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Harpsichord voicing: The player's auditive and tactile perception

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Abstract

When a harpsichord player presses a key with his/her finger, a jack is raised toward the string, and a plectrum, which is attached to the jack, plucks a string. The string/plectrum interaction depends on the mechanical and geometrical properties of the plectrum, which are thus expected to have an influence on a) the initial conditions of the string vibration, therefore the sound; b) the mechanical reaction of the key, therefore the haptic feedback.

Players and makers have a thorough but quite informal knowledge of these relationships and accordingly attach a great deal of importance to the "voicing process", during which the plectra are selected and shaped in order to provide the instrument with interesting sound features while preserving a homogeneity of timbre and touch over the whole tessitura.

A perceptual test was designed in order to investigate the relationship between the characteristics of the plectra and the way they are perceived. During semi-directed interviews, experienced harpsichord players played and evaluated two different sets of plectra (made by professional makers). Subjective evaluations were obtained from the verbalisation data and analysed with a psycho-linguistical method, focusing on the auditive and tactile aspects, as well as on their interaction. A perception-based characterisation of the sets of plectra is proposed, resulting from the comparison of the multimodal psychological measurements with the geometrical and mechanical measurements.

Keywords: harpsichord, auditory perception, tactile perception, voicing

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1. Introduction

Harpsichord string plucking is the result of complex mechanical phenomena. When a finger presses a key, a "keylever" raises a "jack" on which a "plectrum" is attached. The plectrum is a very small piece (historically made of feather, nowadays often made of a plastic called "polyoxymethylene", or known as the commercial name "delrin") which elevates the string before releasing it. Although the sound one hears is the further result of complex coupling mechanisms between the bridge, pins and strings [1], and of complex radiation patterns due to the vibroacoustic behaviour of the soundboard [2, 3], the vibrating string undoubtedly is the driving force of the sound. Yet the plectrum appears to be important because its geometrical and mechanical properties can alter its interaction with the string [4, 5, 6, 7, 8]. This potentially results in different initial conditions provided to the vibrating string (presumed influence on the sound), and a potentially different mechanical reaction of the key (presumed influence on the haptic feedback).

Players and makers have a thorough but quite informal knowledge of these relationships and accordingly attach a great deal of importance to the "voicing process", during which the plectra are selected and shaped in order to provide the instrument with interesting sound features while preserving a homogeneity of timbre and touch over the whole tessitura.

Considering sound features and timbral quality raises the question of perception. A very small amount of research reports about perception and the harpsichord can be found in the literature: in [9] listening tests were conducted in order to check if one can hear differences in performances by different players; in [10] listening tests were carried out in order to check if one can discriminate between "loud" and "soft" touch.

In the present study, the perceptual test was designed in order to investigate the relationship between the characteristics of the plectra and the way they are perceived. Additionally the present test focuses on the player's point of view: experienced harpsichord players were asked to play and evaluate two different sets of plectra (two "voicings") during a free playing task.

This paper first describes the free playing and verbalisation experiment (section 2), then the method used for the analysis of the verbalisations (section 3) and eventually the results obtained so far (section 4).

2. Experiment

2.1 Subjects

Eight harpsichord players (numbered S1 to S8) took part in the experiment. All of them have a full-time professional activity involving harpsichord playing: concerts, masterclasses, lessons or recordings.

2.2 Harpsichord

A harpsichord made by French maker Marc Ducornet was used. Its specification are those of a small single-keyboard (56 notes, from G1 to D6), single-stop (eight-foot) harpsichord inspired by the instruments of French makers of the 17th century. This harpsichord is usually played by docents at the Music Museum in Paris during musical and pedagogical visits.

2.3 Voicings

Before the realisation of the plectra (cutting, carving), the keyboard of the harpsichord had been adjusted, and two identical series of jacks had been prepared.

Two professional harpsichord makers were involved in the project. Each of them was given the harpsichord, the series of jack, polyoxymethylene (plectra) and felt (dampers) as raw materials, and asked to produce a series of plectra adapted to this very harpsichord. No further instruction was given to the makers, so that they were free to shape the plectra and dampers their own way.

The two series of jacks fitted with the shaped plectra form the two "voicings" investigated in this study. They are given the names V1 and V2. Figures 1 and 2 are photographs of plectrum number 46 (corresponding note E5) of V1 and V2 respectively.

Each subject was presented to V1 and V2 successively, with a short break in between. The order of presentation was randomised and balanced across subjects.



Figure 1: Example of a plectrum of voicing V1 (side view)

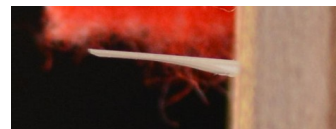


Figure 2: Example of a plectrum of voicing V2 (side view)

2.4 Task

The task was a free playing task. The only instructions given to each subject were:

"Please play on this harpsichord the way you would do if you were looking for an instrument for a personal purchase or an upcoming concert. Please freely tell us about your feelings when playing."

These instructions, given for the first voicing (V1 or V2) presented to the subject, were repeated for the second voicing (V2 or V1) after a short break (5 to 10 minutes, corresponding to the time needed for the experimenters to remove the first series of jacks and install the second one). The subject was not told that the voicing / the series of jack had been changed during the break.

The instructions were deliberately loose in order to let the subject focus on what really was relevant to her/him: No evaluation criterion was suggested to the musicians. The role of the experimenters was to keep the conversation going, asking for details, rewordings, *etc.* In order not to influence the subject, the experimenters took care to not use words if they had not been previously used by the subject.

The harpsichord player sat at the harpsichord and could play and talk while a microphone recorded his speaking, two microphones (X-Y position) recorded the sound radiating from the soundboard, and another microphone recorded the experimenters' speaking. All tests took place in the same room (used for pedagogical visits at the Music Museum), which was chosen for its acoustic neutrality.

The mean duration of a test (1 subject, 2 voicings played and evaluated) was 76.6 (± 7.7) minutes.

3. Analysis

In this section we describe the analysis method for the verbal data gathered during the test described in section 2. The verbal data (8 musicians, 1.25 hours of talk for each of them) was first transcribed (the whole set of transcriptions is called "corpus"). Then through the analysis (section 3.1) semantic categories were identified (section 3.2).

3.1 Method

The analysis method has been proposed in previous works, *e.g.* in [11, 12], where a more detailed description of the analysis method can be found. In line with these works, we made the observation that:

- a) There is only a few lexical resources of French (the language spoken during the tests) that are primarily used to describe sounds, many lexical forms are borrowed from the lexicon of vision (*e.g. bright¹, dull, clear*), everyday life (*e.g. flat, elegance*), or describe the source rather than the sound [13];
- b) In a particular context involving experts of a specific domain the meaning of words can be different from their common sense meaning: here professional harpsichord players play and speak about their instrument;

1 Italic font denotes words and sentences used by the musicians.

- c) However the same word can be given a different meaning by different speakers, or different words used by different speakers can anyway point to the same concept.

Before comparing how the two voicings are verbally described, the analysis should therefore focus on identifying the meaning of the words used by the subjects in order to address the previous remarks. The identification and corpus-based definition of "semantic categories" gives us a framework in which we can compare different words used by different subjects.

The first part of the analysis consisted in extracting the parts of the discourse describing either the harpsichord in general, parts of it, such as jacks or plectra, or the sound or the touch. For each of these parts we kept track of the speaker, the current voicing and any relevant information about the context (what kind of music, in which tessitura she/he was playing, is it a comparison with the previous voicing, etc.).

The second part of the analysis consisted in identifying the meaning of each word used in the descriptions. For this purpose we made use of linguistic marks such as reformulations, oppositions, appositions, metadiscourse, or use of adverbs and comparatives/superlatives.

Words referring to similar concepts and having either similar meanings (semantic proximity), e.g. *loud* and *powerful*, or opposite meanings (semantic distance), e.g. *loud* and *soft*, were grouped into semantic categories. Six semantic categories were identified, from which only two examples are given in section 3.2 for brevity reasons.

3.2 Examples of semantic categories

Tables 1 and 2 show the semantic categories labelled "Loud" and "Timbral aspects". Each table groups together words referring to the same concept. Words were further organised into semantic subcategories:

1. Although it can be induced from the verbal data that a *strong* voicing results in *harder* plectra which produce *louder* sounds, hence that the three concepts can be merged together in our analysis, it seems convenient to split the category into the three following subcategories, according to the object which is described in discourse: "Loudness of the sound", "Hardness of the plectrum", "Strength of the voicing". Note that the boundaries between subcategories are clearly porous.
2. The category "Timbral aspect" is more a "meta-category", i.e. it gathers together different concepts which do not have clear relationships with one another. One aspect is the "roundness" of the sound, the other one is the "muddled" aspect of the sound.

In each subcategory, words were put in the central column if they share a meaning similar to the label of the subcategory (e.g. *powerful* has a similar meaning as *Loudness of the sound*) and in the right column if they have a meaning opposite to the label of the subcategory (e.g. *cosy* has a meaning opposite to the *Loudness of the sound*). Note that in the tables the original French is not given for brevity reasons. A tentative English translation is proposed instead, which is quite word-to-word on purpose, in order to not introduce a further degree of interpretation from the experimenters.

Label of the subcategory	Quasi-synonyms of the label (+)	Quasi-antonyms of the label (-)
Loudness of the sound	<p><u>Descriptors of the sound:</u> amplified, attack, dental attack, attack with consonants, clear, makes me want to play, hard, emission, emotion, energy, easy to play, intensity, let the harmonics develop, lively, loud, long, range, presence, present, power/powerful, reinforced, resistance, resonates more, resounding, satisfactory, more sound, stressed, substantial, violent, volume</p> <p><u>Descriptors of the plectrum:</u> plucks enough, tough</p> <p><u>Descriptors of the touch and player's actions:</u> leeway in dynamics, make an effort to make it sound, finger pressure, touch</p>	<p><u>Descriptors of the sound:</u> beautiful, convenient, cosy, flat, hollow, the note is lost, sensual, sluggish, soft, some notes disappear, less sound, weak</p> <p><u>Descriptors of the plectrum:</u> jack row shifted to the right, smaller plectrum length under the string, thinner</p> <p><u>Other descriptors :</u> feels better, instrument to play for a 2- or 3-person audience, music for a small room, one must attack stronger, one feels one must restrict oneself when playing, 1 string per note</p>
Hardness of the plectrum	<p><u>Descriptors of the sound:</u> loud, resounding, violent</p> <p><u>Descriptors of the plectrum:</u> hard, resistance, resounding, substance, thick</p> <p><u>Descriptors of the touch:</u> have more under the fingers</p>	<p><u>Descriptors of the sound:</u> dull, false, sluggish, soft</p> <p><u>Descriptors of the plectrum:</u> feather, flexible, soft, thin, weak, the jack does not go back well</p> <p><u>Descriptors of the touch and player's actions:</u> light, soft, smaller keyboard of a two-keyboard instrument</p>
Strength of the voicing	<p><u>Descriptors of the sound:</u> elegance, hard, power</p> <p><u>Descriptors of the plectrum:</u> counterbalances the fact that there is only 1 string per note, hard, plectrum oversteps (longer plectrum length under the string), register brought forward, register brought in, strong, vigour</p> <p><u>Descriptors of the touch and player's actions:</u> easy to play, leeway in dynamics, harpsichord responds to the player's attack</p>	<p><u>Descriptors of the plectrum:</u> smaller plectrum length under the string, the jack row shifted to the right, sounds weaker</p>

Table 1: Words in the semantic category "Loud". The words are organised in three subcategories respectively labelled with: "Loudness of the sound", "Hardness of the plectrum", "Strength of the voicing". For each label, words with meaning similar (quasi-synonyms) to the label are grouped, and words with meaning different (quasi-antonyms) from the label are grouped.

3.3 Verbal description of each voicing

The last stage of the analysis was conducted the following way:

1. Go back to the verbal descriptions of harpsichord, sound and touch;
2. Arrange them according to the semantic categories identified through the linguistic analysis;
3. Further arrange them according to the voicing that was played when the evaluation was made;
4. Distinguish between "comparative" (when the subject is explicitly comparing both phases of the test) and "absolute" evaluations (when the subject was explicitly mentioning that she/he was talking about a general feature of this very harpsichord, or when no comparison was possible e.g. during the first phase of the test);
5. Summarise each evaluation (see [11]) as either a positive (+) evaluation (for a given category, the description uses a quasi-synonym of the label within an affirmative sentence, e.g. *the sound is round* or a quasi-antonym within a negative sentence e.g.

the sound is not flat), or a negative (-) evaluation (quasi-synonym within a negative sentence, *e.g. the sound is not round*, or quasi-antonym within an affirmative sentence, *e.g. the sound is flat*). Note that "positive" and "negative" are not judgements from the experimenters but only arbitrary choices made in order to make the analysis easier;

6. For each subcategory and each voicing, sum all positive and negative evaluations, keep absolute and comparative evaluations separated, and keep track of the subjects and the number of occurrences.

Section 4 presents the results of this redistribution and summary of the evaluations of each voicing according to the two semantic categories presented here.

Label of the subcategory	Quasi-synonyms of the label (+)	Quasi-antonyms of the label (-)
Round	<p><u>Descriptors of the sound:</u> balance/balanced, beautiful, beautiful attack, beautiful fundamental, better, brass string, character, dark, deep/depth, echo, generous / generosity, harmonics, 5th harmonic sounds longer, a lot of harmonics, harmonics spread out, harmonics pass by, human, long sound, magnificent, sound quality, resonance, round, roundness, sluggish, soft, sweet, warm / warm, the way the sound develops, weak</p> <p><u>Descriptors of the plectrum:</u> flexible</p> <p><u>Descriptors of the touch and player's actions:</u> easy to make the instrument sing, feel comfortable, let strings vibrate, play with resonance, play calm pieces, play with legato, sensations of the smaller keyboard (of a two-keyboard instrument)</p> <p><u>Other descriptors:</u> the damper dampens smoothly, very small decrescendo before the sound dies out</p>	<p><u>Descriptors of the sound:</u> bright / brightness, constrained, dead, dental attack, flat, hollow, infertile, no / less harmonics, loud, machine, mechanical, precise, uniform</p> <p><u>Descriptors of the plectrum:</u> this plectrum does not look like the other ones</p> <p><u>Descriptors of the touch and player's actions:</u> have difficulty make the instrument sing, play virtuoso pieces, play staccato</p> <p><u>Other descriptors:</u> practice harpsichord, basic harpsichord, new harpsichord, steel strings, string not well stretched</p>
Muddled	<p><u>Descriptors of the sound:</u> chord resonates globally, low-mids., muddled, nasal</p>	<p><u>Descriptors of the sound:</u> beautiful, clear, lights up, loud, makes me want to play, hear the notes clearly separated in chords, presence, sounds like a succession of attacks, transparent</p> <p><u>Descriptors of the touch and player's actions:</u> have difficulty with playing legato</p>

Table 2: Words in the semantic category "Timbral aspects". The words are organised in two subcategories respectively labelled with: "Roundness" and "Muddled". For each label, words with meaning similar (quasi-synonyms) to the label are grouped, and words with meaning different (quasi-antonyms) from the label are grouped.

4. Results

Tables 3 and 4 show the evaluations produced by the subjects on each of the voicings, according to the semantic categories "Loud" and "Timbral aspects" respectively. For each subcategory and each voicing the column "Evaluation" gives the evaluation ("+" and "-" for evaluations with meaning respectively similar or opposite to the label of the subcategory, "[comp]" and "[abs]" respectively for a comparative evaluation between V1 and V2, and for an

absolute evaluation), and the column "Occurrences" gives the information about which subjects produced such an evaluation and how many times she/he did it. For example, it can be seen in table 3 that V1 was judged by S2 (twice), S3 (eight times) and S7 (once) to be louder than V2; and S6 said once (when playing V1, the first voicing presented to S6) that the voicing, generally speaking, was not strong.

Label of the subcategory	V1		V2	
	Evaluation	Occurrences	Evaluation	Occurrences
Loudness of the sound	[comp.] + [abs.] -	S2(2), S3(8), S7(1) S6(2)	[comp.] - [abs.] -	S2(11), S4(1) S3(1), S4(1)
Hardness of the plectrum	[comp.] + [abs.] -	S2(3), S3(4) S6(3)		
Strength of the voicing	[comp.] + [abs.] -	S3(3), S5(3) S6(1)		

Table 3: Evaluation of the 2 voicings according to the semantic category "Loud".

Label of the subcategory	V1		V2	
	Evaluation	Occurrences	Evaluation	Occurrences
Round	[comp.] +	S7(9)	[comp.] +	S2(7)
	[abs.] -	S7(1), S8(1)	[abs.] + [abs.] -	S1(3) S7(11)
Muddled	[comp.] -	S6(2)	[comp.] +	S6(4)

Table 4: Evaluation of the 2 voicings according to the semantic category "Timbral aspects".

From table 3 the following observations can be done:

- Comparative evaluations show that V1 was judged as giving a *louder* sound, whereas V2 was judged as giving a *softer* sound. Absolute evaluations, *i.e.* with respect to the previous experience and knowledge of the musicians, show that generally speaking, the harpsichord in itself *could be louder*, or in other words neither V1 nor V2 was *loud enough*;
- Evaluations of V1 in comparison with V2 show that plectra of V1 were perceived as *harder* than those of V2. Absolute evaluations however show that the plectra of V1 were perceived by one subject as *soft*;
- Evaluations of V1 in comparison with V2 show that V2 was perceived as *stronger* than V1, although a subject stated in an absolute evaluation that *the harpsichord could have been voiced stronger*.

From table 4, the following observations can be done:

- Two subjects (each of them with almost the same number of evaluations) compared V1 and V2 according to the "roundness", coming to opposite conclusions, suggesting that the roundness is not a relevant feature to distinguish between V1 and V2. Absolute evaluations tend to show that the harpsichord of the study has a sound which was perceived as rather *not round*, though no clear consensus appears;
- Only one musician evaluated the *muddled* aspect of the sound, and clearly stated that sounds obtained with V1 were less *muddled* (or *clearer*) than sounds obtained with V2.

5. Conclusion

This undergoing study has shown that a linguistic analysis of verbal evaluations produced by experienced musicians in playing situation can exhibit differences in perceived sound and touch between different voicings. In this study, it was possible to discriminate the two voicings according to the *loudness* of the resulting sound (which depends on the *strength* of the voicing, that is on the *hardness* of the plectra). A difference in the timbral quality could be identified, one voicing producing *muddled* sounds, the other one producing *clear* sounds.

The analysis described in this paper is currently being done on four other semantic categories. The following of this study will also concentrate on the analysis of the data from the microphones recording the radiated sound, in order to find acoustic correlates to the perceptual evaluations: for example the measured sound level is presumably related to the perception of *loudness*, timbral descriptors such as the spectral centroid may correlate with the perception of timbral aspects.

Another aspect of further work is the comparison of the perceptual descriptions of each of the voicings with mechanical and geometrical measurements that have been done on the same plectra [14].

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