Influence of the manipulation of interaural cross-correlation on room acoustical perception

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Abstract

In a psychoacoustical experiment the spatial impression of different rooms has been evaluated for original and manipulated Binaural Room Impulse Responses (BRIRs) where the Interaural Cross-Correlation (ICC) has been increased. Different parts of the impulse responses were manipulated and the BRIRs have been convolved with anechoic music signals to obtain the stimuli for the experiment.
Subjects had to rate the spatial impression of these manipulated signals with focus on the perceptual attributes "Listener envelopment" (LEV), "Apparent source width" (ASW) and the "Presence" (PRE) of a sound source. The results of these ratings are shown as a function of the strength of the manipulations.
The dependencies of these perceptual attributes will be discussed. It appears that LEV is strongly influenced by changing the ICC, but only when it is changed throughout the full BRIR. The effect on ASW is much smaller.

Introduction

The acoustical quality of a room can be assessed with physically measureable room acoustical parameters. These parameters may vary strongly on very short distances even smaller than the size of a head (de Vries et al. 2001, [2]), but the perception of sounds in a room is hardly affected by those short distance variations. The quality of the acoustics of a room can also be assessed by perceptual attributes, which describe the perception of sounds in a room. Binaural room impulse responses

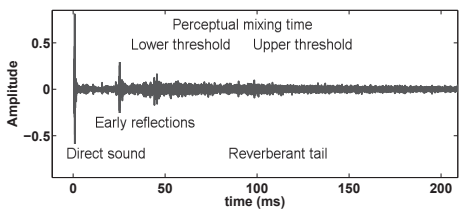

Figure 1: First 200 ms of a binaural room impulse response. The frontal part with direct sound and early reflections contains directional information. The reverberant tail still contains spatial but no directional information (Klockgether and van de Par 2012, [4]).

(see fig.1) represent the acoustical information of a room and can be used to study perception of sounds in a room. The apparent source width is usualy linked to the early reflections in the first part of the impulse response (Hidaka et al. 1995, [3]), whereas the perceived envelopment is linked to the diffuse tail (Beranek 2008, [1]). The range of changeover between both parts of the impulse response is the perceptual mixing time (Lindau et. al. 2012, [5]).

Method

In a psychoacoustic experiment, different parts of BRIRs were directly manipulated. The left panel of figure 2 shows, that either the first part, the reverberant tail, or the complete impulse response is manipulated. The manipulation of the BRIRs was realised by cross-mixing the left (L) and right (R) ear channel with the following equations:

$$L' = \sum_f (L_f + \alpha R_f) \cdot \frac{\mathrm{RMS}(L_f)}{\mathrm{RMS}(L_f + \alpha R_f)} \ ,$$

$$R' = \sum_f (R_f + \alpha L_f) \cdot \frac{\mathrm{RMS}(R_f)}{\mathrm{RMS}(R_f + \alpha L_f)} \ .$$

The manipulated left and right channel L' and R' are the sum of the original channels, whereas the mixing parameter α sets the percentage of the respectively corresponding channel. The manipulation is done separately in ERB-sized frequency bands (f) and a normalisation is included to avoid coloration. The right panel of figure 2 shows the resulting interaural cross-correlation of an exemplary stimulus used in the experiment as function of the mixing parameter α. For the stimuli used in the experiment the manipulated binaural room impulse responses were convolved with excerpts of music plays of a violin, guitar or snare drum. All stimuli were presented over headphones with a level of 65 dB SPL. Subjects had to rate the stimuli with a slider due to the perceived envelopment by the sound within the extrema "not at all" and "completely", the perceived source width within the extrema "wide" and "small", and the presence of the source within the extrema "weak" and "dominant". Twelve normal-hearing subjects participated in the experiment and repeated it three times.

Results

Figure 3 shows the results of the subjective ratings for the perceptual attributes listener envelopment (LEV), apparent source width (ASW) and presense (PRE) for the excerpts of the different instruments. The ratings for all three perceptual attributes decrease with increasing interaural cross-correlation. Manipulating the cross-correlation on the full length of the BRIR has by far the

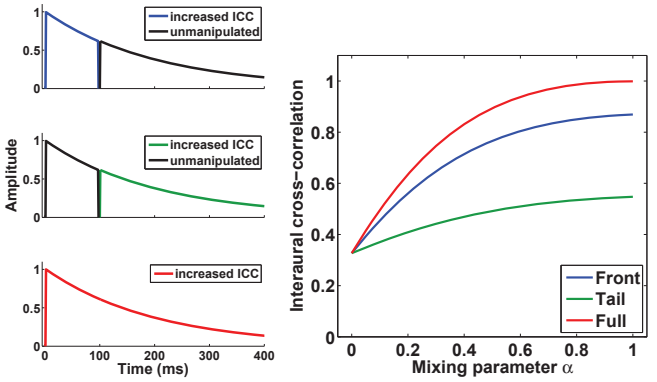

Figure 2: Schematic of the three conditions of manipulated binaural room impulse responses. In the coloured parts, the cross-correlation between left and rigth ear channel was increased. The changeover between frontal part and reverberant tail was chosen at the upper threshold of the perceptual mixing time (left panel) ((Lindau et. al. 2012, [5]). Interaural cross-correlation of exemplary violin stimuli from the experiment as function of the mixing parameter α. The correlation of either the first part, the reverberant tail or the complete binaural room impulse response was manipulated (right panel).

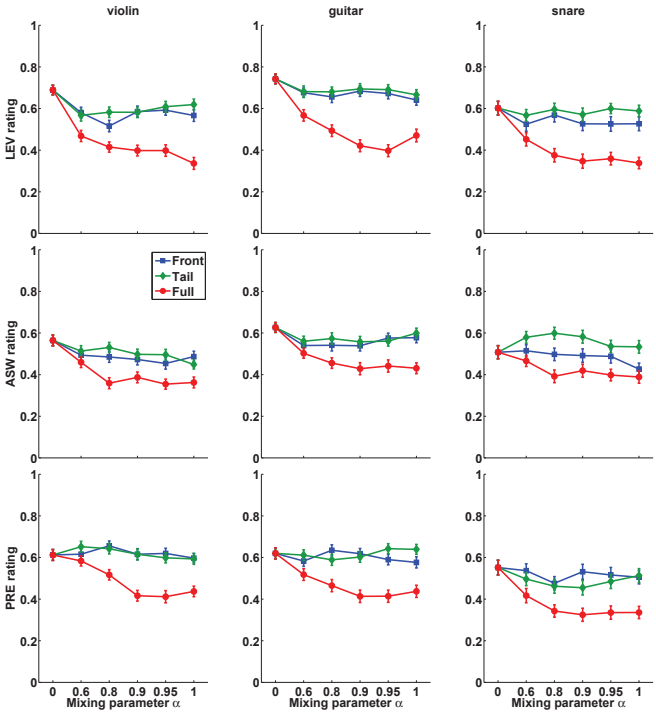

Figure 3: Subjective ratings for perceptual attributes "Listener Envelopment" (LEV), "Apparent Source Width" (ASW) and "Presence" (PRE) as function of the mixing parameter α for three different instruments. Either the interaural cross-correlation of the first part of the impulse response, the reverberant tail or the complete impulse response was increased. Data show mean values of twelve subjects and impulse responses of two different rooms with standard error.

strongest effect on the ratings. There are small differences for the three instruments. The snare drum data show generally little lower ratings for all three attributes and the guitar little higher ratings but all instruments show about the same trends. Even though there is just a small difference in the overall cross-correlation level for the front and the full manipulated stimuli (see fig. 2, left panel), the ratings for both stimuli differ strongly. The LEV-rating is equally strong affected by the tail as well as by the front manipulation. The ASW-rating also decreases a little with increasing cross-correlation of only the reverberant tail of the BRIR.

Discussion

The ratings of the psychoacoustic experiment show, that perceived listener envelopment is not only depending on the reverberant tail of an impulse response. They also show that subjects still feel some kind of envelopment by a sound source even when the correlation of both channels of the BRIR is close to one. The perceived source width seems also be affected by the reverberant tail of the impulse response. The perception of the highly correlated front of the impulse response might be masked by the uncorrelated reverberant tail. The data shows that subjects are highly sensitive to small correlation differences at high correlation levels but very insensitive to changes at low correlation levels which can be seen by the big difference in the ratings between the front and full manipulation of the BRIR.

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