

SOUND LEVELS AT MUSICIANS' EARS FROM CLASSICAL INSTRUMENTS DURING SOLITARY PRACTICE

The power, the dry component, and
the room component

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Introduction

Sound levels at musicians ears

Dry component (direct + body reflections)

Room component

Total = Dry + Room

Relevant to

Noise & Health

Musicians perceived Dry-Room balance

ISO-23591 Annex, data and calculation scheme:

Power and room component *at forte*

Not the Dry component and the total SPL



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Outline

- The input data: O'Brien measurements
- Extracting the dry component: Two models
- Results
- Discussion
- Conclusion

Input data

Measurement data from **O'Brien** (2013)

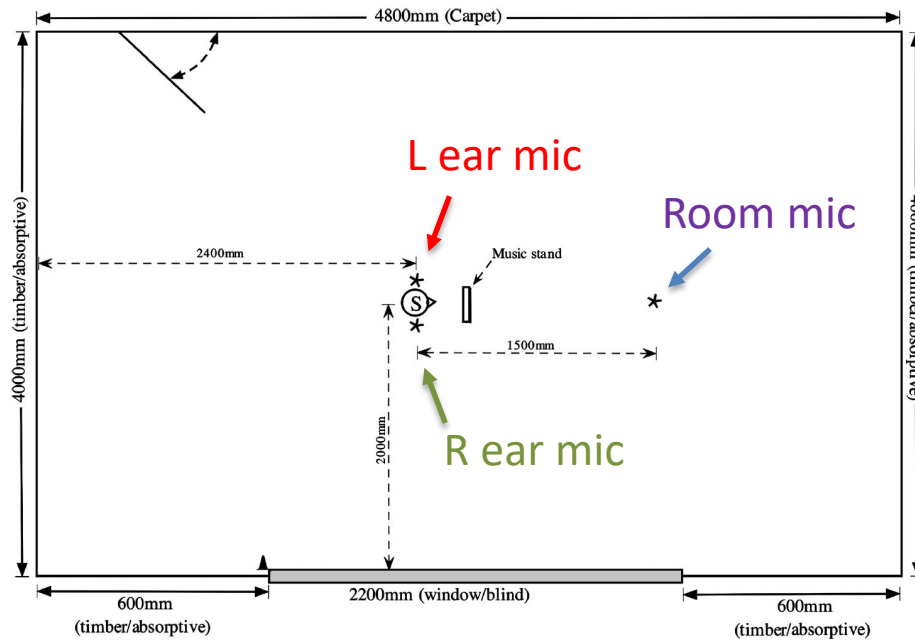
19 instruments, 35 musicians, in «typical» practice session

LpA.eq (25 min)

- Left ear
- Right ear
- 1.5 m distance from musician

The room and positions

Plan, positions, musician, 3 microphones (O'Brien 2013)



$L \times W = 19 \text{ m}^2$

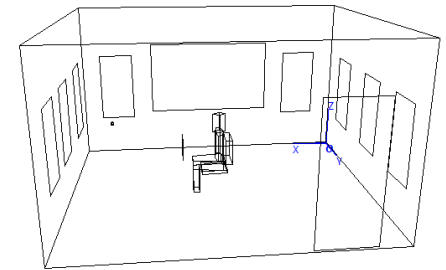
$H = 2.8 \text{ m}$

$V = 54 \text{ m}^3$

$RT = 0.4 \text{ s}$

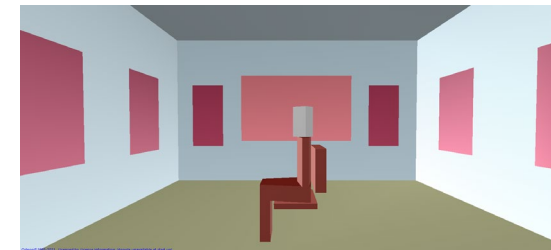
$G_{\text{room}} = 23 \text{ dB}$

3D model wire-mesh



Odeon©1985-2021 Licensed to: License information /dongle unavailable at start up!

3D model interior view



«Typical» practice session, 19 instruments

1. Tuning note at piano (15 s)
2. Tuning note at mezzo-forte (15 s)
3. Tuning note at forte (15 s)
4. Tuning note at fortissimo (15 s)
5. Technical work (5 min)
6. Don Quixote (15 min)
7. 1–6 combined including breaks (approximately 23 min)

Bass clarinet (1)
Bass trombone (1)
Bassoon (2)
Bb clarinet (2)
Cello (3)
Contra bassoon (1)
Double bass (2)
Eb clarinet (1)
Flute (2)
Harp (1)
Horn (3)
Oboe (3)
Piccolo (2)
Side drum (1)
Trombone (2)
Trumpet (3)
Tuba (1)
Viola (2)
Violin (2)

Extracting Dry and Room components

Method 1: Odeon model

Built-in directivities

Best fit to measurements

Dry = SPL in «black» model

Uncertainty: Diffraction and
body reflections

Method 2: Classical model

Room = SPL @ 1.5 m
corrected for brass directivity

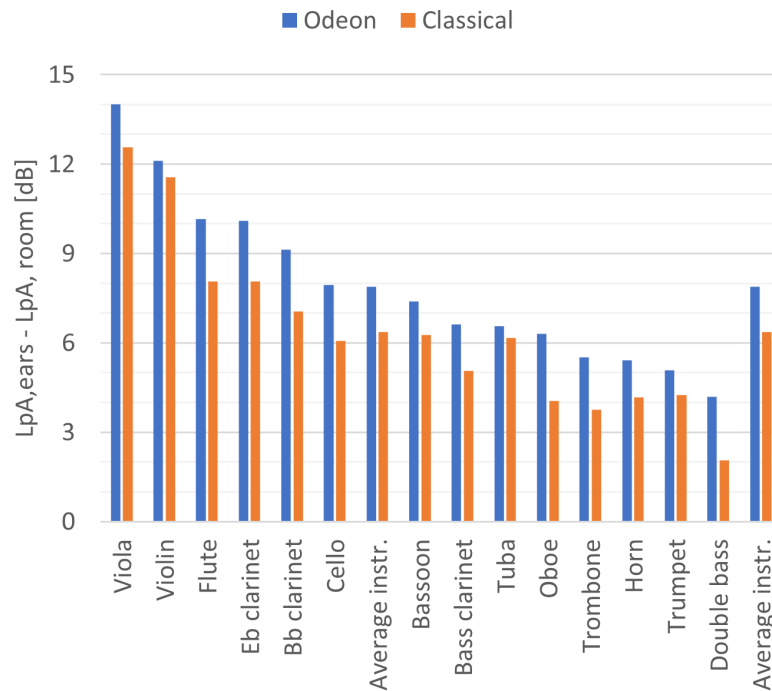
Dry = Total minus Room

Uncertainty: Directivities

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Difference (dB): Total - Room



Comment:

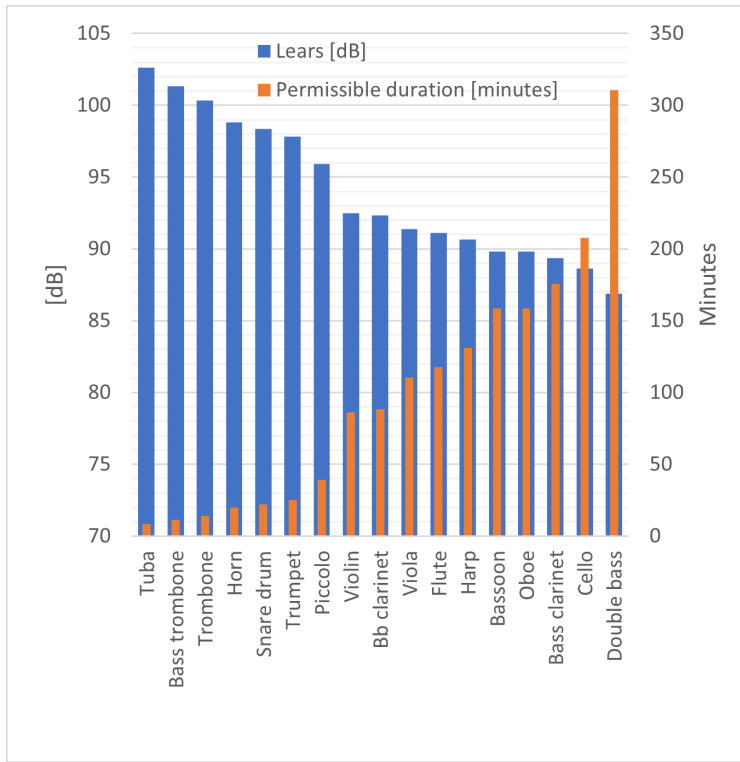
Total exposure from average instrument is 6-8 dB stronger than room level

Odeon and Classical models

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Noise & Health at *forte*



Practice at forte

$V = 54\text{m}^3$

$RT = 0.5\text{s}$

SPL 87 – 103 dB at ears

Permissible unprotected
duration 8 – 310 minutes per day

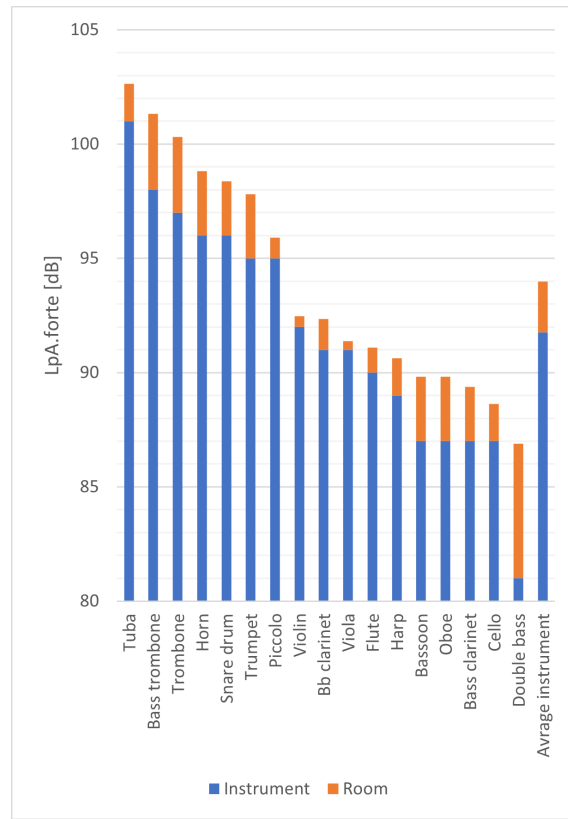
Leftmost: Tuba

Rightmost: Double Bass

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How much room amplification?



Practice at forte

$V = 54\text{m}^3$

$RT = 0.5\text{s}$

Room amplification,
average instrument +2.2 dB

from 0-1dB for violin/viola
to 6 dB for double bass

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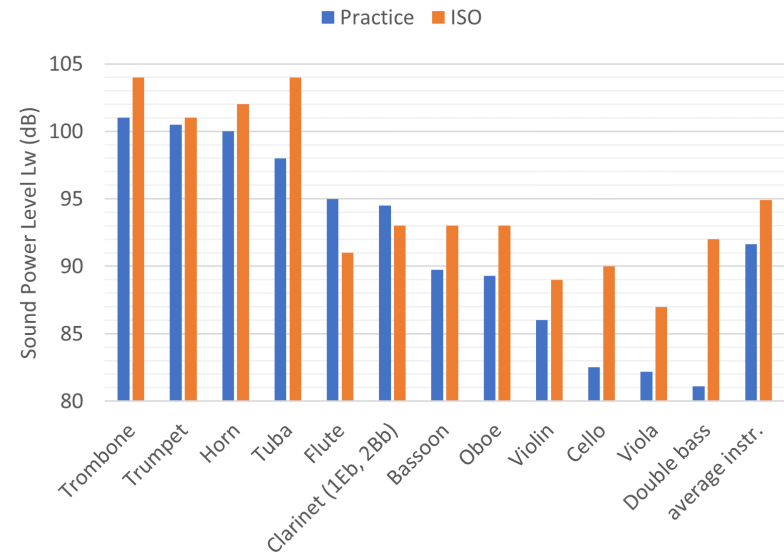
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O'Brien mixed practice vs ISO *forte*

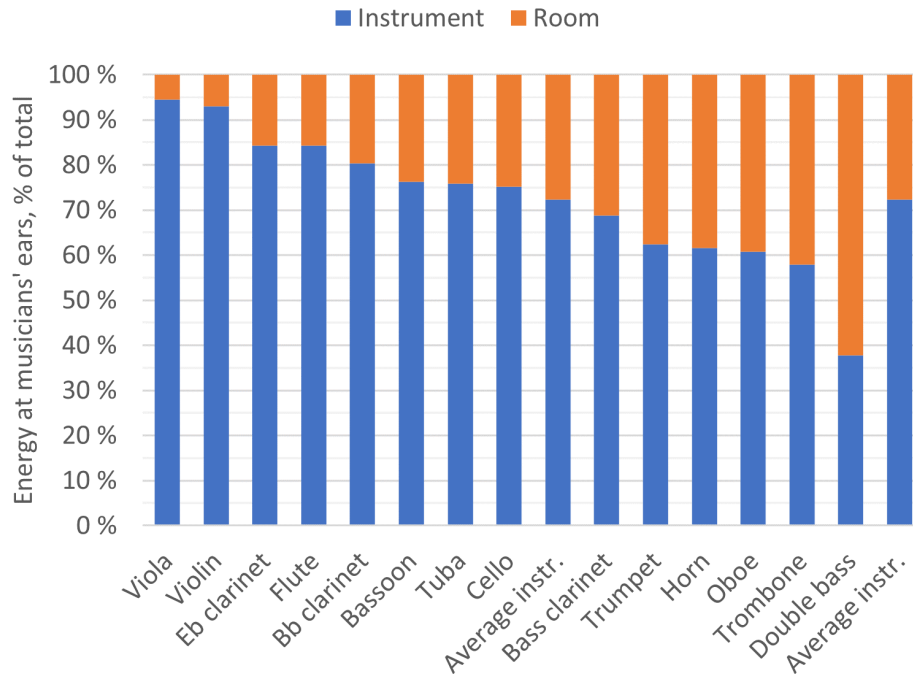
ISO *forte* levels are on average 3.3 dB louder than those in O'Brien's mixed practice

Flute / Clarinet are softer in ISO

Trumpet is practically equal



Dry – Room hearing balance



In solitary practice at *forte* :

Sound at musicians ears is
Dry sound + Room sound

From the average instrument, there is
72% Dry and 28% Room

Viola/Violin 92-94% Dry and 6-8% Room

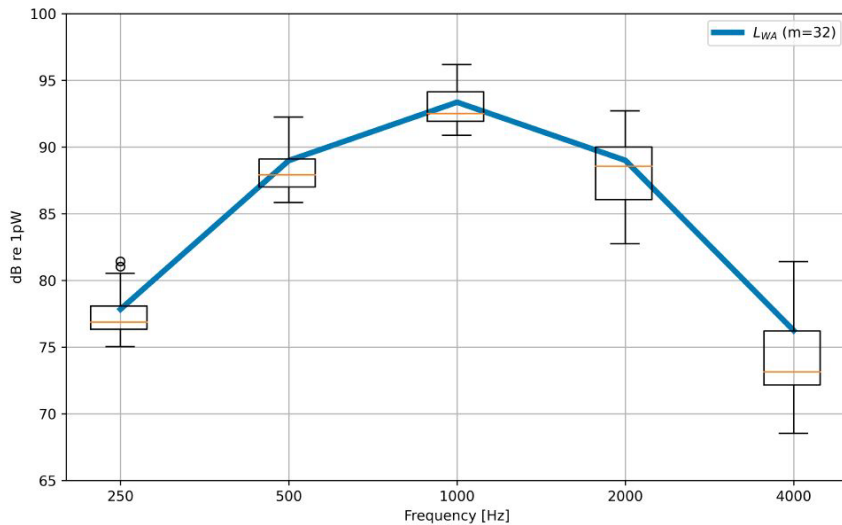
Double Bass 38% Dry and 62% Room

May be different at *pp-mf*

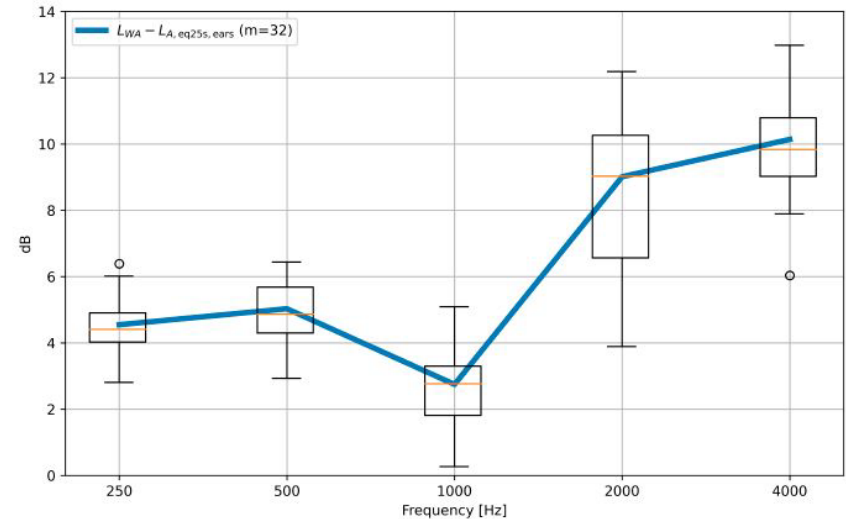
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Helbæk-Kjølborg, Master Thesis (NTNU 2023)



Clarinet $L_{WA} = 98$ dB spectrum @ forte

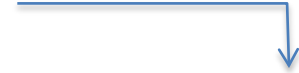


Clarinet $L_{WA} - L_{pA,dry}$ spectrum @ forte

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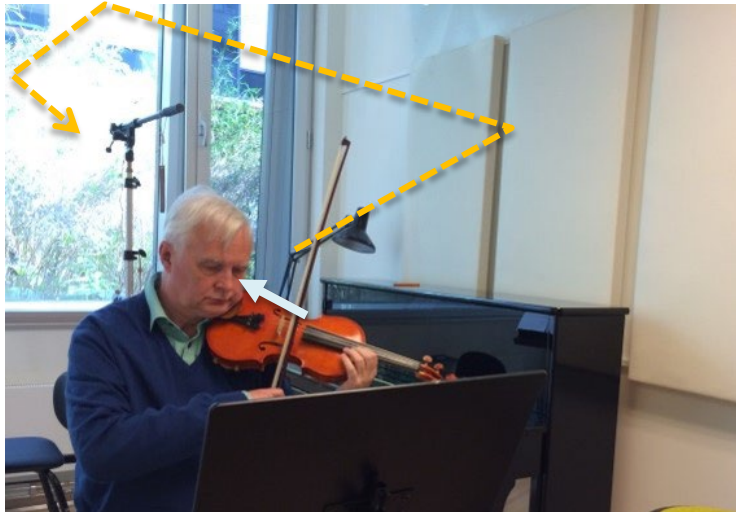
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R' - average distance from ears
to apparent source centroid



The missing link in ISO 23591

$G_{\text{dry.ears}}$
a transfer function that takes near-field
and directional effects into account



	Dry.ears-Lw [dB]	R' [m] (omni source)	G.dry.ears [dB] (omni source)
19 instruments			
Viola	4	0,17	35
Violin	3	0,19	34
Piccolo	0	0,27	31
Flute	-1	0,31	30
Eb Clarinet	-1	0,31	30
Contra Bassoon	-1	0,33	30
Bb clarinet	-2	0,35	29
Bassoon	-3	0,40	28
Tuba	-3	0,40	28
Harp	-3	0,41	28
Cello	-3	0,41	28
Bass clarinet	-5	0,48	26
Snare drum	-5	0,53	26
Trumpet	-6	0,56	25
Horn	-6	0,57	25
Oboe	-6	0,58	25
Bass trombone	-7	0,62	24
Trombone	-7	0,62	24
Double bass	-11	0,95	20

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Conclusions

- Without the Dry component, sound exposure will be underestimated by 2-14 dB
- Combining present results with ISO 23591 Annex, total SPL can be calculated for 17 instruments

In a practice room where $V = 54\text{m}^3$ and $RT = 0.5\text{ s}$:

- Total SPL at musicians' ears at *forte* is 87 – 103 dB, on average 95 dB
 - This is 3.3dB louder than equivalent level over O'Brien's «typical» practice session
- Permissible unprotected practice duration at *forte* ranges from 8 min to 310 min
- Room amplification is from 0.5 dB to 6 dB, on average 2.2 dB
- Room component ranges from 6% to 62%, average 28%, of total sound heard by musician

An updated paper with corrected results for BASSOON is available at www.akutek.info

THANK YOU !

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