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ACOUSTIC SPECTRUM AND TIMBRE VARIATION OVER THE ATTACK IN THE TXISTU

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Abstract

The Basque txistu is most likely the first musical instrument unique to the Basque Country. It is like a recorder, with only four holes, which is held and played in the left hand. The single most important aspect of txistu playing is use of wind, which touches many aspects of music-making, such as intonation, dynamics, articulation and vibrato production.

One of the major difficulties in attaining proficiency on the txistu is getting good control over the instrument's timbre. This is controlled by the wind intensity, the fingers position and the attack of the notes. Due to the characteristics of the txistu, it is difficult to obtain some transitions among notes. The player surpasses these obstacles by means of alternative positions for the same note and/or a different way of attack.

The purpose of this study is therefore to analyze the attacks and the influence that they have on the pitch and timbre. We wish to observe the different kind of attacks as well as their utility for the expressiveness of a melody. Students new to the txistu are instructed to articulate different configurations of the vocal tract. In this study we examine the influence of the elected attack technique and their utility for the playing of specific melody demands.

INTRODUCTION

One of the first musical instruments are bird bones with holes that have been found in Istallöskö (Hungary) and are dated to the aurignacian age, 20000 years ago. It is therefore possible that this primitive flute was accompanied by some type of percussion; however, there are no references of someone simultaneously playing a woodwind instrument with percussion accompaniment, until 1240 when some iconographic testimonies were discovered in Exeter Cathedral. The references of these so-called tambour pipes, that extend throughout Europe, with the instruments hatching from different regions, take different forms. In the Basque Country, the first engravings of this type come from the thirteenth century and can be found in the Our Lady of the Assumption monastery [1].

The txistu is one of the most advanced instruments of the flute family with a mouthpiece and three lateral holes. Traditionally the txistu was accompanied by a small drum to interpret the music for the popular dances. Today, as well as being the protagonist in festivals, weddings and other events, txistu teaching in music schools has made the txistu evermore common to be found with other instruments and integrated into the orchestra.

In this work we carry out and study of the txistu´s acoustic properties. Firstly we will discuss the imperfections of the sounds, which are due to the physical imperfections and the limitations derived by the simplicity of the instrument that only has three sound holes. This characteristic gives the player the advantage of being able to play the txistu with one hand and use the other to play the percussion; however this can limit the possibility of achieving a perfect tonal sound, which can be a disadvantage when the txistu is played with other instruments. This will be discussed in the section named "acoustic spectrum and interval analyses". Secondly we investigate the frequency range a note can go throughout in the section "control over the instrument timbre". Also we will analyze the different types of attack and the consequences that are taken from the transitory regime result in the part "the study of the transient for different articulations". Finally, the conclusions of this study will be presented.

DESCRIPTION

The txistu family includes three instruments that only differ on their size: the silbote, the txistu and the txirula. The largest of all, the silbote can be tuned to Bb, B or C. Instrumentalist has to use both hands due to its large size. The txistu is generally tuned to F, F# or G, a perfect fourth or a perfect fifth higher than the silbote. Finally, the smallest of all, the txirula is tuned to C, an octave higher than the silbote.

All this instruments have the same number of sound holes, two in the front and one in the back of the instrument. The txistus are made of ebony, bog or walnut. Originally they were made in one piece then they changed to two parts and later to three. These modifications permit to vary the tuning slightly introducing rings of wood at the intersection of pipes, or to change the inferior piece and convert the txistu to another tonality. Figure 1 shows a lateral view of the two parts of an F tuned txistu. In figure 2 one can see the mouthpiece in detail. We can appreciate that the txistu is constituted of a truncated conical wooden pipe as the principal piece, with three lateral sound holes in the final part of the cone which are numbered 1, 2 and 3. A metallic mouthpiece conducts the air flow until reaching the metal reed. When the distance between the mouthpiece end and the metal reed (L) varies, moving the reed, the sound slightly changes.

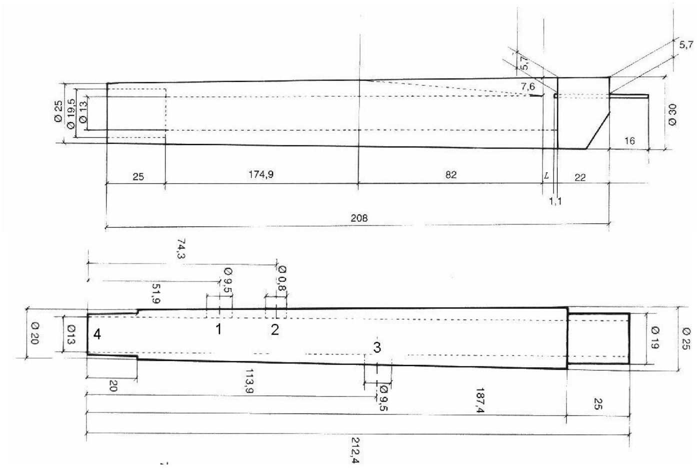

Figure 1 – Lateral view of the two parts of a txistu: the mouthpiece and the F intonation part. The tone holes are named 1, 2, 3 and 4 is the bore end hole. (Lengths in mm)

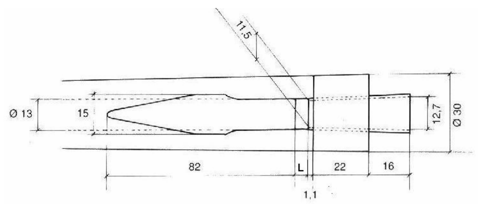

Figure 2 – Upper view of mouthpiece of the txistu with variable length L between reed and mouthpiece [2]

EXPERIMENTAL SETUP

The sounds of the instrument were recorded with a Prepolarized Free-Field, ½" Microphone (Brüel&Kjær, 4189-A-021) and a PULSE analyser (Brüel&Kjær). The microphone was placed approximately 50 cm in front of the txistu. Obtained data have been analysed with Pulse 10 software from Brüel&Kjær. In addition, the sound intensity was measured with an "Extech Instruments 407727" sound level meter placed 50 cm in front of the txistu.

ACOUSTIC SPECTRUM AND INTERVAL ANALISYS

The txistu is a transposing instrument. In this first part, we will analyze the txistu partials. We will discover the partials that appear with the play of every note and the importance of each one.

There are various fingering configurations to obtain the notes of the txistu. In this part we will refer to the first harmonic scale, which can be obtained covering sound holes 1, 2 and 3. Figure 3 shows the FFT spectra of the successive notes

obtained increasing blown pressure. The value of the pressure level measured with the digital sound level meter varies from 70 dBC to 102 dBC.
With soft blowing, the txistu emits a D3 that has even partials. If the musician increases the blowing pressure, the txistu emits the D4, gradually increasing the blowing pressure we will ear notes a perfect fifth higher, after a perfect fourth, a third major and a third minor, higher than the precedent note.

All this notes have in common that the maximum values appear at the same frequencies and the relative amplitude of the maxima determines the note we will perceive.

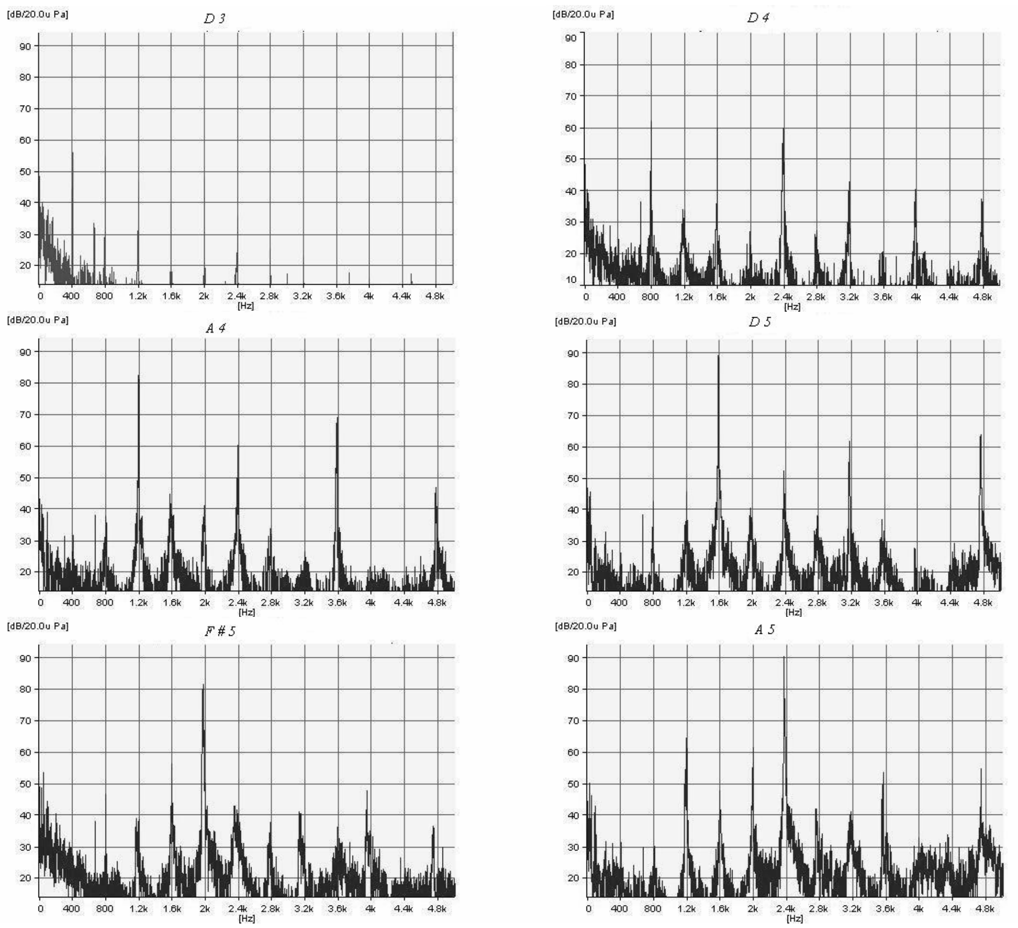

Figure 3 – FFT of notes with closed holes articulation.

Figure 4 illustrates the deviation of the perfect fourth, perfect fifth and octave intervals. The intervals obtained from the maxima of the graphics shown in Figure 3 are compared with the theoretically predicted by the scale of just intonation. For the notes without odd harmonics it is not possible to describe the deviation of the perfect fourths and fifths [3].

Some of these notes are considerably altered from the ideal, although the player corrects then by slightly varying the fingering or using another articulation. The analysis of other articulations does not give additional information.

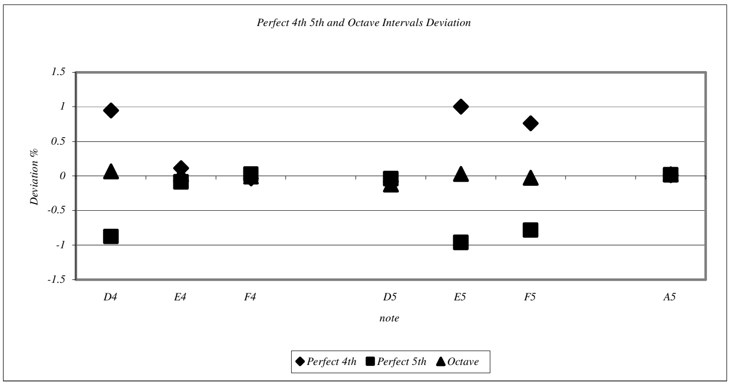

Figure 4 – Intervals deviation

CONTROL OVER THE INSTRUMENT TIMBRE

The distance between the end of the mouthpiece and the metal reed (L) is variable and can slightly change the sound. When L decreases, high pitch notes sound easily in a natural form, however low pitch notes will have less intensity and increasing blowing pressure will produce a higher note. So it is necessary to attain equilibrium to interpret all the instrument tessitura.

Like all flutes with a reed, the frequency of the txistu depends on the air pressure. In this section we will analyze how the frequency ranges between notes varies and which are the physical variables that can change these values.

Table 1 shows the maximum and minimum values of the frequency for each note. The lowest frequency corresponds to the minimum air pressure necessary to make the note sound and the highest frequency corresponds to the maximum pressure, just before the note changes to the next register [4].

Note	L= 4.5mm			L= 5mm		
	F. Min. (Hz)	F. Max. (Hz)	Dif (cents)	F. Min. (Hz)	F. Max. (Hz)	Dif (cents)
D4	776	792	35.33	778	800	48.28
E4	888	902	27.08	888	906	34.74
F4	928	940	22.24	942	958	29.16
G4	1054	1066	19.60	1044	1066	36.10
A4	1174	1194	29.24	1168	1184	23.55
B4	1308	1344	47.00	1322	1336	18.24
C5	1402	1420	22.09	1398	1408	12.34
D5	1574	1604	32.69	1559	1578	20.97

Table 1– Pitch variation for variable blowing pressure and different L

In some notes, the difference between the maximum frequency and the minimum is greater than the others. For L= 0.45cm the low frequency notes move in a smaller range and pass to the next register easier than for L= 0. 5cm. The high frequency notes are more comfortable to play with small L and it is possible to make them sound with different dynamics, having a wider pressure and frequency variation range. This can be related to the acoustic impedance of the instrument, when ´L` is greater the acoustic impedance will have deeper and sharper minima in low frequencies. When ´L` is smaller the acoustic impedance will have a more regular figure in all frequencies [5].

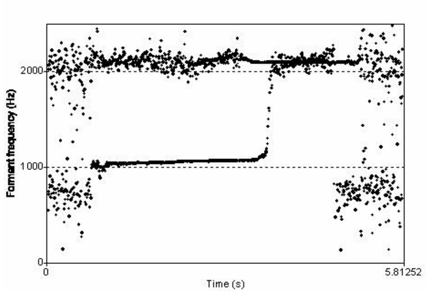

Figure 5 – Pitch contour graph for note G while changing the blown air pressure.

THE STUDY OF THE TRANSIENT FOR DIFFERENT ARTICULATIONS

The player has followed the method proposed by Juan Vega [6]. Basic tongue position corresponds to “ee eh” pronunciation. With the tongue in this position, various consonants can be easily articulated such as the “T”, the “D” and the “R” (like in “paradise”). Figure 6 shows basic tongue position for this articulation. Articulation “T”, that does not necessarily have to be aggressive, can be used when the air canal is closed, but “D” and “R” need an open canal to sound properly.

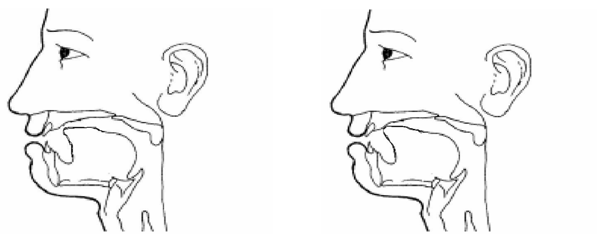

Figure 6 – Articulation with free tongue tip

The consonant “K” is not sounded by the tip of the tongue. This consonant rises in the throat and can be alternated with the articulations mentioned before to achieve the velocity. If “teketeketeke” is articulated it is possible to obtain six notes in a short amount of time, much quicker than articulating “tetetetetete”.

In Figure 7 it is possible to observe the attack of the even partials of the note D5 for different articulations. The second partial appears and grows quicker than the rest. The fourth and eight partials are very different in weak articulations such as “R” and “D”. This leads us to believe that they are important in the perception of the sound.

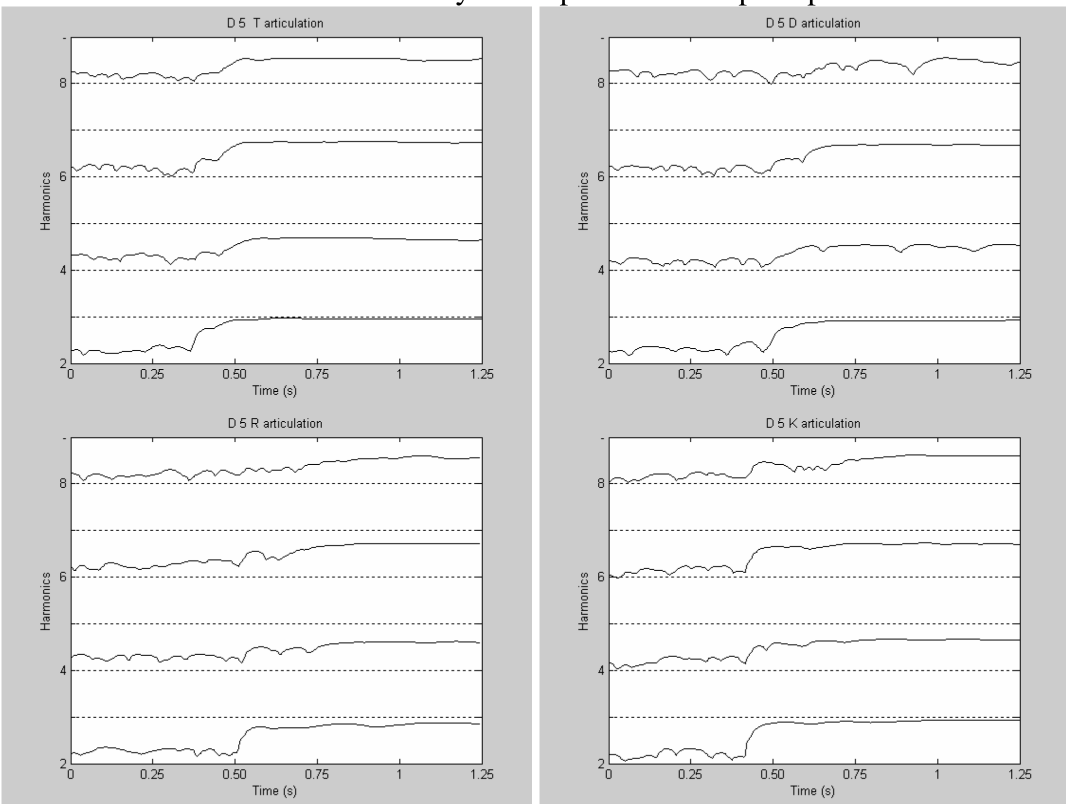

Figure 7 – Attack transients of even partials for note D5 for different articulations. The distance between grid lines is 100 dB in the ordinate.

Table 2 shows the attack time values for D5 note in different articulations. The attack time of the partials was calculated as the interval from when it reached the -50 dB threshold of the maximum log-mag amplitude up to reaching the -5 dB threshold of the maximum log-mag amplitude [7]. The fastest attack is found in articulations “T” and “K” and the rise in “D” and “R” is less abrupt and slower.

Note	*D5 T*	*D5 D*	*D5 R*	*D5 K*
Frequency (Hz)	*1600*	*1587.5*	*1600*	*1600*
Attack Time (s)	*0.135*	*0.155*	*0.220*	*0.120*
Frequency (Hz)	*3200*	*3175*	*3200*	*3200*
Attack Time (s)	*0.570*	*1.625*	*0.945*	*0.625*
Frequency (Hz)	*4800*	*4762.5*	*4787.5*	*4800*
Attack Time (s)	*0.145*	*0.215*	*2.010*	*0.385*
Frequency (Hz)	*6400*	*6362.5*	*6387.5*	*6387.5*
Attack Time (s)	*0.545*	*1.410*	*1.940*	*0.730*

Table 2– Attack Time of harmonics with articulation T, D, R and K

The shortest attack time appears in "K" articulation. For this reasons it is used in very quick passages of music where other articulations are not effective.

CONCLUSIONS

The pitch and the timbre of the txistu depends on various factors such as the tube length, de distance L between mouthpiece and metal reed, the temperature, the humidity or the materials quality. In the study of the perfect fourth, perfect fifth and octave intervals, we find 1% deviations from the theoretically predicted by the scale of just intonation. The player corrects them varying fingering.

When the distance L between the mouthpiece and the reed varies, the sound changes. Higher distances favour low frequency notes whereas shorter distances improve high frequency notes. This can be related to the change of the acoustic impedance of the instrument with L.

In the study of the attack transients for different articulations (K, T, D, R), the fastest attack is found for "K" then for "T", being the rise in "D" and "R" less abrupt and slower. These characteristics explain that "K" articulation is usually used in very quick passages. In all the cases, the second partial appears and grows quicker than the other studied partials. The time evolution of the fourth and eight partials is different in weak articulations ("R" and "D") than in the others. This leads us to believe that these partials are important in the perception of the sound.

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