Use of temporal information in recognition of amplitude-compressed speech by older adults

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Abstract: Older and younger hearing-impaired listeners were tested on their recognition of VCV syllables processed using the signal-correlated noise method. This method results in a time-varying speech envelope modulating a noise carrier, and preserves temporal cues while minimizing spectral information. Recognition scores were obtained for uncompressed SCN syllables and for the same speech tokens after digital processing with a syllabic compression algorithm. In control conditions, recognition was tested for VCVs that included both temporal and spectral information. Younger and older listeners groups were matched for mean hearing thresholds up to 3 kHz. A high-pass masker was included to eliminate contributions from the basal end of the coeclea. When compared to younger listeners with similar hearing losses, the older listeners demonstrated poorer performance on the compressed SCN signals. These results suggest that the poorer temporal resolution abilities of older listeners may play a role in their recognition of amplitude-compressed speech.

INTRODUCTION

Amplitude compression, available in many hearing aids, uses a variable-gain amplifier which alters the natural time-intensity variations of the speech signal. These changes can reduce the availability of temporal cues for speech recognition. Listeners over 65 have been shown to have more difficulty understanding speech than young listeners with similar hearing, in part because of an age-related decline in temporal processing ability. For these listeners, a natural deficit in temporal processing coupled with compression-induced alterations of speech may be particularly deleterious.

METHOD

Four groups of listeners participated: (1) listeners aged 18 to 40 with normal hearing (20 dB HL or better) from 250 to 3000 Hz; (2) listeners over age 65 with normal hearing from 250 to 3000 Hz; (3) listeners aged 18 to 40 with mild-to-severe sensorineural hearing loss; (4) listeners over age 65 with mild-to-severe sensorineural hearing loss. Mean hearing thresholds for each of the groups are shown in Figure 1. For both the normal-hearing and the hearing-impaired listeners, mean thresholds differed by less than 5 dB. Since mean group thresholds were matched only up to 3 kHz, a high-pass gated masker was included in all conditions to prevent contributions from the basal end of the coeclea. Differences in performance between the young and older groups can thus be attributed to aging effects, rather than to differences in hearing sensitivity.

![Figure 1](image-url)
Speech stimuli were 16 vowel-consonant-vowel syllables, each using the common vowel /a/ and one of 16 consonants. The speech tokens were spoken by four talkers for a total of 64 items. Each token was digitally recorded at a 44.1 kHz sampling rate and processed in four conditions.

In two of the conditions, speech contained both temporal and spectral information. One of these conditions ("compressed") was amplitude-compressed using a digital algorithm which altered the temporal cues in the signal. The other ("linear") was not amplitude-compressed.

In the remaining two conditions, speech was processed to minimize spectral information using the signal-correlated noise method suggested by Schroeder (1). In this process, each digital sample is randomly multiplied by a +1 or -1. The resulting signal preserves temporal cues but contains minimal spectral information. This signal was also presented in a linear and a compressed condition.

Subjects were seated in a double-walled sound booth and listened to the speech monaurally through headphones. Speech was presented at 90 dB SPL to maximize audibility. Presentation order of the four conditions was randomized to prevent order effects. In a single run, the subject heard the entire set of 64 speech tokens presented in a random order for a single condition. In each condition, subjects listened to practice runs until asymptotic performance was reached.

RESULTS

Mean recognition scores (in percent correct) are shown in Figure 2. In all test conditions, performance is poorer for the older group than for the hearing-sensitivity-matched young group. This effect is more pronounced for the temporal-only speech than for speech containing both temporal and spectral information. Because mean thresholds were closely matched between groups, these differences appear to be due to age-related deficits in the ability to utilize the temporal information in the speech signal. These deficits may affect older listeners' ability to benefit from amplitude-compression hearing aids.

REFERENCES