Verbal description of musical sound timbre in Czech language and its relation to musicians profession and performance quality

Stepanek Jan, Musical Acoustics Research Centre, Academy of Performing Arts Prague, Czech Republic
stepanek@hamu.cz www.hamu.cz/zvuk

Moravec Ondrej, Musical Acoustics Research Centre, Academy of Performing Arts Prague, Czech Republic
moravec@hamu.cz www.hamu.cz/zvuk

Proceedings of the Conference on Interdisciplinary Musicology (CIM05)
Actes du Colloque interdisciplinaire de musicologie (CIM05)
Montréal (Québec) Canada, 10-12/03/2005

Abstract

The three *sound-context free* experiments were provided with Czech music professionals as respondents: questionary survey for the collection of verbal attributes, dissimilarity pair test of attributes mostly used for the description of timbre and the test for suitability of a set of verbal attributes for the description of other aspects of musical performance. Frequency vocabularies of verbal attributes used in Czech language for the timbre description of musical sound were created from survey results for all respondents as well as for three main groups of musicians: string instrument players, wind instrument players and key instrument players, and compared. Three-dimensional common perceptual space of musical sound timbre was established from dissimilarity pair test results, but it is expectable that the number of its dimensions is not definitive. Verbal descriptions of these dimensions can be: 1. *gloomy*, *dark – clear*, *bright*, 2. *harsh*, *rough – delicate*, 3. *full*, *wide – narrow*. At least two first dimensions of common perceptual space are jointly shared by five investigated professional groups (players of string, wind and key instruments, composers & conductors, sound designers). Attributes of every individual dimension reveal mutual behaviour according to description of timbre, performance quality and artistic expression.

Introduction

Multidimensional nature of timbre was undoubtedly accepted by majority of researchers. The main interest is the question of existence and the search for common system of perceptual dimensions. This goal is filled in retrieval of salient dimensions or features of timbre on specific sound contexts. Perceptual space of sounds of studied context is constructed based on results of subjective statements. The interpretation of dimensions can be made using acoustic characteristics of sounds (Grey 1977) or verbal attributes (Bismarck 1974) or both. When using verbal attributes, the problem arises how to select representative, suitable and complete set of attributes according to tested sound context timbres. Bismarck's attribute pairs (Bismarck 1974 a) were selected from previous studies and validated by the group of experts before using in listening tests. Spontaneous verbal description of tested sounds collected within experiment was used for the interpretation of perceptual spaces in (Stepanek 2002; 2004), this experiment is also described in CIM05 contribution (Stepanek & Otcenasek 2005).

All above mentioned experiments represented approach going from timbre description of specific sound context to possible generalization (bottom-up approach). Stumpf 1890 has used semantic analysis of verbal attributes and without any experiment (in contemporary sense) has obtained three dimensions:

1. *dunkel – hell* (*dark – bright* in English)
2. *stumpf / weich – scharf / rauh* (*unpointed / soft – sharp / rough*)
3. *voll / breit – leer / dünn* (*full / wide – empty / narrow*)

In this contribution described approach to the study of timbre can be named top-down, because it starts from the detection of common experience of musicians and follows its deeper and more precise qualification. No sound context was used in provided experiments (*sound-context free* experiments). This approach uses sociological exploration, psychological experiment methods (Guilford 1954) and represents certain kind of cultural studies on the community of Czech speaking musicians.

The main aims of the research were:

1. To search for verbal attributes (words and expressions) used by musicians for description of timbre.
2. To construct common perceptual (semantic, verbal) space, to establish its dimensionality and verbally describe individual dimensions. To ask if all musicians share common perceptual space or what are the criteria dividing them into groups with different timbre perception models.
3. To ask musicians for suitability of verbal attributes for the description of timbre or other aspects of musical performance.

Experiments

Three sound-context free experiments were provided with Czech music professionals as respondents, only their opinions and experiences were observed. Questionary survey was used for the collection of verbal attributes and creation of frequency vocabularies. Results of dissimilarity pair test of attributes mostly used for the description of timbre were used for the construction of common perceptual space as well as perceptual spaces of selected professional groups. A special test for suitability of use of a set of verbal attributes for the description of other aspects of musical performance was prepared, carried out and evaluated.

Experiment I: Questionary survey

Method. Questionary survey was applied for the collection of verbal attributes used by musicians for the description of timbre. The questionary was composed of two parts. In the first part respondents described their personal profile – age, instrument(s) they play, music profession, education, etc. The second part of the questionary was divided into three subsections. In the first subsection respondents wrote down in free order the words and expressions which they use for the description of musical sound timbre, in the second one they wrote down groups of synonyms and in the third one groups of antonyms.

The first part of the questionary was used for the description of population sample and for the discrimination of respondents into classes according to selected criteria. The second part as a whole was used for building of individual respondent vocabulary. Common vocabulary or partial vocabularies for respondent groups were then created from individual vocabularies. The second and the third subsections of the second part of the questionary were used for the determination of word relations (see Moravec & Stepanek 2003b).

Results. Finally 120 filled forms of questionary were acquired. The survey was carried out among students and professors of Music Faculty on Academy of Performing Arts in Prague, soloists and members of several symphonic and chamber orchestra from different regions of the Czech Republic, teachers from musical schools and people from recording studios. These groups overlap in some cases, e. g. professors of the musical faculty are often also members of orchestras or solo players. More detailed description of the respondent distribution is in Moravec & Stepanek 2003a. In the following analysis the division to only main instrument groups (bow, wind, keyboard) the respondents play, was used in order to reach sufficient amount of respondents in individual classes (Figure 1).

Respondents wrote down 1964 different verbal attributes in total, 30 attributes from common vocabulary have relative frequency greater then 25 % (attribute used at least by 30 respondents); list of these attributes is in Table 1.

Partial vocabularies of groups of bow, wind and keyboard instrument players were compared with frequencies in common vocabulary. Relative and absolute frequencies of attributes in respondent groups are shown in Figure 2.

Discussion. The prominent differences between the whole respondent sample and each group of respondents, supported also by prominent differences between pairs of groups, yields to only a small number of verbal attributes, which are significantly more or less frequently used by studied groups:

attributes:	more frequently used	less frequently used
bow	sweet, hearty	gloomy, round, ringing, narrow
wind	round, narrow	radiant, hearty, lucid
keyboard	ringing	sweet, rough, hearty, cool, wide, narrow

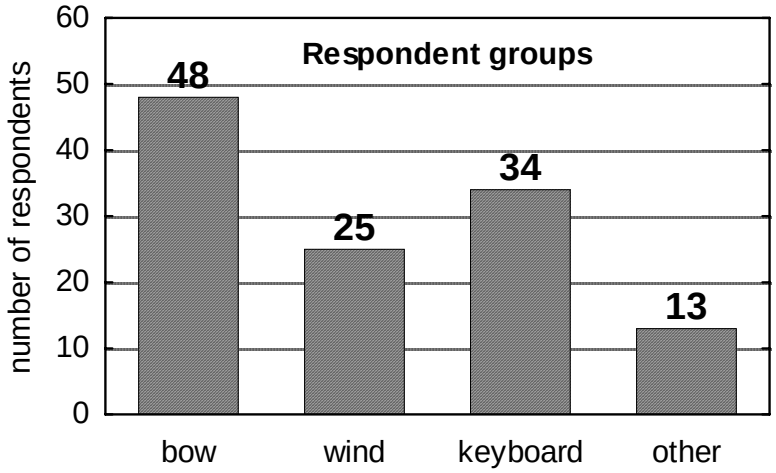

Figure 1. Questionary survey respondent groups according to instrument class they play.

Table 1. Thirty the most frequently used verbal attributes from common vocabulary with their absolute (f_{abs}) and relative (f_{rel}) frequencies and ranks (including ties) in common and partial (according to respondent group) vocabularies. Attributes from *sharp* to *narrow* were used in experiment II and III.

Verbal attribute		Frequency – all respondents		Rank in respondent group			
Czech original	English translation	f_{abs}	f_{rel}	all	bow	wind	keyboard
ostrý	sharp	94	78.3	1	1	1	1
temný	gloomy	79	65.8	2	5	2	2
měkký	soft	78	65.0	3	2	3	4
jasný	clear	75	62.5	4	3	4.5	4
sametový	velvety	61	50.8	5	7	6	4
jemný	delicate	58	48.3	6.5	9.5	11.5	6.5
kulatý	round	58	48.3	6.5	14.5	4.5	8
tupý	unpointed	55	45.8	8	11	8	10
drsný	harsh	54	45.0	10	12.5	19.5	6.5
světlý	bright	54	45.0	10	16.5	11.5	10
tvrdý	hard	54	45.0	10	9.5	8	15.5
sladký	sweet	53	44.2	12	4	15	22
plný	full	51	42.5	13	12.5	8	15.5
hrubý	rough	46	38.3	14.5	7	15	37
tmavý	dark	46	38.3	14.5	21.5	15	15.5
teplý	warm	43	35.8	16	21.5	23.5	15.5
zářivý	radiant	42	35.0	17	16.5	45	22
čistý	pure	40	33.3	18.5	26	15	19
vřelý	hearty	40	33.3	18.5	7	31	78
barevný	colored	38	31.7	20.5	19	45	12
zvonivý	ringing	38	31.7	20.5	39.5	19.5	10
chladný	cool	36	30.0	23.5	14.5	31	61.5
průzračný	lucid	36	30.0	23.5	24	65.5	15.5
široký	wide	36	30.0	23.5	32	15	37
úzký	narrow	36	30.0	23.5	39.5	8	37
kovový	metallic	34	28.3	26.5	32	31	22
studený	cold	34	28.3	26.5	27.5	31	37
svítivý	shining	32	26.7	28	48	19.5	37
zastřený	blurred	31	25.8	29	19	23.5	28.5
hladký	smooth	30	25.0	30	39.5	45	28.5

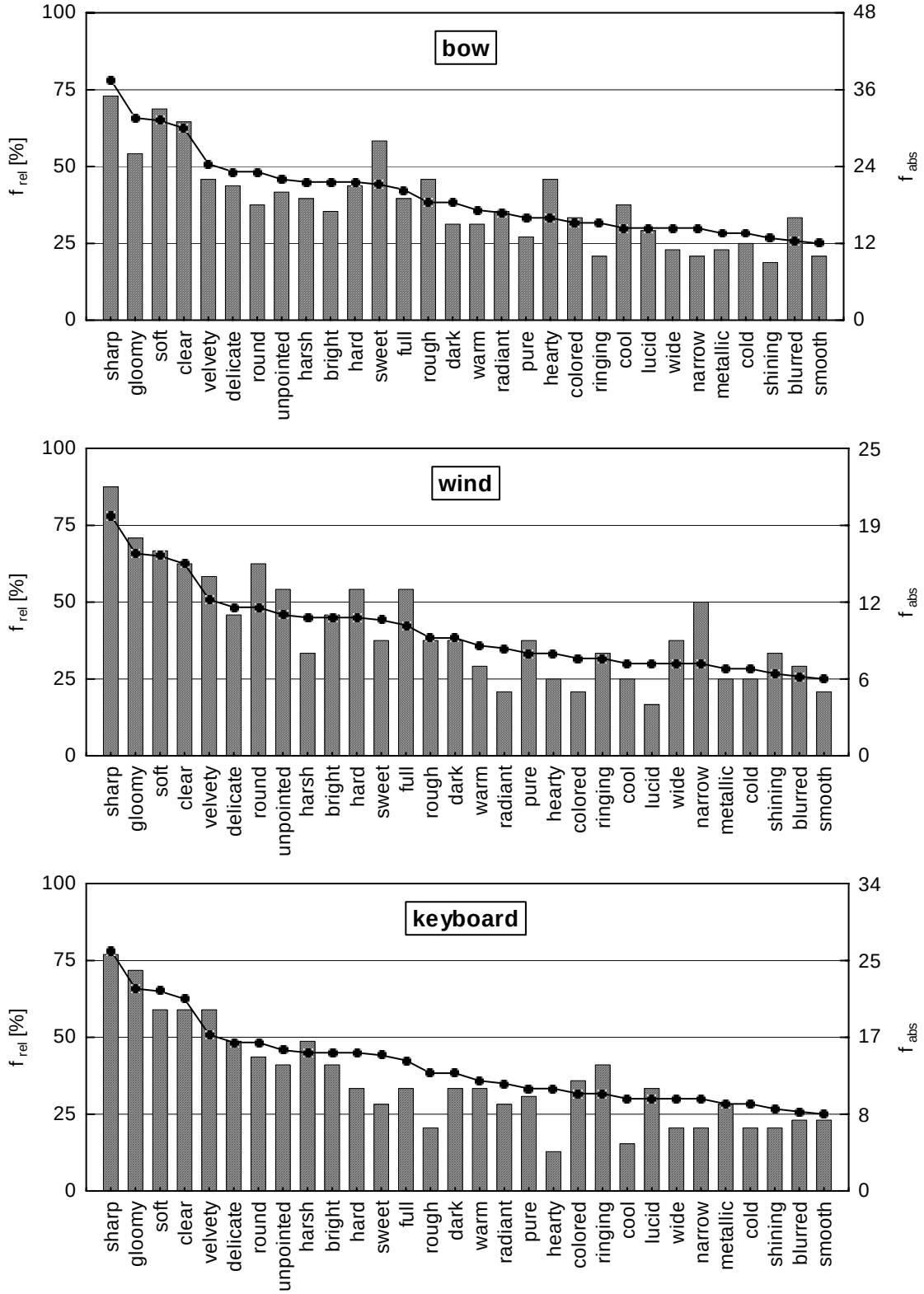

Figure 2. Relative (f_{rel}) and absolute (f_{abs}) frequencies of attributes in partial vocabularies of respondent groups (bars) compared with relative frequencies in common vocabulary (line with markers). The order of attributes from common vocabulary was preserved.

Experiment II: Dissimilarity pair test

Method. Sound-context free dissimilarity pair test was performed on 25 verbal attributes most frequently used in questionaries (going from sharp to narrow in Table 1). Respondents were asked to quantify their opinion on the dissimilarity of attributes according to timbre description (Moravec & Stepanek 2004), going from their internal image of timbre.

Obtained dissimilarity matrices were evaluated using latent class approach applied on the weighted Euclidean model (CLASCAL). Overview of multidimensional scaling models is for example in McAdams & all 1995, more precise description of CLASCAL procedure can be found in Winsberg & De Soete 1993; 2002. Latent class approach was used on a set of all test respondents and also on respondent groups defined by their music profession.

For the comparison of resulting perceptual spaces the method of optimal fitting of external scales (Borg & Groenen 1997, 60-69) – in our case dimension coordinates of compared group perceptual space, generalized to the case of correlated dimensions (*immersion* of external scales into perceptual space described in Stepanek 2004) was used. This local comparison of individual dimensions can be more sensitive for partial discrepancy of spaces then global comparisons (for example Procrustean transformation, see Borg & Groenen 1997).

Interpretation of each perceptual space was based on the search of (nearly) orthogonal system of space objects (attributes); the goal was also to find attributes with (nearly) opposite position in perceptual space. System of *n* orthogonal attributes in n-dimensional perceptual space was considered as its successful interpretation.

Results. Forty three respondents took part in dissimilarity pair test. The constitution of respondent groups according their music profession is given in Table 2. Retest made on a subset of attributes exhibited satisfactory reliability of all respondents.

Application of CLASCAL procedure yielded to the division of respondents into three classes (Table 2). All respondents shared common model with three-dimensional space of verbal attributes, classes differed in weights of each dimension. No correlation of respondent classification with music profession was found, the main criterion for their division into classes was the manner they used the dissimilarity evaluation scale (e.g. mean value of dissimilarity), see also Moravec & Stepanek 2004.

CLASCAL procedure was also applied separately on each professional group results to discover or better describe eventual differences in timbre judgement based on music profession of respondents. Optimal models of professional groups are in Table 2.

Immersion of all dimensions of optimal models of apriori groups into common perceptual space was successful (highly significant correlation coefficients), angles contained between individual immersed dimension coordinates embodied only slight deviations from 90^{o} (Table 3).

An example of a system of (nearly) orthogonal and opposite verbal attributes in common perceptual space is in Table 4. Similar systems were found also in optimal model perceptual space of all groups.

Table 2. Respondent groups in sound-context free dissimilarity pair test according music profession (apriori groups), their division into CLASCAL classes (aposteriori grouping) and optimal CLASCAL models of apriori groups. *Di* denotes i-dimensional solution, *Sj* denotes model without specificities (j=0) or with specificities (j=1).

Music profession (apriori group)	Number of respondents	Class 1	Class 2	Class 3	Unclassed	Optimal model of apriori group
bow	12	3	3	2	4	D3S1
wind	6	1	1	0	4	D2S1
keyboard	7	0	0	3	4	D2S1
composer/conductor	8	1	1	3	3	D3S0
sound designer	6	2	0	2	2	D3S1
other	4	0	0	2	2	-
all together	43	7	5	12	19	-

Table 3. Comparison of perceptual spaces of respondent group optimal models with common perceptual space: immersion results. Success of immersion: Pearson correlation coefficient between dimension coordinates of group optimal model and coordinates of its immersion. Measure of the deformation of group perceptual space due to immersion: angles contained between immersions of individual dimensions.

Music profession	Dimension	Correlation coefficient	Angle [°]	
			Dim 1	Dim 2
bow	Dim 1	0.994	–	
	Dim 2	0.986	84	–
	Dim 3	0.989	86	84
wind	Dim 1	0.995	–	
	Dim 2	0.975	86	–
keyboard	Dim 1	0.993	–	
	Dim 2	0.983	95	–
composer/conductor	Dim 1	0.994	–	
	Dim 2	0.990	88	–
	Dim 3	0.977	89	87
sound designer	Dim 1	0.995	–	
	Dim 2	0.989	99	–
	Dim 3	0.980	102	89

Table 4. System of (nearly) orthogonal and opposite verbal attributes in common perceptual space. Angles between close and opposite attributes are under the diagonal, between orthogonal attributes are above diagonal. Criterion of deviation up to 20° from exact value (0°, 180° and 90°) was postulated to be sufficient for the selection. Representative attributes are bold.

Angle [°]	gloomy	dark	clear	ringing	harsh	rough	delicate	sweet	full	wide	narrow	cool
gloomy	–				**84**	75	**91**	94	**71**	68	**109**	80
dark	5	–			84	76	93	93	66	63	113	84
clear	**176**	172	–		**97**	106	**89**	84	**106**	109	**75**	104
ringing	173	172	10	–	89	98	95	93	111	114	68	95
harsh					–				**92**	88	**77**	62
rough					10	–			93	89	76	57
delicate					**159**	152	–		**106**	109	**85**	97
sweet					168	167	32	–	77	80	114	129
full									–			
wide									4	–		
narrow									**169**	165	–	
cool									142	138	31	–

Discussion. Application of CLASCAL procedure on dissimilarities of all 43 test respondents established three-dimensional common perceptual space of verbal attributes. It was not possible to explain respondents aposteriori classification from their music profession (Table 2), on the contrary immersion of all perceptual space dimensions of music profession groups into common perceptual space was highly successful and revealed small deformation of angles between pairs of immersed dimensions (Table 3). Because some respondent group optimal solutions were only two-dimensional, we may conclude that at least these two dimensions are shared by five investigated professional groups: players of string, wind and key instruments, composers & conductors and sound designers. Another word there is no substantial difference among opinions of Czech speaking musicians on relations among verbal attributes describing timbre.

Comparing systems of nearly orthogonal verbal attributes interpreting common and group perceptual spaces (example of the system for all respondent group is in Table 4) implies following dimensional verbal attributes system for the description of musical sound timbre in Czech language:

1. ***temný*** / ***tmavý*** – ***jasný*** / ***světlý*** (***gloomy*** / ***dark*** – ***clear*** / ***bright*** in English)
2. ***drsný*** / ***hrubý*** – ***jemný*** (***harsh*** / ***rough*** – ***delicate***)
3. ***plný*** / ***široký*** – ***úzký*** (***full*** / ***wide*** – ***narrow***)

When we look on the dimensional attributes postulated by Stumpf 1890 (see also their list in the Introduction part of this paper), we can see good agreement in the first and third dimension. Attribute *sharp* is missing in more different second dimension, which is moreover most prominent attribute in almost all timbre studies with sound contexts. This fact was undoubtedly the main reason for its detailed study (Bismarck 1974 a, b). The position of attribute *sharp* in perceptual spaces of all respondents and professional groups in the results of our experiment is similar and approaches to the plain defined by the first two dimensions in quadrant defined by attributes harsh and clear. When we select representative attributes for each dimension based on their position in frequency vocabulary (Table 1), it is possible to draw following scheme of common perceptual space of timbre (Figure 3).

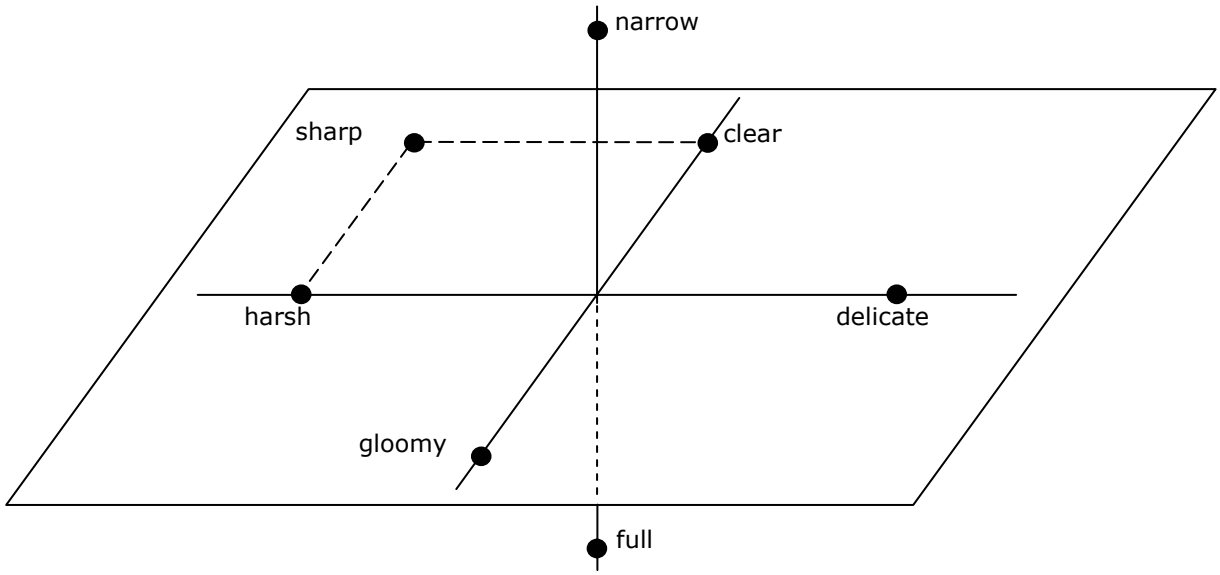

Figure 3. Scheme of representative verbal attributes in three-dimensional perceptual space of timbre. Czech verbal attributes were replaced by their English translation.

Experiment III: Test of suitability

Method. Opinions of musicians on the use and suitability of verbal attributes for the description of timbre in more specific aspects of musical performance were detected. Respondents answered six questions (Table 5) asked consecutively for each of sixty selected verbal attributes (attributes from *sharp* to *narrow* are in Table 1, rest of attributes was selected from frequency vocabulary based on previous experiments, list of them see in Table 6).

Judgment scales were quantified for processing of results and then basic statistical characteristics for each question and verbal attribute were calculated and compared: median, mean value, etc.

Results. Twenty experienced musicians took part in this test. Mean values of judgements were selected for the presentation of results which finely represent the differences in attribute judgements.

Mean values revealed that dimensional attributes *gloomy*, *dark*, *clear*, *harsh*, *rough*, *delicate*, *full*, *wide* and *narrow* found in experiment II and attribute *sharp* are considered more then appropriate for the description of musical sound (question number two) and (except *rough*) are used more then often (question number one). Results on question number three in individual attributes are summarized in Figure 4, where the attributes are ranked by decreasing mean value and dimensional attributes and

attribute *sharp* are displayed with full bars. Mean values of answers on questions four to six for dimensional attributes and attribute *sharp* are summarized in Figure 5.

Table 5. Questions and scales used in suitability test of selected verbal attributes.

No.	Question	Judgment scale			
1	I use this attribute for musical sound description:	never	occasionally	often	very often
2	I consider it for musical sound description:	unappropriate	partly appropriate	appropriate	very appropriate
3	Attribute is suitable for description: - attack or steady state	rather attack	both		rather steady state
4	- **timbre** of detached tone of some instrument	unappropriate	adequate		very appropriate
5	- **kind (quality) of play** of tone played on some instrument	unappropriate	adequate		very appropriate
6	- **artistic expression** connected with musical performance	unappropriate	adequate		very appropriate

Table 6. Additional 35 verbal attributes used in suitability test with their English translation and order in frequency vocabulary (first 25 attributes from *sharp* to *narrow* see in Table 1).

Czech original	English translation	Order	Czech original	English translation	Order	Czech original	English translation	Order
kovový	metallic	26.5	konkrétní	definite	62.5	nakřáplý	huskily	114.5
zastřený	blurred	29	znělý	voiced	62.5	pisklavý	piping	114.5
průrazný	piercing	32.5	šustivý	rustle	72.5	jadrný	racy	126
tenký	thin	32.5	výrazný	pronounced	79	živý	lively	126
hebký	silky	39	kultivovaný	sophisticated	90	syčivý	hissy	137.5
medový	honey	39	skřípavý	rude	90	přidušený	damped	153.5
dutý	hollow	43	břeskný	brazen	98	šumivý	brisk	153.5
nosný	carrier	46	vyrovnaný	balanced	98	hučivý	thudy	175
lesklý	glossy	49.5	chvějivý	vibratory	105	kolísavý	unstable	175
plochý	flat	54	řídký	sparse	105	bzučivý	buzzy	209
mečivý	bleaty	57.5	bručivý	grumpy	114.5	nasální	nasal	252.5
dunivý	rumbly	62.5	mdlý	dull	114.5			

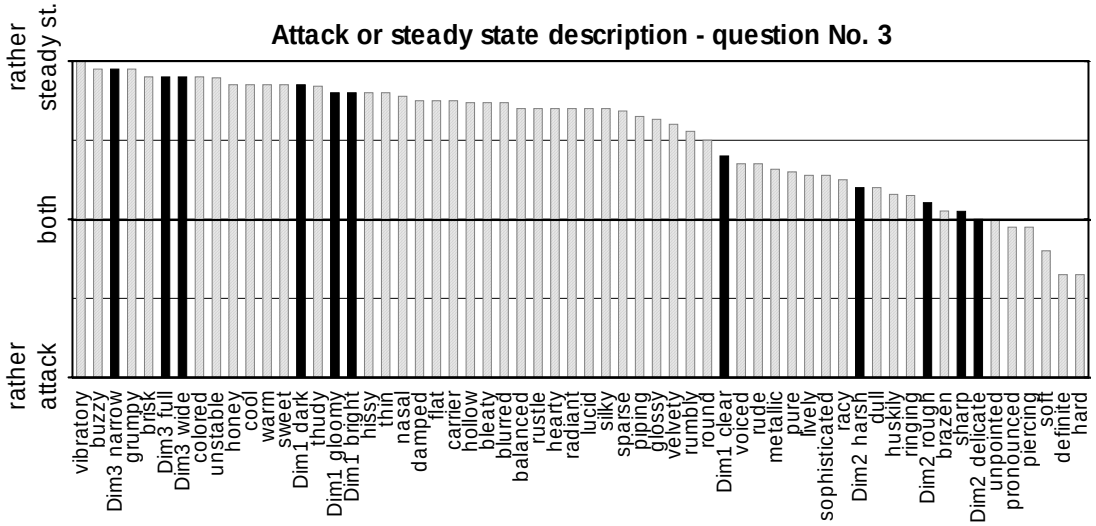

Figure 4. Mean values of answers on question three – suitability of the attribute for description of attack or steady state of the tone. Values of dimensional attibutes and attribute *sharp* are drawn with filled black bars.

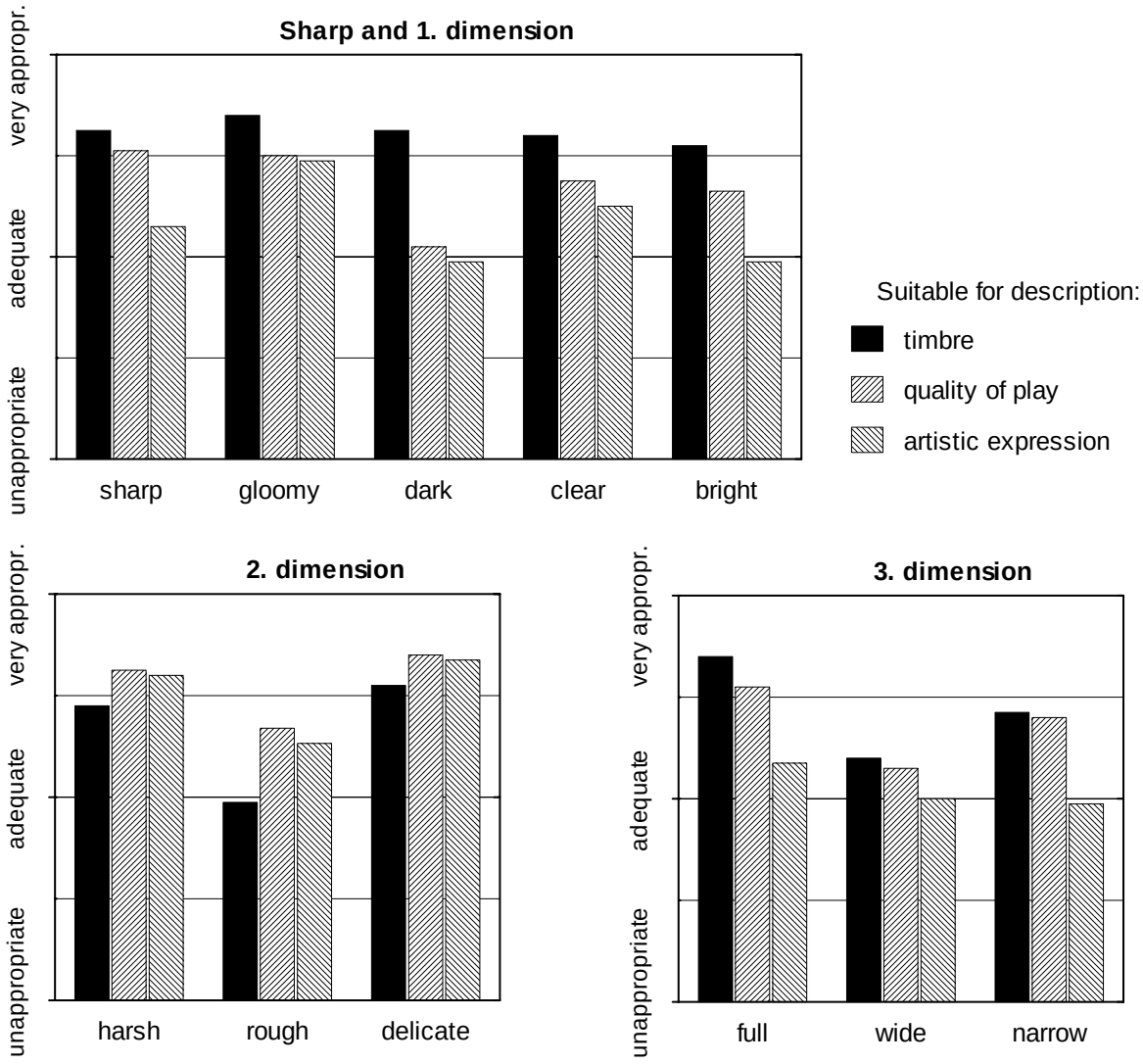

Figure 5. Mean values of answers on questions number four to six for attribute *sharp* and dimensional attributes.

Discussion. Attribute *sharp* and dimensional attributes found in experiment II revealed as appropriate and often used for the description of musical sound, which supported their importance among other studied attributes.

Attributes representing the third and first dimensions are more suitable for the description of steady state part of the sound (Figure 4); *sharp* and second dimension attributes are suitable for both attack and steady state.

In all attributes representing the first dimension dominated suitability for the description of timbre of detached tone (Figure 5) – we may call ***first dimension as timbre dimension***. In second dimension attributes dominated suitability for the description of quality of play of tone together with artistic expression – we may call ***second dimension as quality of play and artistic expression dimension***. In attributes of third dimension dominated suitability for the description of timbre and quality of play of tone – we may call ***third dimension as timbre and quality of play dimension***.

Attribute *sharp* according to questions four to six behaved similarly to attributes of the first and third dimensions.

General discussion and conclusions

Described experiments implied existence of at least three-dimensional common perceptual space of verbal attributes used by Czech speaking musicians for the description of musical sound timbre. At least two first dimensions are shared by five investigated professional groups. Attribute *sharp* – most often occurred in dictionaries – lies in the plain of the first and second dimensions but it showes not to be a dimensional attribute.

From the results of experiments we may conclude that there is no substantial difference in use and opinions on relations of verbal attributes used for the description of timbre among groups of Czech speaking musicians. Dimensional attributes and attribute *sharp* revealed as appropriate and often used for the description of musical sound, which supported their importance among other attributes. Attributes representing individual dimensions proved similar behaviour according to suitability for the description of timbre, quality of play and artistic expression.

Consistency, robustness, quality of results and also their similarity with previous results approved rightfulness and applicability of used approach in research of timbre – to ask respondents for their opinions and experience about timbre without any sound context. Nevertheless found verbal attributes and their discovered relations will be used in future listening tests with various sound contexts.

Future study of verbal attributes used for the description of timbre aims at two ways: in semantic or linguistic analysis of dimensional (most important) attributes found in Czech language and in search for similar structures of attributes in other languages.

Acknowledgments. The research was supported partly by the Grant Agency of the Czech Republic (Project No. 202/02/1370) and partly by the Ministry of Education and Youth of the Czech Republic (Project No. 1M6138498401).

References

Bismarck, G. von. (1974a). Timbre of steady sounds: A factorial investigation of its verbal attributes. *Acustica* 30: 146-159.

———. (1974b). Sharpness as an Attribute of the Timbre of Steady Sounds, *Acustica* 30: 159-172.

Borg, I., Groenen, P. (1997). *Modern Multidimensional Scaling, Theory and Applications*. Springer-Verlag, New York.

Grey, J. M. (1977). Multidimensional perceptual scaling of musical timbres. *Journal of the Acoustical Society of America* 61 (5): 1270-1277.

Guilford, J. P. (1954). *Psychometric methods*. McGraw Hill, New York.

McAdams, S., Winsberg, S., Donnadieu, S., De Soete, G., Krimphoff, J. (1995). Perceptual scaling of synthesized musical timbres: common dimensions, specificities, and latent subject classes. *Psychological Research 58*: 177-192.

Moravec, O., Stepanek, J. (2003a). Verbal description of musical sound timbre in Czech language. In *Proceedings of the Stockholm Music Acoustics Conference (SMAC'03)*, Stockholm, 643-645.

———. (2003b). Collection of Verbal Descriptions of Musical Sound Timbre in Czech Language. In *Proceedings of the 7th International Colloquium "ACOUSTICS '03"*, Zvolen – Šachtičky, 23-26.

———. (2004). Perceptual spaces of verbal attributes used for description of musical sound timbre in Czech language. In *Proceedings of 7. CFA / 30. DAGA*, Strasbourg, 881-882.

Stepanek, J. (2002). The Study of Violin Timbre Using Spontaneous Verbal Description and Verbal Attribute Rating. In *Forum Acusticum Sevilla 2002* (ISBN 84-87985-06-8): MUS-06-008.

———. (2004). Relations between perceptual space and verbal description in violin timbre. In *acústica 2004 Guimarães*, Portugal, CD ROM: AFP 077-S.

Stepanek, J., Otcenasek, Z. (2005). Acoustical correlates of the main features of violin timbre perception. *CIM05 Montreal*.

Stumpf, C. (1890). *Tonpsychologie I-II*. S. Hirzel Verlag, Leipzig 1883.

Winsberg, S., De Soete, G. (1993). A latent class approach to fitting the weighted Euclidean model, CLASCAL. *Psychometrika 58*: 315-330.

———. (2002). A bootstrap procedure for mixture models: applied to multidimensional scaling latent class models. *Applied Stochastic Models for Business and Industry 18*: 391-406.