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PSYCHOPHYSICS & MUSIC PERCEPTION

Abnormally salient sounds for hearing-impaired listeners wearing hearing aids: Is it due to excessive loudness or distorted timbral characteristics?

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Introduction

In a complex auditory scene, when the acoustic characteristics of a sound differ significantly from the others, making it perceptually distinct, the sound is considered salient, meaning it will capture our attention. It has been often reported that some sounds become excessively salient when hearing impaired wear their hearing aids (HA). This study aims at understanding the influence of salience on the perception of a complex auditory scene by hearing-impaired individuals equipped with hearing aids (HIHA). Therefore, we are investigating acoustic characteristics that, when modified, will create a greater perceptual difference in HIHA compared to those with normal hearing (NH). We focus here on timbre characteristics and their influence on loudness because those are the main features modified by the HA. This poster presents the results from two pilot experiments that aim to address two alternative hypotheses. (i) Is loudness perception influenced by timbral characteristics in a different way between the HIHA and the NH ? (ii) Are some timbral characteristics distorted in the HIHA perception such as a small difference creates a large perceptual increase?

Stimuli

The stimuli co-varies on 4 perceptual timbral dimensions : brightness, roughness, attack and spectral variation (dimensions commonly found in perceptual timbre studies). The stimuli are synthetic in order to sample the dimensions regularly and independently. Exp (i) : 14 sounds were created, only 6 were rough, and 2 had varying spectral. Exp (ii) : 20 sounds were created homogeneously distributed in the timbral physical space.

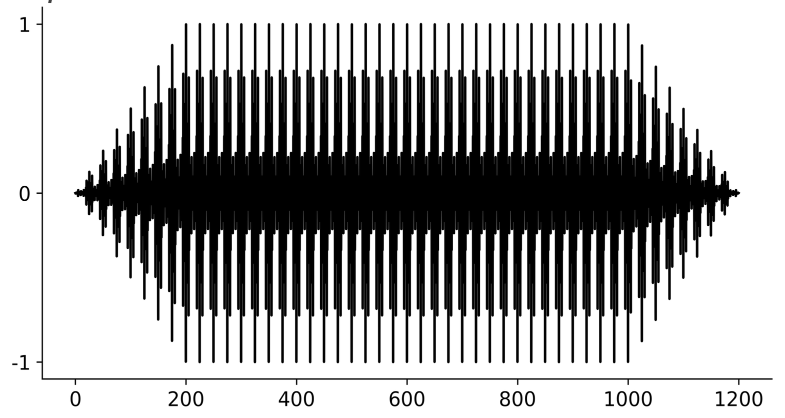


Fig1 : Wavform of one stimuli

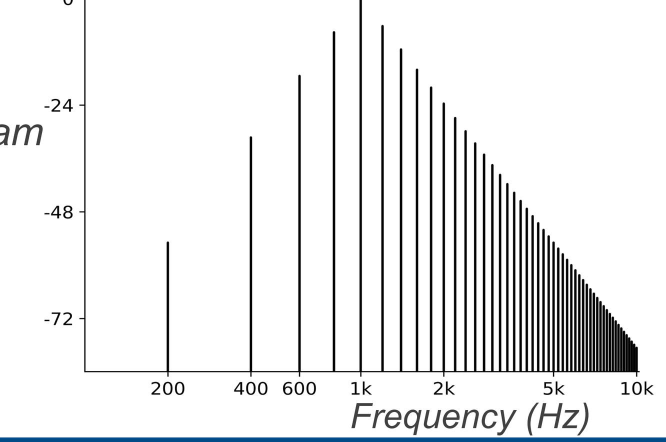


Fig2 : Spectrogram of one stimuli

Technical insides of the stimuli :

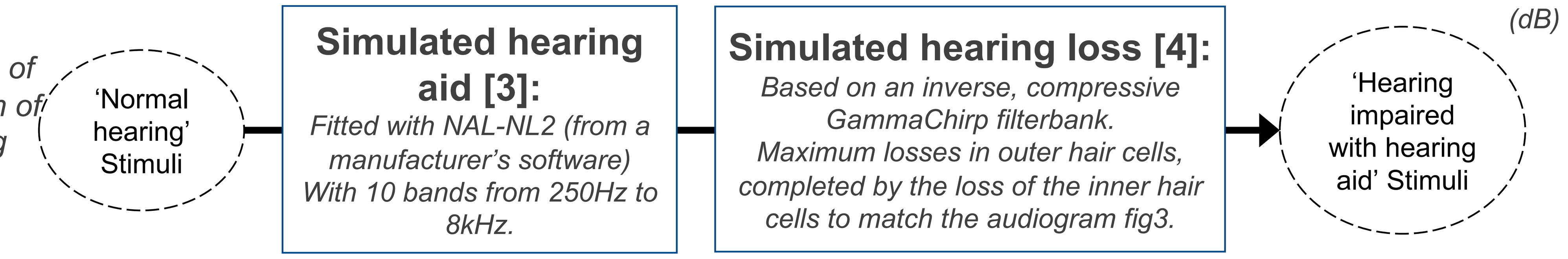
- Harmonic sounds (F0 = 200 Hz). Filter slope = -24 and -18 dB/ octave in respectively exp (i) and (ii). [1]
- Brightness varies with the position of the center frequency of the filter (cf). Exp (i) : 6 values of cf are fixed from 700 to 2600 Hz with a 30% difference step (well perceived differences). Exp (ii) : the 20 values of cf are fixed from 600 to 1815 Hz with a 6% step (larger than 1 JND [1]).
- The sound is made rough by modulating it with a depth m and a roughness frequency rf. Exp (i) : m = {0,0.5,1} and rf = {25,50,75} Hz. Exp (ii) : rf = 45 Hz and the 20 values of m are evenly distributed between 0 and 1. rf values are chosen in the range of roughness perception by HI.
- Attack time is log-spaced between 20 and 300ms as a half sine function with 3 values for exp (i) and 20 for exp (ii). This value were chosen as typical attack times [2]
- The spectrogram varied temporally in two ways. In exp (i), during the first 100ms, the cf went 560 hz up, as to model the following appearance of the higher harmonics [2]. In exp (ii), the slope of the upper part of the filter closed over time (from -N to -18 dB/octave) as to model the stronger attenuation of the higher harmonics. N varied in equal step for the 20 sounds between 8 and 18.

Participants

Exp (i), 5 young normal-hearing (NH) participants did the experiment with the 'normal hearing' stimuli. 5 other NH did exp (i) with a 'hearing impaired with hearing aid' version of the stimuli (graph 1). They are the hearing impaired (HI) group.

Exp (ii), only the 'normal hearing' version of the experiment was done with 5 NH.

Graph1 : Description of the creation of the 'hearing impaired' Stimuli



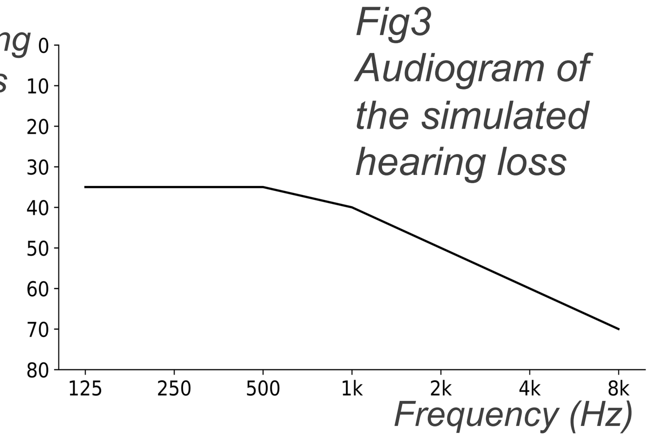


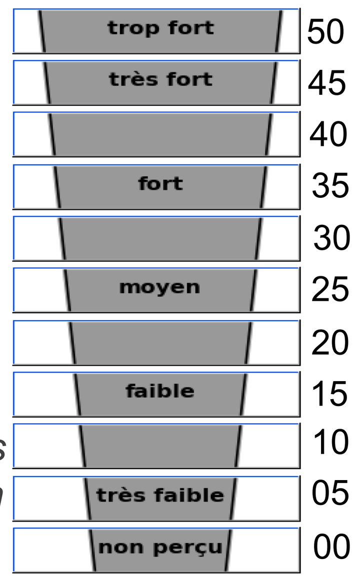
Fig3 Audiogram of the simulated hearing loss

Methods

Experiment (i) was a CLS experiment using the ACALOS procedure [5,6]. The participants were presented with a fixed stimuli at different levels and rated the loudness using the scale 'non perceived" to "too loud" (fig4). They scaled the loudness of the 14 sounds successively. To access the variability of participant's answers, the CLS of a 1 kHz pure tone was repeated twice

Experiment (ii) was a dissimilarity judgment experiment. The 20 stimuli were equalised in loudness at 65 dB in a previous experiment. Participant listen to all the 190 paired combinations of the 20 stimuli and had to judge the dissimilarity within each pair, using a slider going from 'very similar' to 'very different'.

Fig4 : The 11 categories in French of the Categorical Loudness Scaling (CLS). The categories are then transformed in Categorical Units (CU) – written on the right.



Results

Fig5 shows the test and retest data of the CLS procedure for the 1kHz sound. Those data where then fitted by a piecewise linear function [6]. The fig6 compares the lower and the upper slope of the fitted function between the mean of the same complex sounds in a not rough and a rough version.

Fig7 gives the results of the dissimilarity judgment analysed with the CONSCAL method [2,7]. For each timbre dimension we get a spline function connecting the physical dimension to the perceptual one.

Fig5 : Results for NH and HI of the test-retest on the 1kHz sound.

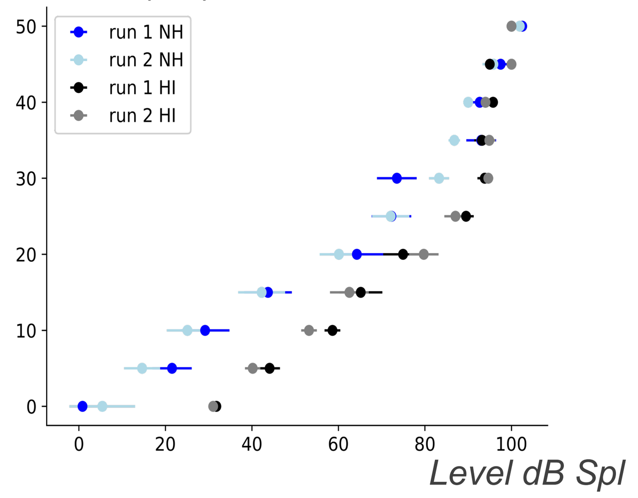
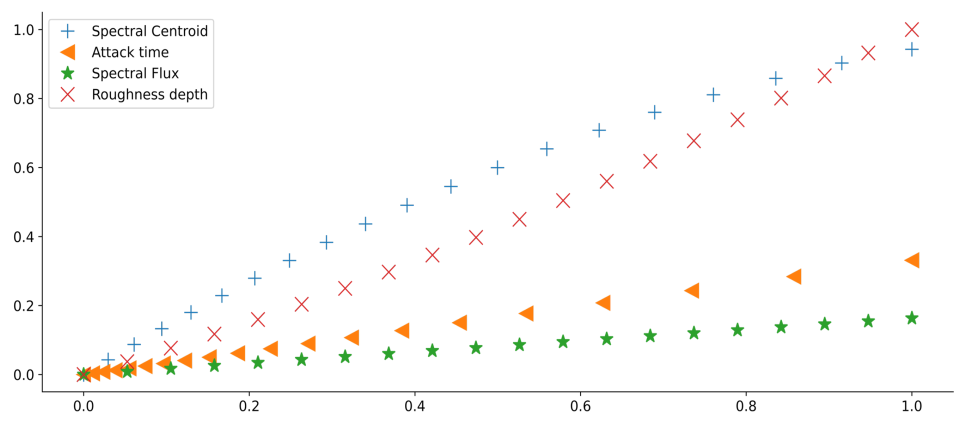


Fig7 : Results for NH of the perceptual timbral dimension in function of the physical one.



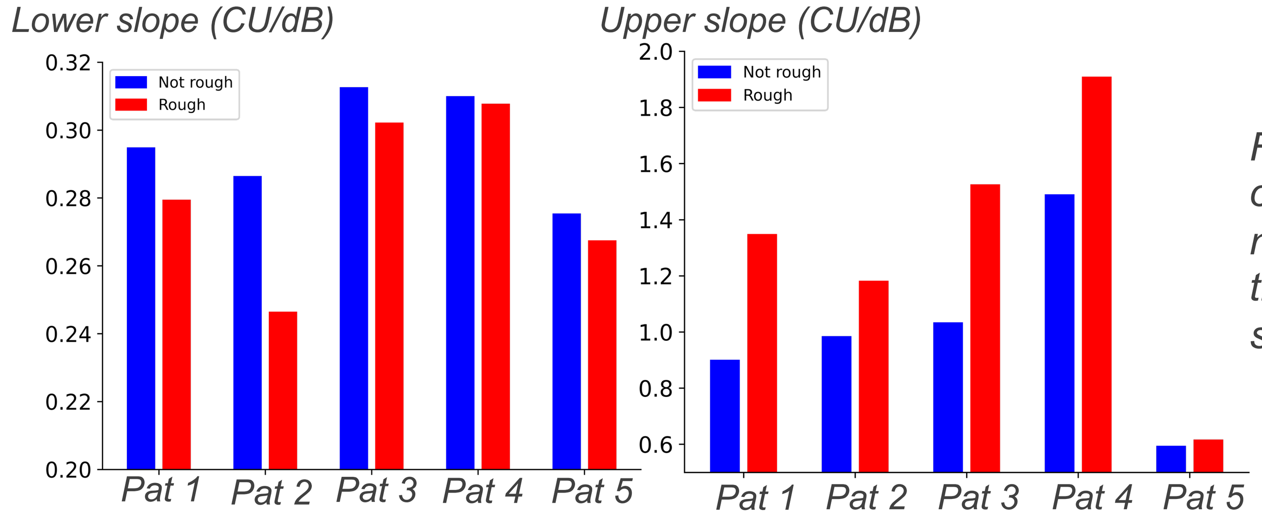


Fig6 : Mean results on the rough and not rough sounds for the lower and upper slope.

Discussion

As this is a pilot study and due to the small number of participants, no statistical test and conclusion can de done by now, but it gives us numbers of clues for the next steps :

- Roughness seems to have a global impact on perceived loudness as most participants showed the same pattern in the results. At high sound level, the perceived loudness seems to increase more rapidly for a rough sound in comparison to a not rough sound. At low sound level, the effect seems to be the opposite.
- Brightness seemed to have as well an impact for high sound level : the higher the cf, the steeper the curve. Spectral flux and attack time seemed to have no impact.
- Exp (ii) gave us insights on the psychophysics curves of the timbre dimension. Brightness and roughness dominated clearly on attack time and spectral flux. It will be interesting to see the curves of the HIHA group.

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