful for violin makers and specialists in setting up and adjusting instruments during discussions with performers.

Furthermore, identifying word consistency between players can contribute to development of pedagogical and directorial methods, as well as ways of annotating music scores for composers and arrangers.

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REFERENCES

Bellamare, M. and Traube, C. (2006) Investigating piano timbre: relating verbal description and vocal imitation to gesture, register, dynamics and articulation. In Baroni, Addessi, Caterina and Costa (Ed.), *Proceedings of the 9th International Conference on Music Perception and Cognition* (pp. 59). Bologna, Italy.

Borg, I. and Groenen P.J.F. (2005). *Modern Multidimensional Scaling: Theory and applications*. Springer.

Dünnwald, H. (1991). Deduction of objective quality parameters on old and new violins. *Catgut Acoust Soc. J. Vol.1, no. 7 (series II) (pp. 1-5).*

Kendall, R. A. & Carterette, E. C. (1992a). Verbal attributes of simultaneous wind instrument timbres. I- Von Bismarck's adjectives. *Music Perception* **10**: 445-468.

Kendall, R. A. & Carterette, E. C. (1992b). Verbal attributes of simultaneous wind instrument timbres. II- Adjectives induced from Piston's Orchestration. *Music Perception* **10**: 469-502.

Stepanek, J. (2002). The study of violin trimbre using spontaneous verbal description and verbal attribute rating. In *Proceedings of Forum Acusticum,* Sevilla, Spain.

Stepanek, J. and Otcenasek, Z. (2004). Interpretation of violin spectrum using psychoacoustics experiments. In *Proceedings of the Internaitonal Symposium on Musical Acoustics,* Nara, Japan.

Stepanek, J. and Otcenasek, Z. (2005). Acoustical correlates of the main features of violin timbre perception. spectrum using psychoacoustics experiments. In *Proceedings of the Conference on Interdisciplinary Musicology,* Montreal, Canada.