

Supplementary material for the paper:

Comparing the auditory distance and externalization of virtual sound sources simulated using non-individualized stimuli

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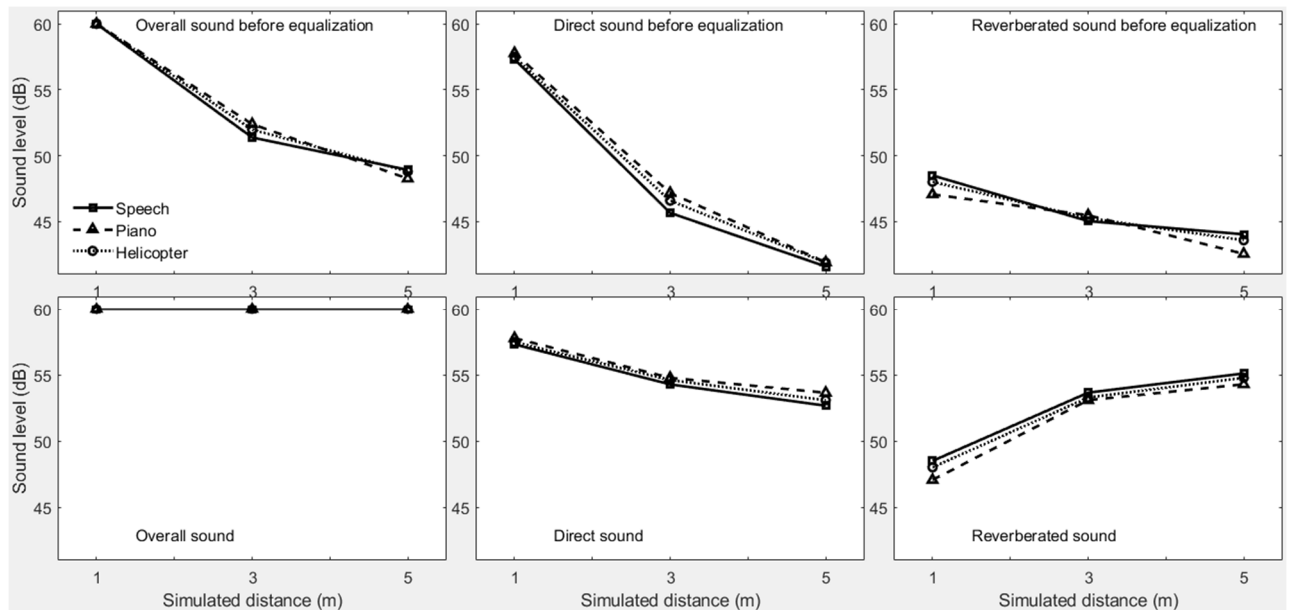
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Condition	IAAC	T60 left (s.)	T60 right (s.)	DRR left (dB)	DRR right (dB)
BRIR1m_0	0.95	1.30	1.36	16.1	15.4
BRIR3m_0	0.94	1.38	1.45	5.6	5.6
BRIR5m_0	0.92	1.38	1.43	3.4	3.7
BRIR1m_30	0.81	1.36	1.34	18.8	12.4
BRIR3m_30	0.69	1.45	1.39	8	3.5
BRIR5m_30	0.70	1.45	1.40	4.7	1.3
BRIR1m_60	0.67	1.17	1.32	6.9	19.5
BRIR3m_60	0.50	1.20	1.33	-0.4	8.7
BRIR5m_60	0.45	1.21	1.36	-3	5.2
Dio_BRIR1m_30	1	1.35	1.35	16.5	16.5
Dio_BRIR3m_30	1	1.44	1.44	7.9	7.9
Dio_BRIR5m_30	1	1.45	1.45	4.1	4.1
Dio_BRIR1m_60	1	1.29	1.29	18	18
Dio_BRIR3m_60	1	1.32	1.32	7.7	7.7
Dio_BRIR5m_60	1	1.36	1.36	3.9	3.9

Supplementary table 1: Room acoustical parameters computed on the BRIRs used for the simulations. IAAC: interaural coherence, T60: reverberation time (in seconds, computed on the left or right ear), DRR: direct-to-reverberant ratio (in dB, computed on the left or right ear).

condition	signal type	speech	piano	helicopter
BRIR1m_0		0	0	0
BRIR3m_0		8.6	7.6	8
BRIR5m_0		11.1	11.7	11.2
BRIR1m_30		0	0	0
BRIR3m_30		9	7.6	8.1
BRIR5m_30		11.2	11.4	11.4
BRIR1m_60		0	0	0
BRIR3m_60		8.2	7.8	7.8
BRIR5m_60		10.7	11.5	11.1

Supplementary table 2: Gains (in dB) applied to the BRIR stimuli to equalize their mean overall sound level across ears

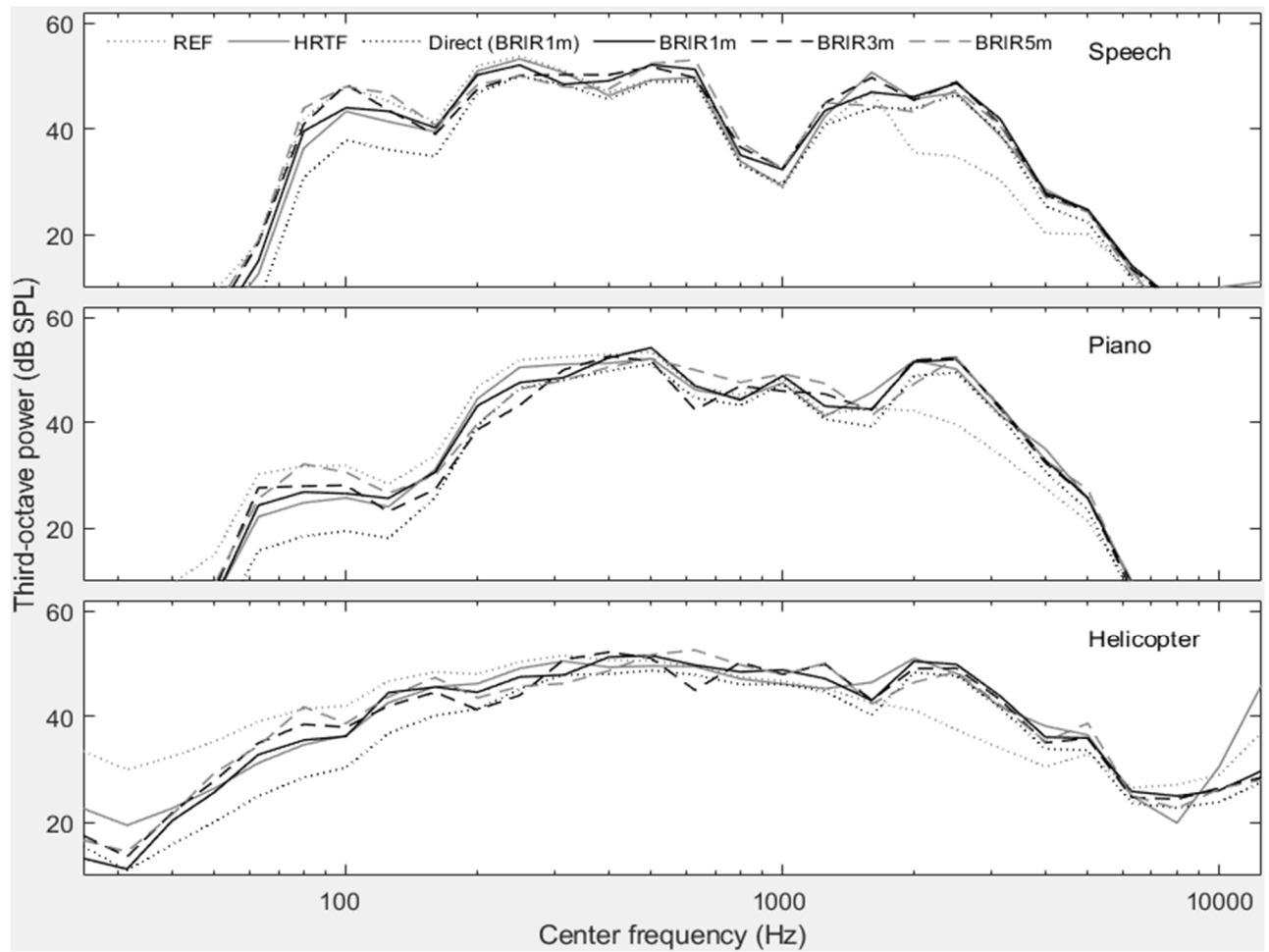


Supplementary figure 1: Broadband sound levels (in dB, mean across ears) of the overall (left panels), direct-only (middle panels) and reverberated-only (right panels) BRIR sounds in the frontal condition plotted as a function of simulated distance, before (top panels) and after (bottom panels) sound level equalization, for each of the three sound types (speech, piano, helicopter). Very similar results were obtained in the lateral conditions.

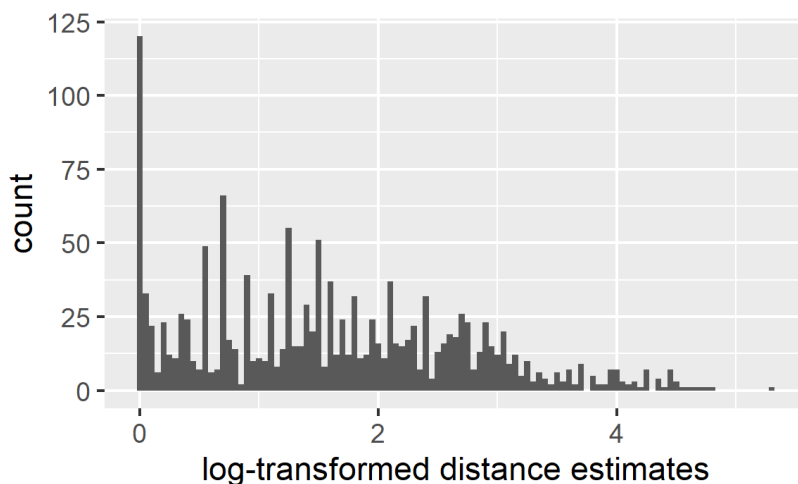
Method used for this analysis: the BRIRs had been measured at a constant level of the direct sound across distances to optimize the signal-to-noise ratio during the measurements. In order to analyze the stimuli without level equalization, (broadband) gains were applied to the overall BRIRs in order to re-introduce the inverse-square-law variation with distance of their direct sound level. The three original sounds calibrated at 60 dB SPL were convolved with the resulting BRIRs. For each simulated direction (0°, -30°, and 60°), a unique gain was applied to these convolved signals so that their level differences induced by simulated distance were preserved and the three sounds at 1 m were at 60 dB SPL.

In addition to the overall stimuli analysis, the levels of the direct-only and reverberated-only sounds were computed. Each BRIR was split into its direct and reverberant components. The three original sounds were convolved with each component separately to create direct-only and reverberated-only versions of the stimuli. Because the computation of power level depends on signal duration, the direct-only and reverberated-only signals were trimmed to the same duration, the one of the corresponding original sounds, before the analysis. The same gain was applied to the direct-only and reverberated-only signals to account for the fact that they were shorter than the overall stimuli, so that the relative level differences across overall, direct-only and reverberated-only signals were preserved in the analyzes. This gain was chosen so that the composition of the direct and reverberated levels equals the overall level.

To get the direct-only and reverberated-only versions of the stimuli after sound level equalization, the direct-only and reverberated-only signals were multiplied by the gains used to equalize the level of the overall stimuli in the experiment (see Supplementary table 2).



Supplementary figure 2: Third-octave spectra of the stimuli in the frontal condition, after sound level equalization, for the left ear and the three types of sound (speech, piano, helicopter). Very similar results were obtained at the right ear, and also in the lateral conditions. The direct-only version of the 1-m BRIR sounds is considered for comparison to the HRTF sounds, to highlight the influence of the different manikins and loudspeakers used in the BRIR vs. HRTF measurements. The method used to obtain the direct-only version of the stimuli is described in the caption of Supplementary figure 1.



Supplementary figure 3: Histogram of the log-transformed distance ratings (by 0.05 steps)

Extern./Binary Dist.	1/1	0/0	0.5/0.5	1/0	0/1	1/0.5	0/0.5	0.5/1	0.5/0
Processing condition									
REF	13	24.1	0	0	25.9	0	16.7	20.4	0
HRTF_0	11.1	22.2	1.9	0	38.9	0	11.1	13	1.9
HRTF_30	40.7	9.3	0	0	25.9	0	3.7	20.4	0
HRTF_60	51.9	7.4	1.9	0	18.5	5.6	1.9	13	0
BRIR1m_0	20.4	14.8	1.9	1.9	22.2	0	9.3	29.6	0
BRIR3m_0	14.8	11.1	1.9	0	16.7	1.9	9.3	44.4	0
BRIR5m_0	33.3	7.4	3.7	0	29.6	0	7.4	18.5	0
BRIR1m_30	63	3.7	1.9	1.9	7.4	0	1.9	20.4	0
BRIR3m_30	70.4	0	0	0	7.4	1.9	1.9	18.5	0
BRIR5m_30	72.2	0	0	0	14.8	0	1.9	11.1	0
BRIR1m_60	66.7	1.9	1.9	0	7.4	0	0	20.4	1.9
BRIR3m_60	75.9	0	1.9	0	7.4	3.7	0	11.1	0
BRIR5m_60	79.6	1.9	0	0	5.6	0	0	13	0
Dio_BRIR1m_30	16.7	22.2	1.9	0	25.9	0	9.3	24.1	0
Dio_BRIR3m_30	24.1	14.8	0	0	37	0	9.3	13	1.9
Dio_BRIR5m_30	16.7	14.8	0	0	25.9	1.9	9.3	27.8	3.7
Dio_BRIR1m_60	14.8	16.7	0	0	35.2	0	14.8	16.7	1.9
Dio_BRIR3m_60	25.9	13	1.9	3.7	33.3	0	7.4	14.8	0
Dio_BRIR5m_60	20.4	14.8	1.9	0	33.3	0	5.6	22.2	1.9
ITDILD_BRIR1m_30	44.4	7.4	0	0	16.7	0	11.1	20.4	0
ITDILD_BRIR3m_30	57.4	7.4	0	0	20.4	1.9	5.6	7.4	0
ITDILD_BRIR5m_30	59.3	5.6	0	0	14.8	0	11.1	9.3	0
ITDILD_BRIR1m_60	35.2	11.1	0	0	27.8	1.9	7.4	14.8	1.8
ITDILD_BRIR3m_60	42.6	7.4	1.9	0	22.2	0	11.1	14.8	0
ITDILD_BRIR5m_60	37	5.6	1.9	0	18.5	0	11.1	24.1	1.9
ITDILD_HRTF30	48.1	11.1	0	0	18.5	1.9	5.6	13	1.9
ITDILD_HRTF60	31.5	14.8	0	1.9	29.6	3.7	9.3	5.6	3.7
Accros all conditions	40.3	10	1	0.4	21.7	0.9	7.1	17.8	0.8

Supplementary table 3: Comparison of the externalization and binary distance ratings (averaged across repetitions) represented as a percentage of the data for which the externalization and binary distance ratings are 0 (in), 0.5, and 1 (out). Distance ratings were transformed into binary responses using a distance threshold set at 10 cm: ratings of less than 10 cm counted as 0, ratings above 10 cm as 1.

Extern./Binary Dist.	1/1	0/0	0.5/0.5	1/0	0/1	1/0.5	0/0.5	0.5/1	0.5/0
Distance threshold for binary distance (in cm)									
1	40.8	6.7	0.9	0.3	24.2	0.4	8	18	0.8
20	39.7	11.3	1.2	0.5	20.8	1.3	6.8	17.6	0.8

Supplementary table 4: Comparison of the externalization and binary distance ratings (averaged across repetitions) represented as a percentage of the data for which the externalization and binary distance ratings are 0 (in), 0.5, and 1 (out), summarized across all processing conditions. Here, distance ratings were transformed into binary responses using distance thresholds set at 1 or 20 cm.