



## The musical arm of the bagpipe player: a cultural and mechanical approach “EuroRegio2016”

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### Abstract

There are over 130 different types of bagpipes in the world, from India to Ireland, Sweden to Tunisia. Despite their many organological and esthetical differences, they are all played thanks to the movement of the arm on a bag, creating enough pressure to activate the reeds and produce sound. This study aims to investigate the control of the bag by the musician's arm and how this affects the expressive possibilities. The bag, we posit, is not just a mechanism to create continuous sound. In this article, we analyse how the performer starts and stops the sound of the bagpipe.

**Keywords:** bagpipe, pressure, ornamentation, control of a musical instrument, attacks.

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## 1 Introduction

There are over 130 different types of bagpipes in the world, from India to Ireland, Sweden to Tunisia. Despite their many organological and esthetical differences, they are all played thanks to the movement of the arm on a bag, creating enough pressure to activate the reeds and produce sound. Repertoires, scales and registers vary according to the instruments and their musical cultures, going from a fully chromatic scale over two octaves (the uilleann pipes from Ireland) to a diatonic scale within a range of a sixth (such as the Greek *tsampouna* or the Tunisian *mizwid*).

Bagpipes in their simplest form are composed of a bag with a blowpipe and a melodic pipe. Other pipes can then be added such as a second melodic pipe, semi-melodic pipes or drones. The blowpipe is often fitted with a small valve in order to prevent the air from leaving the bag. In models without this system, the piper uses his/her tongue to prevent the air from escaping whilst s/he breathes in. Alternatively, the blowpipe can be fitted to bellows, thus liberating the piper from the action of blowing into the instrument.

Bagpipes can be classified into three different subsections: single reed bagpipes, double reed bagpipes and hybrid bagpipes with a mixture of single and double reeds [1]. Single reed bagpipes are mainly found in Eastern and Northern Europe as well as South-Western France (*boha*) and a few



archaic models in Spain. Double reed bagpipes are mostly Italian bagpipes and historical seventeenth and eighteenth century instruments from France and England. Hybrid bagpipes, such as the well-known Great Highland Bagpipes, are mostly found in Western Europe with double reeds in the chanter and single reeds in the cylindrical drones.

Bagpipes all function on the same basic principle. Air is insufflated into the bag through a blowpipe or through a set of bellows. The arm on the bag then exerts enough pressure to distribute the air pressure in the bag and activate the reeds, which drives the vibration of the air column in the different pipes. The air supply, the bag and the reeded pipe(s) are the common denominators of the instrument. The lungs or the bellows provide the initial source of air injected into the bag. The pressure in the bag is always distributed by the added pressure of the arm, thus ensuring the flow of air into the pipes. Thanks to its mechanism, bagpipes are able to create a continuous sound, emulating the circular breathing technique.

## 2 Motivation

Unlike fingerings and melodic ornamentation, the musician's arm technique is rarely discussed in bagpipe literature. In 2011 Simon McKerrell [2] evokes how the 'blowing technique' is scarcely discussed: 'blowing is a largely non-verbalised skill, each player learns it individually and develops their own technique'. However, his discussions with pipers and his own experience as a piper allow him to 'agree that steadiness of coordination between blowing and the arm is essential and that blowing harder tends to result in more and greater harmonics and a richer sound'. The only verbalisation that seems to take place, according to his article, is the constant reminder of teachers to their students to 'blow steady': 'young pipers learn to blow the instrument as steady as possible in order that the arm squeezing the bag and the blowing from the lungs work to provide a constant air pressure to the reeds and therefore produce a "steady sound"'.

Despite this lack of verbalisation, bagpipe experts agreed that the breathing technique and the bag were essential elements of their playing [2]. In 2011, Tim Rice conducted a listening experience with Bulgarian bagpipe players [3]. The main criteria for a 'master' piper was the control over the instrument, audible in the first few seconds of the recordings. In this research, we endeavour to understand how the bagpiper exerts control on his/her bag.

Our hypothesis is that the bag, where the air is stored to then be distributed into the different pipes, is constantly controlled by the musician. Understanding this may enhance our comprehension of the importance of the arm in the musical context of the bagpipe. Our main question is: what role does the arm have in the control of the instrument? Leading from this, further questions can be asked such as how does this influence the instrument's repertoire and the musician's performance?

## 3 Protocol

The bagpipe used for our measurements was a Galician bagpipe (*gaita*) with a melodic pipe in C made by Cristobal Prieto in 2005. Part of the hybrid family, the *gaita* has a double reed for the melodic pipe and single reeds for the drones. We asked the musician to use only one drone (C3) and we recorded examples both with and without the drone to compare the strategies used within the playing technique in both situations. The performer is a classically trained recorder player who started learning the bagpipes whilst finalising her performer's degree (Prix) at the Conservatoire in Orsay (France). For the last ten years, she has travelled regularly to Galicia, playing and learning the traditional repertoire with local musicians. Her classical training allows her to be critical of her musical practice from a technical point of view whilst her regular trips to Galicia enabled local musicians to give her feedback on her interpretation of the repertoire. A high level Galician piper

described her level as ‘medium high’ combining high-level finger dexterity with an intermediate level of reproduction of typical Galician ornamentation and of the use of the bag.

We used one of the other drone entries to insert a pressure transducer (Endevco, CA) into the bag, securing it with Teflon tape to render it airtight (Figure 1). The third drone was muted by means of a small tap, ready built into the bagpipe. The sound was recorded with the microphone of a camera placed 3m away from the instrument. Since the sound of the drone is much quieter and lower in pitch than the melodic pipe’s sound, this recording only allowed us to study the sound produced by the melodic pipe. We estimated its fundamental frequencies using the Yin algorithm, [7].



Figure 1 – Galician bagpipe without the melodic pipe, fitted with a pressure transducer on one of the small drones. The large drone (C3) was either opened or closed depending on the extract played.

We asked the musician to play short extracts of about twenty to thirty seconds. This was not an easy task for her as the bagpipe, due to its nature, takes time to emit sound. The musical extracts were therefore shorter than the time span available for the measurements. We asked the musician to play long notes (C4 and G4), long notes with an intended crescendo and decrescendo (C4 and G4), scales that covered the entire range of the instrument and musical excerpts of interest to the musician. These included short samples with pauses and with dynamic variations. The excerpts were repeated twice, once with the drone and once without.

## 4 Preliminary Results

For the purpose of this article, we shall present the findings related to attacks and releases, understanding how the musician started and stopped the sound of the bagpipe. We analysed the data for a single note, held over a few seconds, before moving on to a musical example where a quick arm technique is used to create pauses within the music, thus creating additional musical expression rather than just setting the reeds into vibration.

## 4.1 Attacks and releases

In order to start playing, the musician must put the reeds into vibration. In order to do this he or she will fill the bag up with air in order to increase the pressure at the input of the various pipes (melodic and drones). In the excerpts below, the musician plays first with a drone then without the drone, the latter blocked with airtight tape.

Figures 2 & 3 show the measured pressure (right axis) as well as the recorded sound (left axis), the amplitude of which depends on the soundcard settings, and focus on the attacks for the lower C<sub>4</sub>, the tonic of the melodic pipe played by the musician.

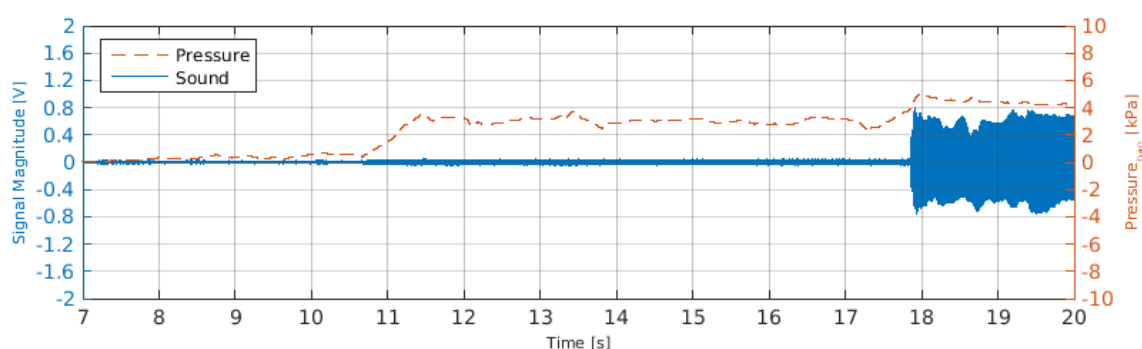


Figure 2 – C<sub>4</sub> attack with drone. Pressure (dotted line) and waveform of the audio signal, measured with the microphone of the camera.

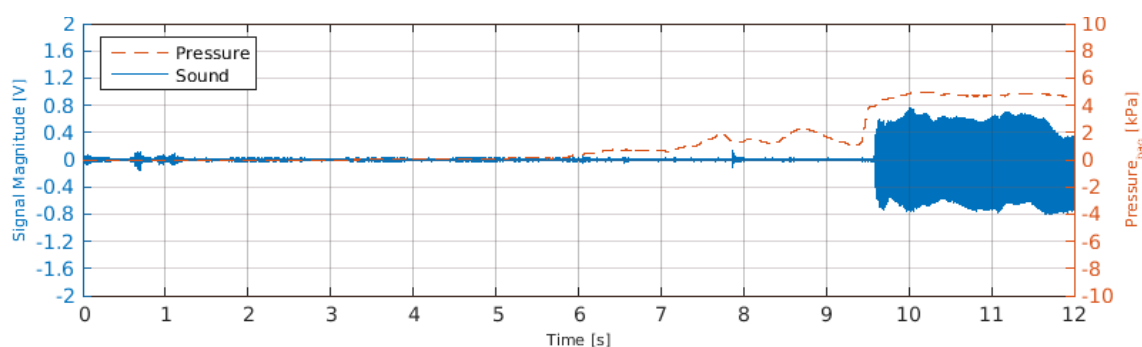


Figure 3 – C<sub>4</sub> attack without drone. Pressure (dotted line) and waveform of the audio signal.

Both figures show a distinct rise in pressure slightly preceding the beginning of the sound corresponding to the necessary pressure required to put into vibration the melodic pipe's double reed. The pressure to put and maintain the reed in vibration is similar in both cases, whether the drone is played or not. It hovers just between 4 and 5 kPa. As a means of comparison, a recorder, at the bottom end of wind instruments' pressure spectrum, uses a pressure of 0,2 to 0,5 kPa. At the top end, the trumpet uses up to 20kPa [5]. Reed instruments such as the oboe and the clarinet are much closer to the bagpipes with a range of 3-5kPa for the oboes and 3-6kPa for the clarinet [6].

In Figure 2, the single reed drone is established before the melodic pipe is put into vibration. This is clearly shown by a stabilised pressure around 3kPa. The attack to put the double reeds into vibration presents a gentle slope, similar to the attack putting the drone into vibration, but rises abruptly as soon as the double reeds start to vibrate. This may be a strategy to avoid the single reeds from stopping their vibration, a common occurrence when they are presented with too much pressure. In Figure 3, however, and in the absence of the drone, the pressure in the bag is lower as the musician

prepares to play the melodic pipe and has no need to maintain a drone. The attack to put the double reeds into vibration is in two parts. The rise from 1kPa to 3kPa is very abrupt before changing into a gentler slope between 3kPa and 5kPa.

These observations are confirmed in the following musical extracts, the final part of the traditional Galician 6/8 piece *Loliña* (figure 4) played by the musician.



Figure 4 – *Loliña*, part 5. Melody outline.

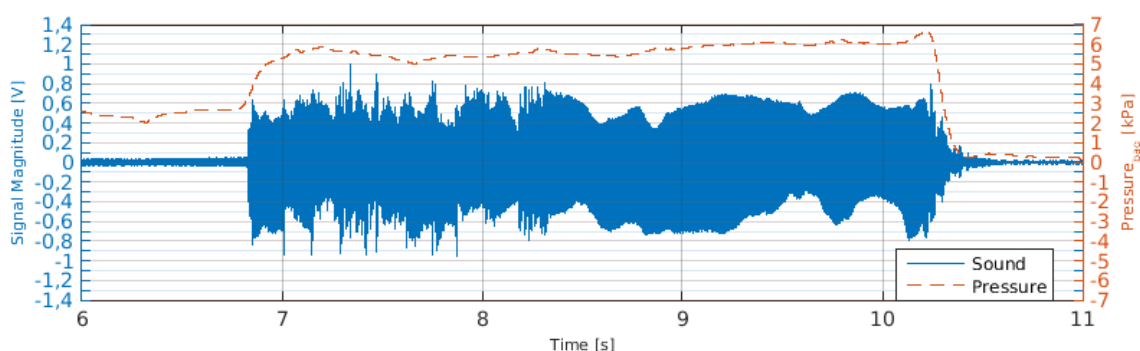


Figure 5 – Musical excerpt *Loliña 05* with drone.  
Waveform of the audio signal and bag pressure (dotted line).

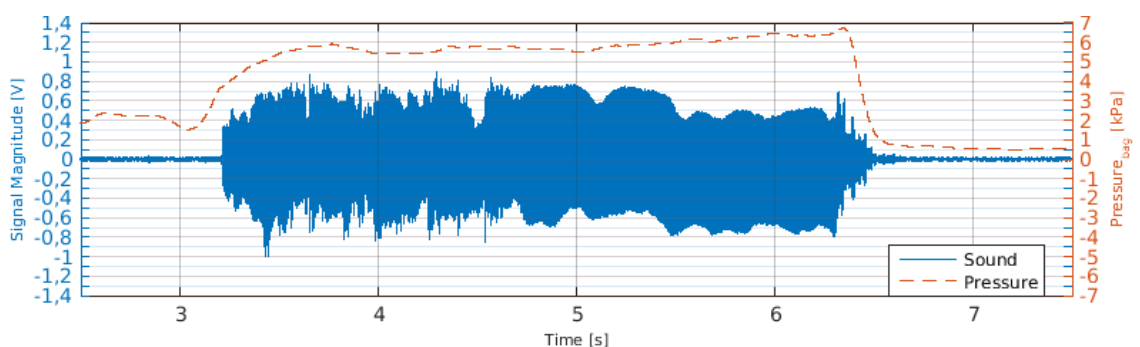


Figure 6 – Musical excerpt *Loliña 05* without drone.  
Waveform of the audio signal and bag pressure (dotted line).

Here again we observe that the attack with the drone is slightly more abrupt than the attack without the drone. In figure 5 the pressure goes from 3kPa to 6kPa in about 0.3s whereas in figure 6, the pressure rises from 2kPa to 6kPa in 0.6s, about double the length of the previous attack. This may be due to the fact that the pressure is already at a certain level and that only a quick rise in pressure is needed to put the double reed in vibration. It may also mean that the attack must be more direct when the drone is already playing. We must note, however, that neither of these excerpts is played within a musical context where the performer would need to keep time with other musicians. The nature of the attack might change in such a context.

Figures 2-6 clearly show similar pressure profiles. In all extracts, whether the melodic pipe is played with or without the drone, the pressure is kept approximately constant in the bag just over 4 kPa regardless of the total airflow through the pipes. The latter will naturally increase when the drone is activated thus leading the musician to increase his/her muscular effort in order to maintain the same pressure.

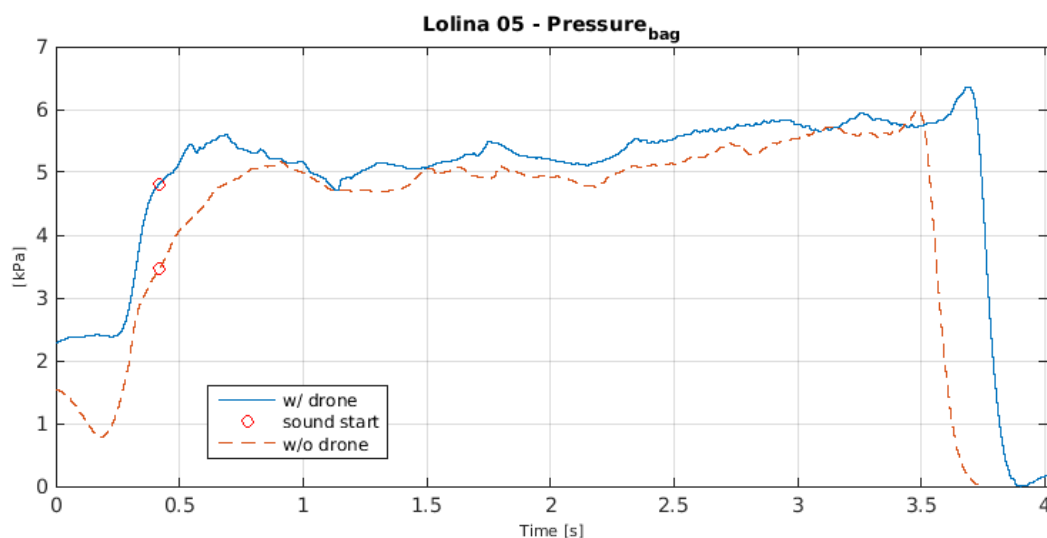


Figure 7 – Musical excerpt Lolina 05. Comparison of pressure with and without drone (dotted line). The beginning of the sound emission is indicated by the small circle.

Figure 7 clearly shows that the two pressure profiles for Lolina part 5 are very similar. Interestingly, however, the figure shows that the melodic pipe reeds are put into vibration at different pressure levels: almost 5kPa with the drone and only 3kPa without the drone. Additionally, in both cases the pressure continues to rise after the sound has started before stabilizing at around 5kPa. The extract without the drone uses slightly less pressure overall than the extract with the drone.

The difference of effort required by the musician may be one of the factors leading to different attacks. Indeed, the pressure is lower when the drone is active than when it is muted and it seems that this decrease must be compensated by a bigger effort of the musician on the bag in order to get the double reed vibrating. This may be why attacks with the drone have a slightly more abrupt pressure curve. This may also explain why the melodic pipe needs more pressure for the reed to be put into vibration when the drone is in use (Figure 7). Indeed, with the drone the airflow is increased and the pressure needs to be higher for both single and double reeds to vibrate. This hypothesis would require to be further studied while measuring the airflow expired by the musician.

Finally, we observe a slight peak at the end of both attacks before the pressure becomes stable (see figure 7). This may be a technique to enhance the precision of the attack and to make sure that the reed is set into motion as fast as possible before adjusting the frequency of the note in relation to the drone. A similar peak is also observed at the end of the musical extracts, indicating a rise in pressure before the vibration ends. This is probably a strategy in order to empty the bag suddenly and lower the pressure in an abrupt way thus ensuring that neither the drone's single reed nor the melodic pipe's double reed will continue to play when the arm is detached from the bag. This would gain to be put in relation with some visual motion capture measurements in order to observe the movement of the arm when releasing the note.

#### 4.2 Attacks within a musical example

Attacks and releases at the beginning and end of a piece are used to start and stop the vibration of the reeds. The quality of the control exerted by the musician can be witnessed by the precision of the attacks at the beginning and end of the music. Such attacks are however not solely limited to the beginning and end of pieces. In the Galician repertoire, musicians also use sudden arm movements in order to stop and start the reeds within a short period of time. This allows the musician to create

pauses within the music. It demands a certain level of skill as both the drone and melodic pipe reeds need to stop and start at the same time with great precision.

The following extract of O Bico, a Galician piece, uses this technique in order to create pauses in the music. The pause is repeated four times in the same musical phrase and is played at the same melodic moment of the phrase, repeated twice:



Figure 8 – O Bico, part 2. Simple melody outline without the ornamentation.

The pressure in the bag is shown in Figure 9.

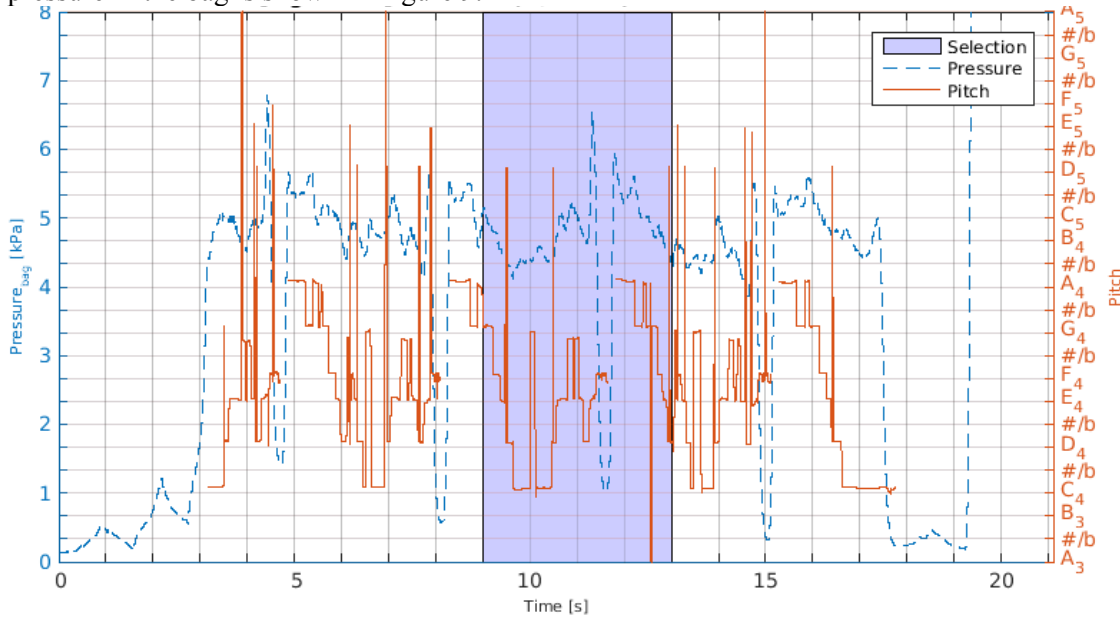


Figure 9.1 – O Bico part 2 with drone. Pressure (dotted line) and frequency.

We can observe here that the pressure dips dramatically four times during the melody, coinciding with the four pauses in the melody. Let us observe one of these depressions, chosen for its lack of disturbance in the frequencies.

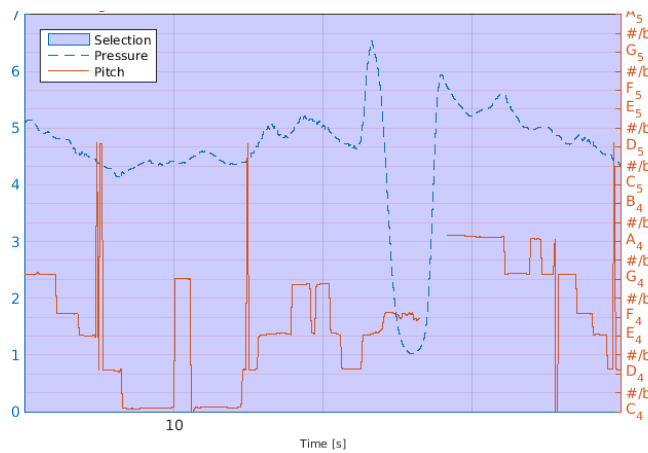


Figure 9.2 – O Bico part 2 with drone, detail. Zoom of highlighted extract portraying a pause in the music. Pressure (dotted line) and frequency.

Much like the previous attacks described, Figure 9.2. shows that there is a sharp increase in pressure before the bag is released. The note lingers slightly as the pressure decreases and ends slightly after the lowest part of the depression. The pressure then increases rapidly and peaks. The reed is put into vibration again and the pressure decreases as it stabilises.

The shape of the pressure clearly indicates conscious control on behalf of the musician as the note ends just after the lowest point of pressure and starts only when the pressure peaks again. This indicates that the musician has to anticipate his/her movements so that the end and beginning of the note arrive at the right time in the musical phrase. As these are not simultaneous actions, it demands considerable skill from the musician who needs to activate his/her arm at precise moments in order to control the pressure in the bag.

The following figures (10.1 and 10.2) show the same phrase played without a drone.

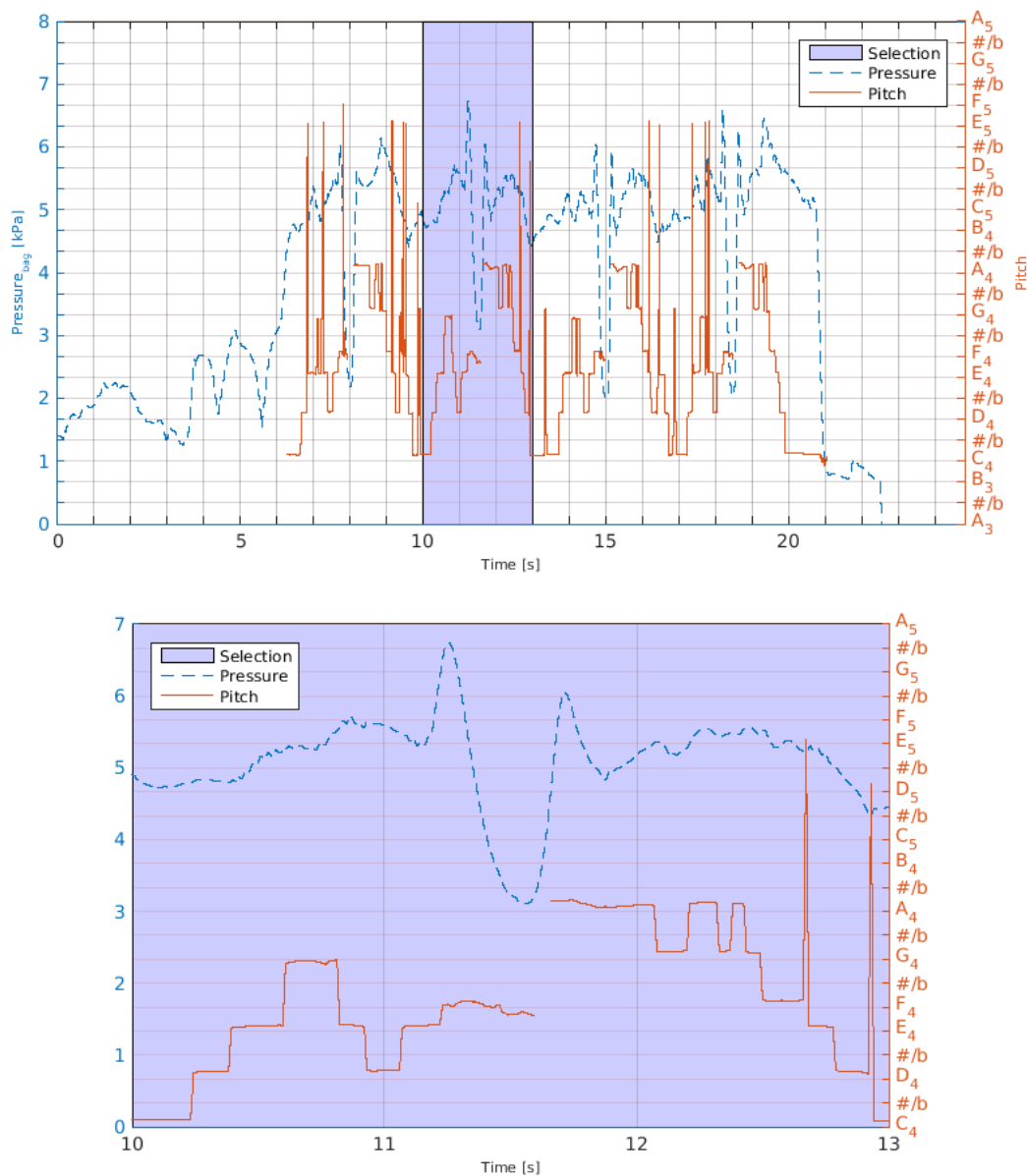


Figure 10 – O Bico part 2 without drone. Full extract (10.1) and zoom (10.2).  
Pressure (dotted line) and frequency.





The general shape of the pressure for the pauses within Bico without the drone (Figure 10) is the same as the pauses with the drone (Figure 9). We can observe a peak, a sharp depression, the note ending at the bottom of the peak, a sharp increase in pressure, a peak and the stabilisation of the pressure. There are, however, several differences. The pressure does not dip as low as in the excerpt with drone: we can observe a variation of around 3.5 kPa in contrast to a variation of 5.5 kPa for the melody with drone. Additionally, the reeds are put into vibration sooner in the extract without drone, as the music starts before the pressure peak rather than after. This leads us to think that the airflow may be responsible for this discrepancy, as the bigger pressure variation is observed in the melody played with drone. However, in both cases both peaks before and after the pause are at roughly the same pressure: 6.5 kPa for the initial peak and 6 kPa for the second peak. This leads us to think that the reeds require a certain amount of pressure to function correctly, unrelated to the airflow.

The last two observations point towards the fact that the musician will need more effort to put the reeds back into action when the airflow is increased. The huge variations of pressure during the pauses also has a musical impact. These pauses cannot last for too long or the bag will not retain enough air for the musician to exert pressure on in order to raise it back to 6 kPa to put the reeds into action. If the pause is too long, the musician will have to blow some air into the bag in order to compensate for the air liberated by the pipes.

These figures show that the arm controls the pressure in the bag with great precision. It is responsible for creating attacks and stopping the sound precisely. Regardless of the airflow, the musician will need the same amount of pressure to maintain the reeds in vibration. This means that the higher the airflow, the more effort the musician will need to keep the pressure at the level required (around 4 kPa for this instrument with this set of reeds).

Attacks differ according to context. The musician controls the attacks according to their position in the musical score and according to the set up of the instrument. The figures above clearly show that the musician is aware of the way his/her instrument functions and anticipates musical moments by controlling the pressure in a precise way.

## 5 Discussion and Conclusion

We have shown through the preliminary results of our study that the arm is an essential element of the musician's performance. The arm carries out a specific mechanical action to control to begin and end the music but also to provide a constant source of air pressure that allows the reeds to vibrate continuously. The arm can also become an integral part of the musical expressivity of the player, adding an extra layer to the music and its ornamentation. These musical movements, embedded within the instrument's culture and repertoire, are facilitated through the combination of the reeds, the melodic pipe and the bag.

Despite a lack of literature, the movement of the arm seems to be one of the most significant aspects linked to bagpipe playing. When a new bagpiper receives his or her first instrument, the first element s/he must master is the movement of the arm for without it s/he would not be able to produce a sound. The bag is also the first source of adjustment for pipers: small, big, unwieldy, comfortable, resistant, flexible, all these aspects will be unconsciously taken into account when trying a new bagpipe.

Our study aims to delve further into the control of the bag by the musician's arm and how this affects the expressive possibilities. The bag, we posit, is not just a mechanism to create continuous sound. Our goal is to understand and detail the different kinds of expressivity and ornamentations created by the use of the bag such as dynamics, phrasing and intonation adjustments. A cultural element appears when we compare different bagpipes and find different strategies used by the musicians, developed specifically through their instrument and adapted to the repertoire they play.



Further research will involve the study of the arm's action on the bag, mainly through the analysis of its muscular activity through electromyography and of its movement through a motion capture system. It will also compare the arm activity of high-level musicians with an intermediate musician in order to understand the full range of control a bagpiper can have over the instrument.

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