Quality of bagpipe drone reeds: plastic versus cane?

Mathieu Paquier
EA 3883 LISyC, Université de Bretagne Occidentale, 29238 Brest cedex 3, France, Mathieu.Paquier@univ-brest.fr

Cédric Moign
EA 3883 LISyC, Université de Bretagne Occidentale, 29238 Brest cedex 3, France, cedric-nadege@wanadoo.fr

The Highland bagpipe is a musical instrument constituted of a bag, a blowpipe, a chanter and three drones; the two tenor drones are alike, whereas the bass one plays at one octave lower. These drones are single-reed pipes, with no side-hole, and can produce only flat B. Traditionally, reeds have been made from sections of cane, but nowadays more and more players use synthetic ones. Plastic is interesting to make reeds because they are less dependent on moisture levels, high temperatures and ageing; tuning of the instrument is, therefore, more stable. On the other hand, according to some musicians, the timbre of instruments would be altered by plastic-made reeds. The plastic vs cane debate has been thriven on generally accepted ideas despite the lack, to our knowledge, of study focused on objective and perceptual comparisons of reeds; it is worth recalling that, among bagpipes, the one from Scotland is the most played all over the world. In this study, we first recorded the sounds from drones, at first played alone, then by three with chanter. These drones were equipped with various reeds made of plastic or cane. Then, musicians were asked to give us their feedback about the quality of the recorded sounds.

1 Introduction

Among the bagpipes, the Great Highland one is the most played all over the world. It consists of a bag, a blowpipe used to blow the bag, three drones equipped with single reeds traditionally made with sections of cane, and a chanter; the two “tenor” drones play a B♭3, whereas the “bass” one plays a B♭2. The chanter, a kind of diatonic oboe, is equipped with a double reed. Despite the preference for cane chanter-reeds demonstrated by most pipers, the cane reeds used for drones are more and more frequently replaced by synthetic or plastic ones. Indeed, they have the reputation of a higher stability while playing: their reduced sensitivity to moisture and warmth solves tuning instability [1], a recurring problem with cane reeds. Moreover, their life-span is much longer than the one for cane reeds. Nevertheless, the latter remain still popular because their timbre is preferred by some pipers to that of synthetic ones.

A drone reed is constituted of an empty “open-close” cylinder with a cavity where a vibrating blade is housed. The vibrating part of the blade can be shortened on request by moving a bridle (sort of rubber or string ring).

The scientific literature about bagpipes is very poor and deals only with their special musical scale[2]. The rare studies about the materials used to make reeds have been carried out only for other musical instruments like, for example, the clarinet [3]; but, the structure of its mouthpiece being very different from that of a drone reed, extrapolations are unpredictable. These considerations led us to ask listeners, with and without solid musical background as pipers, their opinions about the quality of drones made with synthetic or cane reeds. We thus prepared three tests focused on listening and assessment of i) single tenor drones, ii) single bass drones and iii) the three drones played as usually done with the chanter (full set). By “assessment”, we meant not only “assessment of the quality of sound”, but also qualitative opinions through the following criteria: “clarity”, “aggressiveness”, “warmth”, “volume” and “immersion”.

2 Material and Methods

2.1 Recordings

In this study 8 different brands of reeds were investigated; half of them were manufactured synthetic reeds, whereas the others were homemade cane ones. Since all of them were brandnew, they had to be played for a few hours before starting recordings. Two sets (consisting of 2 tenor and 1 bass reeds) were always tested for each brand to check whether the produced sounds were alike; moreover, prior to use their settling was deliberately different. One should note that cane reed settling is only by moving the bridle, whereas some synthetic reeds may be settled by moving the bridle, changing the cylinder volume, bending the blade, which increases the extent of possibilities. Two professional pipers, playing each their own pipes, were recorded. The former, denoted A, used a semi-manufactured instrument, whereas the latter, B, employed a “homemade” instrument. Both instruments had a good making and the wooden parts were made of.
ebony. It is worth underlining that our aim was not to observe the effects attributable to the musician or to the instrument, but rather to extend the conditions of playing to make the experiments more realistic.

For each set of drone reeds, we recorded the single bass drone, then one of the tenor drones alone, and finally a slow tune from Britanny played on the chanter with the two tenor- and the bass-drones working together (full set). After removal of the attack and release from the recording, 8-s sequences were kept for the tests on single drone (tests 1 and 2), and 15-s ones for the test on tune (test 3). Thus a total of 32 sequences (8 brands x 2 items/brand x 2 musicians) was recorded for each of the three tests (single tenor drone, single bass drone and chanter with full set of drones).

The tuning pitch was controlled with an electronic tuner.

Recordings were made with a FOSTEX FR2 digital recorder, at a 48-kHz sampling frequency with a 16-bit quantization, in a studio, with a single DPA 4006 microphone placed at 1.20 m from the piper and at 1.60 m from the floor. The recorded sounds were digitally sent to a computer, and the test interface was developed with the Matlab software.

### 2.2 Test Protocol

To carry out the three experiments planned to assess i) single tenor drones, ii) single bass drones and iii) the full set, i.e. three drones played as usually done with the chanter, the listener equipped with Sony CDR2000 headphones was always placed in front of a computer screen. He could hear a sequence followed with the display on the PC screen of five criteria “global assessment” (quality of sound), “clarity”, “aggressiveness”, “warmth”, “volume”. The sixth criterion, “immersion”, was available only for the third test. These terms had been chosen further to a pre-study during which pipers and non-pipers had been asked to tell us the words expressing at best how they qualified and differentiated the sounds from bagpipes. For each criterion the listener had a choice among three boxes as follows: “-”, “~” and “+” respectively corresponding to “low”, “average” and “high”. At the end of a sequence, the listener under test was requested to tick the box matching the most his feeling for the whole of the heard sounds, and the feelings about the sounds played by musician A were not very different from those about musician B (it means that neither the instruments nor the musicians themselves induced a simple effect on the appreciations by listeners). Finally, the tests showed no marked differences between the two items of the same brand of reeds.

### 3 Results

Though the listeners had all been given the three tests in the same order with test 1 at first and test 3 at the end, we will first report on the results of test 3 because its conditions are the most realistic.

#### 3.1 Sound quality for the full set with chanter (test 3)

First of all, none of the factors “listener background”, “musician” and “item 1 or 2” was at the origin of marked differences in assessments; indeed, piper and “non-piper” listeners had very similar opinions about the volume of bagpipes, which was measured to be 105 dB SPL (full set) at 1m during our recording session. In fact, the listeners were asked to adjust the volume of their headphones in order to avoid over-stimulation. We are aware that our tests were slightly biased by the difference of volume between the sounds through the headphones and those by a bagpipe. But, this bias in the protocol is unavoidable because of the very loud sound of the great Highland bagpipe, designed to be played in the open air. In addition, a drone sound must be felt as good by the audience whatever the distance between them and the piper, thus whatever the volume.

Among the 20 listeners implicated in the study, 10 were either non-piper musicians, or non-piper closely interested by music (including pipe music). On the other hand, the other 10 were pipers with different musical backgrounds, i.e. levels of playing, soloists against exclusive band players. This diversity in tested populations was made on purpose to determine whether both populations of listeners had similar quality criteria to assess bagpipe sounds.
Reed material effect
The sounds of drones equipped with cane reeds were significantly better marked by listeners than those from drones with synthetic reeds (p = 0.0025).

Material/Listener interaction:
About the material used to make the reeds, figure 1 illustrates the lack of significance of this factor for the pipers (p = 0.6476). On the other hand, it is significant for the non-pipers (p = 0.0006). Dividing the group of pipers into soloist and band-players evidenced a non-significant trend shown only by soloists who preferred cane reeds to synthetic ones.

Reed brand effect:
Despite the overall preference of listeners for cane reeds against synthetic ones reported above (section Reed material), the significant difference (p < 0.0001) observed between reed brands without taking account the factor “material” highlighted a preference for some brands of synthetic reeds shown by some pipers. Moreover, Figure 3 exhibits significant differences (p < 0.0001) between non-pipers and pipers about reed brands: the reeds considered to be the best by pipers were not always those selected by non-pipers. On the other hand, no significant preference was found between soloists and band-players about preference for certain brands of reeds.

Material/Musician interaction
For the sequences recorded by musician A, the listeners showed close feelings for synthetic and cane reeds. On the other hand, as regards to the sequences played by musician B, the listeners unambiguously preferred cane reeds to synthetic ones (fig. 2; p < 0.0001). These observations suggest that the bagpipe played by musician B would be more dedicated to cane reeds than to synthetic ones, whereas the one owned by musician A would make no difference. One may also wonder whether the Material/Musician interaction is ruled by the factor “Musician” instead of their bagpipes, but this seems less likely.

Reed brand/Musician interaction:
As indicated above, listeners preferred cane reeds to synthetic ones only when the sequences had been played by musician B. Moreover, depending on the musician who has played the sequence, the preferences of the listeners for such and such reed brand (synthetic or cane) are significantly different (p = 0.037). These differences are particulary marked with synthetic reeds (not to the taste of listeners for sequences played by musician B).

Reed brand/Item interaction
The Reed brand/Item interaction is significant (p = 0.0001). It is worth noting that for some brands, the two items gave rise to very different appreciations, conversely to others at the origin of very similar opinions. In other respects, the study provided no evidence of the intuitive variability among cane reeds with respect to synthetic ones. The former are expected to show variations in their quality because of physical irregularities in the sections of cane and of non-standardised and hand-crafted making. It is likely that the differences of sound between two items of synthetic reeds from the same brand come from the settling operations (moving the bridle, changing the cylinder volume, bending the blade) at the origin of a large range of sounds.

![Figure 1](image1.png)

Figure 1: Sound quality of drones (test 3: full set), as a function of reed material and listeners.

![Figure 2](image2.png)

Figure 2: Sound quality of drones (test 3: full set), as a function of reed material and player.

![Figure 3](image3.png)

Figure 3: Sound quality of drones (test 3: full set), as a function of reed brand and listeners.
This observation is reinforced by the significance of the Redd brand/Item/Musician interaction (p = 0.0055): In particular in the synthetic reeds, for some brands, the two items received different marks when they were used by musician B.

### 3.2 Sound quality for the single bass drone (test 2)

None of the factors “material”, “listener”, “item” and “musician” affected directly the results of test 2 about the sound of single bass drones. No interaction involving the listeners (non-pipers vs pipers) was found about their assessment of bass drone sound. The only simple effect observed concerned reed brand (with no consideration for the material: synthetic vs cane).

**Effect of reed brand**

Despite the lack of direct effect of material on the assessment of single bass drone sound by listeners, both groups showed the same preferences for some brands of reeds (p = 0.0393; fig. 4).

![Figure 4: Sound quality of drones (test 2: single bass drones), as a function of reed brand](image)

**Reed brand/Musician interaction**

The listeners gave good marks to some reed brands from the sequences played by musician A, but this was not the case for sequences by musician B. The opposite phenomenon was observed (p < 0.0001) for some other brands. With synthetic reeds these differences were particularly obvious; as for cane reeds, they were rather equally judged by listeners from the sequences of both musicians.

**Reed brand/Item/Musician interaction**

The Reed brand/Item/Musician interaction was found to be significant (p = 0.0413). For some brands, the differences between the two items were more obvious on the bagpipes of musician B than on the one owned by musician A. Thus, the little differences between reeds were more highlighted by the bagpipes of musician B (or the musician B himself) than by the bagpipes of musician A (or musician A himself).

### 3.3 Sound quality of single tenor drone sound (test 1)

As previously observed for the single bass drone, none of the factors “material”, “listener”, “item” and “musician” affected directly the results of test 1 about the sound of single tenor drones. Similarly, no interaction involving the listeners (non-pipers vs pipers) was found about their assessment of tenor drone sound. The only simple effect observed concerned reed brand (with no consideration for the material: synthetic vs cane).

**Reed brand effect**

As previously reported for the single bass drones, even though we found no direct effect of material (synthetic vs cane) on assessment of the single tenor drone sound, the listeners again showed a preference for some brands of reeds (p < 0.0001); moreover, the preferences by non-pipers were alike those by pipers. About reed brands, it is worth noting that the preferences expressed by listeners in the case of single tenor drones were very close to those with the full set; on the other hand, for single bass drones, there were more differences.

![Figure 5: Sound quality of drones (test 3: single tenor drones), as a function of reed brand](image)

**Material/Musician interaction**

Analysis of results showed a significant Material/Musician interaction (p < 0.0001). Concerning the sequences played by musician A, most of listeners preferred synthetic reeds to cane ones. The reverse situation was observed for sequences by musician B: the preference of listeners was to cane reeds, but it was not obvious.

It is worth recalling that, under full set conditions, listeners had also a better opinion of cane reeds in sequences by musician B, but showed no clear
preference for material in the sequences by musician A.

Reed brand/Musician interaction
As previously observed for single bass drone, the listeners gave good marks to some brands of reeds from the sequences played by musician A, but this was not true for sequences by musician B. The opposite phenomenon was observed \((p < 0.0001)\) for some other brands. This interaction confirms the Material/Musician one described above since the brands of synthetic reeds and those of cane reeds were usually more appraised for sequences played by musician A and by musician B, respectively.

Reed brand/Item/Musician
As previously observed for single bass drones, we found a significant Reed brand/Item/Musician interaction \((p = 0.0008)\) for the single tenor drone. The differences between the two items from a same brand were more evidenced by the bagpipes of musician B than by that of musician A. Once again, the little differences between reeds were enhanced by the bagpipes of musician B (or the musician B himself) compared to the bagpipes of musician A (or musician A himself).

3.4 Correlations between quality of sound and other criteria

This paragraph will focus on the correlations between the quality of sound assessment and the other criteria the listeners had to assess in order to determine whether a drone sound qualified as good would be rather clear, aggressive, warm, loud or immersive. Moreover, we will also wonder about the sameness of these correlations for single tenor drones, single bass drones and under full set conditions, and between non-piper and piper listeners.

Warmth
Among the criteria only “warmth” was systematically and significantly correlated with the quality assessment over the three tests (tenor, bass and full set), and for all the listeners (non-pipers and pipers). Indeed, when a sound was well appreciated, it was also considered as “warm” \((r(32) > 0.601; p < 0.0002)\). This observation was more obvious among pipers.

Agressiveness
Agressiveness was conversely correlated to the quality assessment. With the exception of the non-piper listeners during test 3 (we only observed a trend \((r(32) = -0.223; \ p = 0.2213)\)), this observation was found to be significant for the whole of listeners and tests \((r(32) < -0.439; \ p < 0.011)\). This criterion seems more problematic for the sound of single tenor drones compared to single bass drones. Moreover, under full

set conditions, contrary to the non-pipers, the pipers were greatly disturbed by sound aggressiveness \((r(32) = -0.619; \ p < 0.0001)\).

Clarity
Among the listeners, pipers and non-pipers do not share the same feeling about clarity: for the former, in the three tests, clarity is significantly correlated to quality \((r(32) > 0.391, \ p < 0.0263)\); for the latter, the correlation is low and not significant \((r(32)<0.285, \ p>0.1142)\). For pipers, the strength of the correlation can be ranked in decreasing order from test 3 to test 1 as follows: full set conditions \((r(32) = 0.891, \ p < 0.0001)\) > single bass drone \((r(32) = 0.608, \ p = 0.0001)\) > single tenor drones \((r(32) = 0.391; \ p = 0.0263)\).

Volume
It is worth recalling that, under full set condition, the “volume” criterion refers to the volume of the sound by drones with respect to the sound by the chanter. We found a correlation between this criterion and the quality assessment only in test 3 (full set conditions) with non-piper listeners where the correlation was significantly positive \((r(32) = 0.484, \ p = 0.0045)\); in this case, the positive correlation suggests that non-piper listeners enjoyed the strong volume of the sounds by drones compared to the chanter; on the other hand, we had the feeling that the pipers attached very little importance to the chanter/drones balance. In fact, as the instruction was to assess the quality of sounds by drones, but not by the whole bagpipe, this balance had no effect on their opinion.

3.5 Correlations between other criteria

We found a correlation between “Warmth” and “Immersion” criteria whatever the listeners.

“Clarity” and “Agressiveness” were inversely correlated for the three tests and all listeners.

“Volume” and “Immersion” were correlated only in the case of non-piper listeners.

“Clarity” and “Immersion” were correlated only in the case of piper listeners.

“Agressiveness” and “Immersion” were inversely correlated only in the case of pipers.

“Clarity” and “Agressiveness” were correlated in the three tests when listeners were non-pipers, and inversely correlated in test 3 (full set) in the case of pipers.

“Warmth” and “Volume” were correlated only in test 3 (full set) in the case of non-piper listeners.

“Volume” and “Agressiveness” were correlated only in test 3 (full set) in the case of non-piper listeners.
We never found any correlation between “Clarity”, “Warmth” and “Volume”.

To resume, there is not systematic redundancy between the various criteria with the exception of the couples “Warmth” and “Immersion”, and “Clarity” and “Aggressiveness” (inversely correlated). It is worth noting i) the differences in the association of criteria by piper and non-piper listeners and ii) the differences between test 3 (full set) and tests with single drones (bass and tenor).

4 Conclusion

Under full set conditions, cane reeds were globally more appraised than synthetic ones; this was particularly obvious among non-pipers, far less marked among soloists and not found among band pipers. In tests 1 and 2 (assessment of single tenor drone and single bass drone sounds) the material used to make the reeds had no systematic effect on the preference of listeners.

For the three tests, each bagpipe seemed to be dedicated to some reed brands; in particular synthetic reeds seemed to be better for one of the two bagpipes recorded for this study, and cane ones for the other. Moreover, in some brands of synthetic and cane reeds, items 1 and 2 produced very different sounds.

Among the criteria, all listeners liked warmth and immersion, but not aggressiveness as clearly shown by pipers, who were also fond of Clarity. Non-pipers were seeking a loud volume of drones by comparison with the chanter. On the other hand, the drone/chanter balance was not paramount for pipers.

The next step is the examination of the correlation between these perceptual results and physical parameters of recorded signals, e.g. harmonicity, spectral centroid,…[1],[4].

Acknowledgment

We acknowledge all the listeners who participated to this study, and Philippe Boisard, Hervé Le Floc’h, Erwan Ropars, and Marie-Paule Friocourt for their support and advice throughout this project.

References