

Research of perceptual and physical descriptors discriminating clarinet reeds of similar softness

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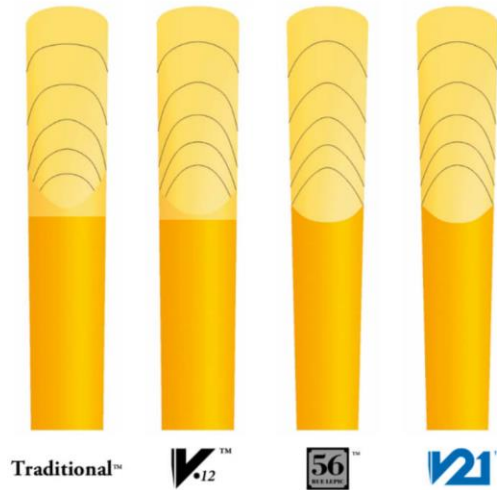
For reed manufacturers

Clarinet reeds = 4 characteristics

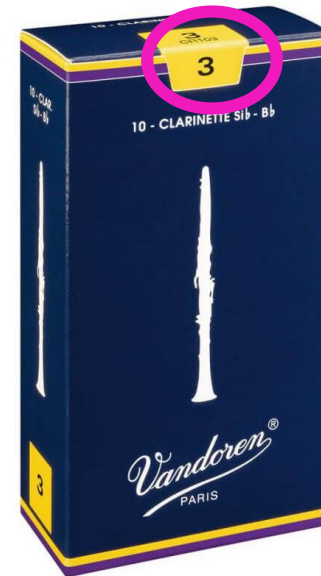
Material



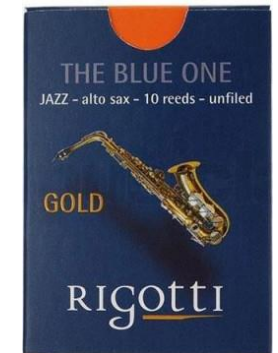
Cut



Strength



Brand



For musicians – Perceptual descriptors

Softness

Related to the ease of playing

Brilliance correlated with softness
[Petiot et al. 2017]

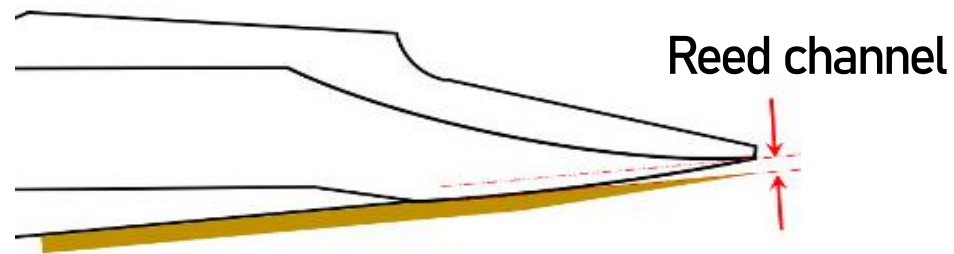
Intonation



Relative to tuning

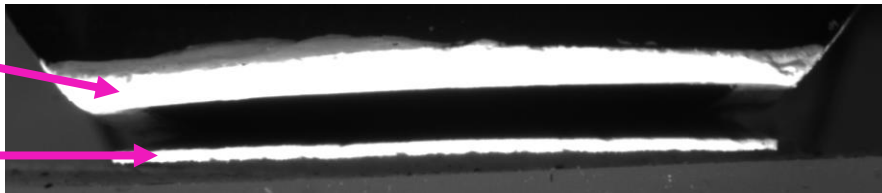
For scientists – Physical measurements

Opening at rest
(S_{00})



Mouthpiece

Reed



[Taillard 2018]

Stiffness
(K)

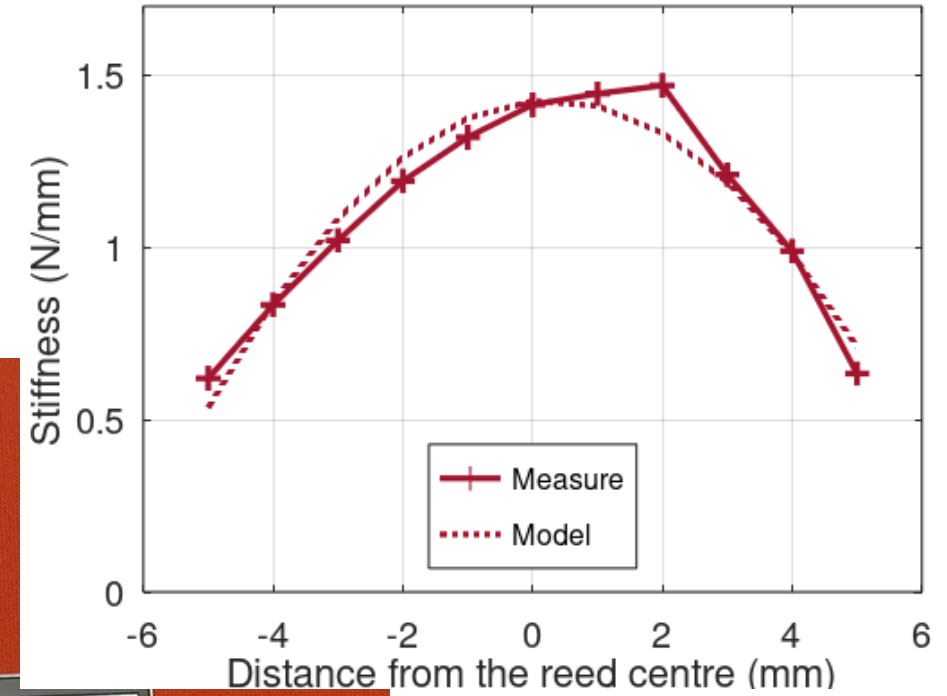
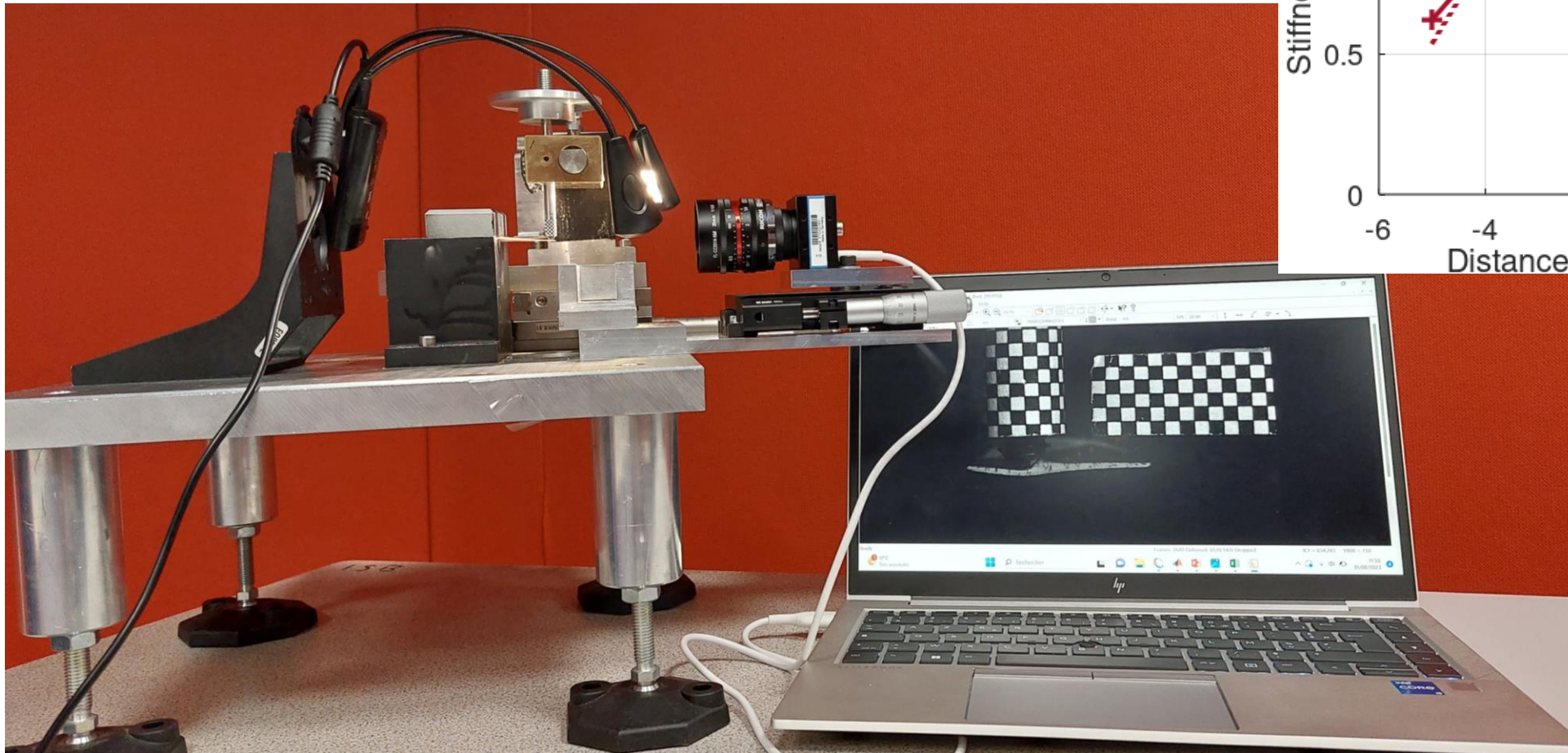
Physical measurement
In $N.mm^{-1}$ or $N.mm^{-2}$

On the
- reed alone
- reed + mouthpiece + lip

[Gazengel et al. 2016, Taillard 2018, Kemp et al. 2020]

For scientists – Physical measurements

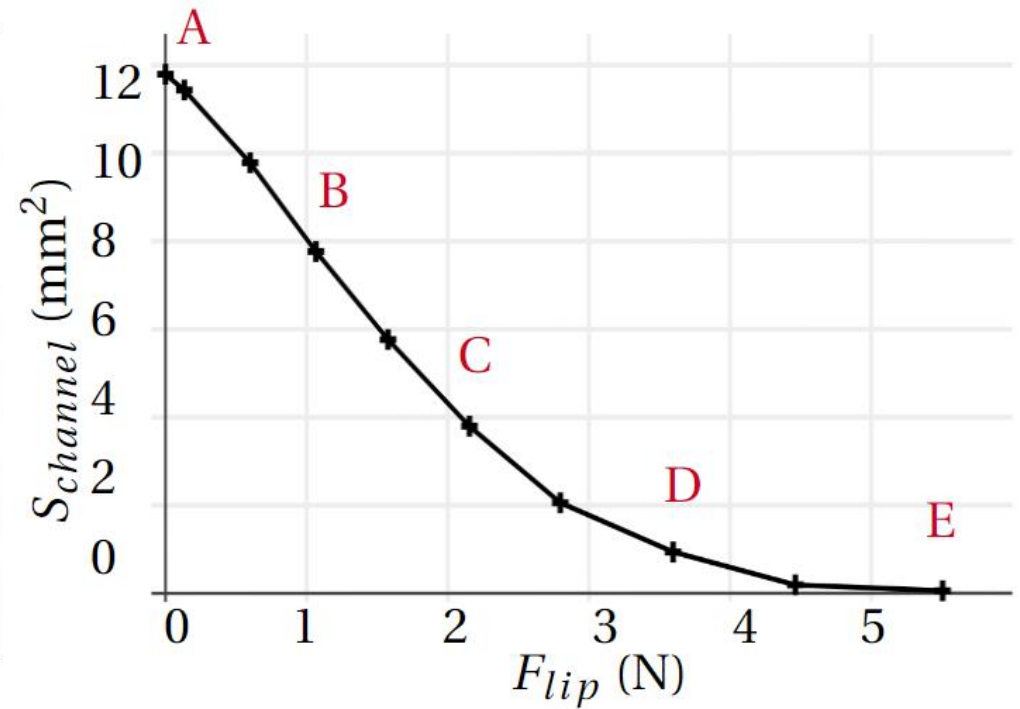
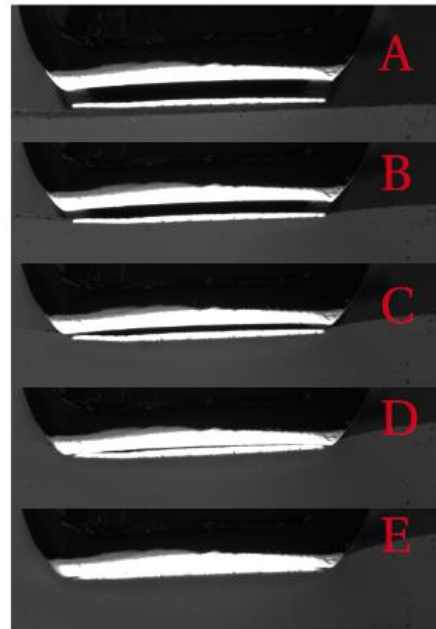
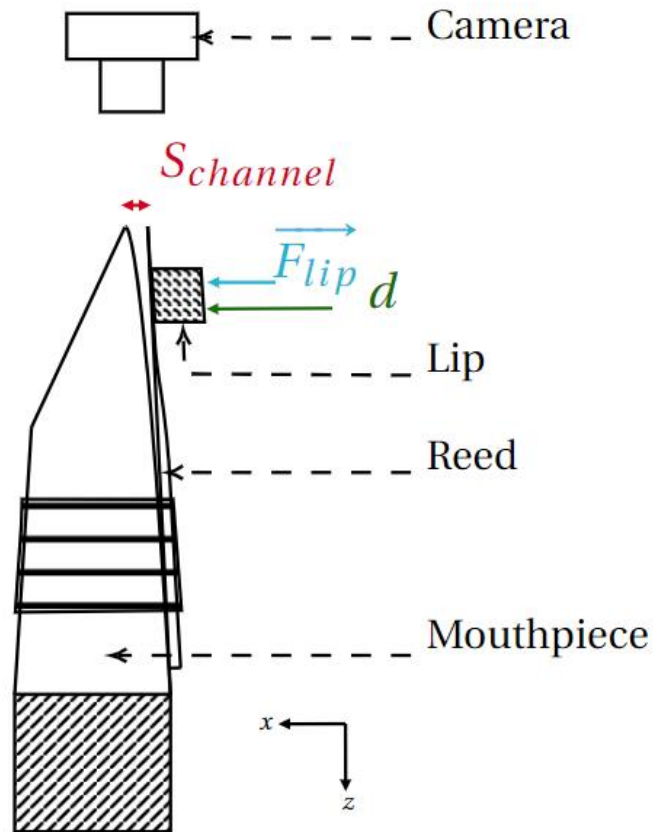
Reed alone



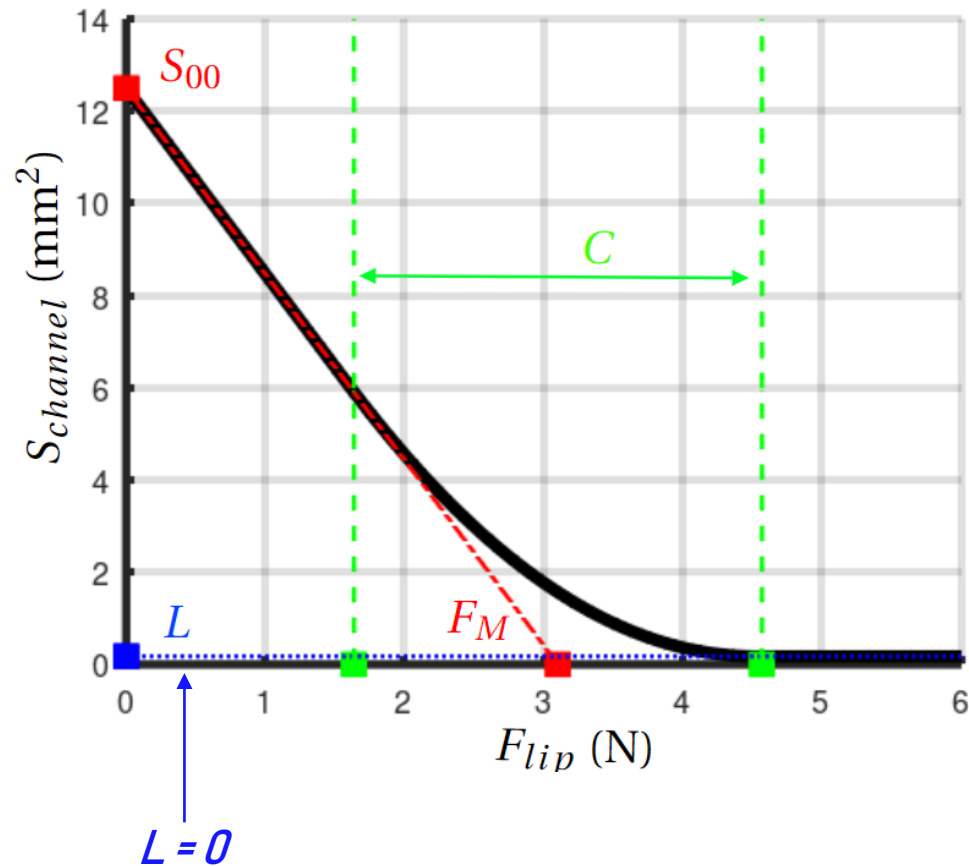
*[Ablitzer et al. 2018,
Gaillard et al. 2023]*

For scientists – Physical measurements

Reed + mouthpiece + lip



For scientists – Physical measurements



3 parameters :

- **S₀₀** = opening at rest
- **K** = $\frac{F_M}{S_{00}}$ linear stiffness
- **C** = width of the nonlinear part

Link between measurements and perception

	Softness / Brilliance	Intonation
Stiffness (K)	<p>- Gazengel et al. 2016 200 reeds + 1 musician + 3 repetitions</p> <p>Reed alone Same strength</p>	
Strength		<p>- Taillard 2018 40 reeds + 1 musician + 4 repetitions</p> <p>Reed + mouthpiece + lip Different strength</p>
Opening at rest (S_{00})		

Main goals of the experiment

-> **Does intonation explain the difference between reeds with similar softness ?**

Perceptual experiment

-> **Does opening at rest explain intonation ?**

Physical measurement

Perceptual experiment

-> Does intonation explain the difference between reeds with similar softness ?

Step 1 – Selection of reeds of similar softness making a **classification**

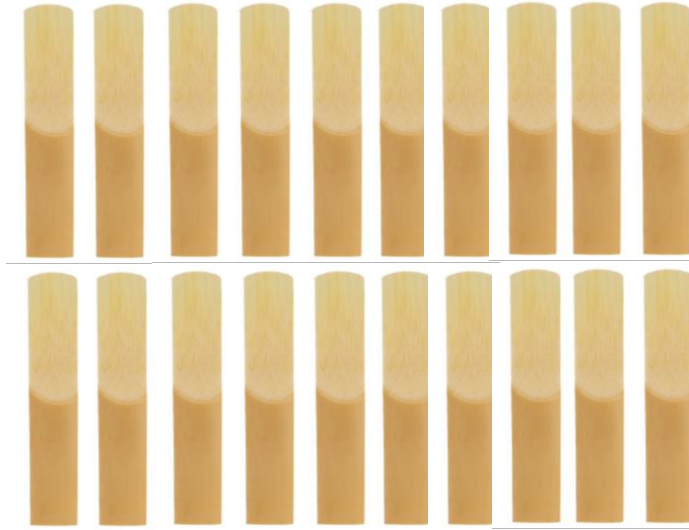
Step 2 – **Paired-comparisons** between the reeds of similar softness

- Asking the musician which **criteria** enable them to differentiate the reeds

Perceptual assessment : Classification



+



20 reeds sold as identical

=

Softness classification
10 times (10 or 30 days)

2 musicians
Choosing the name and number of class

Classification

Clarinetist A

Pre professionnel

Reeds Vandoren V12 3.5

Mouthpiece Vandoren M30



Clarinetist B

Pre professionnel

Reeds Vandoren Classic 3.5

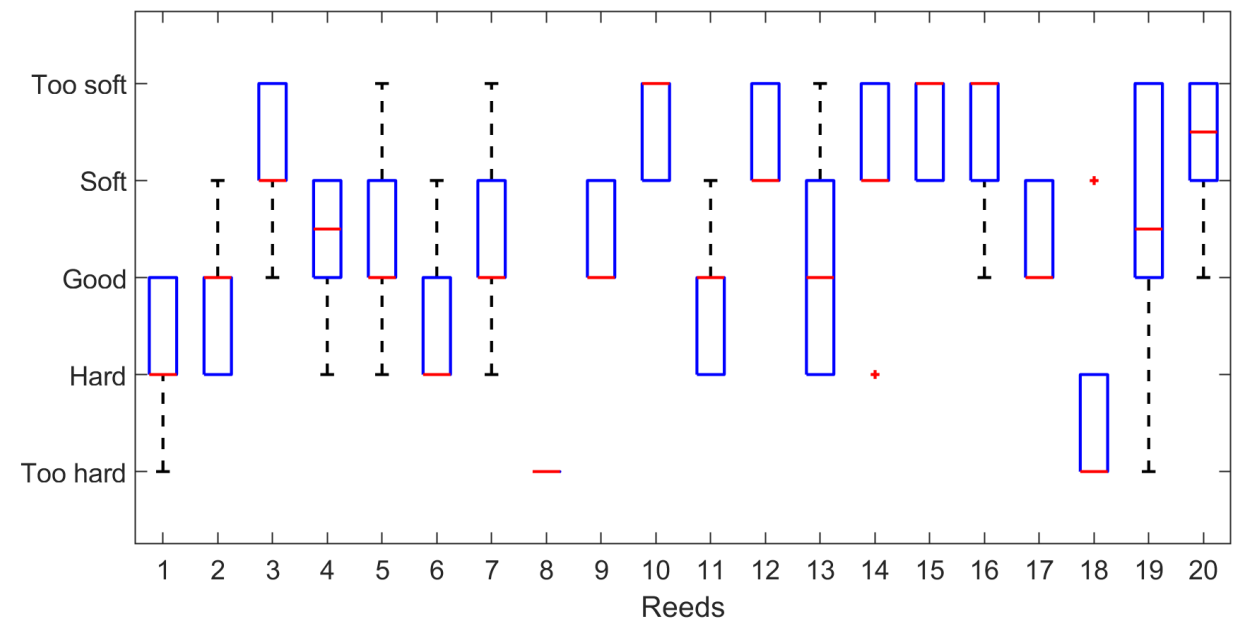
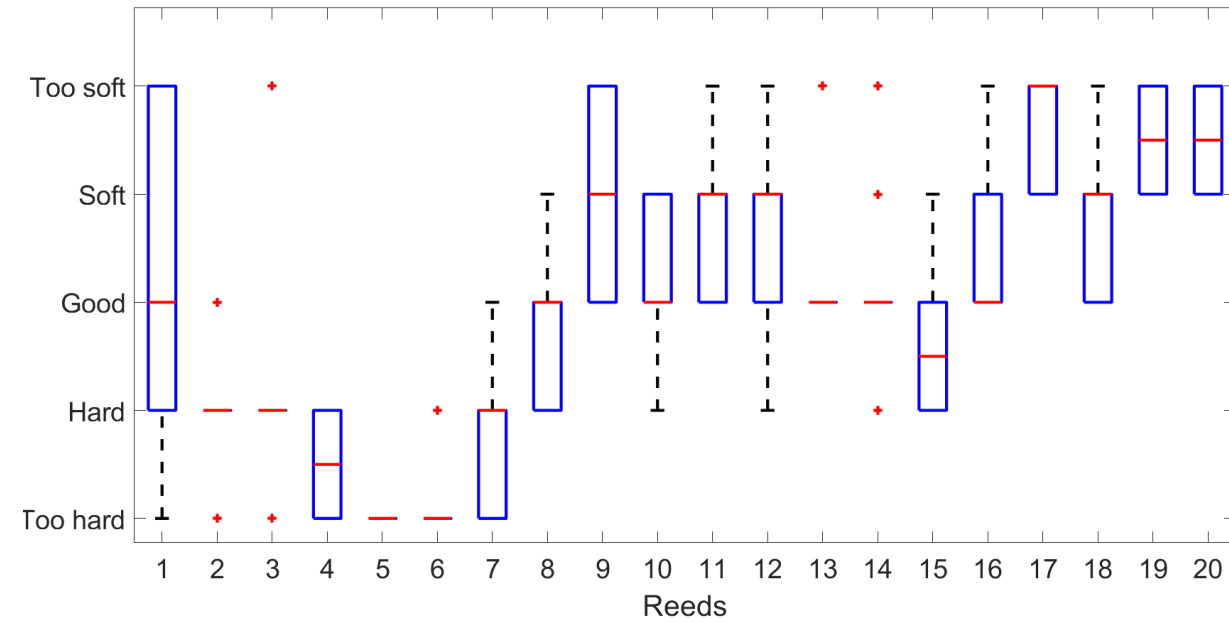
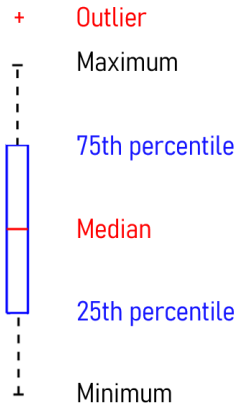
Mouthpiece Vandoren BD5



Classification

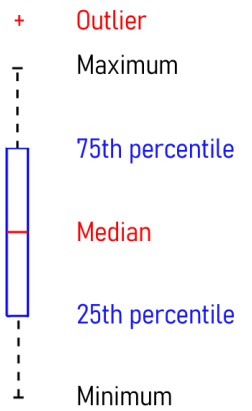
Clarinetist A

Clarinetist B



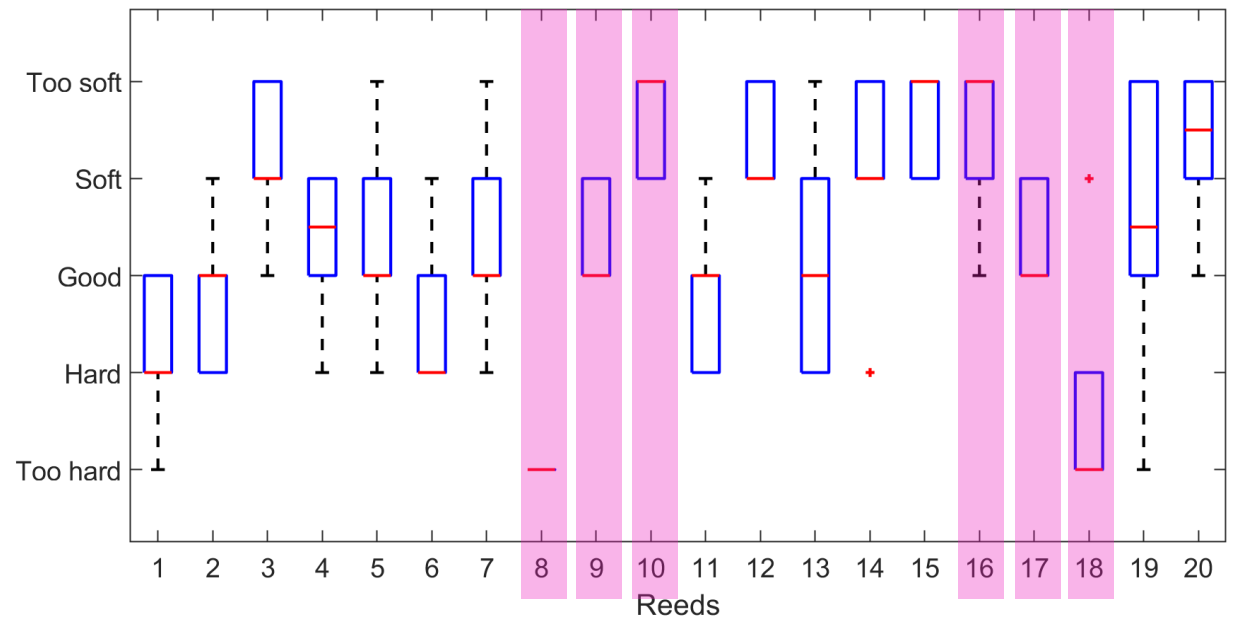
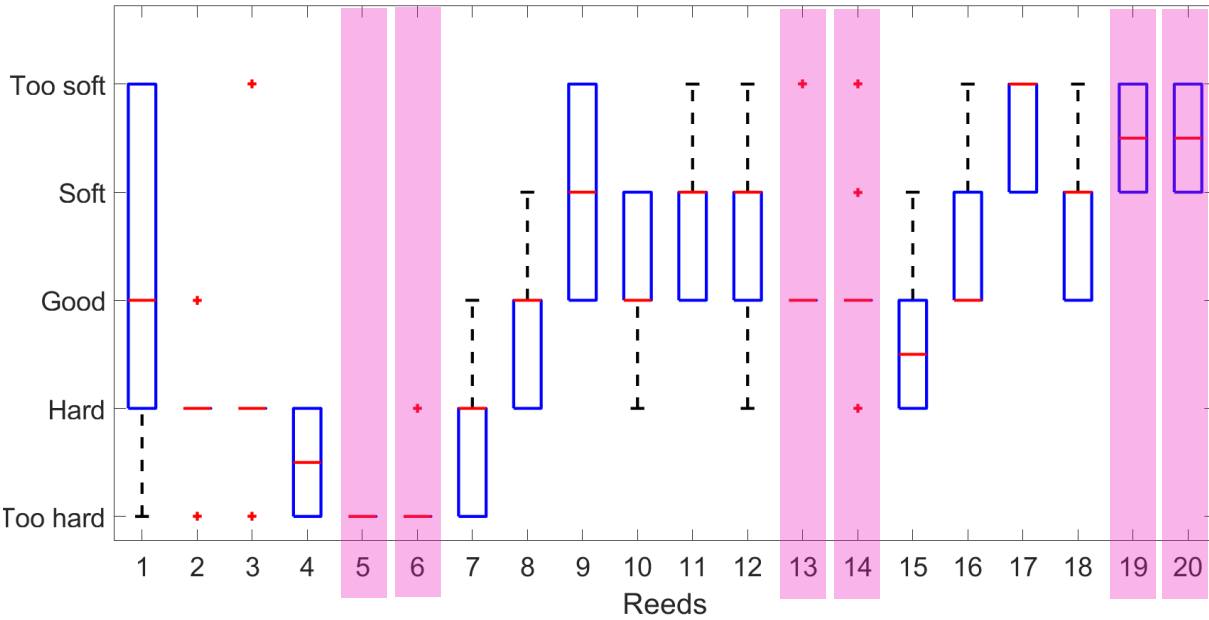
Friedman test : No effect of the repetition + Significant effect of the reed

Perceptual assessment : paired comparisons



Clarinetist A

Clarinetist B



6 reeds for paired comparisons

Perceptual assessment : paired comparisons

10 paired-comparisons (x2) for each clarinetists

-> Are the reed identical or not ? Why ?

	Clarinetist A	Clarinetist B
Good answer	18/20	15/20
Most employed criteria	Softness Brilliance of the sound	Softness Brilliance Attack

From 16 seconds to 25 between the 2 reeds of the pair !! Sensitive memory is about 3 seconds [*Harris et al. 2001*]...

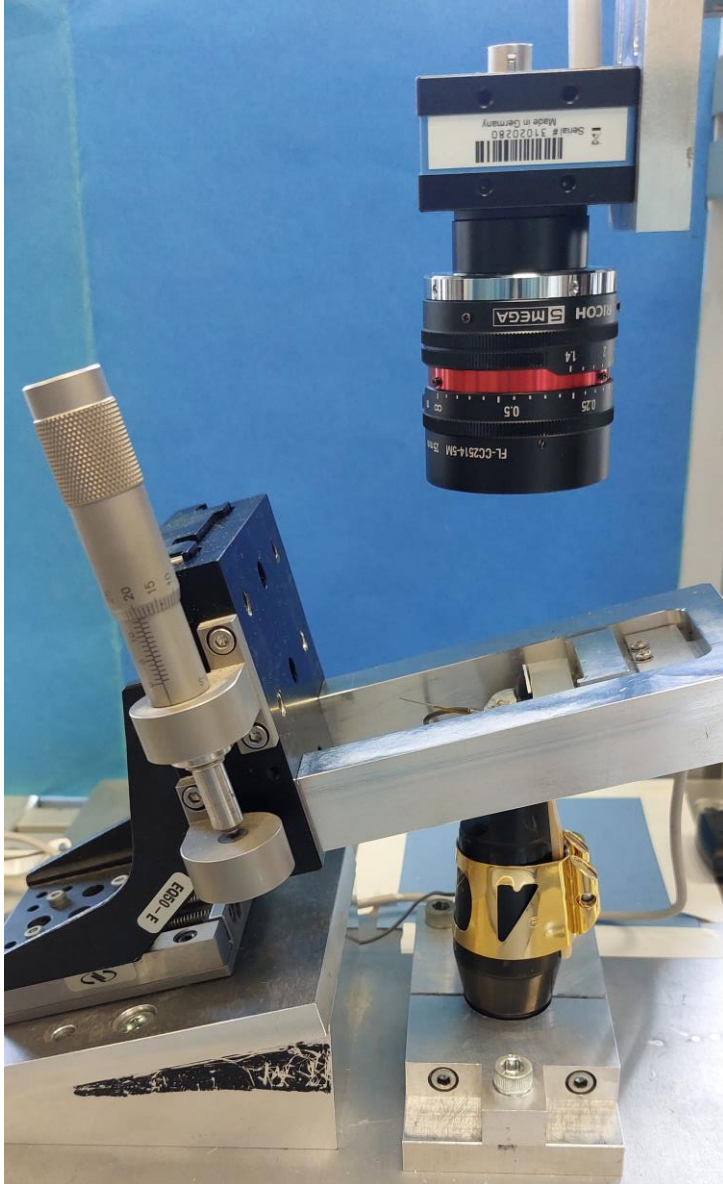
Improvement of paired-comparison method needed !

Physical measurements

~~— Does opening at rest explain intonation ?~~

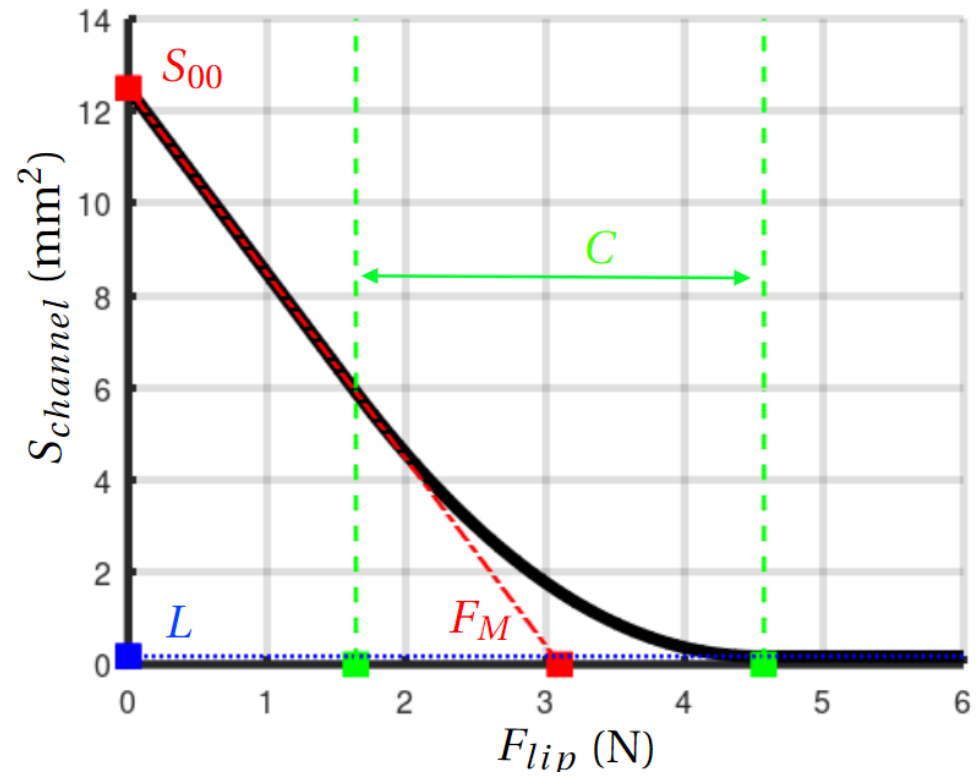
Is it possible to explain the softness thanks to nonlinear stiffness measurement ?

Physical measurements



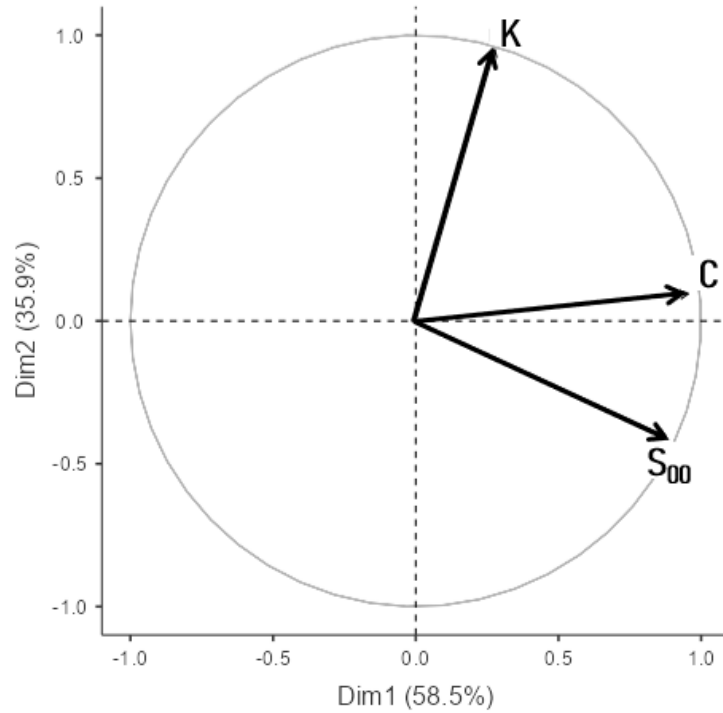
Inspired from [Munoz 2017]

20 reeds for each musician



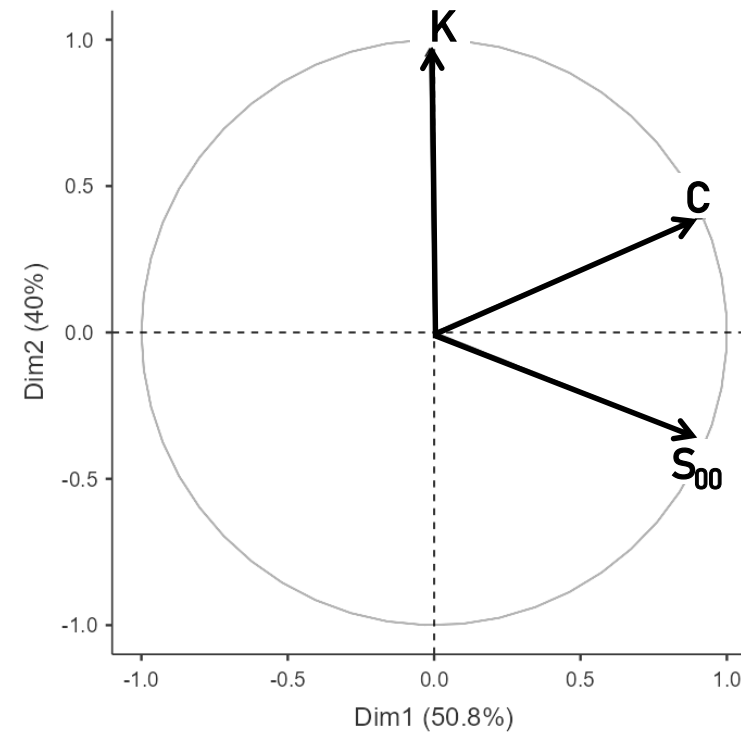
Principal Component Analysis (Jamovi)

Clarinetist A



94,4 % of the variance explained by K and S₀₀

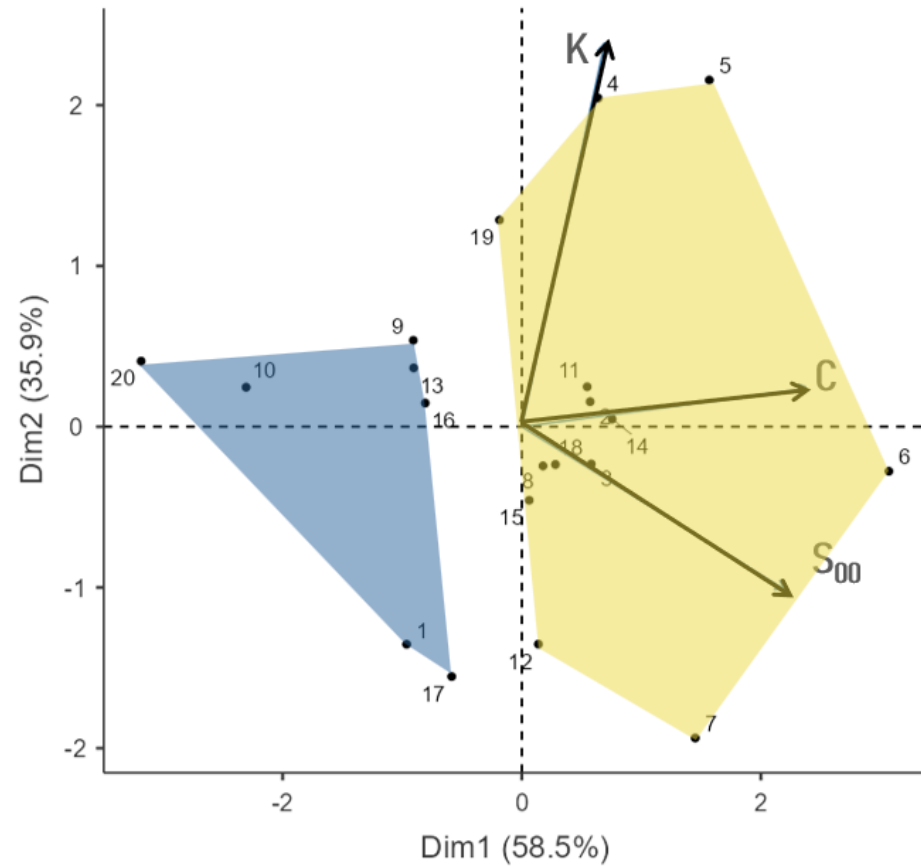
Clarinetist B



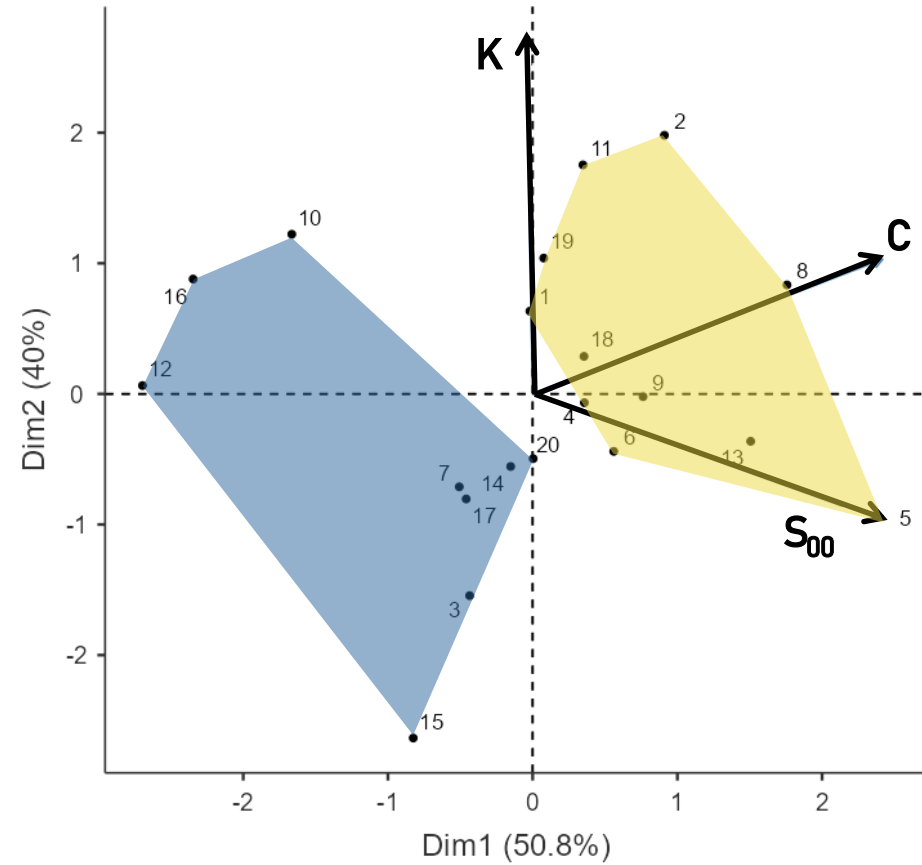
90,8 % of the variance explained by K and S₀₀

Clustering (Jamovi)

Clarinetist A – 20 reeds



Clarinetist B – 20 reeds



The two groups are separated following increasing C.

Correlations (Jamovi)

Clarinetist A

		S00	K	C
S00	r de Pearson	—		
	valeur p	—		
K	r de Pearson	-0.105	—	
	valeur p	0.660	—	
C	r de Pearson	0.724 ^{***}	0.315	—
	valeur p	< .001	0.176	—
Softness	r de Pearson	-0.438	-0.344	-0.793 ^{***}
	valeur p	0.054	0.137	< .001

Note. * p < .05, ** p < .01, *** p < .001

Clarinetist B

		S00	K	C
S00	r de Pearson	—		
	valeur p	—		
K	r de Pearson	-0.273	—	
	valeur p	0.245	—	
C	r de Pearson	0.523 [*]	0.266	—
	valeur p	0.018	0.256	—
Softness	r de Pearson	-0.316	-0.269	-0.768 ^{***}
	valeur p	0.175	0.252	< .001

Note. * p < .05, ** p < .01, *** p < .001

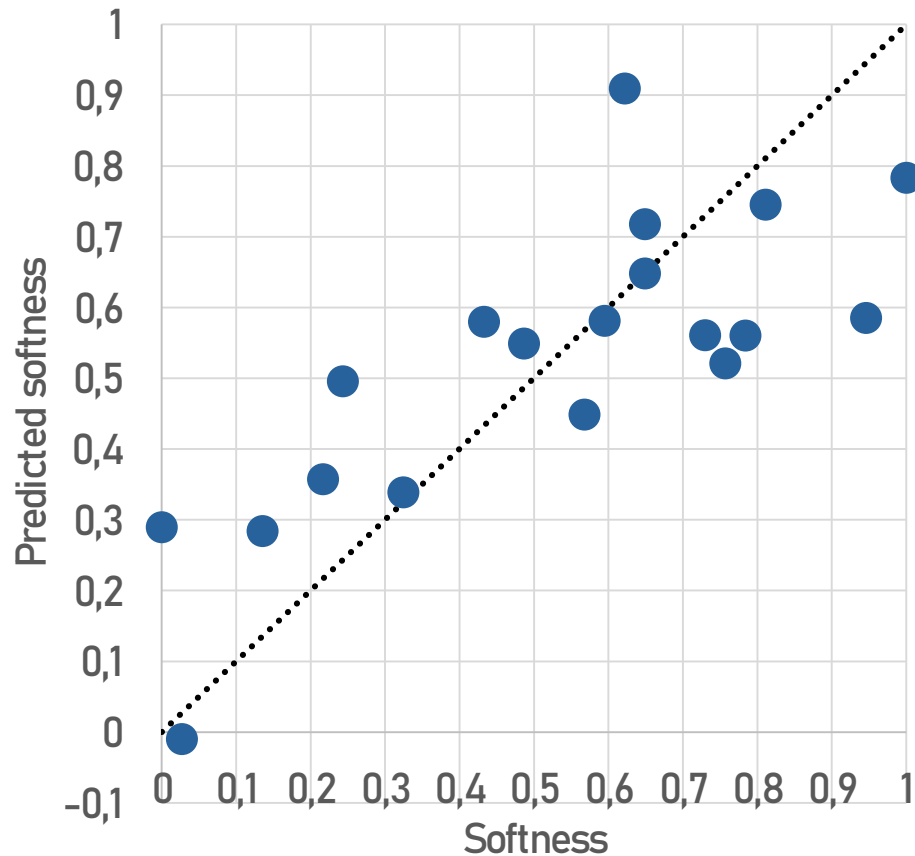
In both cases, **C** is highly correlated to the **softness*** of the reed.

* Mean of the 10 perceptual classifications for each reed

Predictive model (linear)

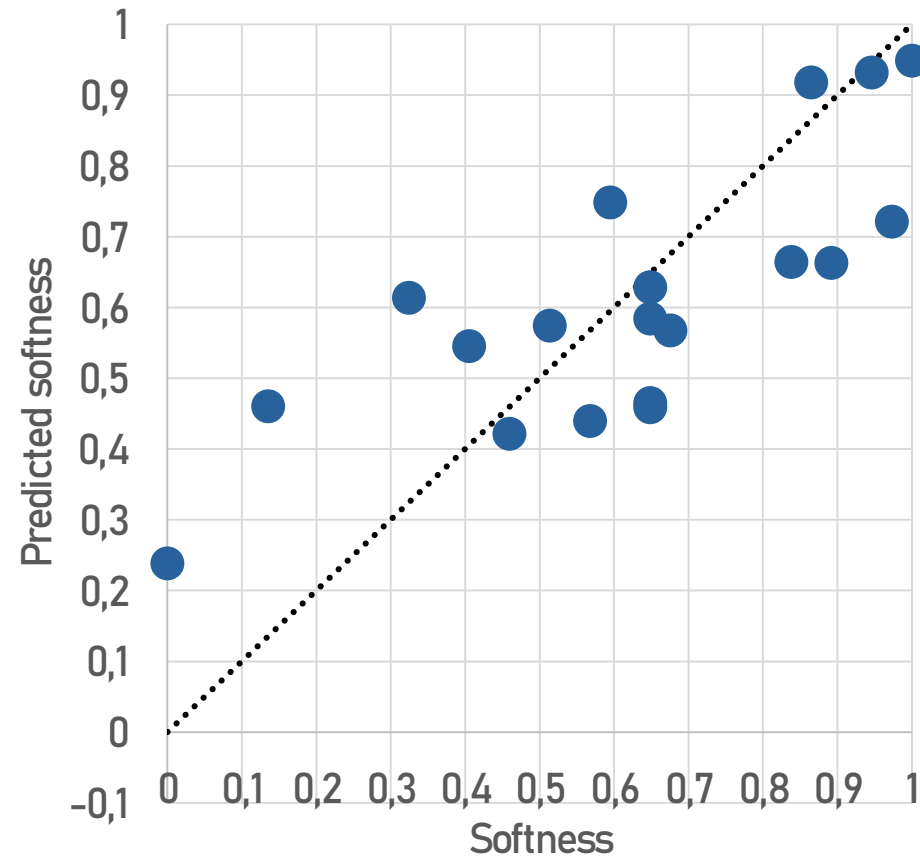
Only **C** is significantly correlated with the perceived softness. $\rightarrow \text{Softness} = a \cdot \mathbf{C} + b$

Clarinetist A



Root Mean Square Error = 0,181

Clarinetist B



Root Mean Square Error = 0,171

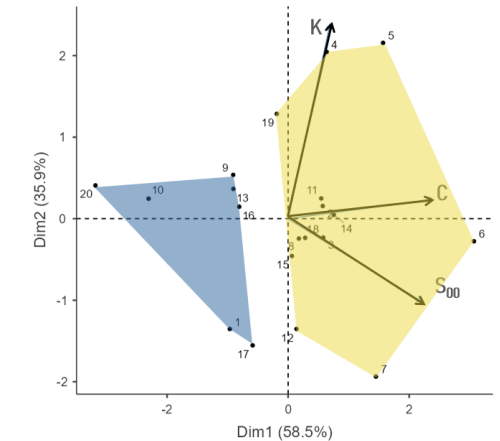
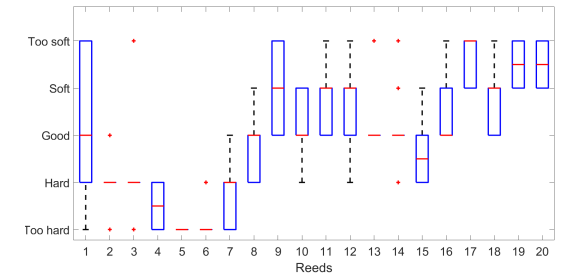
Conclusion and future work

2 efficient measurement methods:

- Classification of reeds is promising (also shown by V.Koehl)
- Differentiating reeds with nonlinear stiffness measurement

Difficult to draw a conclusion:

- Only two musicians: need more data !
- The reeds were not measured on the same mouthpiece for perceptual and physical studies
- Paired-comparisons: robust protocol ? Need to design another experiment ?



Bibliography

Ablitzer, F., & Gazengel, B. (2018). *Caractérisation expérimentale de la déformée statique d'anches simples par méthodes optiques*.

Gazengel, B., Dalmont, J. P., & Petiot, J. F. (2016). Link between objective and subjective characterizations of Bb clarinet reeds. *Applied Acoustics*, 106, 155–166.

Kemp, C., & Scavone, G. (2020). Mechanical, anatomical and modeling techniques for alto saxophone reed evaluation and classification. *Wood Science and Technology*.

Muñoz Arancón, A. (2017). *New techniques for the characterisation of single reeds in playing conditions*. PhD

Murat, Sahin and Eren Aybek. Jamovi: an easy to use statistical software for the social scientists. *International Journal of Assessment Tools in Education*, 6(4):670–692, 2019.

Petiot, J.-F. , Kersaudy, P., Scavone, G., McAdams, S., & Gazengel, B. (2017). Investigation of the relationships between perceived qualities and sound parameters of saxophone reeds. *Acta Acustica United with Acustica*, 103(5), 812–829

Taillard Pierre-André. (2018). *Theoretical and experimental study of the role of the reed in clarinet playing*. PhD



Thank you !

Parameters and uncertainty

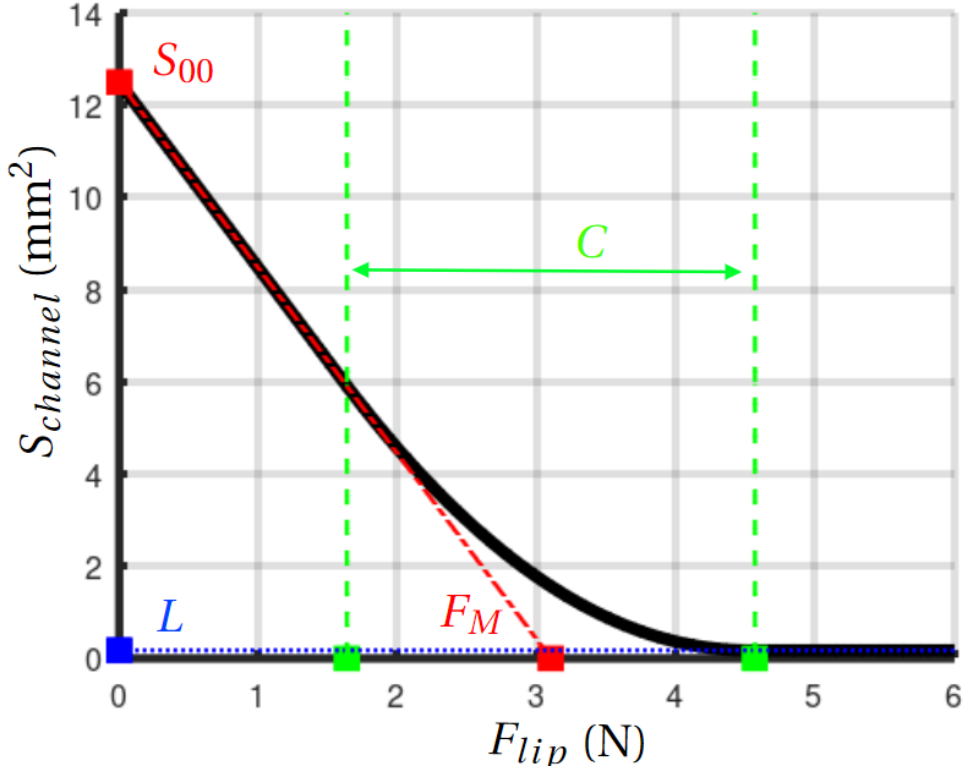
Repeatability 10 measurements of the same reed

Parameter	Mean	Standard Deviation	std/M
S_{00} (mm ²)	12.21	0.18 σ_{10}	1.5%
F_M (N)	3.05	0.06	2%
C	1.52	0.06	3.7%
L (mm ²)	0.15	0.01	6.9%

Measurement of 50 reeds sold as identical

Parameter	Mean	Standard Deviation	std/M
S_{00} (mm ²)	12.18	0.71 σ_{50}	5.8%
F_M (N)	3.36	0.26	7.9%
C	1.55	0.29	19%
L (mm ²)	0.21	0.13	64.9%

$\sigma_{50} > 3\sigma_{10}$ -> reeds can be differentiated

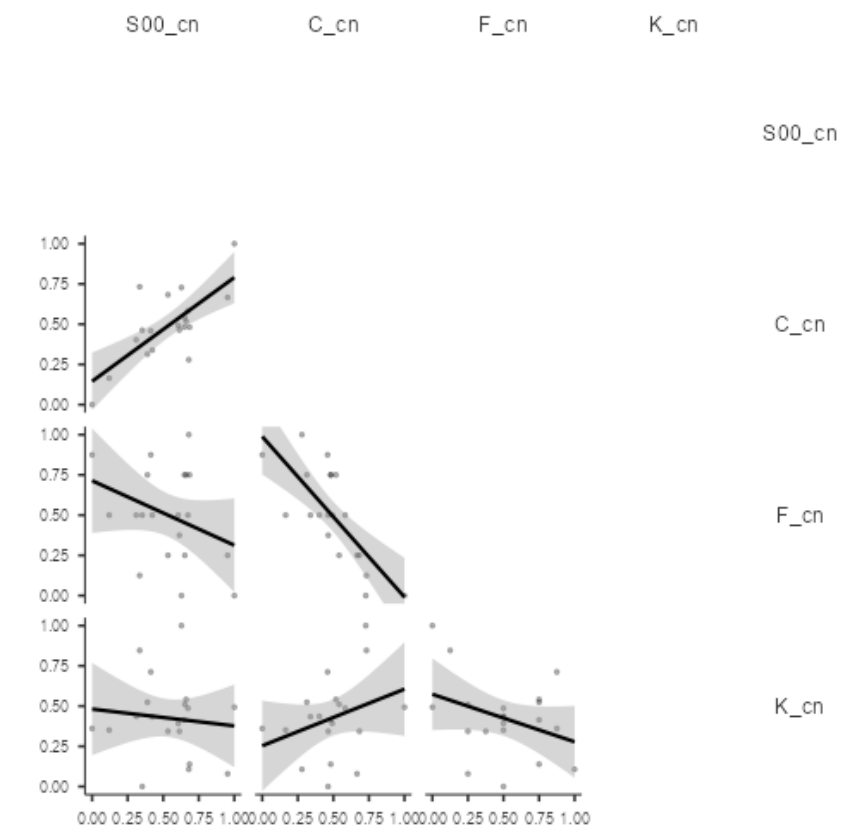


Matrice de corrélation

		S00_cn	C_cn	F_cn	K_cn
S00_cn	r de Pearson	—			
	valeur p	—			
C_cn	r de Pearson	0.724***	—		
	valeur p	< .001	—		
F_cn	r de Pearson	-0.337	-0.747***	—	
	valeur p	0.146	< .001	—	
K_cn	r de Pearson	-0.105	0.315	-0.353	—
	valeur p	0.660	0.176	0.127	—

Note: * p < .05, ** p < .01, *** p < .001

Graphe

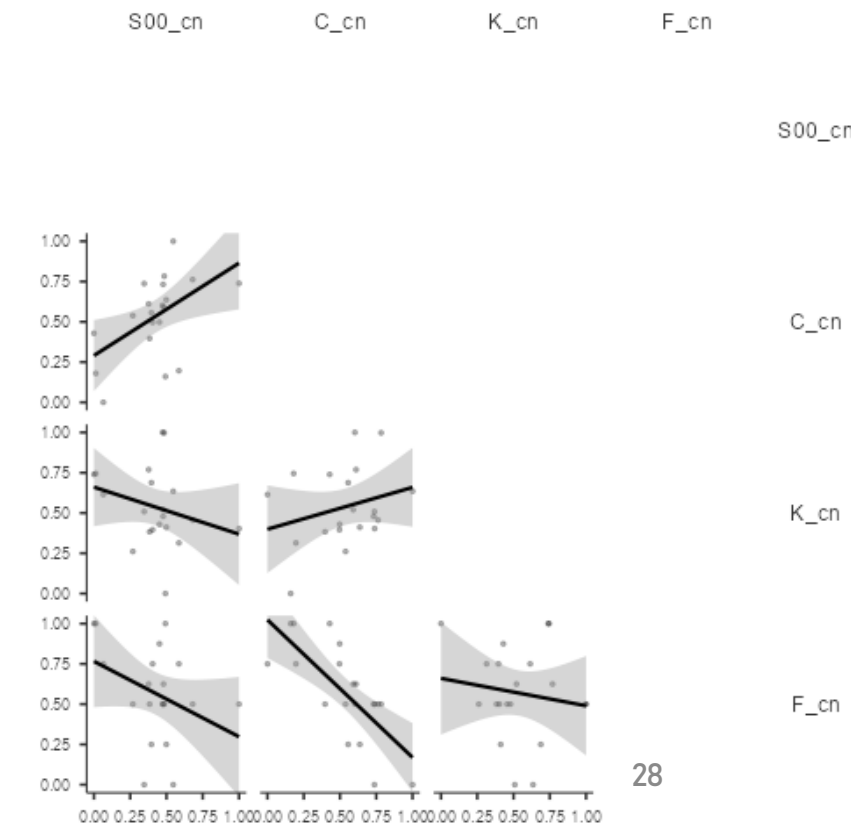


Matrice de corrélation

		S00_cn	C_cn	K_cn	F_cn
S00_cn	r de Pearson	—			
	valeur p	—			
C_cn	r de Pearson	0.523 *	—		
	valeur p	0.018	—		
K_cn	r de Pearson	-0.273	0.266	—	
	valeur p	0.245	0.256	—	
F_cn	r de Pearson	-0.361	-0.723 ***	-0.140	—
	valeur p	0.118	< .001	0.555	—

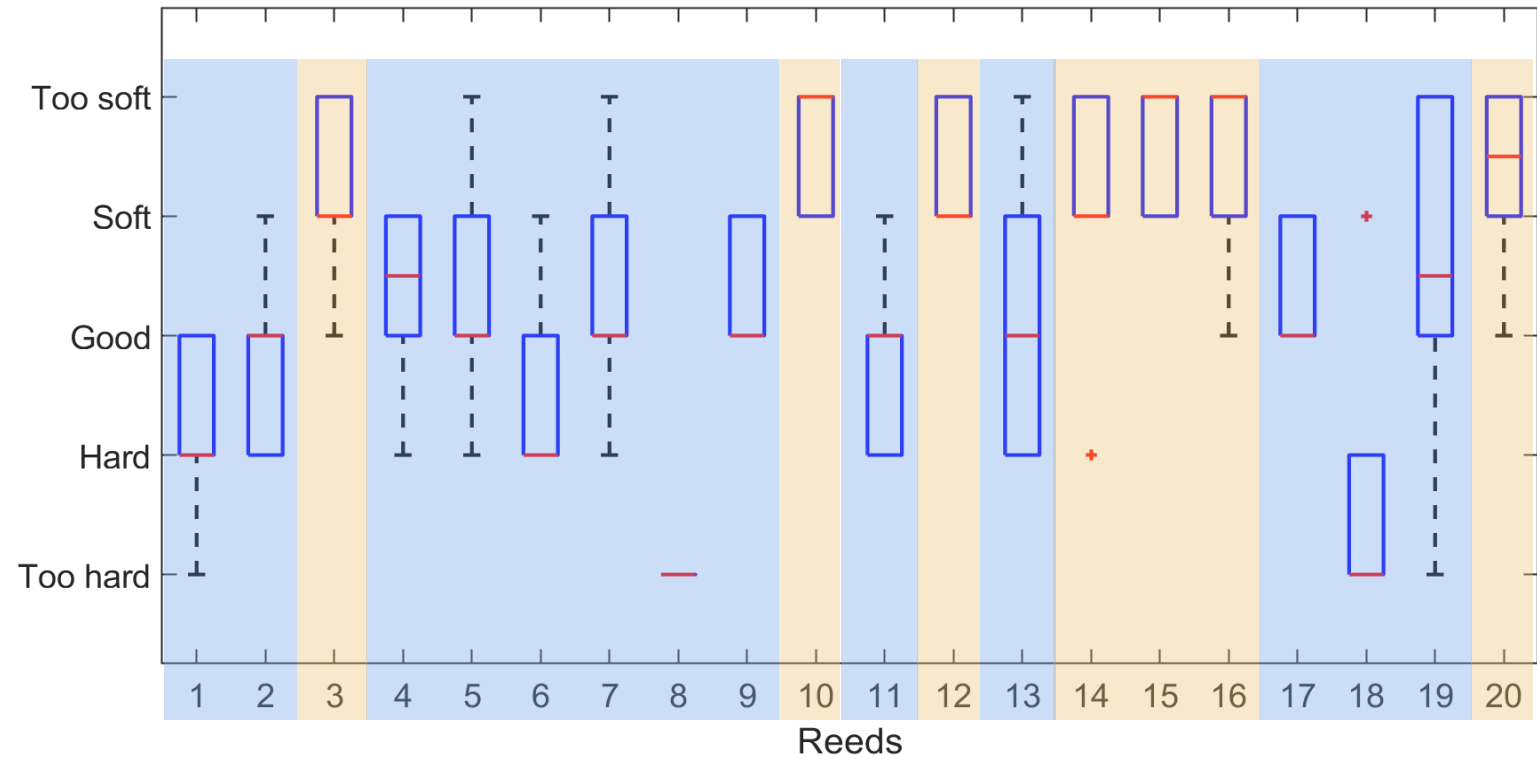
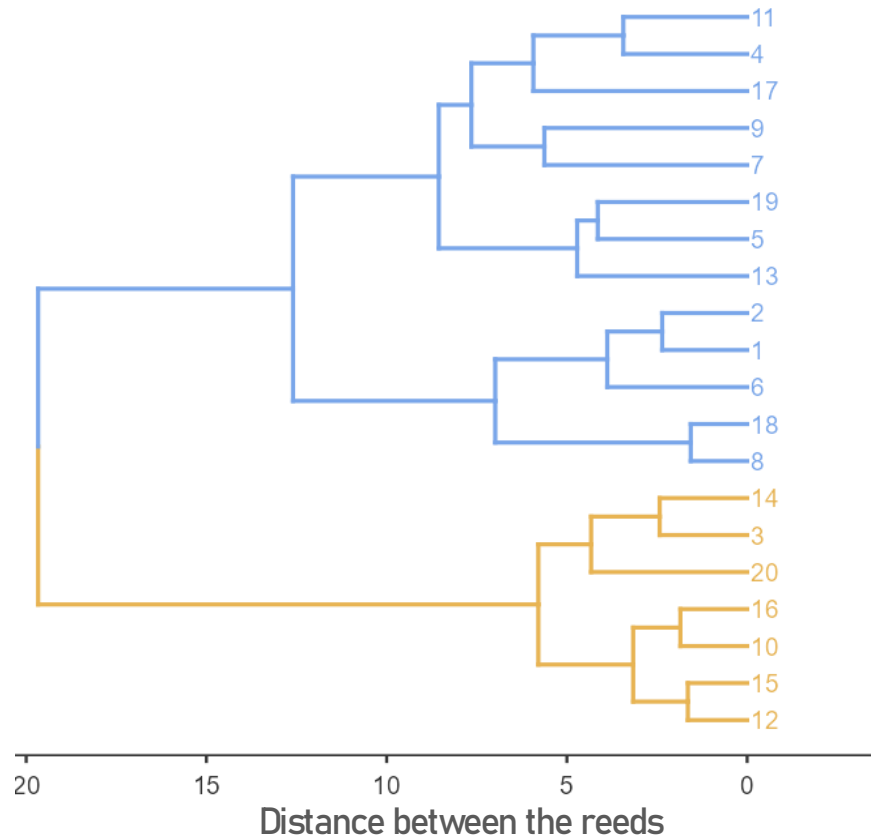
Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Graphe



Clarinetist B – Classification

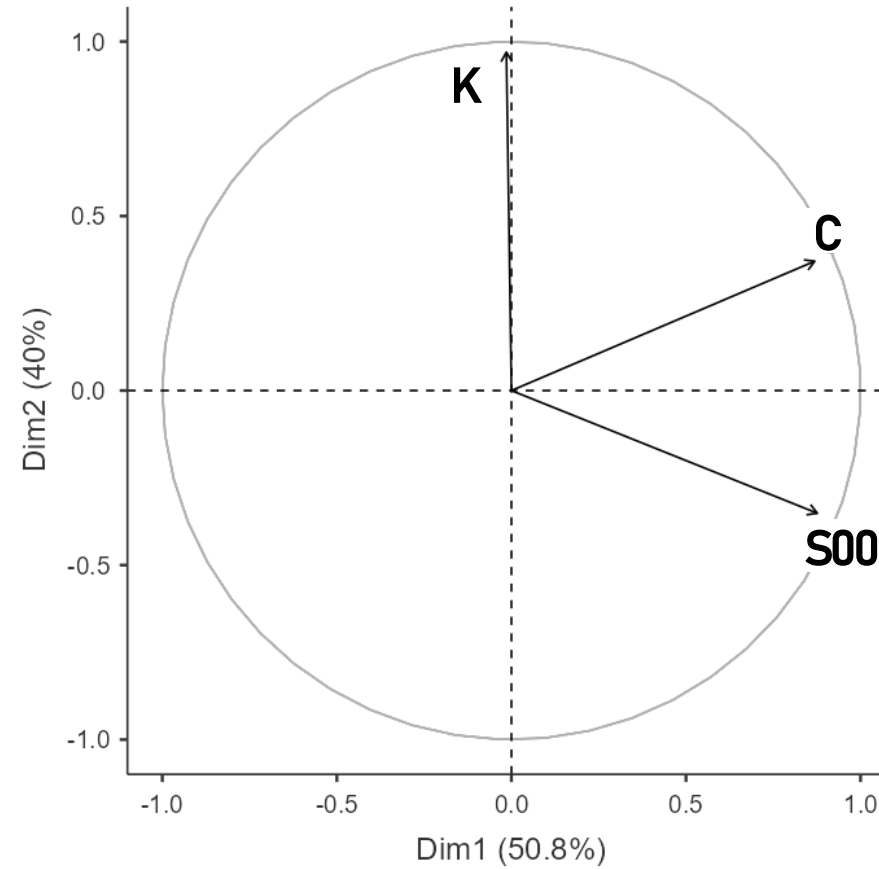
Reed clustering thanks to dendrogram



Classification	Reeds	Quality
Cluster 1	3 10 12 14 15 16 20	Too soft - Soft
Cluster 2	1 2 4 5 6 7 8 9 11 13 17 18 19	Good - Hard - Too hard

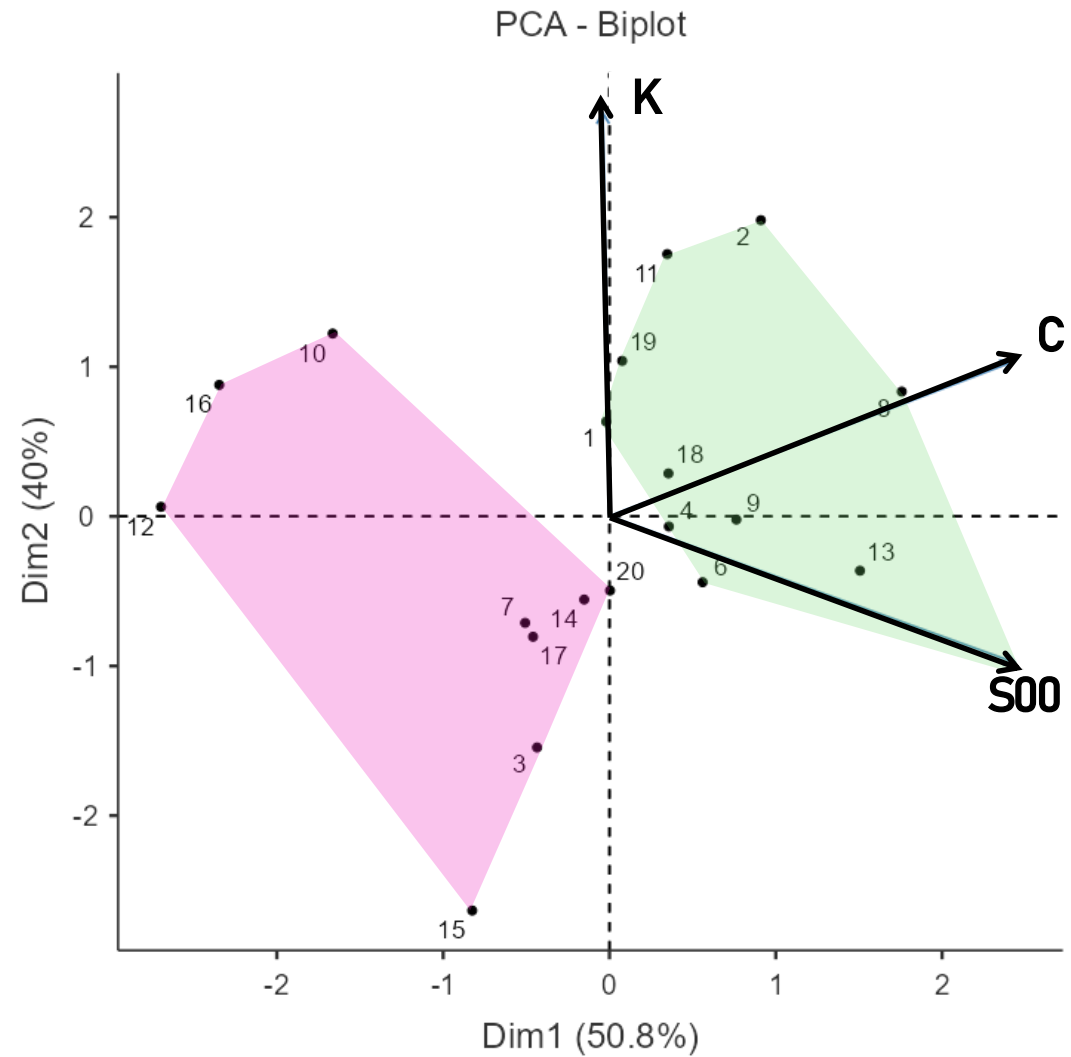
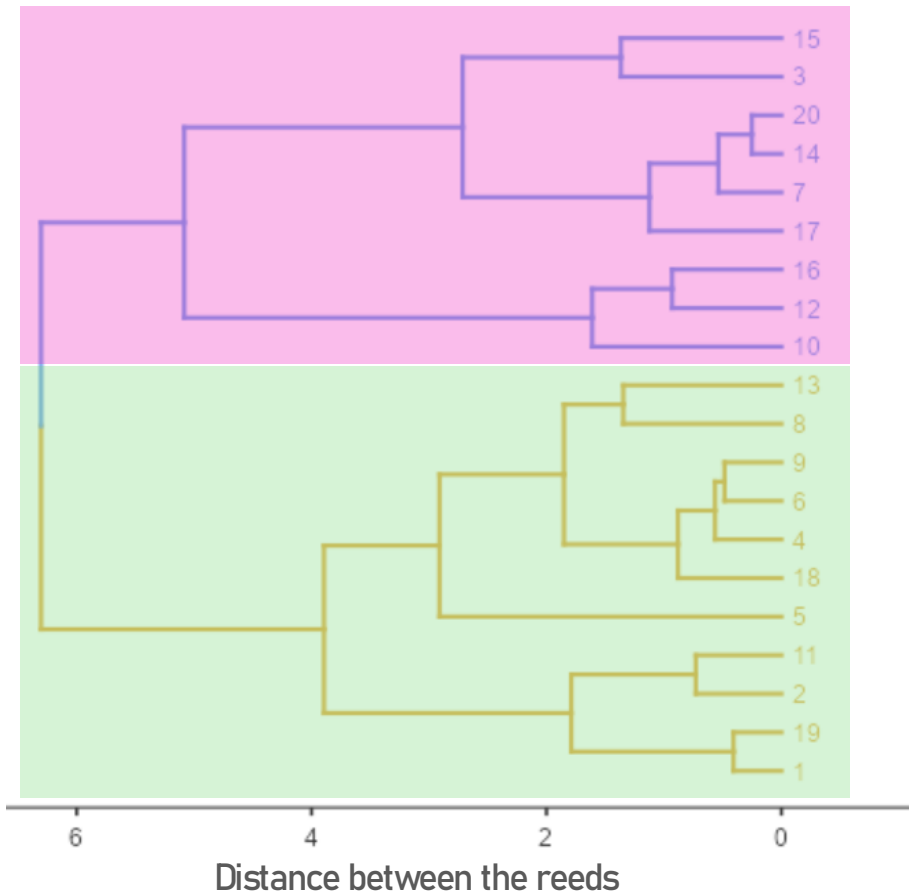
Clarinetist B – Stiffness measurement

Principal component analysis
with 3 parameters



90,8 % of the variance explained by K and S00 (independant parameters).

Clarinetist B – Stiffness measurement



Clarinetist B – Cluster comparisons

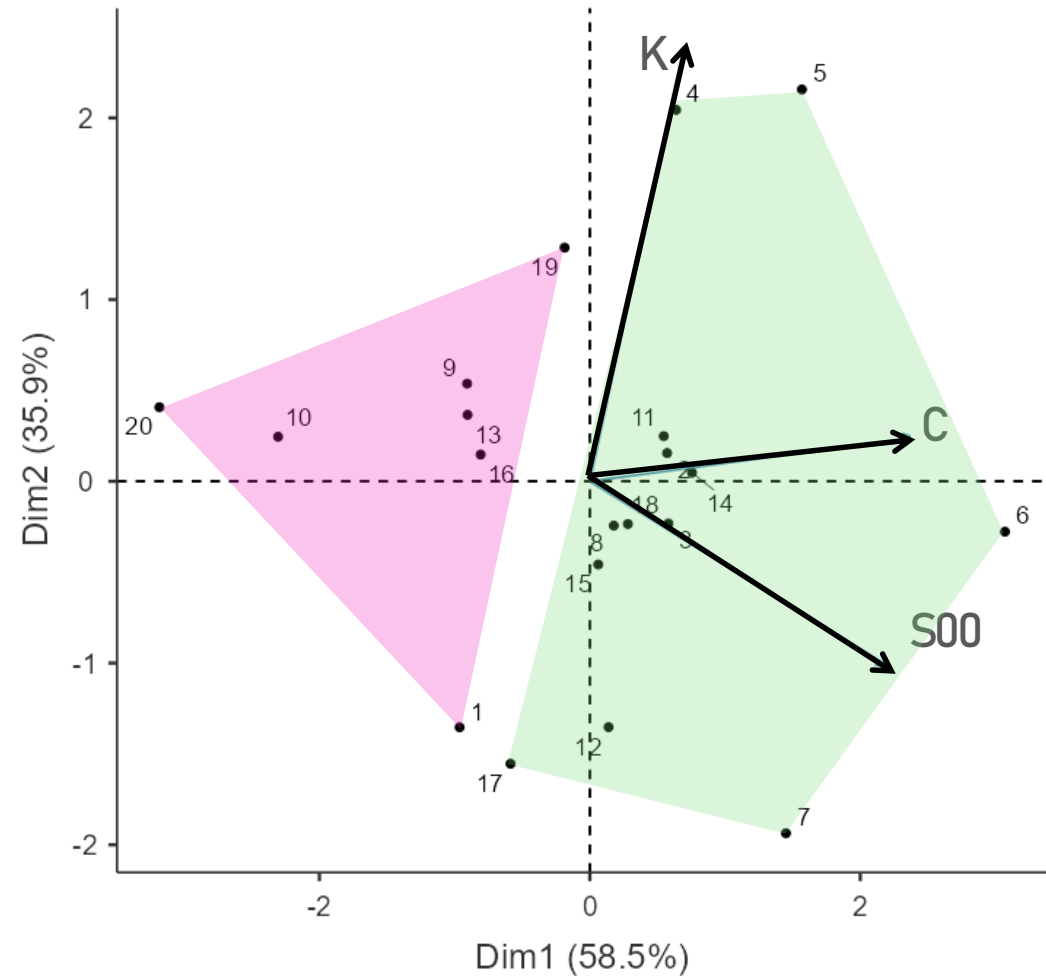
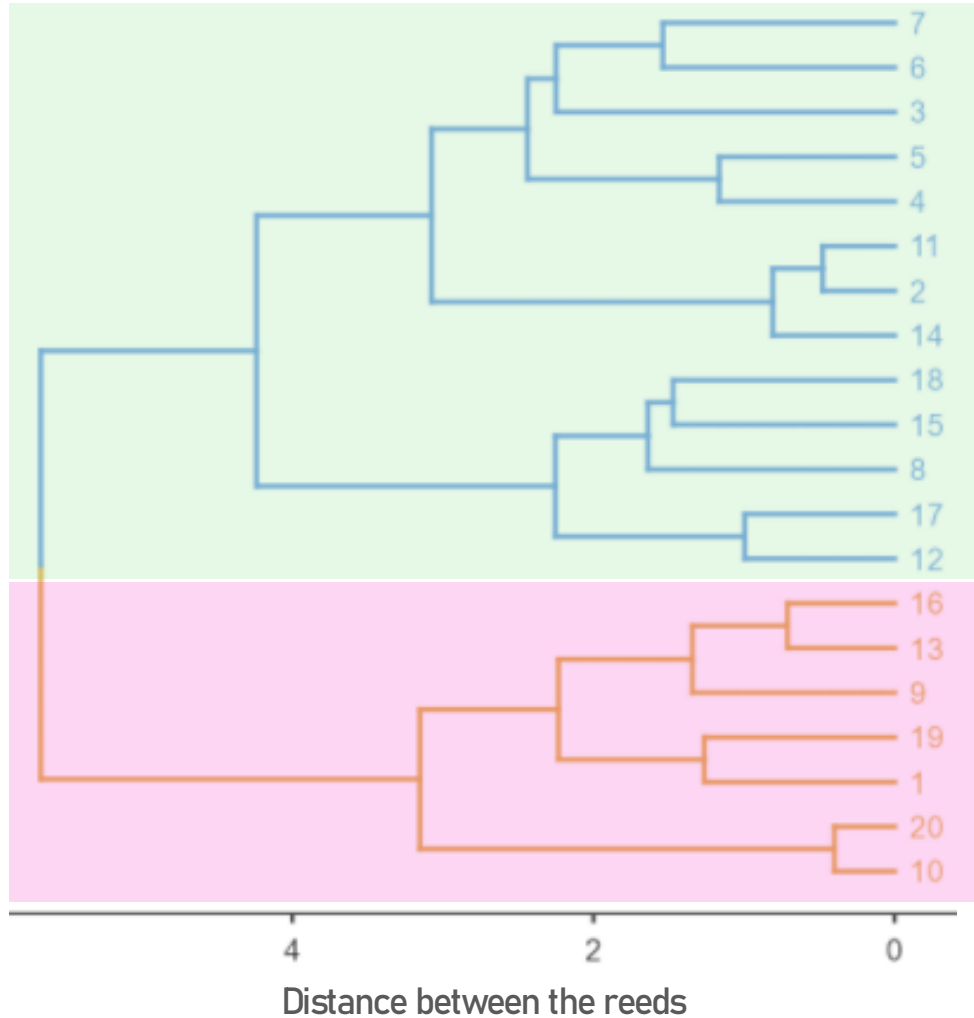
	Clusters	Reeds	Quality
Classification	C1	3 10 12 14 15 16 20	Too soft - Soft
	C2	1 2 4 5 6 7 8 9 11 13 17 18 19	Good - Hard - Too hard
Stiffness	S1	1 2 4 5 6 8 9 11 13 18 19	
	S2	3 7 10 12 14 15 16 17 20	

11 / 11 reeds from S1 are also in C2 -> Small S00 = Soft reeds ?

7 / 7 reeds from C1 are also in S1 -> Hard reeds = Large S00 ?

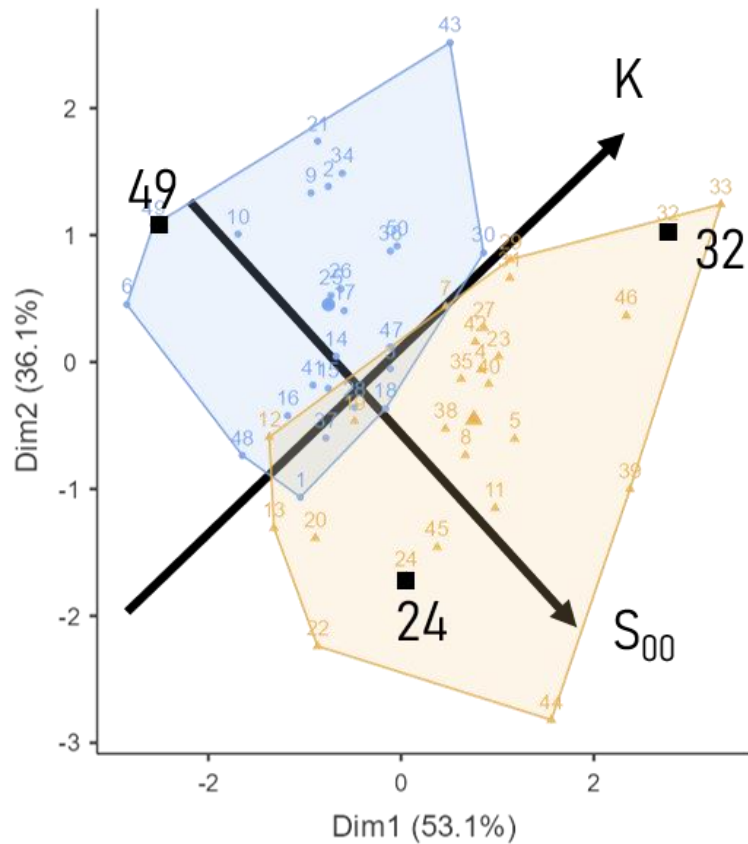
Clarinetist A – Stiffness measurement

D'après dendrogramme (distance mesure Canberra – clustering method ward.D2)



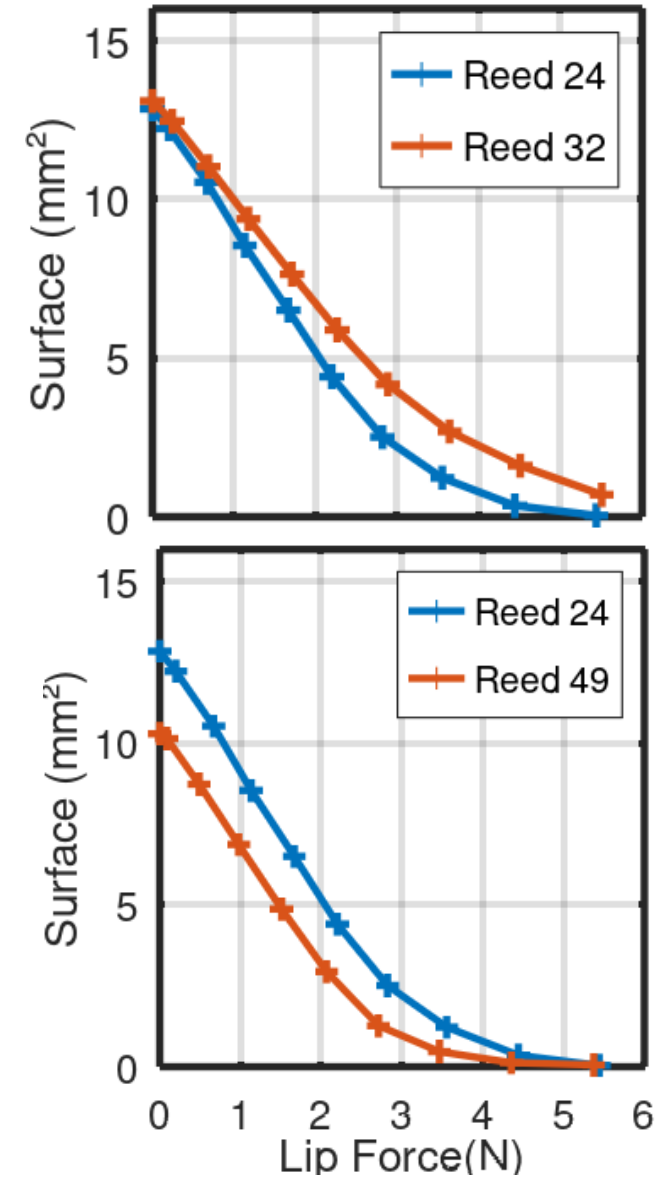
Preliminary results

Clustering -K-means method



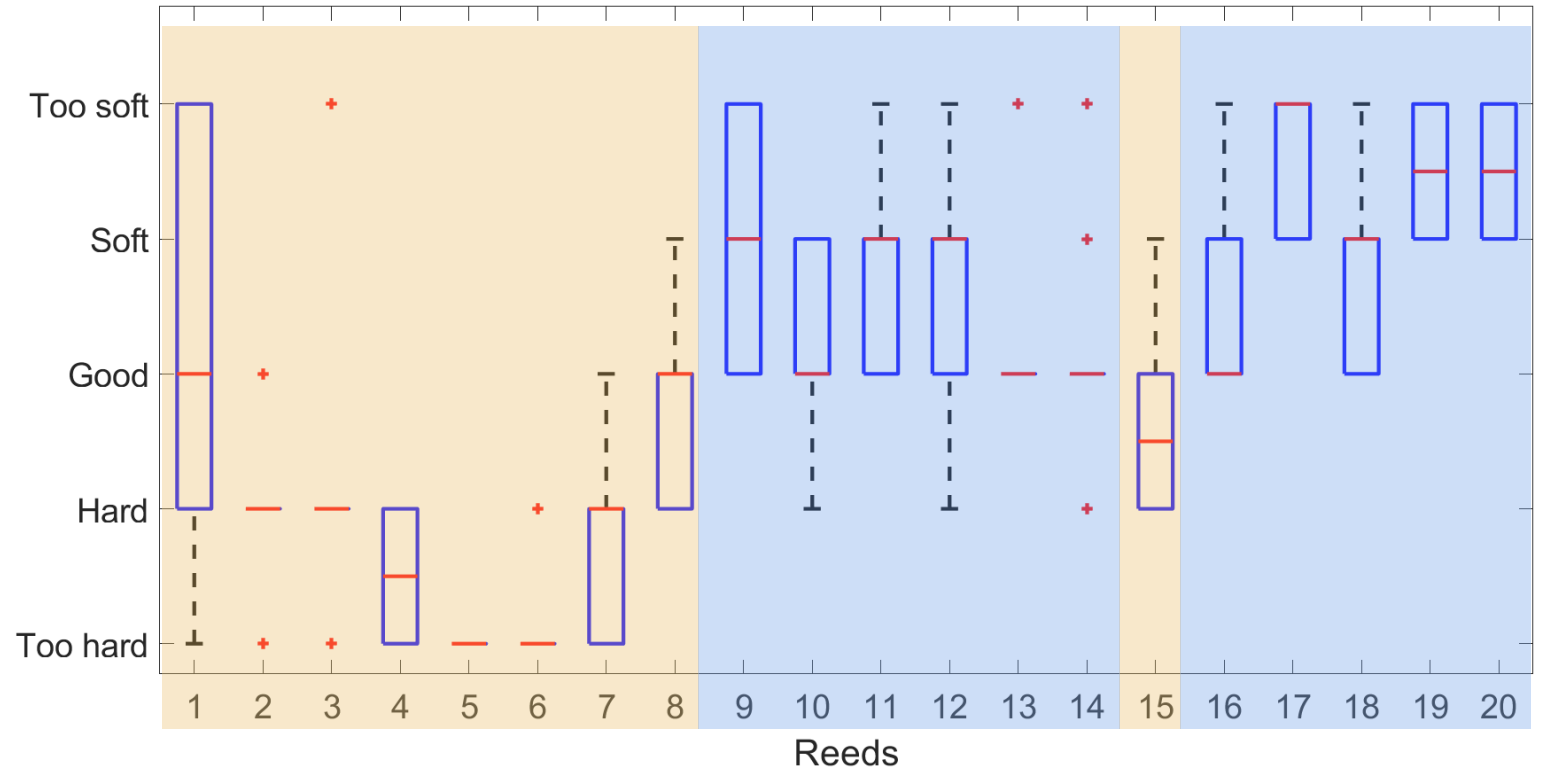
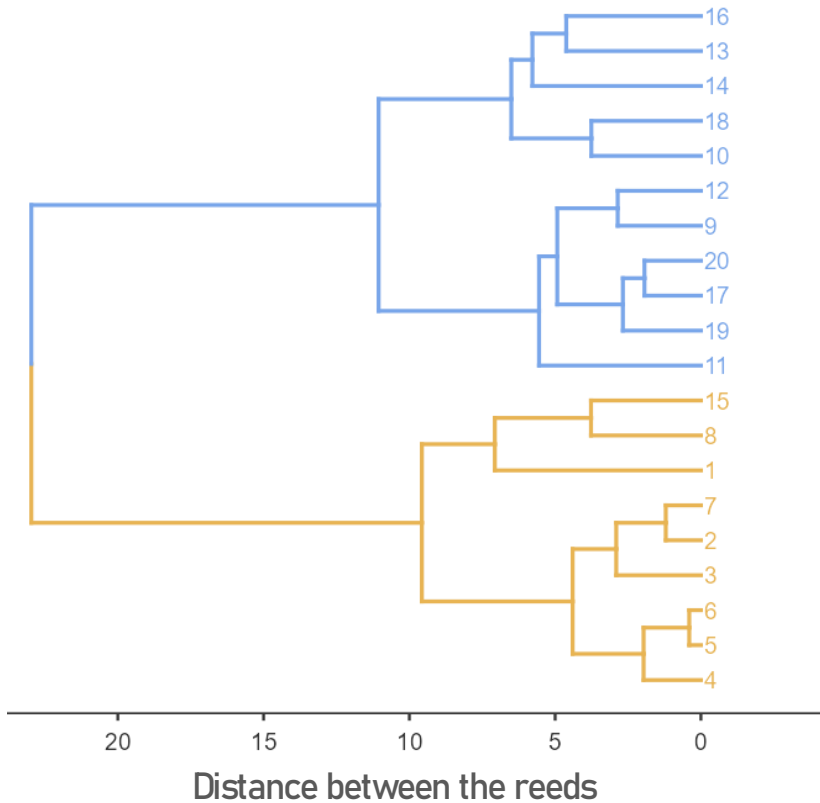
Similar opening at rest

Similar stiffness



Clarinetist A – Classification

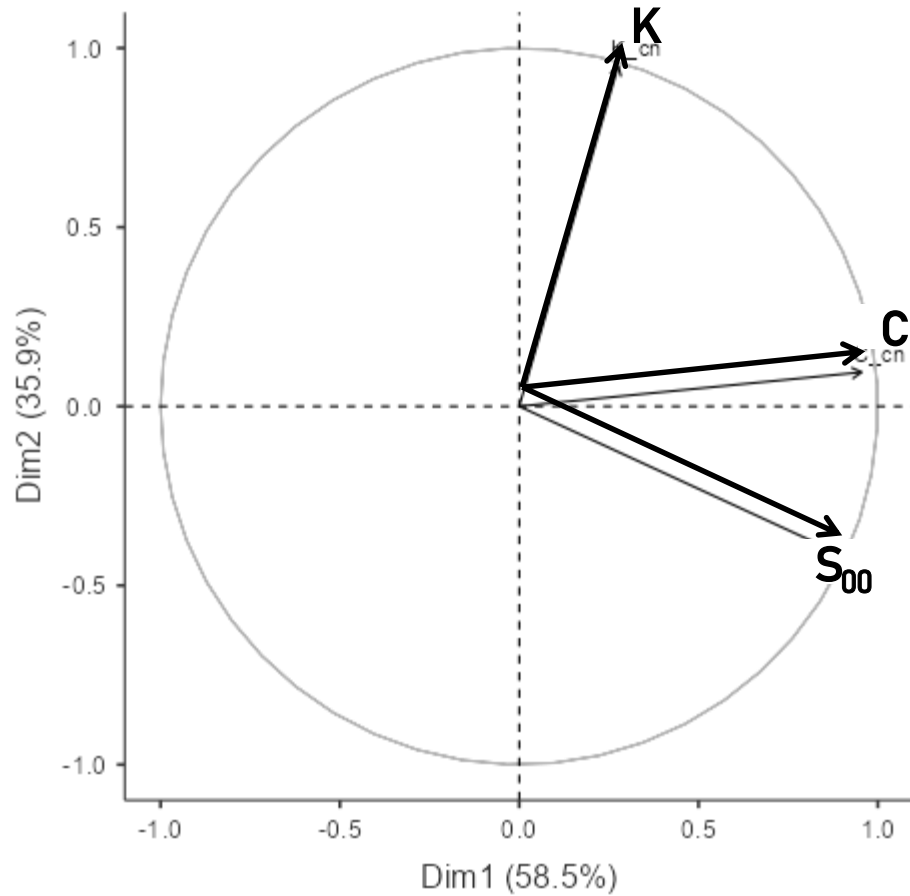
Reed clustering thanks to a dendrogram



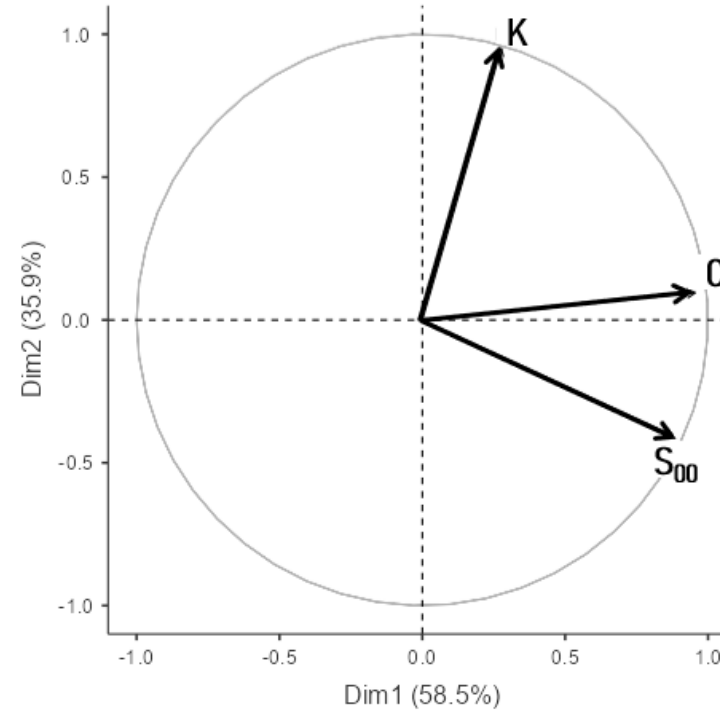
Classification	Reeds	Quality
Cluster 1	9 10 11 12 13 14 16 17 18 19 20	Too soft – Soft – Good
Cluster 2	1 2 3 4 5 6 7 8 15	(Good) – Hard – Too hard

Clarinetist A – Stiffness measurement

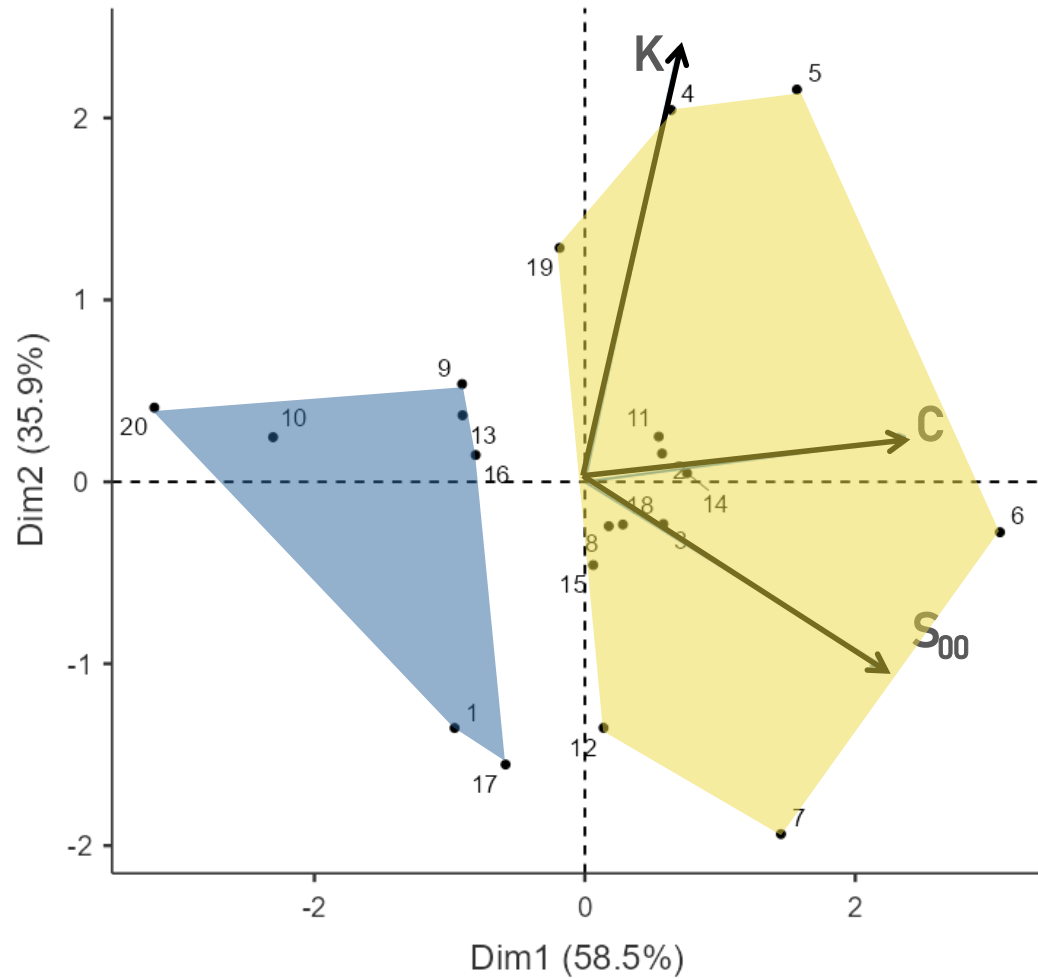
Principal component analysis



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Stiffness measurement - Clustering



The two groups are separated according **C**.

Clarinetist A – Cluster comparisons

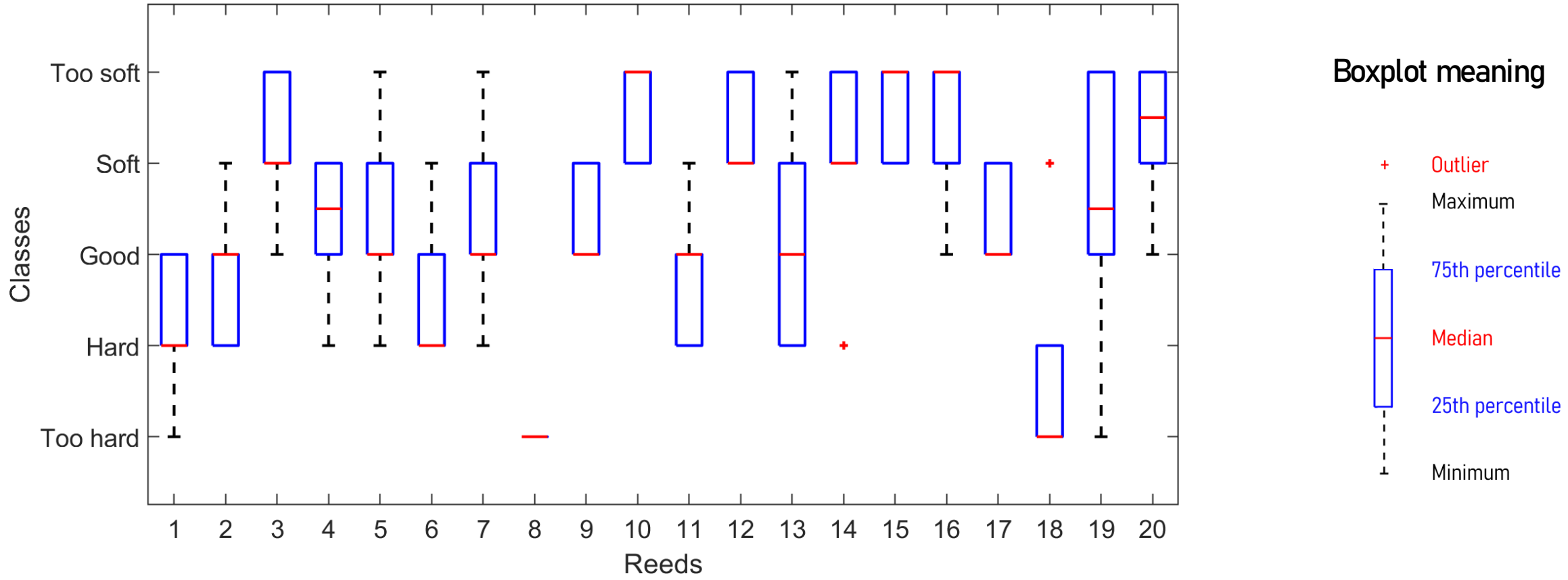
	Clusters	Reeds	Quality
Classification	C1	9 10 11 12 13 14 16 17 18 19 20	Too soft – Soft – Good
	C2	1 2 3 4 5 6 7 8 15	(Good) – Hard – Too hard
Stiffness	S1	1 9 10 13 16 19 20	Small S00
	S2	2 3 4 5 6 7 8 11 12 14 15 17 18	Large S00

6 / 7 reeds from S1 are also in C1 -> Small S00 = Soft reeds ?

8 / 9 reeds from C2 are also in S2 -> Hard reeds = Large S00 ?

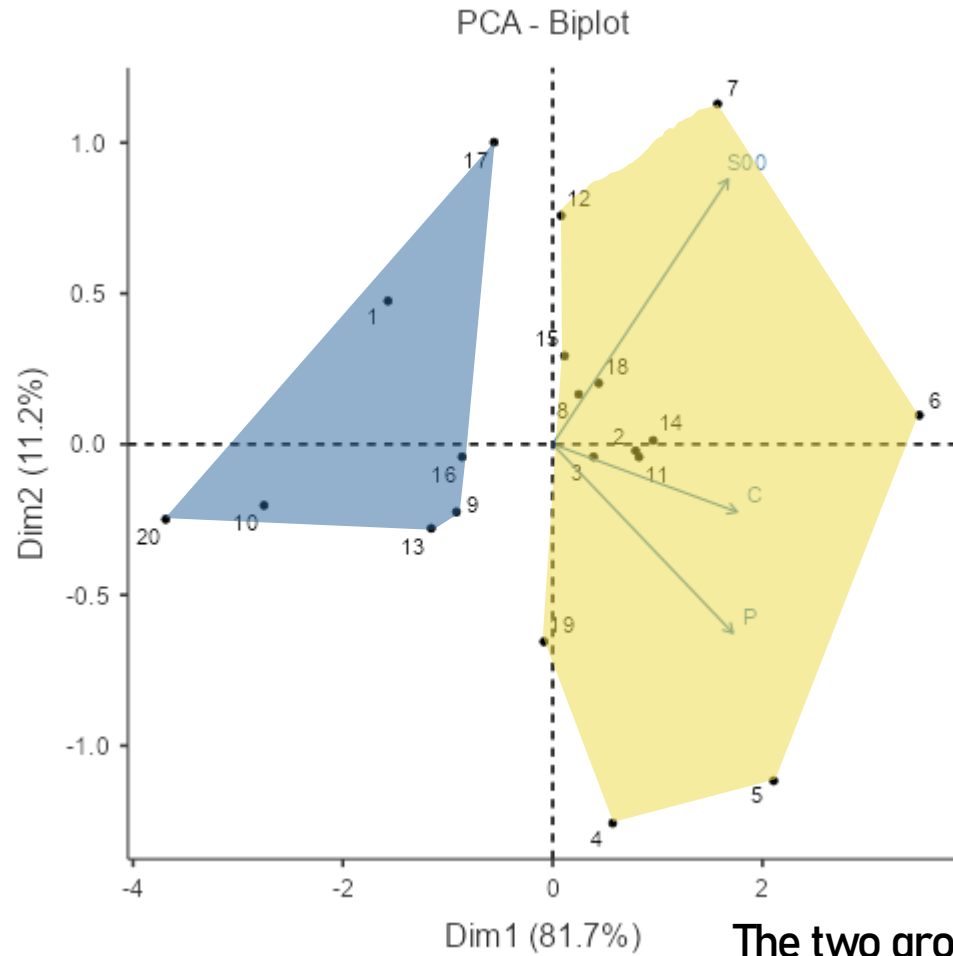
Perceptual assessment : reed classification

Example of results obtained :

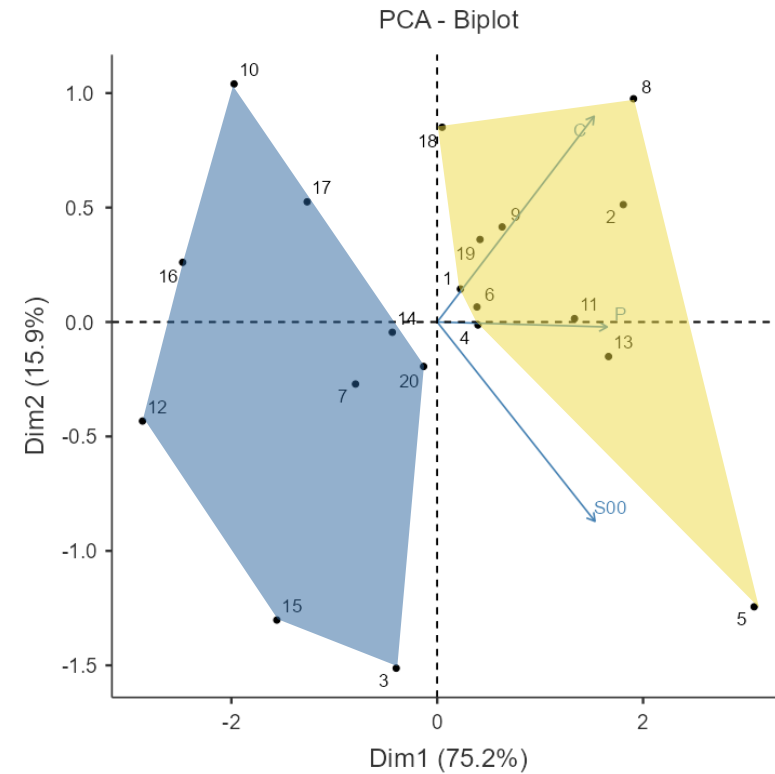


Stiffness measurement - Clustering

Clarinetist A



Clarinetist B

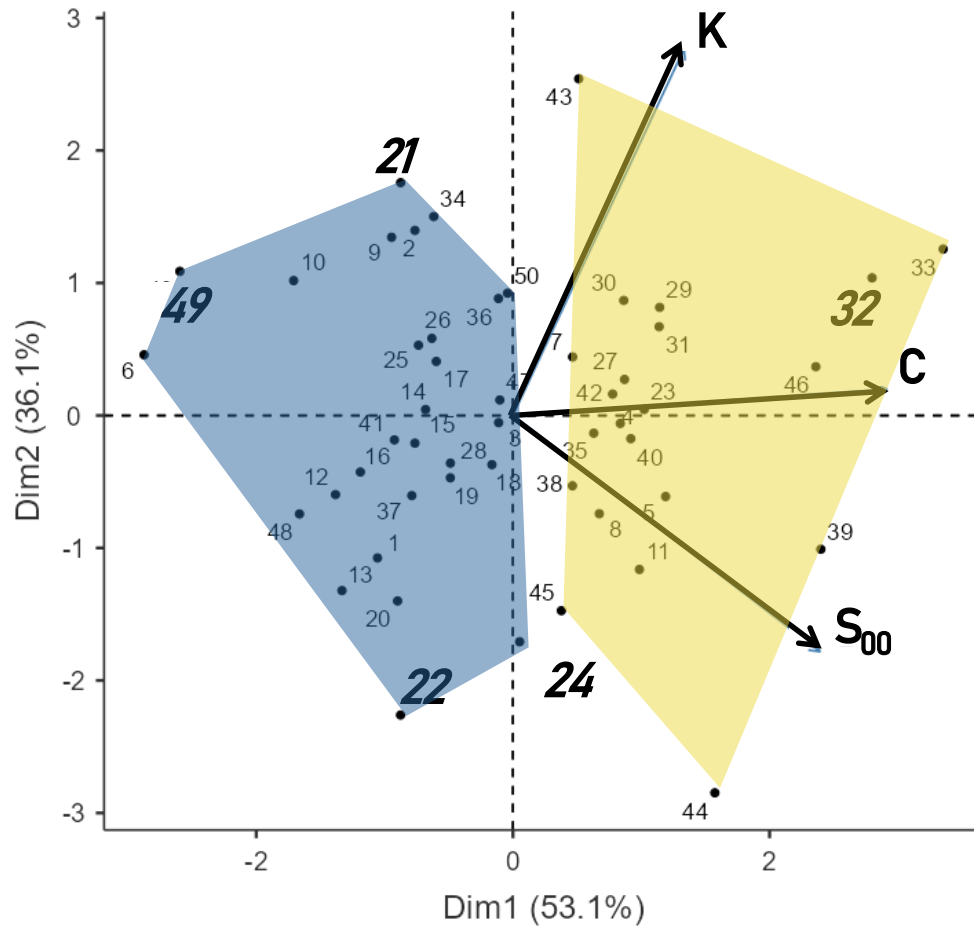


As for preliminary results

Preliminary results

Clustering -K-means method

Parameter values are centered and normalized



Similar S_{00}

Similar K

Similar C

Measured stiffness

