The Effects of Environmental Noise Exposure on the Perception of Temporal Fine-Structure

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Introduction

This work aims at investigating the effects of environmental noise exposure on fine structure perception. Current research [1] delivered psychophysical evidence suggesting that difficulties in perceiving a signal's fine-structure may occur without the auditory threshold necessarily being affected. We were interested in finding out if this phenomenon has relevance within a day-to-day context and thus looked at if and how environmental noise exposure affects both, the auditory threshold and speech intelligibility as a measure of fine-structure perception.

Methodology

For this purpose, we followed 11 normal hearing, younger participants on their daily commute to work. All participants had normal hearing acuity and were proficient in english. They participated in two listening tests, both before and after their commute. All tests were conducted via headphones.

Audiometric Test

The first test was a classical audiometric test, a 3-down/1-up staircase procedure, with single sinusoids as stimuli. The test was shortened to cover only frequencies from 100 to 4500 Hz, in 400 Hz intervals. The sinusoids were presented at random time intervals within a time window of 3 seconds and the subjects indicated by pressing a button if they perceived them. Starting from an initial intensity of 80 dB SPL, for each of these frequencies, the amplitudes of the sinusoid were iteratively reduced or increased, by 3 dB. When the subjects heard the sinusoid three times in a row, their intensity was decreased, when they missed a sinusoid once, its intensity was increased for 30 iterations. The principle is further illustrated in figure 1. In accordance with the recommendations in [2], for each frequency, the last obtained value was taken to indicate the actual hearing threshold.

Words in Noise Test

Fine-structure perception was measured as a correlate of speech intelligibility. Two lists, each comprising 35 words, were randomly assigned from a pool of 70 words for each subject. The words were selected according to the recommendations in [3] and [4]. They were presented to the subjects in the same 3-down/1-up threshold scenario as described above, mimicking the Words in Noise (WIN) test proposed in [5]. For each iteration, the subjects were asked to enter the word they perceived via a keyboard.

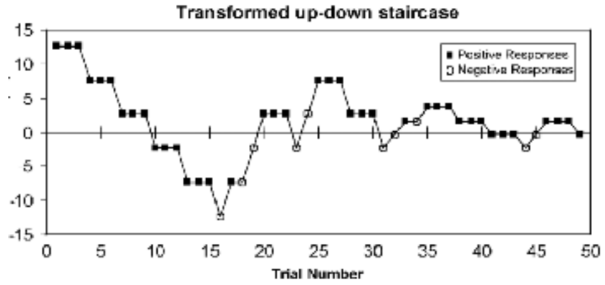

Figure 1: Example of a 3-down/1-up staircase function, from [2].

The background noise was recorded in the George Moore refectory at Glasgow Caledonian University and comprised largely speech. It was compressed to compensate for intensity fluctuations and presented simultaneously to the target words at a level of 80 dB SPL.

Audio Analysis

In order to get a better picture on the sounds the participants were exposed to, the environmental noise on their daily commute was recorded by binaural headphones. Additionally, the intensity of the environmental noise the participants experienced was manually tracked.

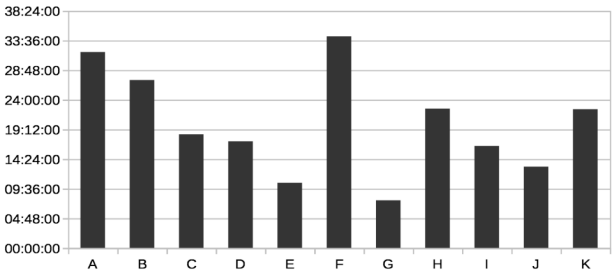

Figure 2: The duration of the commutes in minutes per participant [A-K].

As depicted in figure 2, the duration of the daily commute varied from about eight minutes to 34 and equally, the intensity the participants were exposed to exhibited considerable variations, from 60 dB SPL up to 140. It is likely due to that variability that the sound file analysis did not reveal any significant relations between the decrease in fine structure perception most

participants experienced (which will be discussed in the next section) and properties such as roughness, brightness and sharpness.

Results

The first audiometric test that was conducted before the commute confirmed that all participants indeed had normal hearing. Many participants could slightly improve their results in the second test. Apparently, the habituation effect arising from taking the same test for a second time outweighed many degrading effects on the auditory threshold that may have been caused by the environmental noise exposure.

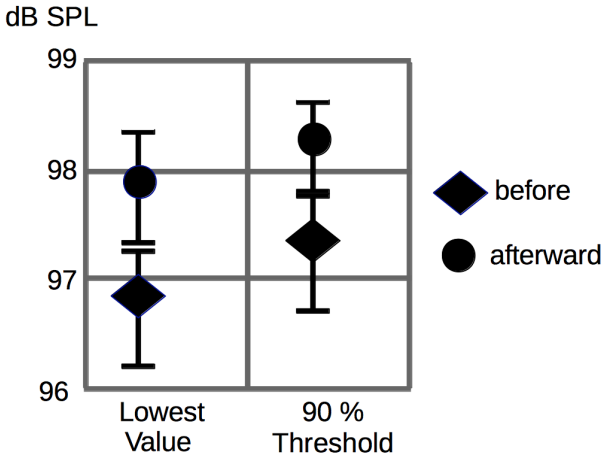

Figure 3: Speech Intelligibility before and after the commute, averaged over all participants.

The same was not true for the speech intelligibility test. Here, with one exception, the performance of all participants decreased by between one and three dB after their commute to work. In figure 3, the 90 % threshold indicating the level beyond which 90 % of all words were correctly understood is contrasted with the minimum level the participants reached during the WIN-test, averaged over all participants.

While these values seem small, Plomp and Duquesnoy found a 4 dB loss in a similar test to affect everyday performance more severely than a 21 dB loss of speech in quiet [6]. Also, these differences were in most cases larger than those between the smallest intensity levels the participants reached within either test and the final threshold value that was assumed to correspond most closely to their actual fine-structure perception threshold.

Conclusion

We have measured hearing acuity by means of an auditory threshold test and a words in noise test, both before and after subjects were exposed to environmental noise on their daily commute. The results suggest that urban noise is likely to cause a decrease in fine-structure perception. Moreover, this decrease appears to occur independently from the values obtained for the auditory threshold.

Both the number of participants and the differences of the outcomes are too small to allow for establishing statistical significance. Yet, the measured decrease in fine-structure intelligibility was consistent for nearly all participants and occurred despite a simultaneous performance increase in the auditory threshold test. Both aspects in combination suggest that temporary hearing loss not only concerns fine-structure perception, but that it is also likely to do so in ways that can not be sufficiently captured by classical audiometric measures.

References

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