'GLOSSY' AND 'BUZZING' IN TIMBRE OF VIOLIN SOUNDS

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ABSTRACT: The listening test on the G3 violin tone played by a musician was processed with recordings from the 98-microphones proportionally surrounding the instrument. Listening revealed that distinguishable timbre changes depending on direction could be described as a combination of at least nine factors. In factor 2 were joined sound properties described by the words 'buzzing' and 'glossy'. Since respondents explained both words differently, "glossy" as feeling of *sss* (high frequency components) and "buzzing" as feeling of *zzz* (lower frequencies) it was only an accidental merge on the used sound context. A dependence of a degree of both sound properties on a sound spectrum is discussed in this contribution.

I. INTRODUCTION

This paper presents the continuation of an earlier study [1], which described variability of sound timbre according to microphone position in the space surrounding a musical instrument. The earlier study used simultaneous sound recordings of one (G3) tone from different places around a single instrument for the listening test (François Gand 1825). Individual recordings thus had a similar temporal fluctuation of corresponding components in a complex tone played by a musician. Due to directivity in instrument radiation and the musician's acoustic shadow, recordings from different places differed in component amplitude, thus in timbre. The listening test led to the discovery of areas where the sound was subject to minimal change; sounds representing each of these areas were selected. In order to obtain word descriptions of the timbre of these 19 representative sounds (characterizations of their properties) that were gathered from respondents' spontaneous answers, a further listening test consisted of quantifying the property levels. Property values attributed to each of the representative sounds were used in factor analysis, from which it emerged that the properties could be divided into at least 9 independent factors (Table 1).

In factor no. 2, properties described by the words 'wide', 'buzzing' and 'glossy' were joined together. Based on discussions with respondents, however, these words did not describe identical perceptions and were not synonyms. While 'wide' described perceptions evoked by a complex tone as a whole, 'buzzing' and 'glossy' were evoked only by one of the distinctive features, phenomena occurring inside the tone. Respondents felt 'buzzing' as something like a *zzz* sound, and 'glossy' like *sss*.

The aim of this study is to examine why the word descriptions 'buzzing' and 'glossy' were joined in one factor and what their spectral causes are.

Factor	1	2	3	4	5	6	7	8	9
DARK	-.15	.25	.13	.05	-.16	**.86**	-.11	-.22	.14
BRIGHT	.10	.04	.18	-.47	.04	**-.78**	.10	.02	.28
SOFT	.40	.52	.15	.09	.04	.07	.03	-.10	**-.71**
BLURRED	.61	.49	.47	.06	.14	.03	-.25	.06	.08
MUTTED	.14	.14	.14	.06	.12	.13	**-.94**	.02	.03
DELICATE	.11	.22	**-.88**	.10	.21	-.02	.17	.19	.08
ROUGH	-.01	.17	.16	.12	**-.92**	.15	.11	-.19	.01
BUZZING	.06	**-.72**	-.08	-.06	.04	-.56	.28	.14	.08
GLOSSY	.01	**-.86**	.26	-.04	.13	-.21	.10	.03	.28
GLOOMY	.18	.09	.18	.03	-.12	.30	-.54	-.67	-.18
NASAL	.09	-.03	.04	**-.95**	.05	-.21	.08	.06	.08
GRAIN	**-.90**	.18	.22	.04	.19	.07	.05	-.08	.05
MASSIVE	-.44	-.01	.14	.14	-.20	.13	.14	**-.82**	.01
FULL	**-.95**	-.07	.00	.12	-.16	.05	.03	.05	.04
WIDE	-.26	**-.92**	.04	.18	.08	.02	.00	-.06	-.03
RICH	**-.79**	-.31	-.13	.20	-.11	.11	.09	-.39	.11
NARROW	.52	.38	.05	-.68	.18	-.03	-.06	.16	-.18
CLEAR	**-.72**	-.49	.02	.16	.19	.17	.12	-.12	.20
Expl.Var	4.04	3.30	1.32	1.76	1.17	1.94	1.44	1.49	.83
Prp.Totl	.22	.18	.07	.10	.07	.11	.08	.08	.05

Table 1. Results of factor analysis

II. METHOD

Average spectra were calculated from recordings of stationary parts of individual representative sounds. Results from the listening test (Table 2) were correlated with the values of spectral harmonic components.

recording	BUZZING	GLOSSY	WIDE
a42	1.00	1.00	.10
a23	1.00	0.00	0.00
b53	1.00	0.00	0.00
a54	2.00	1.00	0.00
a35	3.00	2.00	2.00
a56	2.00	0.00	0.00
a46	1.00	0.00	.10
a26	2.00	1.00	1.00
a16	.25	.25	0.00
a58	2.00	.75	0.00
a18	0.00	0.00	0.00
a29	.50	0.00	0.00
a49	1.00	0.00	0.00
a3a	.50	.25	.50
a5b	.50	0.00	0.00
a1b	1.00	0.00	0.00
a1e	0.00	0.00	0.00
a5f	1.00	0.00	0.00
a2g	1.00	.25	0.00

Table 2. Rating value for the sound properties 'buzzing', 'glossy' and 'wide'

The table (Table 3) indicates harmonic components with frequencies and the values of their correlation for perceptions of buzzing and glossy. Statistically significant correlations are highlighted (for $p < 0.05$ the correlation value is > 0.46). Given that in the context of 19 representative sounds no 'glossy' sound occurred that was not at the same time also 'buzzing', there are statistically significant correlations in nearly identical harmonics for both properties above the 38th harmonic. However, only 'buzzing' correlated significantly on harmonics from 27 to 36.

Harmonic	Frequency [Hz]	Corr.buzzy	Corr.glossy
1	196	.24	.40
2	392	-.33	-.11
3	588	-.28	-.25
4	784	.40	.20
5	980	.42	**.48**
6	1176	.03	.10
7	1372	-.19	-.29
8	1568	-.01	-.14
9	1764	.40	.21
10	1960	.17	.10
11	2156	.30	-.03
12	2352	.09	-.15
13	2548	.41	.07
14	2744	.36	.32
15	2940	.37	.05
16	3136	.16	.01
17	3332	.41	**.61**
18	3528	**.47**	.35
19	3724	.44	.36
20	3920	.33	.27
21	4116	.41	.15
22	4312	**.54**	.18
23	4508	.21	-.05
24	4704	.16	-.13
25	4900	.18	.11
26	5096	.31	.25
27	5292	**.52**	.27
28	5488	**.50**	.31
29	5684	**.67**	.39
30	5880	**.50**	.23
31	6076	**.53**	.42
32	6272	**.47**	**.55**
33	6468	**.51**	.33
34	6664	**.49**	.27
35	6860	**.58**	.25
36	7056	**.59**	.15
37	7252	.42	**.48**
38	7448	**.64**	**.70**
39	7644	**.57**	**.62**
40	7840	**.50**	**.52**
41	8036	**.64**	.42
42	8232	**.57**	**.53**
43	8428	.33	.44
44	8624	**.62**	**.60**
45	8820	.33	.30
46	9016	.38	**.52**
47	9212	.31	.43
48	9408	**.65**	**.58**
49	9604	**.68**	**.70**
50	9800	**.78**	**.68**
51	9996	**.69**	**.54**
52	10192	**.56**	.39
53	10388	.44	.35
54	10584	**.57**	**.48**
55	10780	**.59**	**.47**
56	10976	**.59**	.45
57	11172	**.69**	**.55**
58	11368	**.69**	**.60**
59	11564	.46	**.52**
60	11760	.37	**.48**
61	11956	**.47**	.40
62	12152	**.62**	**.47**
63	12348	**.55**	**.53**
64	12544	**.51**	**.49**
65	12740	**.49**	.43
66	12936	.46	**.50**
67	13132	.45	.46
68	13328	.46	**.55**
69	13524	**.50**	**.70**
70	13720	.40	**.53**

Table 3. Correlation of the harmonic values with results from the listening test for 'buzzing' and 'glossy'

An additional listening test was carried out in order to establish that enhancement of harmonic component level in the 5300 Hz to 7000 Hz (harmonic 27 to 36) frequency region caused an increase in perception of 'buzzing', and in the region above 7300 Hz to 8500 Hz (harmonic 37 and more) caused an increase in 'glossy' perception. The recordings were modified for this purpose by bandpass filtration (see manipulation in [2]) in the aforementioned frequency regions, for each separately. For sounds described as "highly" 'buzzing' and 'glossy' the level was reduced, while for those that did not indicate these properties the level was intensified. The table (Table 4) summarizes the results of the assessment of property ratings of both original and manipulated sounds for three different recordings (a35, a16, a18). Spectra calculated from stationary part for this recordings are in figure (Figure 1).

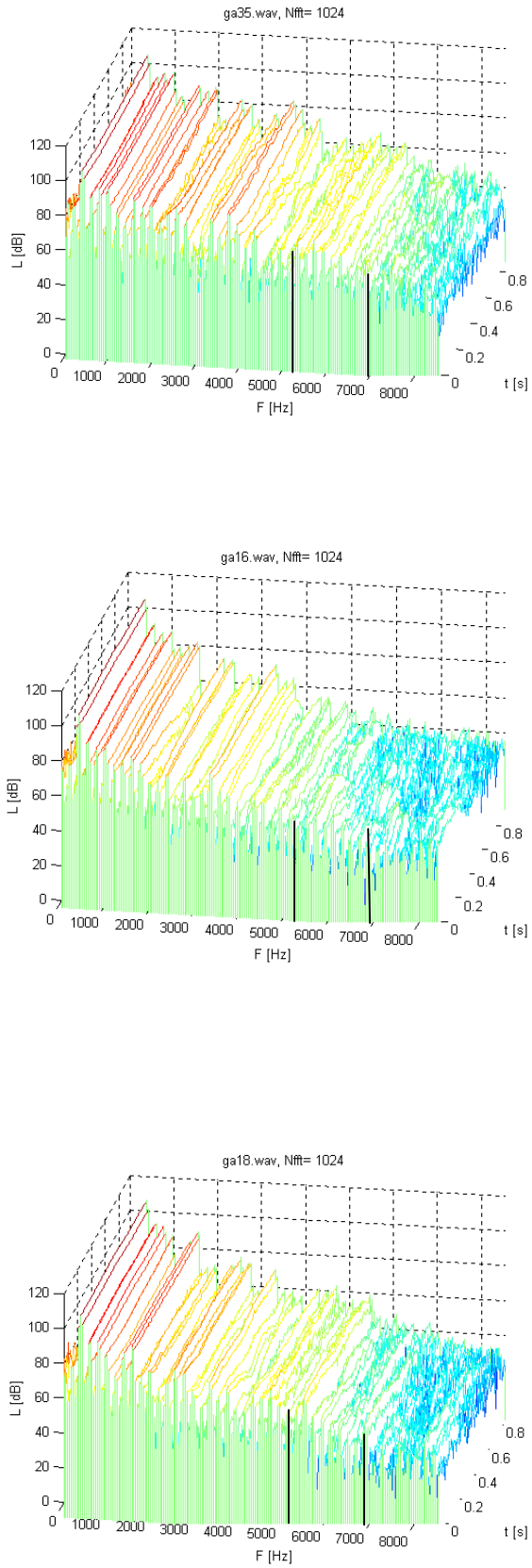


Figure 1. Spectra calculated from stationary part for three different recordings (a35, a16, a18)

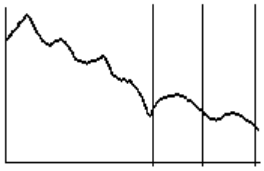
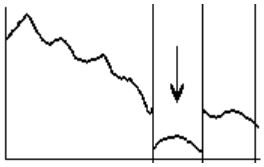
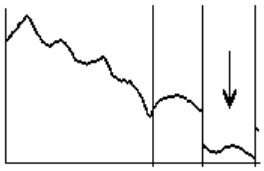
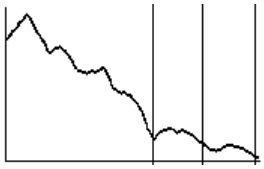
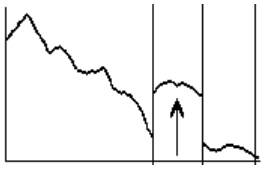
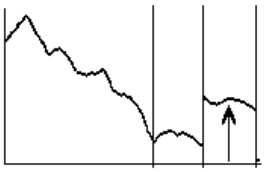
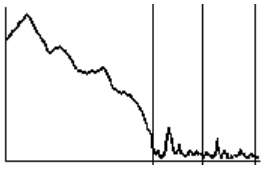
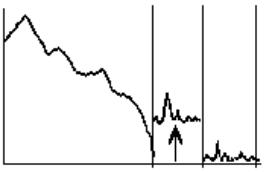
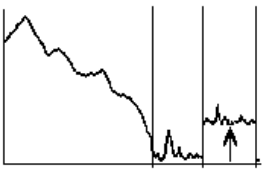
	type of manipulation	rating 'buzzing'	of 'glossy'
recording a35		3	2
recording a35		0	2
recording a35		2	0
recording a16		0	0
recording a16		2	0
recording a16		0	2
recording a18		0	0
recording a18		0	0
recording a18		0	0

Table 4. 'Buzzing' and 'glossy' ratings of both original and manipulated sounds (rating value 0 ... indicates the absence of the property in the given sound, rating value 3 ... indicates a strong occurrence).

III. DISCUSION AND CONCLUSION

The level of harmonic components in the aforementioned frequency band for this tone height (G3) is directly proportional to the levels of 'buzzing' and 'glossy'. Increasing this level above a certain height, which differs in individual recordings, then causes the perception of adulterants in the sounds (several tones heard simultaneously). The case of the recording a18 indicates that in order to perceive 'buzzing' and/or 'glossy', several neighboring harmonics (without further tests, it seems more then 3 or 4) must be present at a higher level in the indicated frequency regions. When the sound did not fulfil this requirement, not even an increase of the harmonic level elicited the perception of 'buzzing' and/or 'glossy', i.e. one or two harmonic component are not enough.

The reason for joining both investigated properties in a single factor no. 2 was the prevailing presence of both properties in the individual recordings in our listening context of stimuli. In the given context, it is possible with manipulation to obtain a sound combination that was not originally present, where the 'buzzing ' property did not exist but 'glossy' did.

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