Neurophysiological insights into hearing aid amplification schemes

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Abstract
Phonocentric compression schemes for hearing aids have been developed based on psychoacoustic principles such as speech intelligibility, sound contrast, and loudness enhancement. Guiding compression parameters that optimize all of these perceptual metrics has proved difficult. The goal of this study was to find optimal single-band gain adjustments around the hearing aid prescription to maximize speech intelligibility and speech audibility in the impaired auditory pathway. This was achieved by exciting the impaired auditory nerve, via the model, with speech stimuli and analyzing the neural responses. The optimal gain adjustment was found to depend on whether the error metric included spike timing information or the mean rate information. These results motivate: a) studies to further understand why the spike timing and average rate information are optimized at different levels of gain, and b) development of optimal gain adjustment strategies that minimize the mean absolute error between the normal and impaired auditory nerve neural responses as a function of the input sound pressure level. The results indicate that the NAL-R and DSL amplification schemes tend to find more comfortable gain settings than the NAL-R, where a comfortable gain is increased by 0.5 dB [3]. “Half-gain” rule. That is, for every 1 dB increase in hearing threshold, the most comfortable gain is increased by 1 dB [3].

1. INTRODUCTION

The goal of a hearing aid is to maximize speech intelligibility and reduce the effort needed to understand speech in the impaired auditory pathway. This is usually accomplished by adjusting the gain and frequency response of the hearing aid to increase the audibility of speech above the threshold of loudness. Funded by NSERC Discovery Grant 261736 & the Barber-Gennum Institute for Hearing Research, M. S. A. Zilany and I. C. Bruce

2. METHODS

A. Models

The auditory-periphery model used in this study was the auditory nerve model developed by Zilany and Bruce [3]. The model describes the auditory pathway from the middle ear through to the auditory nerve. The model was modified after a loudness transfer function described by West and Ross [2].

B. Stimuli

Speech recordings were taken from the TIMIT corpus of phonetically-balanced sentences [4]. The corpus consists of 10 phonetically-balanced and 5 phonetically diverse classic sentences spoken in English. The sentences were presented to the model at a sound pressure level of 60 dB SPL before being presented to the model.

C. Gain optimization strategy

Optimal single-band gain adjustments around the hearing aid prescription were determined using the gain adjustment strategy shown in Fig 4a. The gain adjustment strategy compares neural responses to speech sentences on a phoneme-by-phoneme basis to the misspecified normal model. In order to avoid the conflicting and competing effects of compression attack and release times, a constant gain adjustment was applied to the duration of each phone, using the lowest phone boundary from the TIMIT transcriptions.

D. RESULTS

The results indicate that the NAL-R and DSL amplification schemes tend to find more comfortable gain settings than the NAL-R, where a comfortable gain is increased by 0.5 dB [3]. “Half-gain” rule. That is, for every 1 dB increase in hearing threshold, the most comfortable gain is increased by 1 dB [3].

REFERENCES


