

# Does the recorder player control the onset time of the sound?



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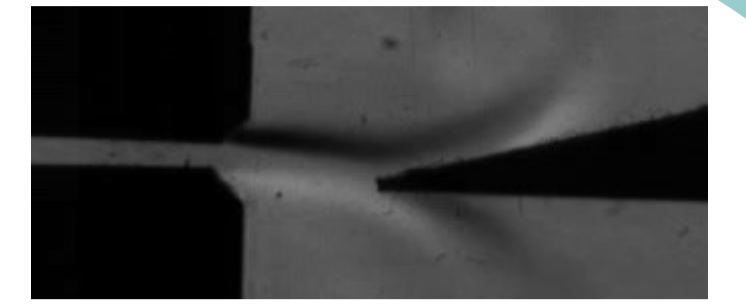
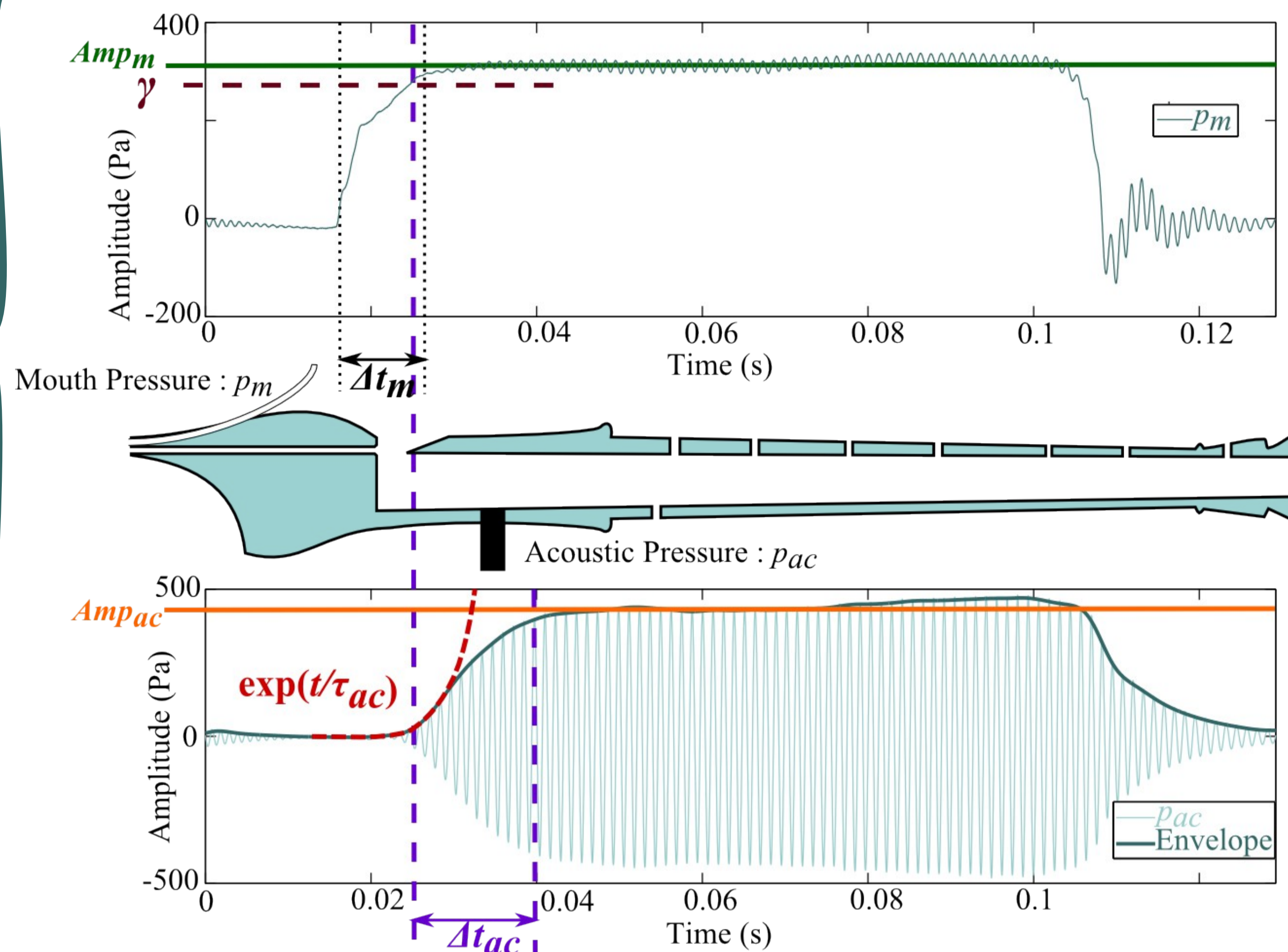
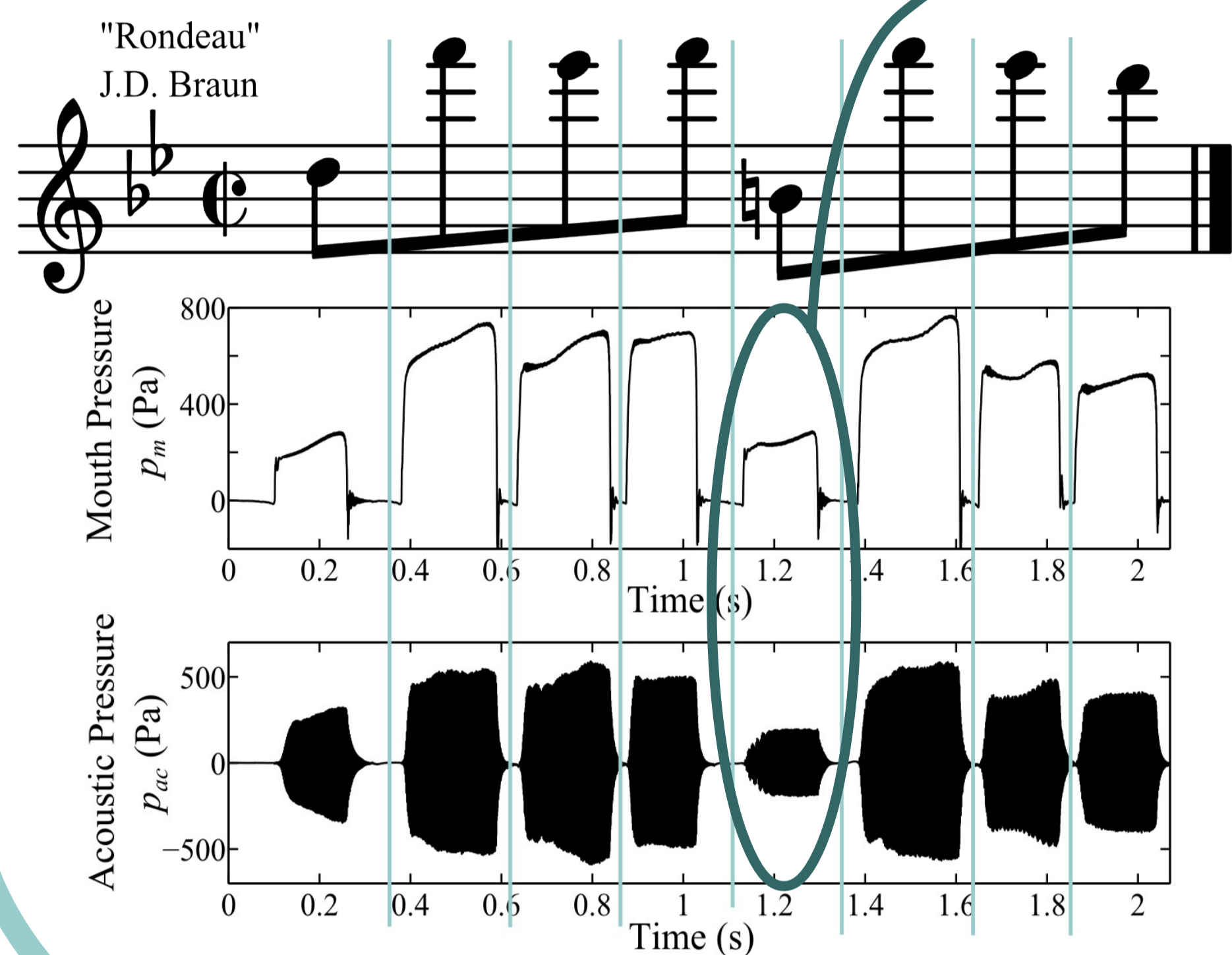
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laboratoire «mécanique –acoustique»

## Acquisition and parameters

- 1 experienced recorder player
- 4 recorders (bass, alto, soprano, sopranino)
- 2799 notes analyzed
- 33 fingerings per recorder



No Acoustic

$Amp_m$  : Mean mouth pressure targeted by the recorder player.

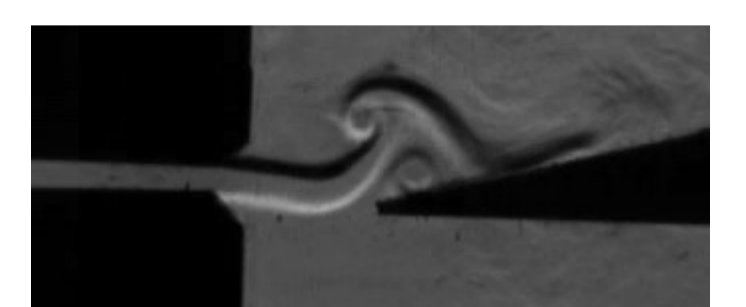
$\gamma$  : Dynamic threshold.

$\Delta t_m$  : Rise time of mouth pressure.

$Amp_{ac}$  : Mean acoustic amplitude at the end of the transient.

$\Delta t_{ac}$  : Rise time of acoustic pressure.

$\tau_{ac}$  : Characteristic time of the exponential increasing of acoustic.

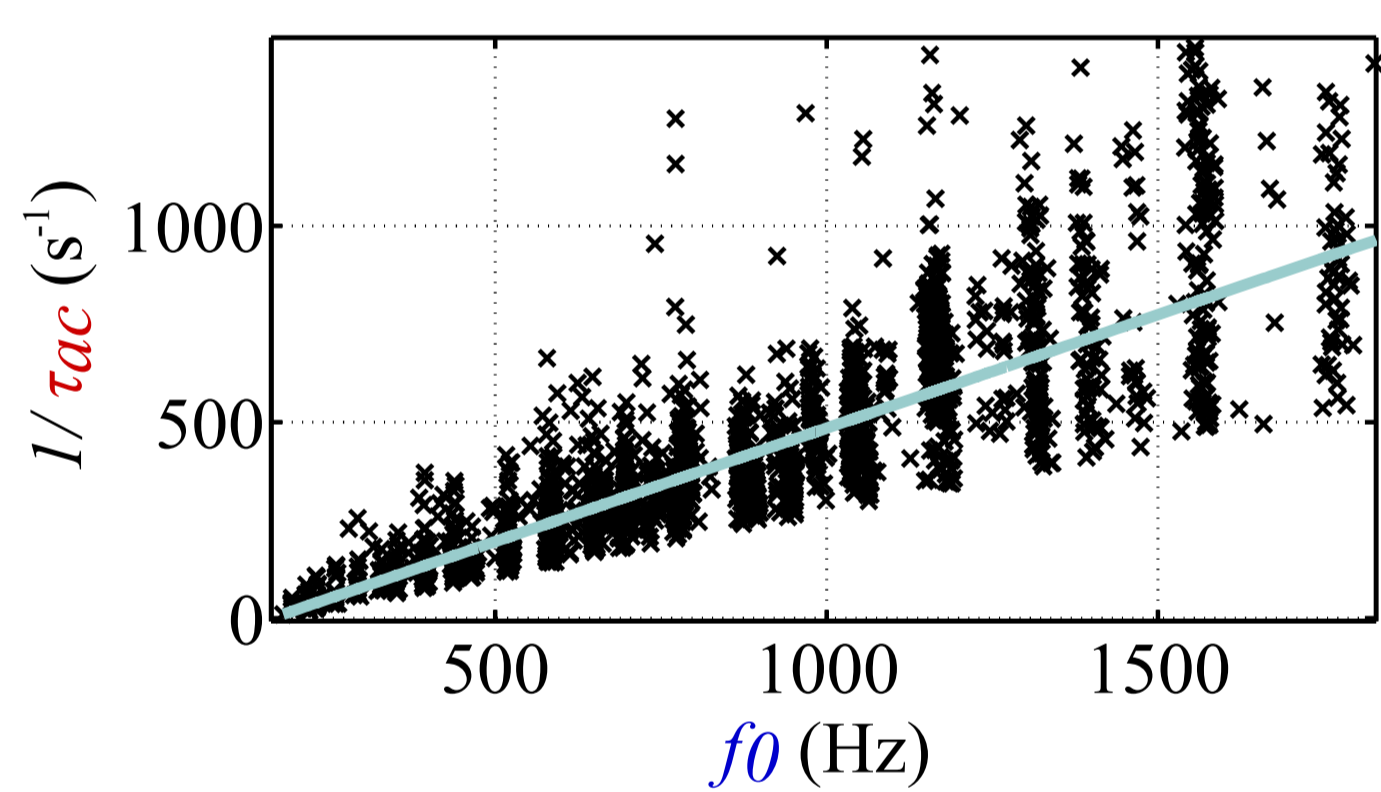


Stable Acoustic

## Different fingerings : different behaviors

- Global analysis : relations not linked to musician control.

- Acoustic times ( $\Delta t_{ac}$  and  $\tau_{ac}$ ) are related to the frequency ( $f_0$ ) of note by linear relations :



$$\begin{cases} 1/\tau_{ac} \approx 0.57f_0 - 96 \\ \Delta t_{ac} \approx 9.5/f_0 \end{cases}$$

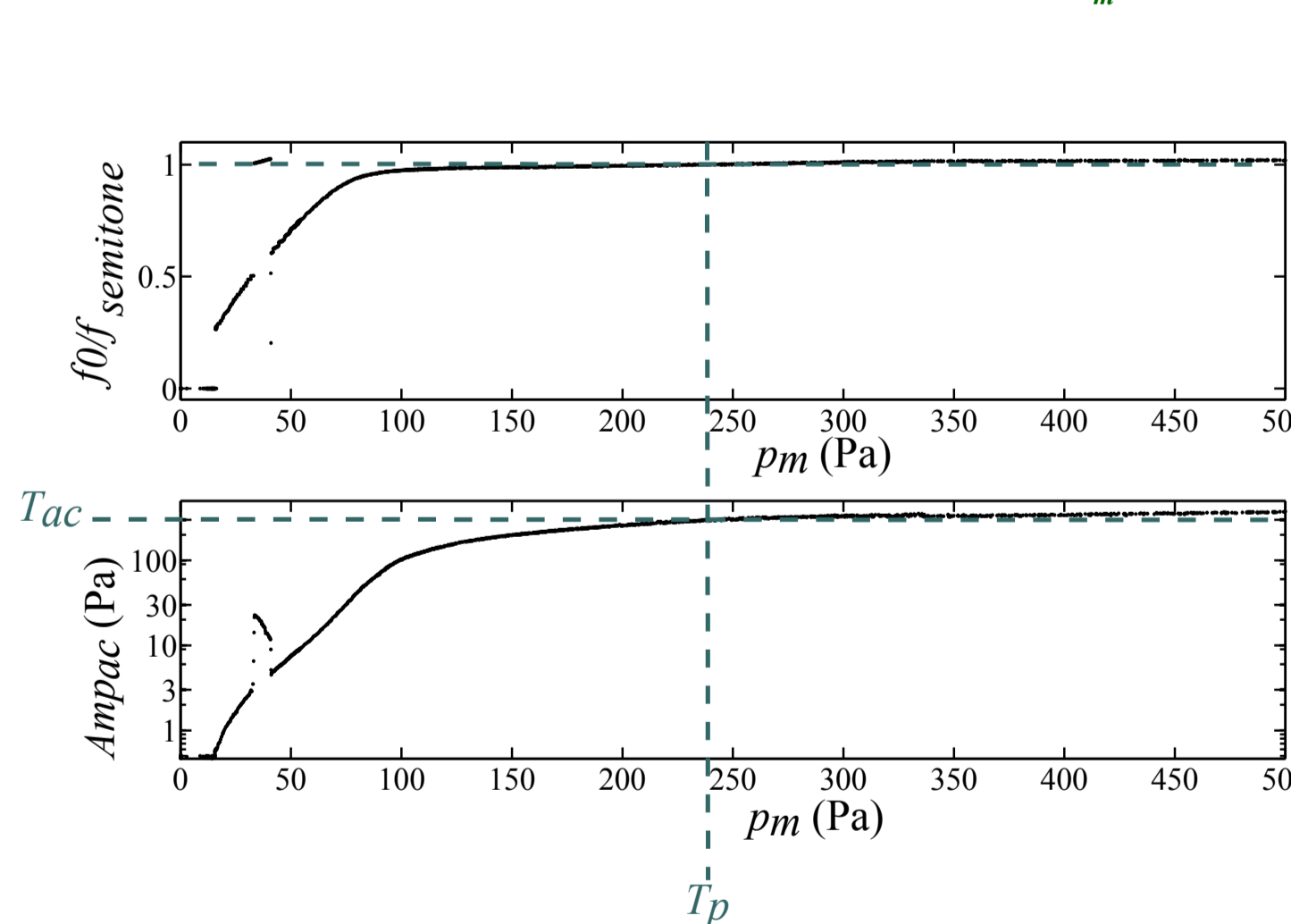
Normalized and centered acoustic times :

$$\begin{cases} 1/\tau_{ac}' = \frac{1/\tau_{ac} - (0.57f_0 - 96)}{0.57f_0 - 96} \\ \Delta t_{ac}' = \frac{\Delta t_{ac} - 9.5/f_0}{9.5/f_0} \end{cases}$$

Normalisation of parameters

- Behavior on each fingering is characterized by blowing with a artificial controlled supply pressure :

- Mean mouth pressures ( $Amp_m$ ) and typical acoustic amplitude ( $Amp_{ac}$ ) are related to the fingerings :



$T_p$  : Controlled mouth pressure to play in tune with an equal tempered scale for each fingering ( $f_0 = f_{semitone}$ ).

$T_{ac}$  : Amplitude of acoustic when  $Amp_m = T_p$

Normalized and centered mouth pressure amplitude, dynamic threshold and amplitude of acoustic:

$$\begin{cases} Amp_m' = \frac{Amp_m - T_p}{T_p} \\ \gamma' = \frac{\gamma - T_p}{T_p} \\ Amp_{ac}' = \frac{Amp_{ac} - T_{ac}}{T_{ac}} \end{cases}$$

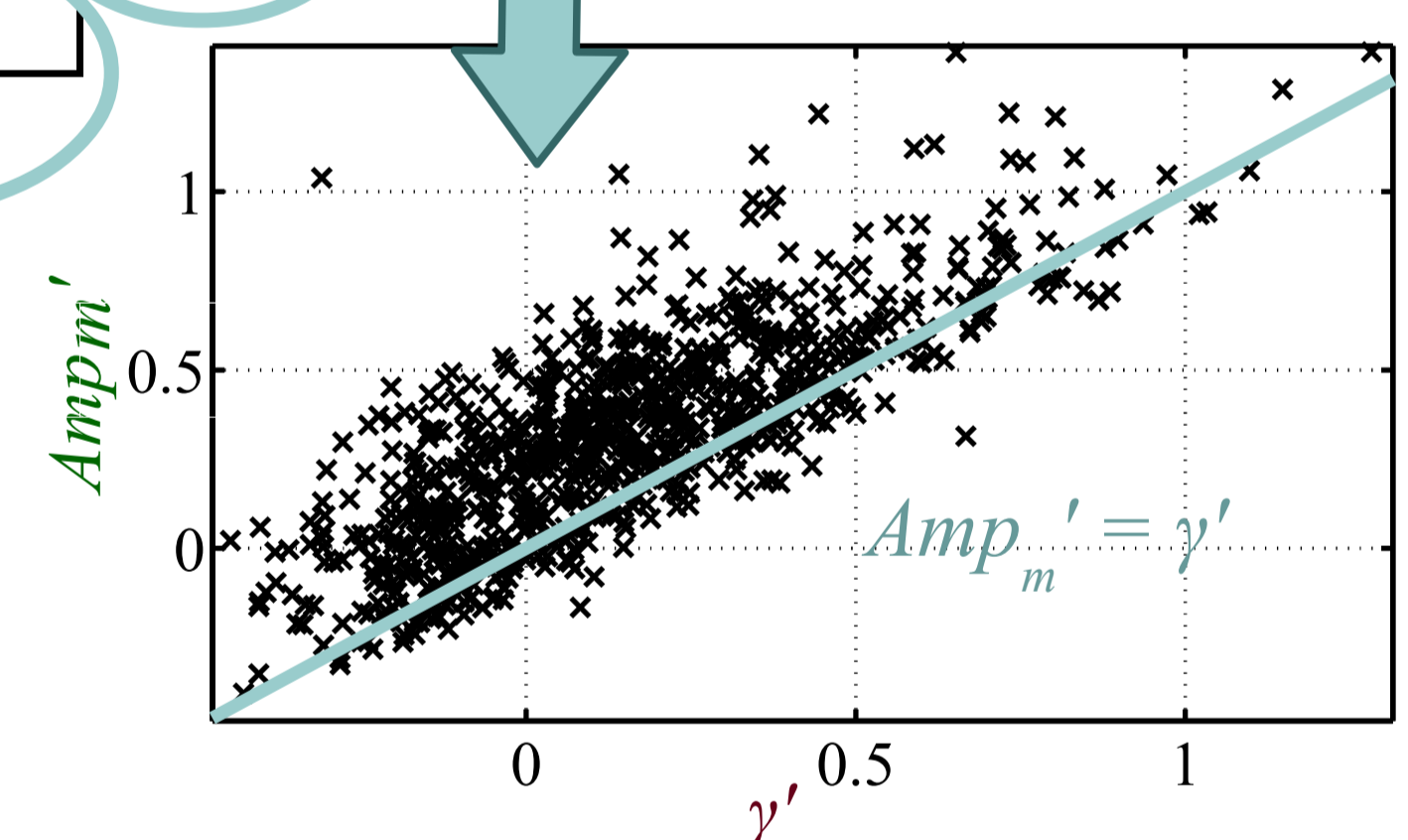
- For a given fingering, the tuning of the note can also influence the behavior of the instrument :

$$f_0' = \frac{f_0 - f_{semitone}}{f_{semitone}}$$

## Player's control ?

- Normalized parameters are independent of the fingerings.
- Dependences between the normalized parameters are indicated by strong correlations :

	$\tau_{ac}'$	$\Delta t_{ac}'$	$Amp_{ac}'$	$f_0'$	$Amp_m'$	$\gamma'$
$\Delta t_m'$	0	0	0	0	0,2	-0,1
$\gamma'$	0,1	0	0,5	0,5	0,8	
$Amp_m'$	-0,1	0,1	0,5	0,5		
$f_0'$	0,2	0,3	0,6			
$Amp_{ac}'$	0,2	0,4				
$\Delta t_{ac}'$	0,2					



- The relations between the oscillation pressure ( $Amp_{ac}'$ ) and the blowing pressure ( $Amp_m'$ ) and the frequency ( $f_0'$ ) are already known and understood (see paper references).

- The correlations between the acoustic times ( $\tau_{ac}'$  and  $\Delta t_{ac}'$ ) and the frequency ( $f_0'$ ) are lower than expected.

- The high correlation between  $Amp_m'$  and  $\gamma'$  can, in part, be due to the relation :  $Amp_m' \geq \gamma'$

## Controlled supply pressure

- Notes played with a controlled supply pressure are analyzed.

Different target pressure are used for the different fingerings.

Linear relations between the acoustic times and the frequency of the notes can be found as with the musician :  $\begin{cases} 1/\tau_{ac} \approx 0.93f_0 - 169 \\ \Delta t_{ac} \approx 29/f_0 \end{cases}$

- Relations between normalized parameters are highlighted:

	$Amp_{ac}'$	$f_0'$	$Amp_m'$
$\gamma'$	0,8	0,7	0,9
$Amp_m'$	0,9	0,8	
$f_0'$	0,6		

- Correlations between the 2 amplitudes  $Amp_{ac}'$  and  $Amp_m'$  and the frequency  $f_0'$  are higher.

- The dynamic threshold is well linked to the mouth pressure by the relation :  $\gamma' = Amp_m'$

- No clear relations with the two acoustic times ( $\Delta t_{ac}'$  and  $\tau_{ac}'$ ) studied here is underlined : all the correlation coefficients are <0.1

## Conclusion

- The musician is constrained by the physical behavior of the instrument :

- The characteristic times of the acoustic  $\Delta t_{ac}$  and  $\tau_{ac}$  are globally linked to the frequency  $f_0$  of the note played.
- The amplitude of mouth pressure ( $Amp_m$ ) and the amplitude of acoustic ( $Amp_{ac}$ ) are linked to the fingerings.
- The tuning ( $f_0$ ) is linked to the dynamic ( $Amp_{ac}'$ ) of the note played.

- The musician seems to keep a freedom on some parameters :

- The times of acoustic can vary by a factor of 2.
- No clear understanding of the control appears in the value of the correlation coefficients.
- The musician can grow up faster than the instrument :  $Amp_m' \approx \gamma'$

- Differences between musician and controlled pressure data :

- Relation and correlation different : Missing one or more parameters

## Perspective

- Difference between controlled supply pressure and musician :

- The pressure is controlled by a PID controller : same shape of attack transient are used here. It could explain the difference between the relations.

- Influence of the shape of the increasing of mouth pressure :

- The shape of the mouth pressure transient could explained variations of some parameters. It could be interesting to find a parameter that characterizes it.

- Comparison with model ?

- $Amp_m' \approx \gamma'$  → the most part of the increasing of the acoustic occurs when the mouth pressure is stationary.
- The current model of flute-like instrument is valid in this configuration. The comparison between measured and simulated signal could be interesting.