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PRESENTS

Sound exposure of musicians: The own instrument's sound compared to the sound from others

a power point presentation by Remy Wenmaekers

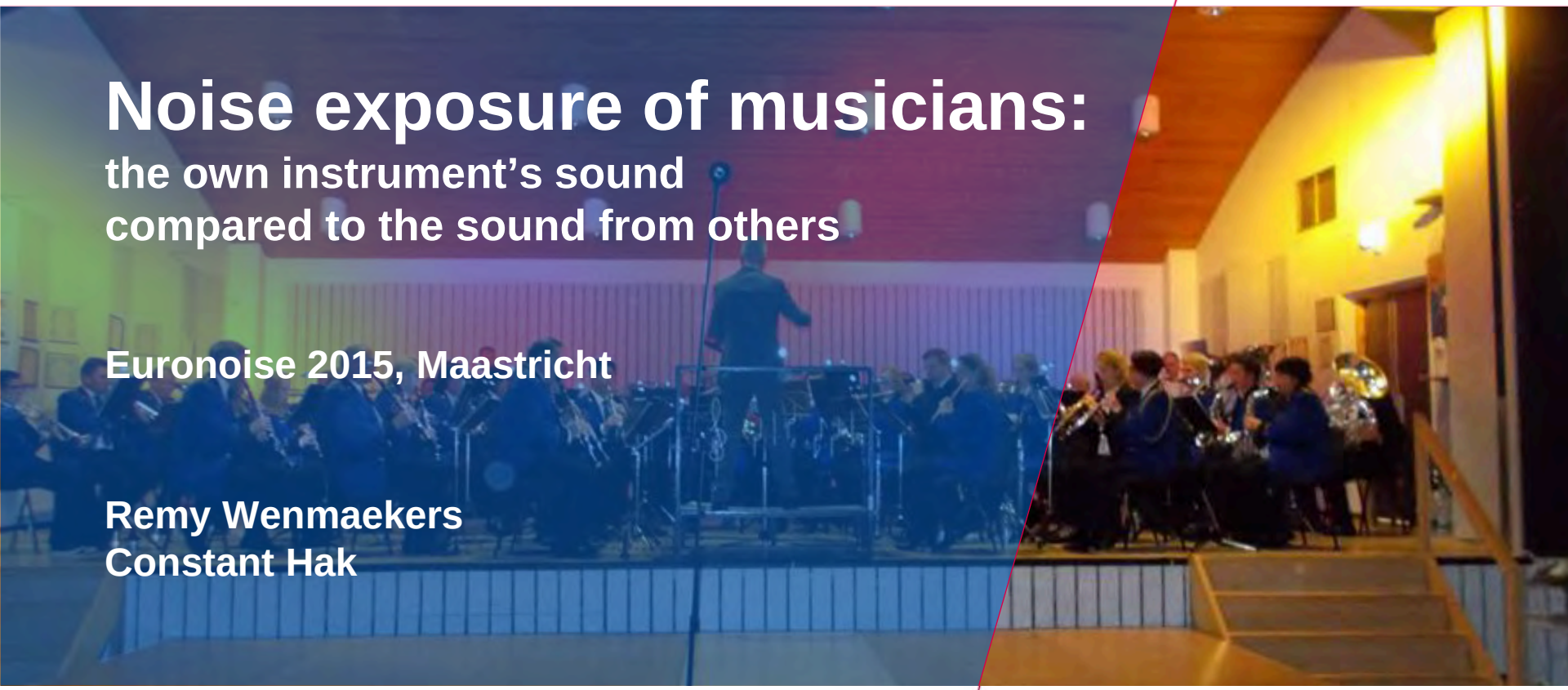
SUMMARY

The noise exposure of symphony orchestra musicians has many different contributions. While playing in the orchestra, measurement devices cannot discriminate between different contributions of different sound sources. When playing at home, rehearsing individually, the own instrument's sound is amplified by the room differently. To investigate how much sound is received from one's own instrument compared to all others in the orchestra, a model is used that calculates the contribution of direct, early and late reflected sound on the noise exposure. Besides looking at the full orchestra rehearsal, a hypothetical case is investigated where one is individually playing the same musical score at home in a small rehearsal space with 8 m2 of sound absorption. In the calculations for the home rehearsal case, silent parts longer than 2 seconds are removed from the input data. Then, the sound level is calculated for the same amount of rehearsal time as for playing the full piece during orchestra rehearsal, resulting in a higher exposure for the same period. The outcome of the model shows, for two examples of musical pieces of 2 to 3 minutes duration, that during orchestra rehearsal the other orchestra members contribute more to the total noise exposure than the own instrument for all instrument groups, with a difference varying from 2 dB(A) up to more than 10 dB(A), depending on the musical instrument and piece. This suggests, that the contribution of the own instrument may play a minor role during full orchestra rehearsal. The total noise exposure during individual rehearsal is 4 dB(A) lower that during orchestra rehearsal for the same amount of rehearsal time, averaged over all instruments. This suggest that, even though individual rehearsal causes more noise exposure from the own instrument than during orchestra rehearsal, the total noise exposure during orchestra rehearsal is still the highest. Click to go to full paper

Related papers:

The influence of Room Acoustic Aspects on the Noise Exposure of Symphonic Orchestra Musicians by Wenmaekers and Hak
A Model for the prediction of Sound Levels within a Symphonic Orchestra based on measured Sound Strength by Wenmaekers and Hak
Level balance between Self, Others and Reverb, and its significance to noise exposure as well as mutual hearing in orchestra musicians (paper) (presentation) by M Skålevik

Noise exposure of musicians:
the own instrument's sound compared to the sound from others



Euronoise 2015, Maastricht

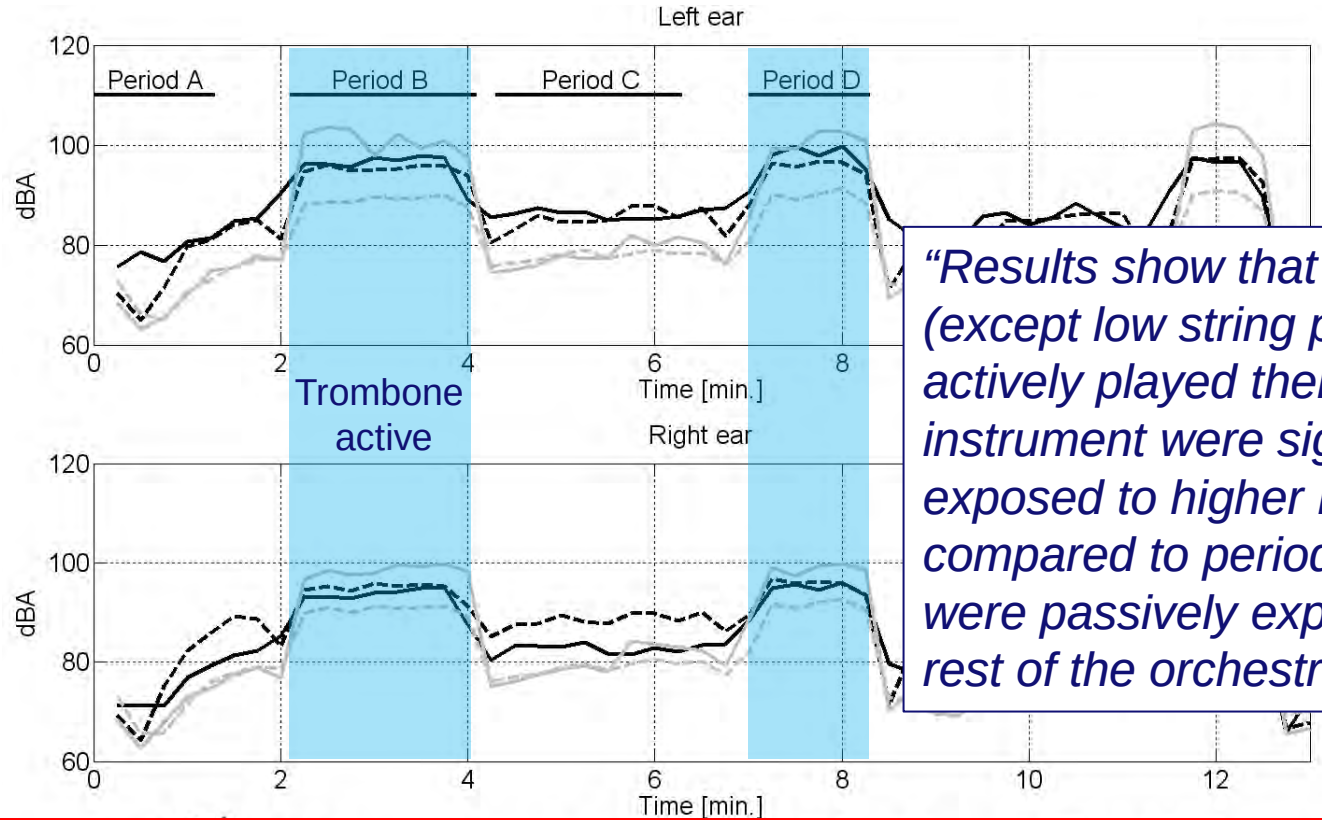
Remy Wenmaekers
Constant Hak

Euronoise 2015 Maastricht

TU/e level acoustics

Where innovation starts

The own instruments level vs others



*"Results show that musicians (except low string players) who actively played their own instrument were significantly exposed to higher L_{Aeq} compared to periods where they were passively exposed from the rest of the orchestra." **

Does this mean:

- **that direct sound of the own instrument causes most of the sound exposure during orchestral play?**
- **that there is no difference in exposure rehearsing at home compared to playing in the orchestra?**

Research Question

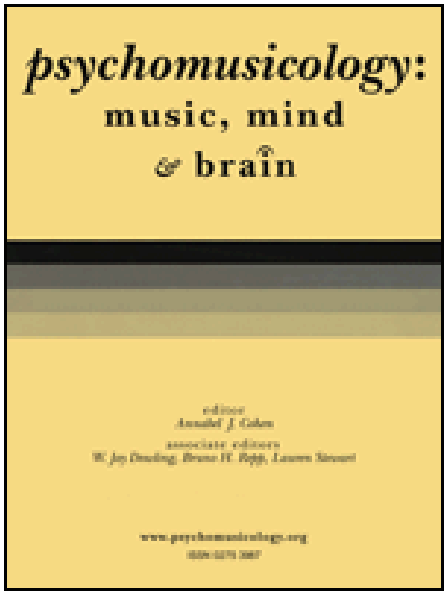
Sound Exposure of Musicians

The own instrument's sound compared to the sound from others:

A) Own instrument **versus** own section and all other players
B) Own instrument in the orchestra **versus** own instrument at home
C) Own instrument at home **versus** total level in the orchestra

For excerpts of Mahler Symphony 1 and Bruckner Symphony 8

Sound level prediction model



Special edition: Leo Beranek celebrated 100 year birthday

Paper In Press

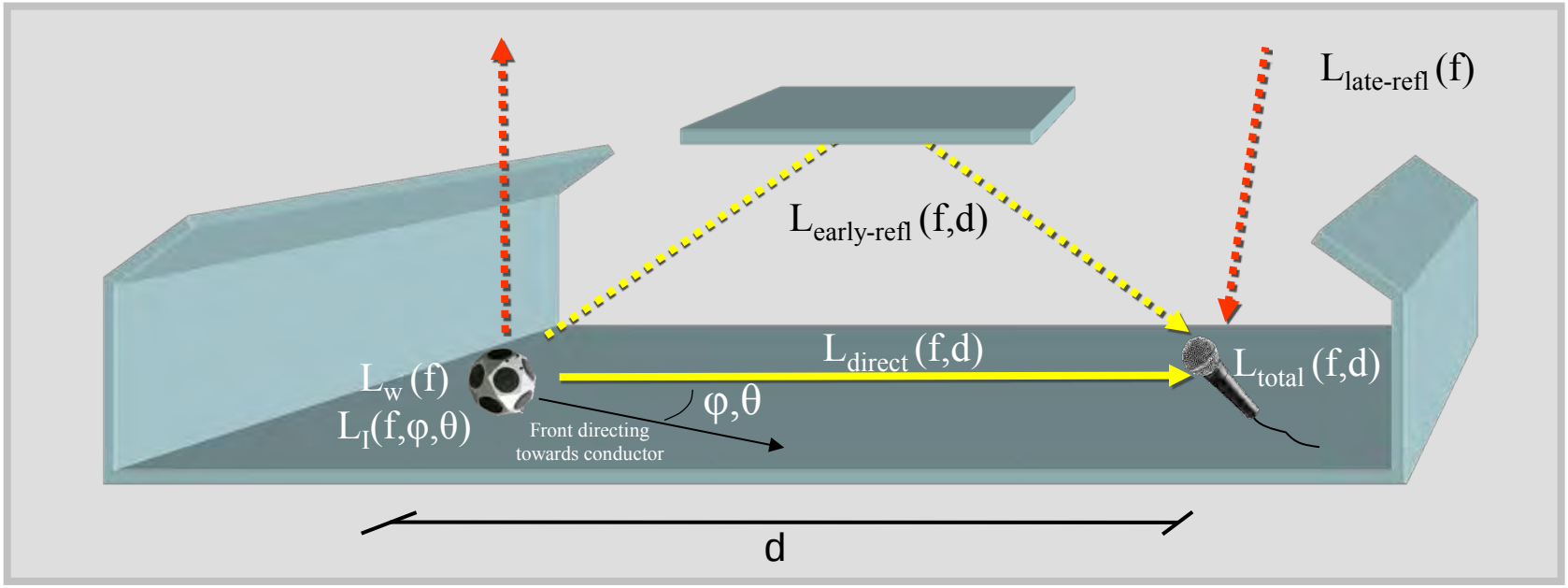
A Sound Level Distribution Model for Symphony Orchestras: Possibilities and Limitations

R. H. C. Wenmaekers and C. C. J. M. Hak
Eindhoven University of Technology

Musicians in a symphony orchestra rely on the direct and reflected sound on a concert hall stage to be able to hear each other. Besides ensemble conditions, members and directors of symphony orchestras are concerned about the noise levels musicians are exposed to. However, the actual contribution of the different parts of the sound field cannot be derived from sound level measurements in orchestras. In this article, a prediction model is presented that can be used to investigate the distribution of the direct, early reflected, and late reflected sound from all musicians to the total sound level at a single musician's position. It is shown that the contributions of each different aspect to the total sound level are in the same order of magnitude. In some cases, the direct sound dominates, while in other cases, the early or late reflected sound does. Considerable variations in sound levels are found between a concert hall, rehearsal room, and orchestra pit, due to the difference in room acoustical properties. An example is presented of calculated sound levels for a violin's position in the orchestra for the 3 halls. The results from the example show that the model has potential for studying the influence of architectural as well as acoustical aspects on the sound levels that occur in a symphonic orchestra, both from a health and musical point of view.

Keywords: orchestra, sound level, acoustics, support, music

Sound paths



L_{direct} : direct sound level

$L_{early\text{-}refl}$: early reflected sound level

$L_{late\text{-}refl}$: late reflected sound level

L_{total} : total sound level

Sound paths

Direct sound other instruments:

$$L_{direct}(f,d) = L_{eq;1m}(f,\varphi,\theta) - 20\lg(d) + \Delta L_{orch}(f,d) + \Delta L_{ear}(f,\theta)$$

Early reflected sound:

$$L_{early-refl}(f,d) = L_w(f) + ST_{early;d}(f,d) - 11$$

Late reflected sound:

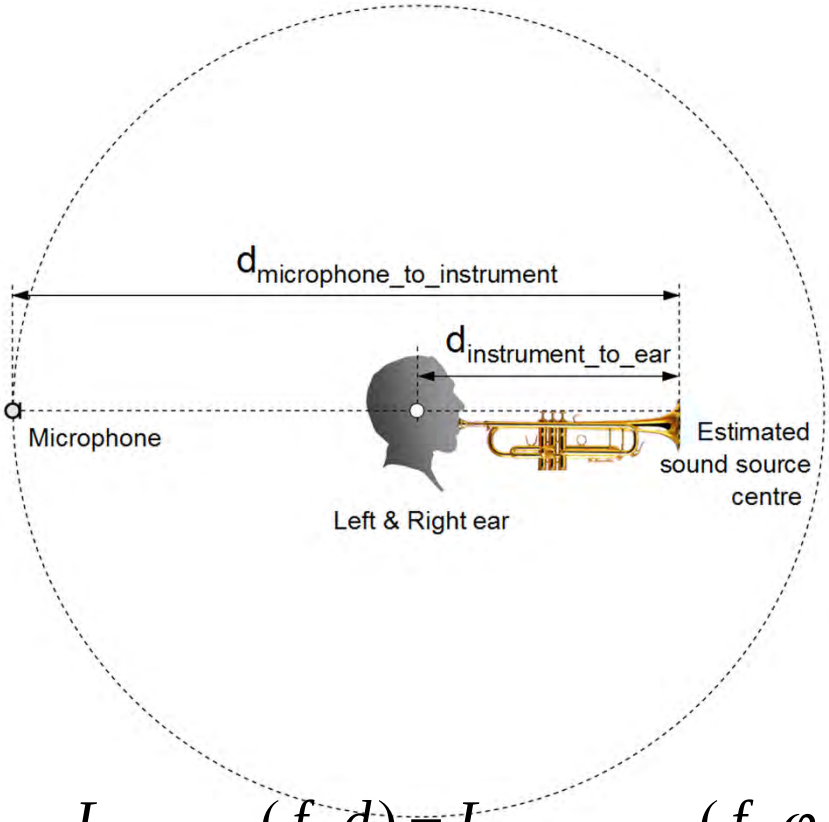
$$L_{late-refl}(f) = L_w(f) + ST_{late;d}(f) - 11$$

R.H.C. Wenmaekers, C.C.J.M. Hak, and L.C.J. van Luxemburg, (2012),
"On measurements of stage acoustic parameters - time interval limits and various source-receiver distances"
Acta Acustica united with Acustica, 98, 776–789.

Direct sound own instrument?

Own instrument sound

Estimation model



Measured anechoic room

Sound level measured in an anechoic room while playing scales (fragment of both piano and forte playing) – Left ear

	A-weighted		
Instrument	Meas	Estim	M-E
Flute 1	86	87	−0.7
Piccolo 1	90	88	1.7
Flute 2	86	89	−3.7
Piccolo 2	92	89	3.3
Trumpet	97	99	−2.2
Flugelhorn	98	100	−2.1
Bass trombone	96	97	−1.4
Trombone	97	97	−0.4
Violin	92	93	−0.9

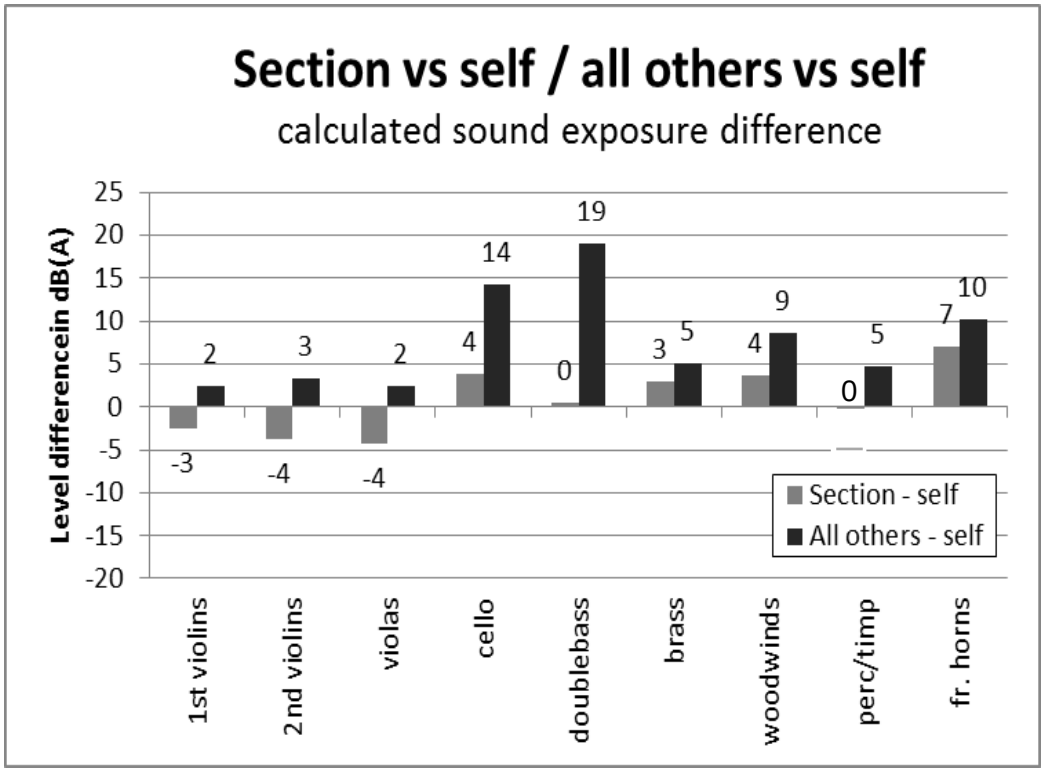
$$L_{direct;own}(f,d) = L_{eq;microphone}(f,\varphi,\theta) - 20\lg\left(\frac{d_{instrument\_to\_ear}}{d_{microphone\_to\_instrument}(\varphi,\theta)}\right)$$

Sound level prediction model

Noise exposure of musicians:

the own instrument's sound
compared to the sound from others

A) Own instrument vs others

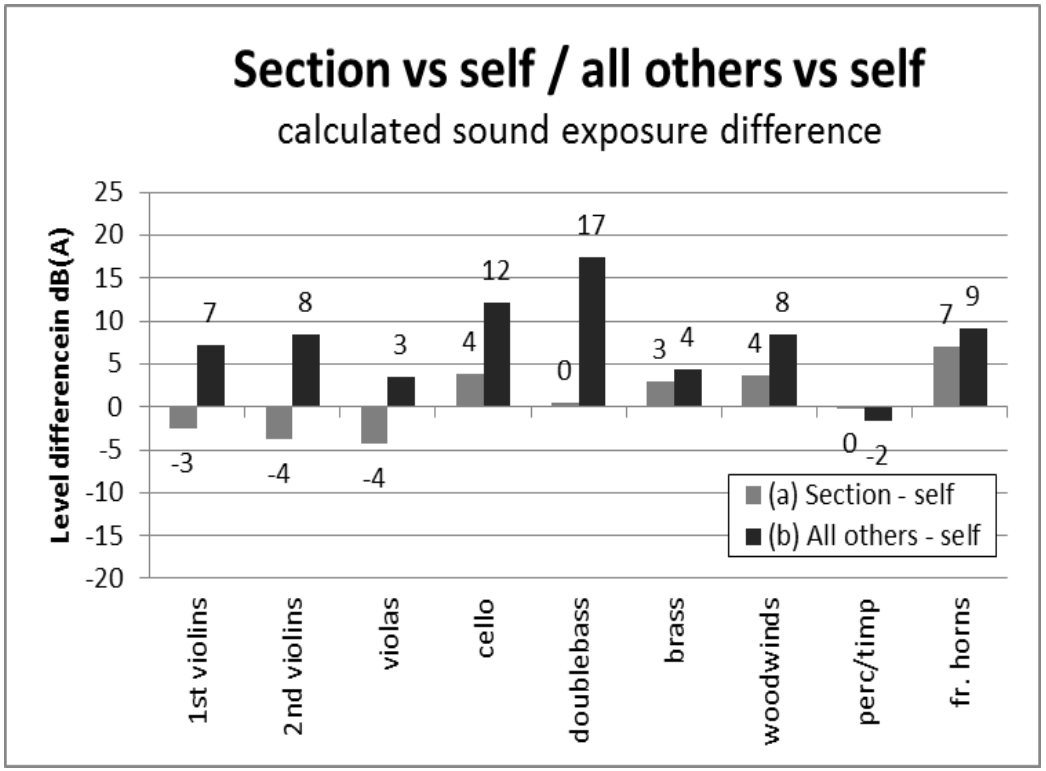


Mahler, calculated using prediction model

Positive:
Other players louder

Negative:
Own instrument louder

A) Own instrument vs others

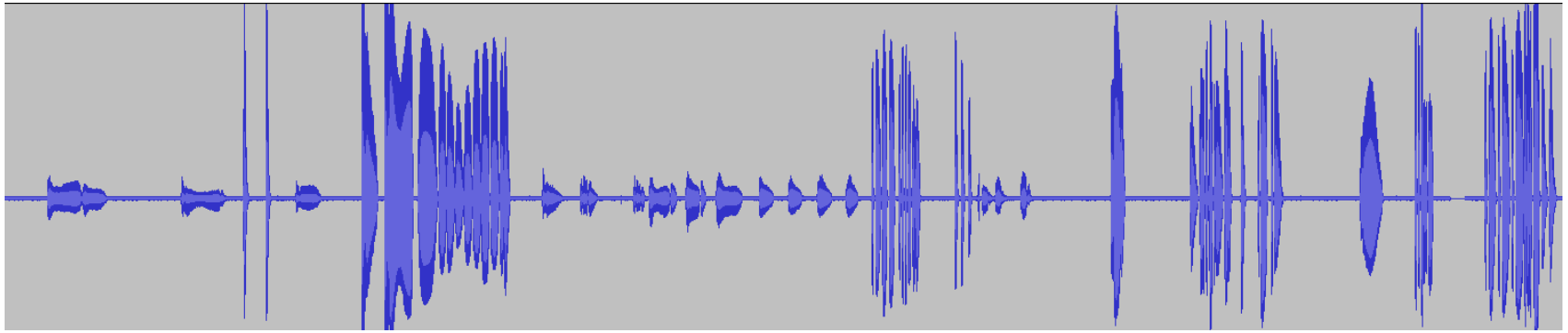


Bruckner, calculated using prediction model

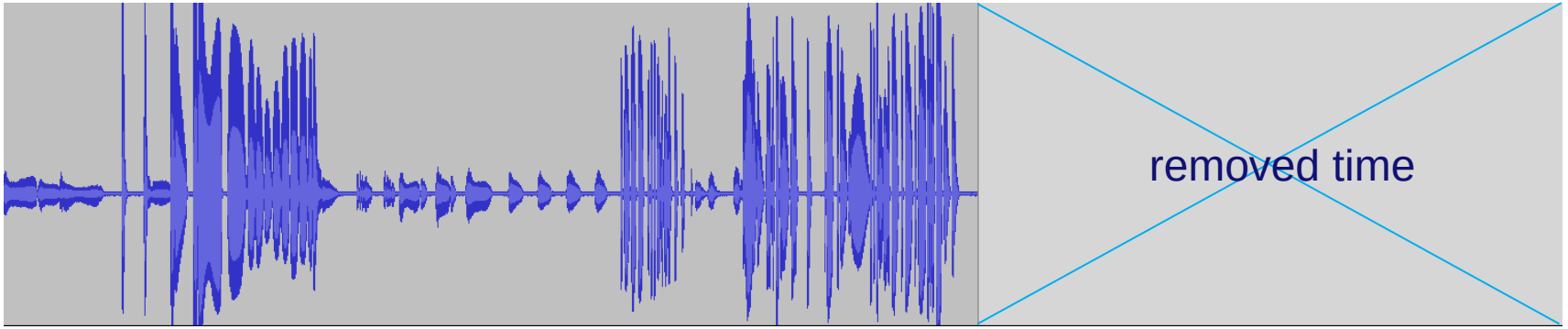
Positive:
Other players louder

Negative:
Own instrument louder

B) Own instrument: home vs orchestra

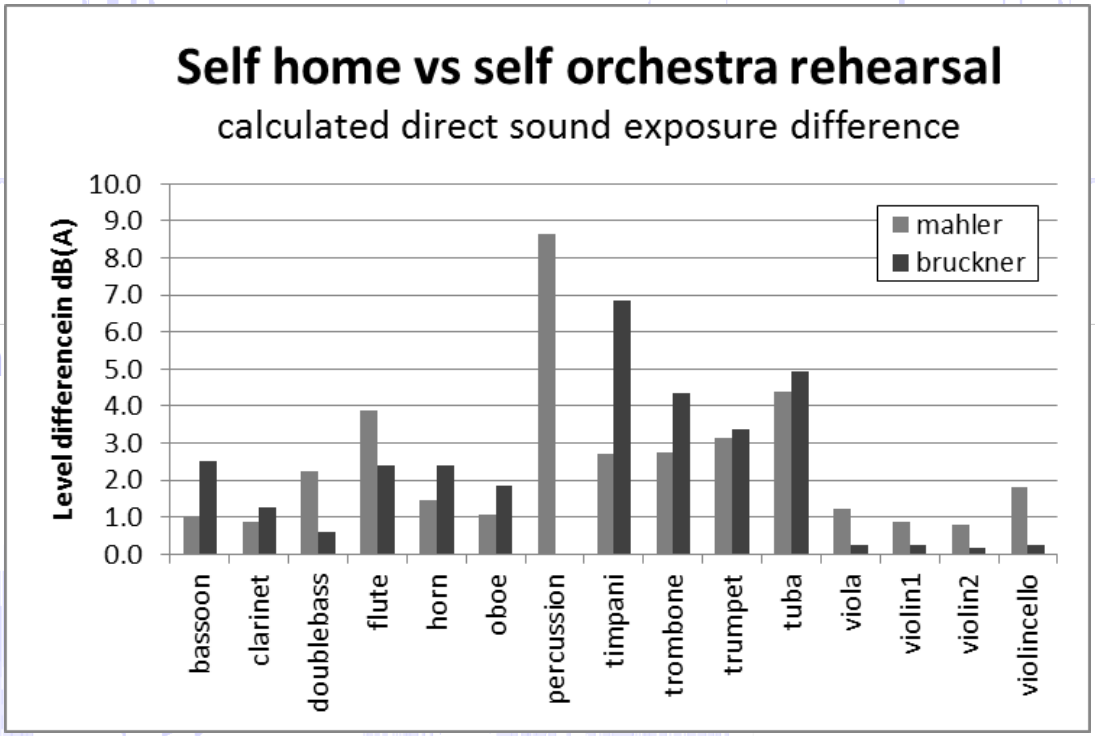


Orchestra rehearsal: pauses in the score



Home rehearsal: skip pauses in the score > 2 sec.

B) Own instrument: home vs orchestra

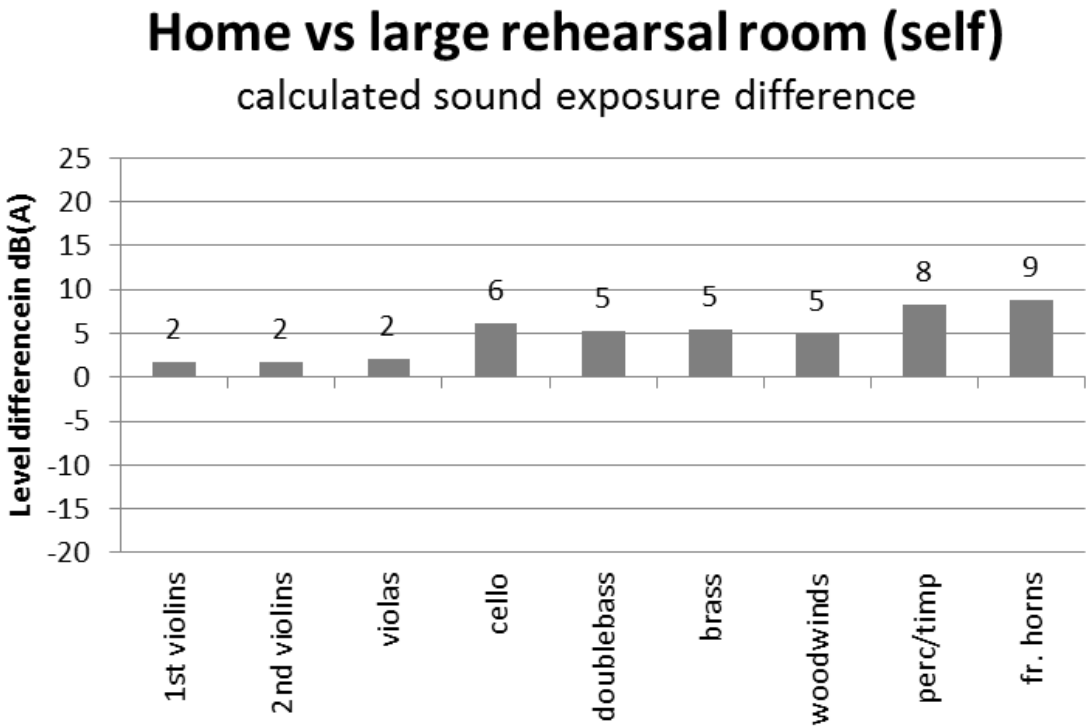


Orchestra reh

Difference in sound level due to skipping pauses

Home rehearsal: skip pauses in the score > 2 sec.

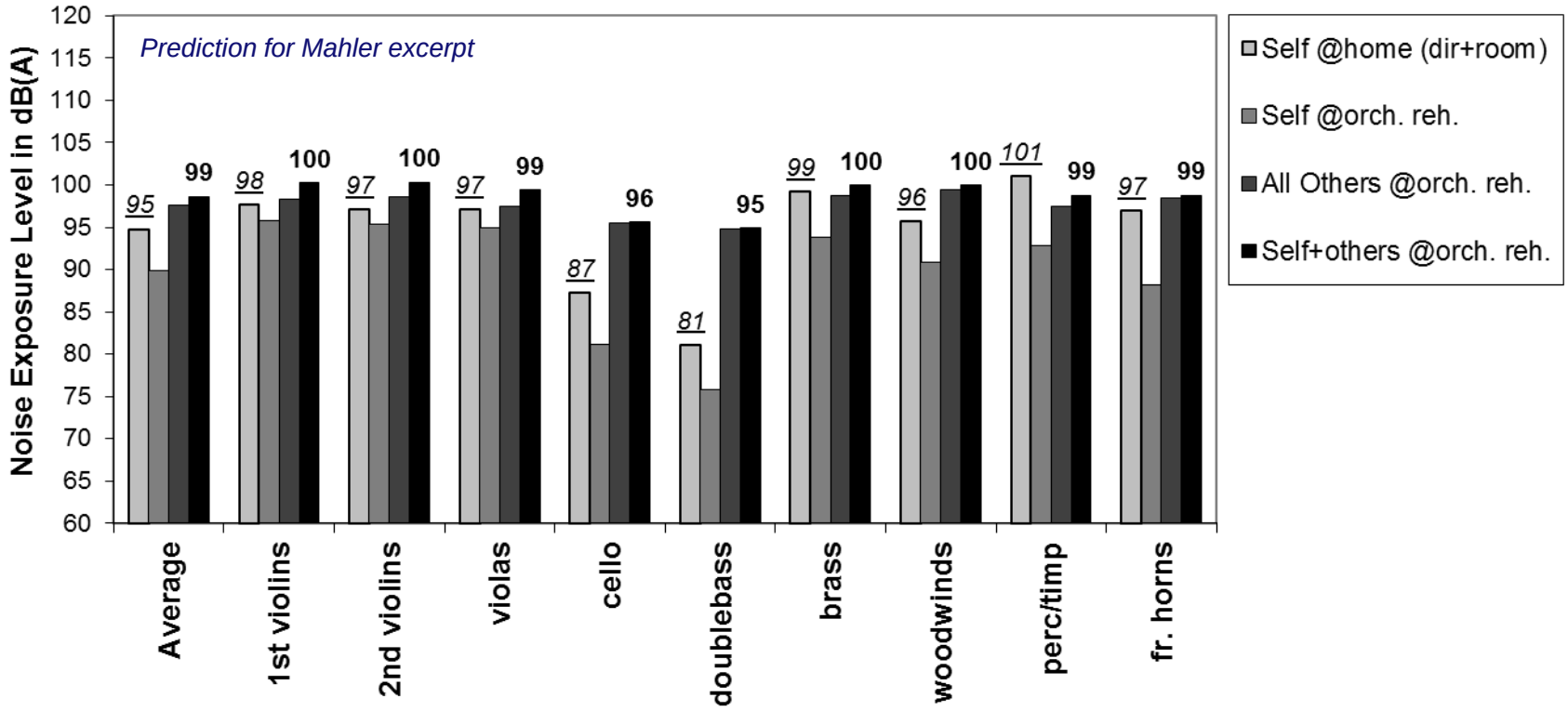
B) Own instrument: home vs orchestra



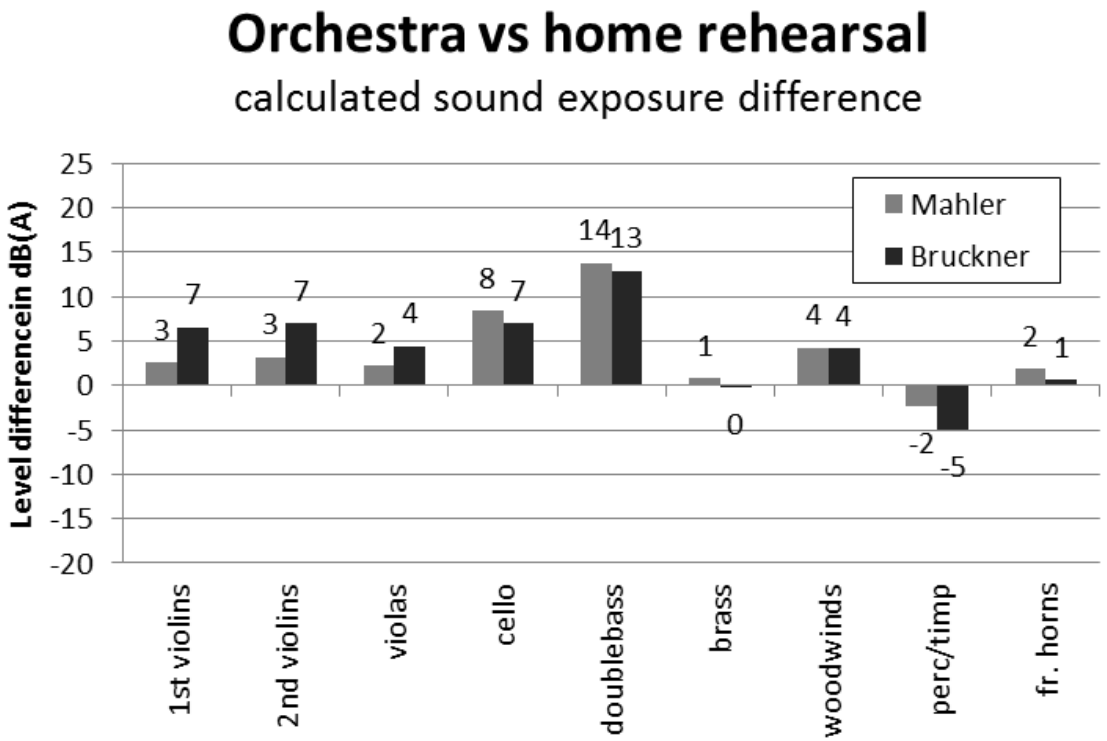
Difference in sound level due to skipping pauses & amplification by the room*

* Estimated using the total sound power and 8 m^2 sound absorption by Sabine's equation Lp = Lw + 10 lg (4/A)

C) Home vs orchestra rehearsal



C) Home vs orchestra rehearsal



Positive:
Orchestra rehearsal louder

Negative:
Home rehearsal louder

Conclusions

For excerpts of Mahler Symphony 1 and Bruckner Symphony 8

A) Own sound versus own section:

High strings: the own instrument is 3 dB(A) louder than the section members
Other groups: the section members are louder or equally loud than the own instrument
Conclusion: unlikely to be able to measure the own sound in the orchestra

B) Own sound, home vs orchestra:

High strings: the own instrument is 2 dB(A) louder at home
Other groups: the own instrument is 5 to 9 dB(A) louder at home
Conclusion: the own instrument is louder when playing at home

C) Total sound, home vs orchestra:

High strings: rehearsing with full orchestra is 2 to 7 dB(A) louder
Low strings: rehearsing with full orchestra is 7 to 14 dB(A) louder
Woodwinds: rehearsing with full orchestra is 4 dB(A) louder
Brass and horns: rehearsing with full orchestra or at home is equally loud
Percussion: rehearsing at home 2 to 7 dB(A) is louder than in the orchestra
Conclusion: for these musical excerpts based on calculated results, the own instruments exposure (at home or in the orchestra) does not dominate over the full orchestra exposure, except for percussion players.

level acoustics

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