Technical University of Denmark

Popular science summary of the PhD thesis

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Title of the PhD thesis	Assessing the effects of hearing-aid dynamic-range compression on auditory signal processing and perception
PhD school/Department	DTU Elektro

Science summary

Hearing loss is often linked to loss of the active biological mechanism of the inner ear. This, primarily, leads to a decreased sensitivity to soft, low-intensity sounds. However, there are other important consequences of this loss. For instance, most hearing-impaired listeners experience *loudness recruitment*. The rate at which loudness increases when a sound level is increased is much higher in hearing-impaired than in normal-hearing listeners. This means that the range of intensities that an impaired listener can perceive is reduced. As a result, hearing aids need to reduce their gain at high levels to avoid sounding too loud and becoming uncomfortable.
The impairment of the inner-ear active mechanisms may also lead to spectral and temporal (related to frequency and time) processing deficits such that, an impaired ear has a decreased ability to resolve sounds that are close to each other in frequency and in time.

Compensating for impaired sensitivity is the main function of hearing aids. Additionally, to reduce recruitment, most modern hearing aids apply a varying degree of amplification (*gain*), depending on the intensity of the input sounds. Low-intensity sounds receive more gain than the ones with higher intensity, effectively “squeezing” the dynamic range of everyday sounds to better match the limited range of intensities perceived by the impaired listener. This processing is known as dynamic-range compression (DRC). DRC can be classified as either *fast-acting* or *slow-acting*, depending on how quickly it reacts to the changes in the sound intensity.

It has been hypothesized that fast-acting DRC processing can mimic, to a certain extent, the active mechanisms of a healthy ear and restore normal *spectral* and *temporal* resolution of the hearing system. This was tested in the first part of the thesis, using simple experiments with normal-hearing and hearing-impaired listeners, as well as simulations with a computer model of the hearing system. It was found that hearing-aid amplification can partly improve the hearing-impaired listeners performance in tasks related to spectro-temporal resolution.

In the second part of the thesis, the consequences of fast- and slow-acting DRC for the recognition of consonants in noise were investigated. It was found that fast-acting DRC provides more gain to the consonant stimulus, leading to an improved understanding of speech. Even though it has been previously hypothesized that fast-acting compression can distort the speech signal, no evidence of that was found in the current study.

However, in certain scenarios fast-acting DRC can introduce artificial interactions between speech and the background noise. In the last part of the thesis, a novel DRC strategy was proposed, that adaptively changes the compression speed based on the detected speech presence. The new strategy was compared to conventional fast- and slow-acting DRC. It provided an equally effective range compression, while avoiding unwanted interactions between the target and the background.

Overall, the results of the studies presented in this PhD thesis provide insights into how hearing-aid amplification affects processing of the acoustic stimuli in the impaired auditory system and how it changes the cues important for speech recognition in noise. Inspired by those outcomes, a novel DRC strategy has been proposed, whose effects on the perception of speech will be studied in the future.