THE INFLUENCE OF REED MAKING ON THE PERFORMANCE AND SOUND QUALITY OF THE OBOE

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ABSTRACT

An essential part of the oboe technique is the reed-making process, where the raw material is carved and shaped. Different oboe schools define different types of shapes, and argue about their adequacy for a better sound and performance. This paper focuses on the perceptual influence of 3 reed-making types.

We chose 6 reeds representing 3 pairs of each style (French, German, American) and recorded 116 sound samples with two oboists in controlled conditions. N=63 sound stimuli were selected: 9 *diminuendo* long tones, 18 eight-note phrases from which 18 low-pitched and 18 high-pitched tones were extracted. Tones were normalized in pitch and intensity to help listeners focusing on timbre. 40 participants (20 non-oboist musicians and 20 professional oboists) completed a free-grouping task on each of the 4 stimulus sets, grouping sounds by global similarity.

Results show that the most salient production parameters are the attack type and the oboist-oboe. The reed-making shows no significant influence on isolated tones and a marginal influence on complex phrases, and inter-reed differences are more important than inter-reed-making differences. Reed-making is important in performance technique but has no influence on the perceived timbre. Future research will deal with performer proprioception of the reed making

1. INTRODUCTION

There are several hypotheses among musicians and musical schools about the importance of reed-making style in the performance technique and the sound obtained. The experiments presented in this paper try to bring an objective study on what really is perceivable in the sound when selecting different reed types, namely the German, French and American styles [9]. We can decompose roughly the elements that influence the sound in oboe performance in three parts: the instrument body, the performer and the reed. Reeds and their shape are essential in the whole production of sound, and as stated by famous oboe theorist Haynes [8] "c'est l'anche qui donne la vie". In spite of the well known importance of the reed, we must wait until the XIXth century to find the first detailed written instructions on how to make a reed, and we may deduct that previously they were transmitted through oral communication and through handicrafts imitation [3].

From the beginning of the XIXth century on, we have very detailed descriptions on reed making and the problems that may arise when sharpening the reed [1,2,5,11, 15,16,18,19], but only Brod [2] makes a comprehensive study on the different ways to sharpen the reed in the different national schools, comparing the different foreign styles, mainly Italian and German, and comparing them to the French style, and he includes some links between reed making technique and sound quality, describing the German style as *dur* (harsh) and *sourd* (muffled) and proposing the French style as the most convenient for a better oboe performance. In Spain there is also a distinction of sound quality made by theorists [10][11].

We have then an extensive theoretical corpus about reed-making and a tentative description of the sound obtained. The goal of this study is to measure the eventual perceptual differences between reed-making styles. The literature does not provide with a systematic study of the influence of the reed-making the sound production in spite of the repeated theoretical importance attached to this process. Some studies, like Ledet's [9], make a reference to the changes in sound perception but we find hardly any experiment that measures the direct influence of reed making on acoustic measurements or perception changes. A specific study focuses on the effect of the intonation of the crow of the reed on the tone quality of the oboe [13] using basically one reed-making style (the American).

[14] investigated the influence of the reed brand on the acoustic proprieties of the sound with no reference to the reed-making style, and they make a survey with oboists with general questions on the reed and no actual perception of the sound. Their results show that professional oboists respond that they find the reed as more important than the oboe body but they don't show a preference for a specific brand, and the authors provide no significance tests on their results. We find the same lack of significance tests in another experiment [4] that used the responses of 5 oboists on several components of the reed structure: tube diameter, internal gauging, and reed brand.

In order to obtain a significant answer on the perceived and measurable influence of reed-making in sound production, we need therefore to control all the stages from the very process of reed making, reed selection, sound recording and sound production, and the creation of a perception task that is centered on sound perception and not abstract descriptions of the reed, and following the methodology of timbre perception experiments.

2. REED MAKING PROCESS

Figure 1. Photograph of the 6 reeds that were chosen for recording the sound material of the experiment.

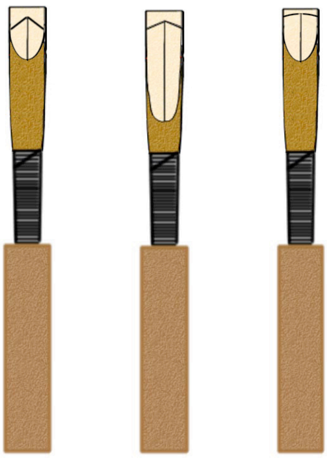

Figure 2. Schematic representation of the 3 styles of reed-making. From left to right: French, American and German. The 3 styles are clearly differentiated by the tip and back areas.

The reed-making process is the essential parameter for this experimental design, and the reeds were made specifically for this research work. We used the 3 main styles defined by Ledet [9]: American, French and German. We tied a total of 25 reeds, using the same manufacturer, staple, internal gouge canes, tube diameter and length. Reed-making was done by hand and when this process was finished, the best reeds with the best material were chosen for the recording. We used a total of 6 reeds, 2 reeds for each type of reed-making. In this experiment, we leave out other aspects of the oboe such as recognition of the different instrument and their schools, the technical aspects of the reeds (type of canes, staples, etc.) or the brand of instruments.

The specific characteristics were as follows:

- Internal gouges: 0’57mm
- Total length (only tied): 74mm
- Total length (cut): 73mm
- Tube diameter: 10'25-10'50mm
- Cane shape: RC12
- Manufacturer of canes: *Le Roseau Chantant*
- Staple: *Chiarugi 47mm 2+*

3. PERFORMANCE RECORDING

3.1 Recorded sounds

Two professional oboists participated in the recording sessions. Both oboists used their own instrument, so that they were used to the idiosyncrasies of their oboe. We made sure that both instruments were of the same type, namely, a Yamaha 831 (professional, semiautomatic), and from the same 4000 series. This provided the maximum similarity in the oboe bodies. Both oboists belong mostly to the German school, and both were trained in Valencia, and were direct or indirect pupils of Lothar Koch. The oboists were instructed to avoid adapting their technique to the reed characteristics. The recording was made in a single session, at the recording studio of the Gandía Campus Radio of the Polytechnic University of Valencia. This room has suitable characteristics for voice and instruments recording. Four AKG C451B microphones were used. These microphones were located one above, one below and two on the sides of the performers, who played sitting and maintaining the same position from the microphones.

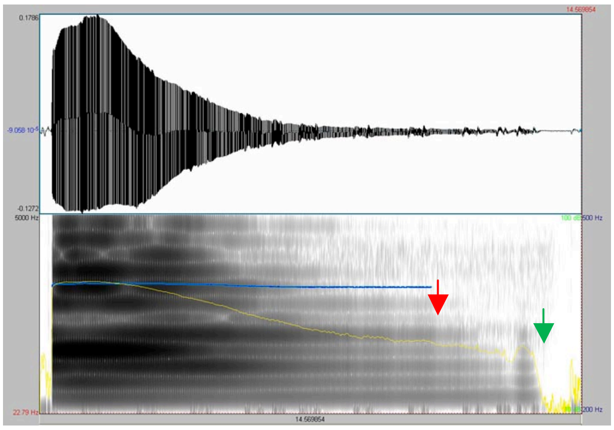

Figure 3. Amplitude/time and sonogram representation of the long isolated tone. The reed arrow points out the end of the stable portion of the sound and the green arrow the end of the perceived sound. The blue line represents F0 (Hz) and the yellow line represents the intensity (dB).

The conditions of temperature (25ºC) and relative humidity (75%) were constant during the 3 hours of the recording session. We recorded 116 sound samples and in this experiment we used the following material:

- Long notes: note G_4, with duration of 12s doing a gradual *diminuendo* (from *fortissimo* to *pianissimo*).
- 8-tone musical phrases: 4 notes G_6 and 4 notes D_4, of 8s. The phrases were played in two ways, first with a tongue attack (i.e. pronouncing the letter "t") and second with a breath attack (without the tongue).
- From each phrase we extracted a low-pitched note (D_6) and a high-pitched note (G_6) with a duration of 1s.

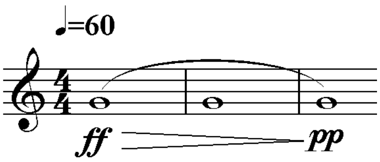

Figure 4. Music notation representation of the *diminuendo* long tone.

The main interest in choosing a long *diminuendo* note is to test the flexibility of the reed. Theoretically, a more flexible reed will allow a larger range of dynamics in the *diminuendo*, although it may induce a progressive drop in pitch. Figure 3 displays the sonogram of a *diminuendo* tone with an indication of the stable and unstable part of the sound. Figure 4 shows the musical notation the musicians had to play.

Figure 5. Music notation representation of the eight-tone musical phrase. The notes that were used in the short-tone experiment are circled out.

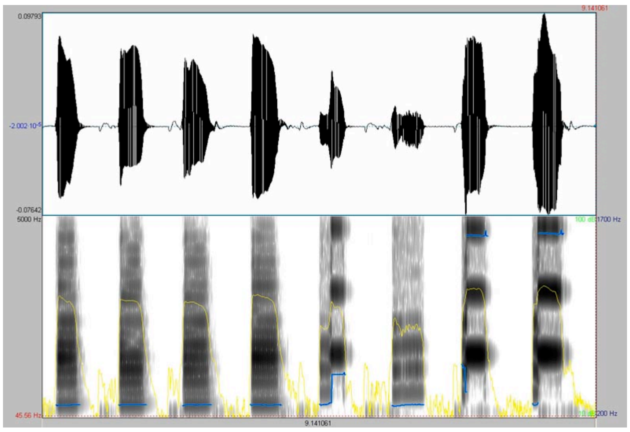

Figure 6. Amplitude/time and sonogram representation of an eight-tone musical phrase. The blue line represents F0 (Hz) and the yellow line represents the intensity (dB).

The 8-note phrase, displayed in figure 5 with musical notation, was used to test the response of the reeds to the different ways to attack a sound. This tests the rigidity of the reed, as some reeds respond better to the air pressure during an attack and some may over-vibrate and play a harmonic tone or fail to sound properly. The tongue attack is sharper and produces an instant increase in pressure. In figure 6 we can see an 8-tone sequence using a tongue attack where some notes fail to sound at the right pitch and intensity.

From the phrase we isolated a low pitched tone and a high pitched tone, selecting preferably the second note of the group as illustrated in figure 5, and if the second note was failed, using the third, so that we had a note with a stabilized sound production without the possible irregularities of the initial or final note of the group. The isolated tones were used to study the timbre with the different reeds and attacks, and the long phrases were used to judge the general stability of the reed with the given attack. The notes that were played use the lower register and higher register of the oboe, with an abrupt change within the phrase that tests the general equilibrium of the reed.

3.2 Acoustic measurements and sound normalization

We did a preliminary acoustic study on the same material and this shows that there are significant differences in pitch according to the reeds and styles of reed-making. Particularly, the German school differed from the American and French.

This experience focuses on the timbral differences between different reeds and reed-making styles, and the most accepted framework for timbre comparison is to use sounds of equal pitch, intensity and duration. Thus we normalized each sound in intensity and pitch, using the theoretical frequency of the note (G_4, D_4, G_6). Even if pitch differences were small, when comparing sounds any pitch change becomes very salient and overcomes other features. Pitch normalization was made by decelerating or accelerating the frequency, therefore we introduced no timbre change, and as the difference in pitch was small (less than a semitone) the speed change has not caused any significant alteration of duration.

4. TIMBRE PERCEPTION EXPERIENCE

4.1 Holistic perception task

The main goal of our experiment is to analyze the effects of reed making on sound timbre. Therefore we have used holistic listening as it is the most accepted perceptual task in timbral studies as described by Grey or McAdams [6,7,12]: in this kind of task, listeners group the sounds according to the global perceived similarity. The timbre research experiments mostly compare inter-instrument differences, but this method is also perfectly suitable to detect timbral differences within the sounds of an instrument. As mentioned before, we normalize the sounds in pitch and intensity, as well as tone duration, as the most accepted working definition of timbre is what differentiates tones of equal pitch, intensity and duration. With the groupings made by each listener, a matrix is made, with 0 when two sounds do not belong to the same group and 1 when they do. The individual matrices have all the properties of a distance, and they are aggregated into a matrix by adding the different values of each listener. The resulting matrix fits again the properties of a distance and can be analyzed with multidimensional scaling techniques to discover the main axes of the perceptual space of the set of sounds.

We insist in the fact that by using a free grouping task, with no previous information on the sounds and no directions on how to classify them, we hope that the listeners will focus on the actual perception of the timbre, and will not try to use their knowledge of reed-making. The goal is to understand if there is any timbre variation associated with reed making, and furthermore, to understand the relative importance of each factor in the global timbre perception, such as differences in the performer, the instrument or the idiosyncrasies of each reed.

4.2 Task

We created four sets of sounds, and each set was presented independently to the listeners. Once the listener had completed the grouping of a given set, the next set was loaded. The sets increased in stimulus complexity and diversity. To establish the order of presentation, we took in account the fact that we had 8-note phrases, and isolated notes from these phrases. As the goal was to force a reduced listening as described by Schaeffer [17], the isolated tones were presented first and the phrase last, presuming that if listeners heard the phrase first, they would try to match the isolated note grouping to what they had done with the complex samples. The *diminuendo* set was the simplest as it had less items which varied less, as no attack differences were present. The sets were presented in this order:

- Stimuli set 1: 9 *diminuendo* long tone (G_4).
- Stimuli set 2: 18 short-tone low-pitched notes (D_4), 9 with a tongue-attack and 9 without.
- Stimuli set 3: 18 short-tone high-pitched note (G_6), 9 with a tongue-attack and 9 without.
- Stimuli set 4: 18 phrases with 4 low-pitched note (D_4) and 4 high-pitched notes (G_6), 9 with a tongue-attack and 9 without.

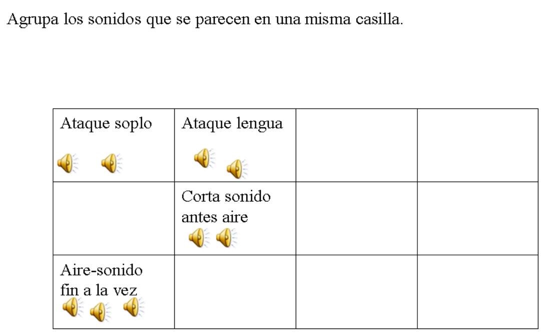

Figure 7. Screenshot of the interactive tool developed for free-grouping sound perception.

Listeners used an interactive interface to listen the sounds and drag the corresponding icons as shown in figure 7. The interface presented the listeners with a set of sounds (associated with an icon that they could freely move and listen) and they had to group them according to their global similarity (holistic listening). In addition, the listeners could write in the boxes a description of the group of sounds and its differentiating features (free verbalization). The listening task was done individually, with headphones and had an approximate duration of 20 minutes.

4.3 Participants

40 participants (20 non-oboist musicians and 20 professional oboists) completed a free-grouping task.

5. RESULTS

5.1 Data

Each classification of a set of sounds corresponds to a matrix which fits all the properties of a distance and it is calculated by adding 1 every time a pair of sounds have been grouped apart.

5.2 Response coherence

We tested the inter-rater response coherence by measuring Cronbach's Alpha, as displayed in figure 8. We can see that the group of oboists has a higher inter-rater coherence, probably due to the fact that oboists are more used to listen analytically the sounds of the oboe and may have common criteria acquired in the learning process.

There is also a clear difference between the *diminuendi* tones and the rest: the *diminuendi* did not have differences in the attack where as in the rest of sounds sets we had 2 types of attack. This has reduced the production differences, and therefore the listeners did not have clear criteria to group the sounds. We will see (figures 10 & 11) that the reed-making differences have not been perceptually very salient. When in a set of items we reduce the factors that may differentiate them, the raters should focus on the remaining factors if they are perceptually relevant. In this case, the *diminuendi* had the reed-making and the performer as production differences, and instead of focusing on reed-making sound differences, they just did not have a consistent grouping, so we can hypothesize that reed-making is not perceptually very relevant for the sets of sounds we have created. Differences between sound sets in the behavioral results may measure true differences in the perceptual qualities of the tones, but we can also consider that the effect of increased practice with the sorting task has derived in a increased agreement between listeners, therefore increasing the Cronbach's Alpha value.

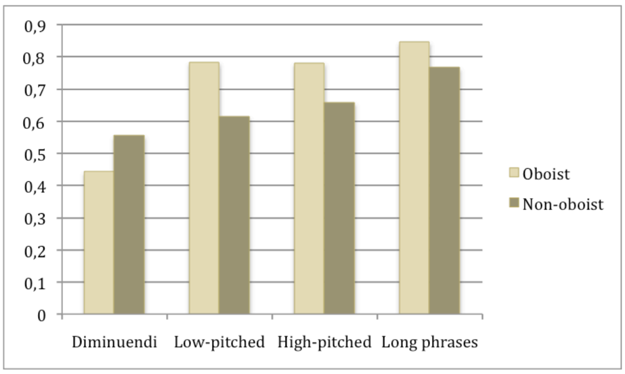

Figure 8. Cronbach's Alpha values for the responses of the two groups of listeners in each set of sounds.

5.3 Multidimensional scaling

We performed a multidimensional scaling on each of the response matrices, using a bi-dimensional model (as the tri-dimensional model did not explain much more variability) to detect the main criteria used by the listeners. The variability explained by the scaling was RSQ= 65% for set 1, RSQ=79% for set 2, RSQ=76% for set 3 and RSQ= 91 % for set 4. As we can see, the variability explained is low except for set 4, and only for set 4 the dimensions obtained could be explained, as shown in figure 9. On the figure we circled out the groups corresponding to the MDS analysis: horizontally (dimension 1) two groups can be divided according to the attack type: breath versus tongue and we have circled out with a dashed line the sounds of breath attack; vertically (dimension 2) also two groups appear according to the performer, we have displayed the sounds of the 2d oboist with a solid line.

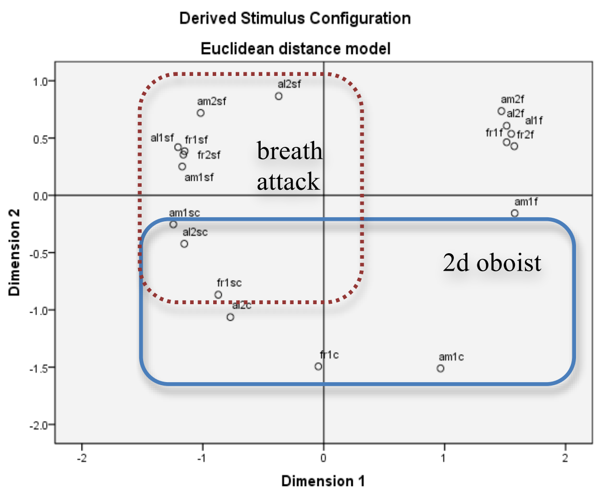

Figure 9. Multidimensional scaling of the stimuli set 4. The first 2 letters are related to the style of lowering: letter S shows a breath-attack. Last letter shows the performer.

5.4 The relative influence of the factors

Tests (Pearson) χ^2				
Stimuli	Participants	χ^2	df	Asymp. Sig. (2-sided)
Diminuendi	Non-oboist	13.0**	1	**.000**
	Oboist	11.7**	1	**.001**
Low-pitched	Non-oboist	2.15	1	.142
	Oboist	5.27*	1	**.022**
High-pitched	Non-oboist	7.78**	1	**.005**
	Oboist	.403	1	.525
Long phrases	Non-oboist	11.1**	1	**.001**
	Oboist	48.3**	1	**.000**

* significant to the 0.05, ** significant to the 0.01

Table 1. Pearson χ^2 test comparing the responses differences for the factor "performer" for each set of stimuli.

To determine if the different styles of reeds affect the perception of listeners, we have done a test of χ^2 dividing the participants into two groups: professional musicians and oboists. We have compared if there were significant differences in the groupings of listeners using the following factors: the oboist (2 oboists), attack (2 types of attack, with the exception of *diminuendi* stimuli which present only one type of attack), reed-making style (3 styles) and reeds (6 reeds: variability inter-reed and intra-school).

Tests (Pearson) χ^2				
Stimuli	Participants	χ^2	df	Asymp. Sig. (2-sided)
Diminuendi	Non-oboist	.140	1	.709
	Oboist	3.91*	1	**.048**
Low-pitched	Non-oboist	.237	1	.626
	Oboist	.501	1	.479
High-pitched	Non-oboist	1.43	1	.231
	Oboist	1.79	1	.181
Long phrases	Non-oboist	5.44*	1	**.020**
	Oboist	.916	1	.338

* significant to the 0.05, ** significant to the 0.01

Table 2. Pearson χ^2 test comparing the responses differences for the factor "reed-making style" for each set of stimuli.

In all the stimuli, the results show that the elements that affect most the perception of the participants are the attack type (table 2) and the performers (table 1), and these differences are significant for both professional musicians and oboists listeners. The performer is not a significant parameter only for short-tone high-pitched notes in the oboists listener group.

As can be seen in table 2, the factor with the least significant differences is the reed-making style; these differences appear only for sentences of 8 notes in the group of listeners who are not oboists (p=,020). In *diminuendi* cases we can observe a significant difference for oboist listeners (p=,048).

Tests (Pearson) χ^2				
Stimuli	Participants	χ^2	df	Asymp. Sig. (2-sided)
Diminuendi	Non-oboist	.566	1	.452
	Oboist	3.37	1	.066
Low-pitched	Non-oboist	.745	1	.388
	Oboist	9.81**	1	**.002**
High-pitched	Non-oboist	3.99*	1	**.046**
	Oboist	2.51	1	.113
Long phrases	Non-oboist	6.22*	1	**.013**
	Oboist	18.1**	1	**.000**

* significant to the 0.05, ** significant to the 0.01

Table 3. Pearson χ^2 test comparing the responses differences for the factor "reed" for each set of stimuli.

By contrast, we can see in table 3 that the differences between individual reeds (independently of the making style) are relevant for both oboists and non-oboists for the low-pitched tones and even more for the complete phrases. In figure 10 we summarize the results of the different χ^2 tests we have performed. As we can see, the attack type is by far the most relevant factor when it is present (it is not present in the *diminuendi* set). The attack type has a significant influence in every case. To have a better comparison for the remaining factors, we eliminated the attack as shown in figure 11.

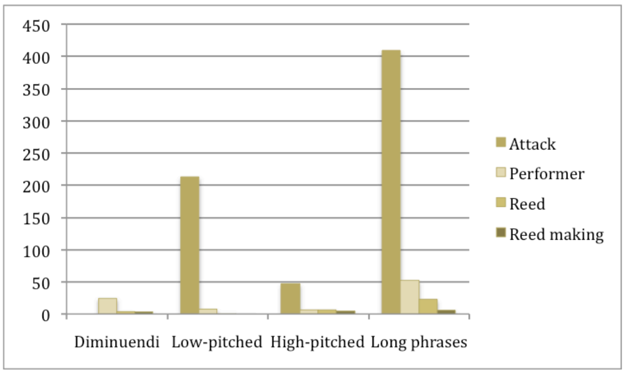

Figure 10. Graphical display of the χ^2 values for the four factors under study.

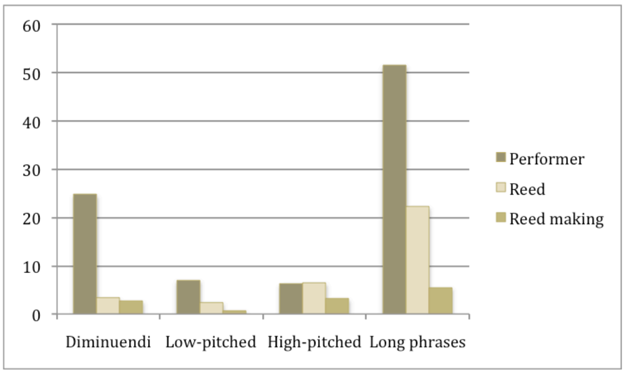

Figure 11. Graphical display of the χ^2 values for the three factors excluding the attack type.

Tables 4, 5, 6 and 7 describe the results for the Pearson Chi-square tests using the responses from all the participants and using as parameter the four factors under study. These results are graphically summarized in figures 10 and 11.

Tests (Pearson) χ^2			
Diminu-endi	χ^2	df	Asymp. Sig. (2-sided)
Attack	-	-	-
Performer	24.738**	1	**.000**
Reed	3.31	1	.069
Reed making	2.71	1	.100

* significant to the 0.05, ** significant to the 0.01

We see in figure 11 that the performer is the most influential factor after the attack, and it is also significant for all the sets. For the *diminuendo* set the importance of the performance is higher than for the other isolated note sets (low and high pitched notes), which can have two causes: the *diminuendo* notes are longer and therefore listeners may distinguish better performance differences, and also, the *diminuendo* notes were performed with the same type of attack; when the most salient feature (attack) is suppressed listeners may focus their attention to the remaining performance differences. As can be seen in the tables, the inter-reed differences are more salient than the inter-reed-making style differences. This means that the specific characteristics of the reed overcome the influences of the reed-making. Furthermore, the reed-making only becomes significant with the 8-tone phrases, where listeners can focus on performing technique (missing notes, performing regularity in the different notes) rather than on mere timbral differences.

Table 4. Pearson χ^2 test results for the *diminuendo* set.

Tests (Pearson) χ^2			
Low-pitched	χ^2	df	Asymp. Sig. (2-sided)
Attack	213.156**	1	**.000**
Performer	7.01**	1	**.008**
Reed	2.393	1	.122
Reed making	.708	1	.400

* significant to the 0.05, ** significant to the 0.01

Table 5. Pearson χ^2 test for the Low-pitched set.

Tests (Pearson) χ^2			
High-pitched	χ^2	df	Asymp. Sig. (2-sided)
Attack	47.099**	1	**.000**
Performer	6.211*	1	**.013**
Reed	6.467*	1	**.011**
Reed making	3.181	1	.075

* significant to the 0.05, ** significant to the 0.01

Table 6. Pearson χ^2 test for the High-pitched set.

Tests (Pearson) χ^2			
Long phrases	χ^2	df	Asymp. Sig. (2-sided)
Attack	408.233**	1	**.000**
Performer	51.552**	1	**.000**
Reed	22.344**	1	**.000**
Reed making	5.511*	1	**.018**

* significant to the 0.05, ** significant to the 0.01

Table 7. Pearson χ^2 test for the Long phrases set .

6. CONCLUSIONS

The main result of our experiment is that reed-making style has a minimal impact on the global shaping of timbre. Performance-related features like the type of attack or the technique of the performer become more salient when they are present and are the only features that consistently influence perception. Multidimensional scaling shows that there is no common strategy, and in particular no strategy associated with reed making, when listeners deal with isolated tones; whereas there are some significant results when listening to 8-note phrases due to attack and instrument differences. Bearing in mind that the isolated tones (high or low-pitched) come from the phrases, and even if it is the same original sound material, the length and added complexity of the phrases bring out different perceptive properties. Long stimuli (isolated *diminuendo* tones and 8-note phrases) bring a more significant distinction between performers, as indicated in table 1. In no case we can detect that reed-making style is a dimension of sound similarity. We can conclude therefore that there is no consistent timbre variation associated with reed making in our material.

First, we point out that the difference between isolated tones and phrases is interesting, as many studies on musical timbre or performance do not compare the results on these two kinds of material. The fact that longer and more complex samples bring coherent classifications can mean that listeners focus their attention on technical performing differences: both performers reported that some sound samples were easier to achieve with one sort of reed than with others, and, for instance, in some cases we have a longer delay in the onset of the high-pitched notes that come after the low-pitched notes, or some notes are not stable more frequently with one type of reed than others. Reed making may therefore influence the technical ability to achieve some technical requirements and will influence the global performance but not particularly the timbre, which is the focus of this paper. The fact that the sounds were normalized in pitch and intensity may also be a factor in the lack of consistent classification strategies, as these two factors are always most salient for trained and untrained listeners; a previous study showed that there were some significant differences between reeds in tuning and other acoustic parameters.

Second, we have detected an important gap between the sound perception and the comments provided by the performers: the two oboists that recorded the sound samples reported differences between the reeds in general and between reed-making styles in particular. Although we did not realize a systematic study of the performers perception, we are inclined to believe that there is indeed a strong mechanical and haptic difference as reed making is consistently reported as an essential part in the oboe functioning, by oboe practitioners and learning manuals. Our future research is going to study systematically the proprioception of the oboe performer, comparing it with the sound perception. For that matter, we are going to use a large set of reeds made using mechanical sharpeners that yield always the same shape. The oboists will play a certain number of exercises that will stress technical qualities of the reed and the oboe, and for each exercise, each oboist will report the proprioception about the elasticity, resistance, ease of use for intonation or for the different types of attack, etc. The resulting exercises will be recorded and the sounds will be used in further tests of sound perception to detect if there are some features of reed making that are sensitive to the performer but not to the audience.

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