

Evaluation of Timbre of Violin Tones According to Selected Verbal Attributes

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Abstract

Violin tones of five different pitches (B3, F#4, C5, G5 and D6) were evaluated according to four selected verbal attributes of timbre (sharp, dark, clear and narrow) and perceived sound quality. Magnitudes of verbal attributes and quality were detected separately for each pitch and each attribute in listening tests of groups of tones. Results of the tests are discussed regarding the concordance of listeners in individual parts of tests and retest stability. It revealed that better retest stability is in the tests with higher concordance. Interrelationships among verbal attributes exhibited stable relation among sharp, dark and clear, but narrow gradually changes its correlation with other attributes in increasing pitch. Perceived sound quality can be successfully predicted from studied verbal attributes.

Introduction

Various methods are used for the study of sound timbre (Hajda & all). The dependence of the results on listened context and listeners in the investigation of this multi-dimensional problem is well known (e.g. Grey). Use of an appropriate listening test method and evaluation of results also influence validity of conclusions.

Adopted Verbal Attribute Magnitude Estimation (VAME) method (Kendall, Carterette) was used in described experiment. The choice of the verbal attributes was based on the results of recent experiment using the same sets of stimuli (Stepanek & all, 1999, Stepanek, Otcenasek, 2001).

Method

Violin tones of five different pitches: **B3**, **F#4**, **C5**, **G5** and **D6** were used as stimuli. Tones of instruments of extremely various qualities, eleven for each pitch, were played *détaché*, *naturale*, non-vibrato, and *mezzoforte*, and recorded in an anechoic room (Stepanek & all, 1997).

For the experiment there were selected following **verbal attributes**, based on the results of spontaneous verbal description of the same sound contexts (Stepanek & all, 1999): ostrý – **sharp**, tmavý – **dark**, jasný – **clear**, úzký – **narrow** and **perceived sound quality**.

Eleven listeners – violin players and sound designers – participated in the listening tests. One verbal attribute in each of five listening sessions was used (in fixed order: sharp, dark, clear narrow and perceived sound quality). The order of listened pitches was defined using Latin squares.

The listeners' task was to rank (sort) the set of eleven signals according to the specified verbal attribute, then to rate sorted signals with values from 0 to 10, and to describe in words other salient features of timbre in signals with extreme values of tested attribute. The method was denoted as a **verbal attribute ranking and rating (VARR)**.

Listeners listened to signals in headphones. The test program was developed in a Matlab (® The Math Works) environment. The listener pressed appropriate button on a PC monitor to play the sound or to move the button to the desired place on a scale. Then VAME method was applied on an individually ranked sequence of signals. The program design allowed the listener to check rated values or rate differences by follow-up listening to any desired signal.

Results

Concordance among judges was evaluated by using Kendall's coefficient of concordance; the results are in Tab. 1. All coefficient values are significant at 5%.

Tab. 1 Kendall's coefficient of concordance.

	B3	F#4	C5	G5	D6
sharp	0.84	0.76	0.83	0.61	0.84
dark	0.80	0.72	0.82	0.58	0.80
clear	0.49	0.20	0.27	0.32	0.19
narrow	0.33	0.42	0.29	0.71	0.35
quality	0.37	0.68	0.55	0.43	0.34

The **Retest** was realised after three to six months following the original tests. On the base of the evaluation of results only selected tones and verbal attributes were used in one retest session. All listeners assessed sharpness on D6 tone and darkness on B3 tone (as an example of high concordant assessment); another four pairs of attribute-tone were selected individually for each listener (typical or extreme judgements) from lower concordant results. Kendall's coefficient of concordance in retest in sharp-D6 was 0.87, in dark-B3 0.81 so a bit higher than in original test. Also agreement with original test was very high (concordance of results both test and retest together in sharp-D6 was 0.84, in dark-B3 0.80). All individual test-retest correlations in sharp-D6 and dark-B3 were significant at 5% (most of them at 1%).

Factor Analysis is another possible view on the correlations of individually rated values. In all following cases principal component method and varimax rotation were used. High concordant tests gave one factor solution (high agreement); lower concordant tests gave two or three factor solution. Example of factor space of all listeners for clear-C5 test is in Fig. 1. The change of the individual position of the listener in test and retest reveals the stability of judgements relative to homogeneity of the whole group of listeners.

The **mean rate values** over the whole listener group calculated for all four verbal attributes and perceived sound quality were the base for the evaluation of listening test results.

Correlations between pairs of verbal attributes for all five tested pitches are in Tab. 2, factor spaces of verbal attributes are

in Fig. 2 (explained variance ranges between 89.3 and 98.0 %).

Correlations between perceived sound quality and verbal attributes are in Fig. 3. Prediction of perceived sound quality from verbal attributes using linear multiple regression led to formulas which are given in Tab. 3, together with coefficients of multiple correlation as a measure of prediction fit success.

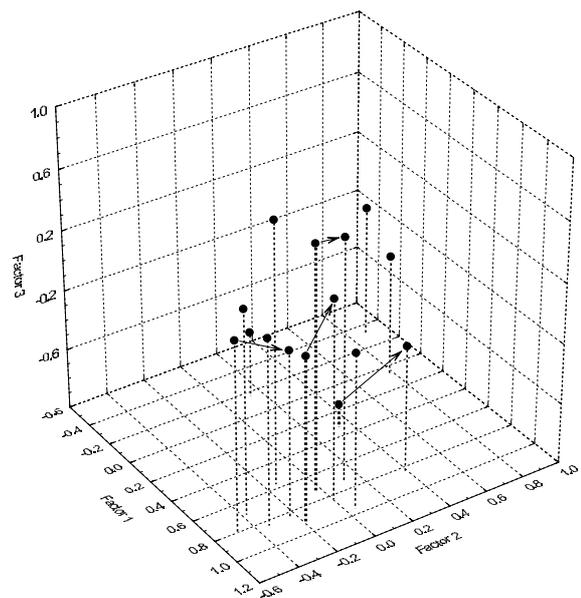


Fig. 1 Example of factor space of listeners for verbal attribute clear and tone C5. Arrows mark changes of listener position from test to retest.

Tab. 2 Correlations between mean rate values of verbal attributes. Significant correlations at 5% are bold.

Tone	attribute	dark	clear	narrow
B3	sharp	-0.98	+0.90	+0.64
	dark	—	-0.93	-0.73
	clear	—	—	+0.59
F#4	sharp	-0.96	+0.68	+0.58
	dark	—	-0.79	-0.54
	clear	—	—	+0.38
C5	sharp	-0.98	+0.79	-0.09
	dark	—	-0.85	+0.19
	clear	—	—	-0.58
G5	sharp	-0.97	+0.83	-0.55
	dark	—	-0.72	+0.40
	clear	—	—	-0.77
D6	sharp	-0.98	+0.86	-0.63
	dark	—	-0.83	+0.60
	clear	—	—	-0.79

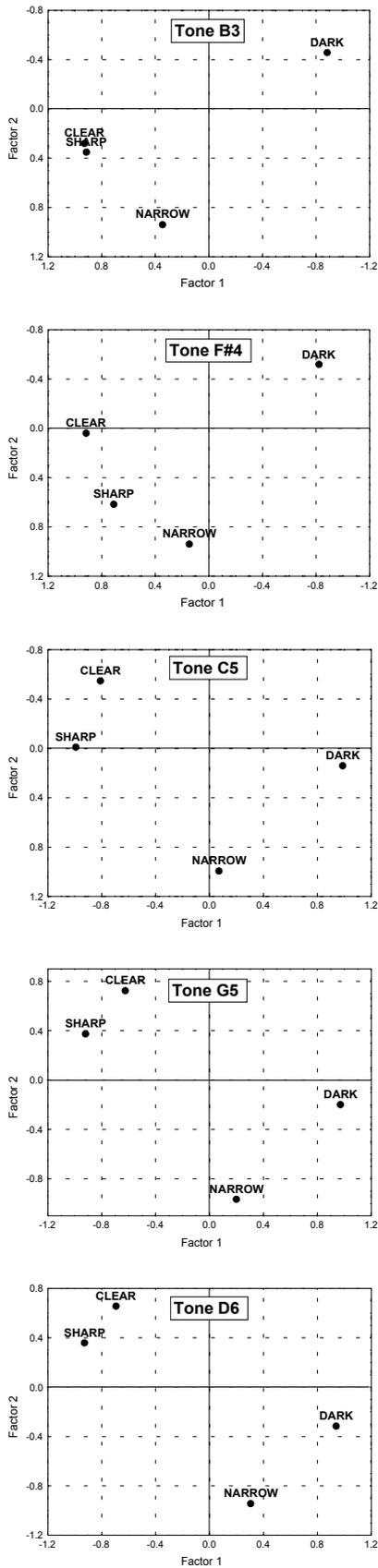


Fig. 2 Factor spaces of verbal attributes.

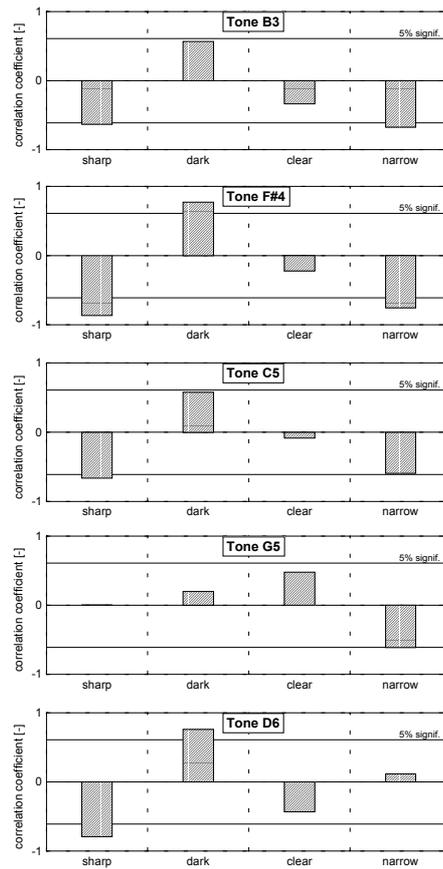


Fig. 3 Correlations between perceived sound quality and verbal attributes with 5% significance lines.

Tab. 3 Perceived sound quality prediction formulas. Abbreviations: S sharp, D dark, C clear, N narrow, R Multiple correlation coefficient.

Tone	Formula	R
B3	$-1.73S - 1.32D + 0.59C - 0.99N + 21.31$	0.96
F#4	$-0.66S + 0.14D + 0.66C - 0.52N + 5.66$	0.97
C5	$-0.68S + 0.52D + 1.35C - 0.34N - 0.28$	0.98
G5	$-0.52S + 0.41D + 1.32C - 0.19N - 0.52$	0.89
D6	$-1.47S - 0.81D + 1.12C - 0.42N + 10.71$	0.98

Discussion

Despite significant concordance among judges in all tested attribute-tone pairs there are evident differences in the stability of individual test results (Tab. 1). Verbal attributes sharp and dark reveal both very high concordance of judges and individual retest stability. It means that these attributes are perceived and understood by listeners equally and unvaried.

Some problems arise with judgement of attributes clear and narrow. Sometimes

listeners had simply less agreement but sometimes were divided into two groups with different strategies in the rating decision (see Stepanek, Otcenasek, 2002 for narrow-C5). In the retest some listeners used the same strategy but some of them used strategy of the second group.

The selection of verbal attributes was based on the results of spontaneous verbal description (SVD) (Stepanek & all 1999). In Stepanek 2002 the results of VARR listening test method described here are compared with results of SVD.

Comparison of correlations between mean rate values of verbal attributes (Tab. 2) or of their factor spaces (Fig. 2) exhibits stable relation between sharp, dark and clear in all five tested pitches, where sharp and dark are opposite attributes. Narrow gradually changes its correlation and position from sharp to dark, this fact is demonstrated in Fig. 4. Relation of attributes sharp and narrow with spectral parameters are described in Stepanek, Otcenasek, 2002.

Correlation of verbal attributes sharp and dark with perceived sound quality (Fig. 3) exhibit different behaviour in tone G5 in which clear and narrow have the main influence in opposite to all other tones where sharp and dark dominate. Influence of narrow decreases substantially in the highest pitch D6. The prediction of perceived sound quality using linear multiple regression and based on four used verbal attributes has high significance in all five pitches.

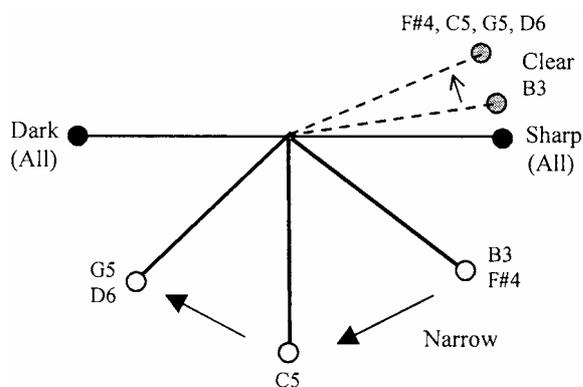


Fig. 4 Generalized factor space of verbal attributes.

Conclusions

Described experiment results revealed that sharp and dark are opposite attributes of timbre on tested context of violin tones and that listeners have a unique and stable model for their evaluation. Relations among verbal attributes sharp, dark and clear are relatively stable; relation of narrow gradually changes with increasing pitch from correlation with sharp to correlation with dark.

Further investigation is necessary with attributes clear and narrow as concerns individual listener strategies and different sound contexts.

The prediction of perceived sound quality based on attributes sharp, dark, clear and narrow on the context of violin tones of high variability in timbre is possible.

References

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Acknowledgements

This research was supported by the Ministry for Education, Youth and Sport of the Czech Republic (Project No. 511100001).

