# PERCEPTION OF EMOTIONAL SPEECH BY LISTENERS WITH HEARING AIDS

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## 1 Introduction

Recognizing the emotional state of a talker is an important part of social interaction. Previous research has shown that normal-hearing older adults do not recognize vocal emotions as well as younger adults [1], but little is known about how older adults with hearing loss perceive vocal emotion. In older adults who are not hearing aid users, hearing sensitivity predicts their valence ratings on a vocal emotion recognition task [2]. Older adults who are hearing aid users may therefore be expected to perform more poorly than their better-hearing peers. Hearing aids may restore the audibility of some vocal cues for emotion recognition, or they may distort the original intonation contour due to frequency and amplitude compression. The present study investigates how well older adults with hearing loss can recognize emotional speech and identify vocal emotions, and whether hearing aids are beneficial for both tasks.

## 2 Method

### 2.1 Participants

Participants learned English before the age of 5 years in an English-speaking country and were in average to excellent health with no speech or neurological disorders. Eleven older adults (mean age = 77.2 years) with hearing loss (Figure 1) were recruited from the community. They were hearing aid users with a median of 5 years of experience, who reported being satisfied with their hearing aids. They had at most two tested frequencies with an inter-aural difference >15 dB HL, except for one older adult who had three tested frequencies with a difference of >15 dB HL.

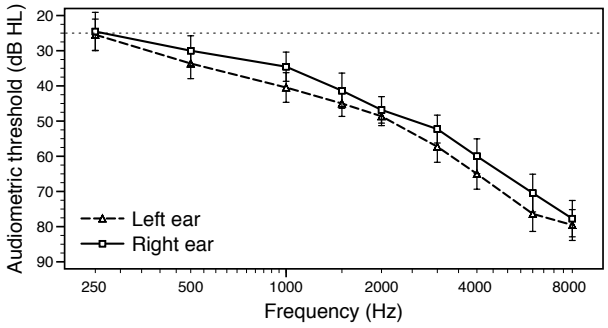


**Figure 1:** Average audiogram of older adults with hearing loss, with standard error bars.

Twenty-seven younger adults (mean age = 18.3 years) were students recruited from an introductory psychology course. They had normal audiometric thresholds of ≤25 dB HL from 250 Hz to 8 kHz in both ears, with inter-aural differences ≤15 dB HL at all tested frequencies, except for one younger adult who had a difference of 20 dB HL at 8 kHz.

### 2.2 Stimuli and procedure

The stimuli were sentences from the Toronto Emotional Speech Set spoken by a young adult female actor to portray seven emotion conditions : Angry, Disgust, Fear, Happy, Neutral, Pleasant Surprise and Sad [3]. These sentences consisted of keywords spoken after a standard carrier phrase (e.g., *Say the word bean*). Listeners were seated in an IAC sound-attenuating booth facing a loudspeaker placed 1.8 m in front at head height. Fourteen younger adults and 11 older adults with hearing loss heard these sentences in quiet, while 13 younger adults heard these sentences in babble noise from the Speech Perception in Noise Test (Revised; SPIN-R) [4] at -5 dB SNR. After each sentence, listeners reported the keyword and used a computer touchscreen to identify the emotion portrayed by the talker. The task order of word recognition and emotion identification was counterbalanced across listeners in each group. Each listener completed 14 practice trials and 168 experimental trials in which 24 words were presented in each of 7 emotion conditions. There were seven available sentence lists that combined each target word with each emotion across lists. Each younger listener was presented with only one list. Each older listener with hearing loss was presented with two different lists in separate sessions: the first without wearing hearing aids and the second while wearing hearing aids.

### 2.3 Data analysis

For each listener group, a repeated-measures analysis of variance (ANOVA) was conducted for each outcome measure of word recognition and emotion identification. For younger listeners, the single factor was emotion. For older listeners, the two factors were emotion and hearing aid condition (unaided or aided). Post-hoc *t*-tests with Holm-Bonferroni correction were conducted to further investigate significant main effects of emotion.

## 3 Results

### 3.1 Effects of emotion and hearing aid use on word recognition

Results are shown in Figure 2, including data from a previous study on normal-hearing older adults who were tested in SPIN-R babble noise at +2 dB SNR [5]. The word recognition accuracy of older adults with hearing loss improved when they used hearing aids compared to when

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they were unaided, as confirmed by a significant main effect of hearing aid condition (Table 1). Compared to normal-hearing older adults tested in noise, older adults with hearing loss performed worse when unaided, but better than older adults in noise when aided ($p$'s < 0.001).

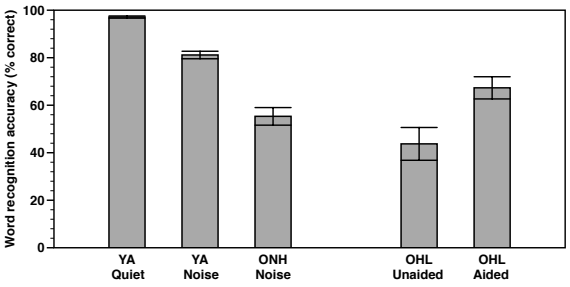


**Figure 2:** Word recognition accuracy of younger adults in quiet and in noise, normal-hearing older adults in noise, and older adults with hearing loss in quiet with and without hearing aids.

There was a significant main effect of emotion on word recognition accuracy for all listener groups except younger adults in quiet, whose performance was at ceiling (Table 1). For younger adults in noise, word recognition accuracy was better in Disgust/Angry/Neutral than in Happy/Sad conditions. For older adults with normal hearing, performance was better in Neutral/Fear than in Happy/Sad conditions, and better in Fear than all other conditions. For older adults with hearing loss, performance was better in Neutral/Angry than in Happy/Sad conditions, and better in Fear than the Happy condition (all $p$'s < 0.05).

**Table 1:** F-values from ANOVAs for word recognition accuracy. Symbols legend: $^{ns}$ $p > 0.05$; $^{\times}p < 0.05$ but no significant pairwise differences; $^{*}p < 0.05$; $^{**}p < 0.001$.

| | Y Quiet | Y Noise | ON Noise | OH Quiet |
|---|---|---|---|---|
| Emotion | $2.44^{\times}$ | 11.44* | 14.4* | 7.49* |
| HA use | - | - | - | 18.8* |
| Emotion x HA | - | - | - | $1.62^{ns}$ |

### 3.2 Effects of emotion and hearing aid use on emotion identification

Results are shown in Figure 3, including data from a previous study on normal-hearing older adults who were tested in quiet [1]. Older adults with hearing loss clearly performed worse than normal-hearing older adults. There was a small but significant improvement in emotion identification when older adults with hearing loss used hearing aids compared to when they were unaided (Table 2).

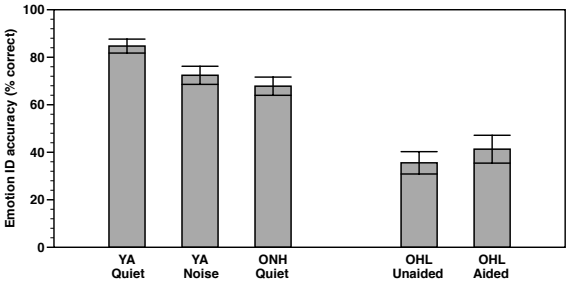


**Figure 3:** Emotion identification accuracy of younger adults in quiet and in noise, normal-hearing older adults in quiet, and older adults with hearing loss in quiet with and without hearing aids.

There was a significant main effect of emotion on emotion identification accuracy for normal-hearing younger and older adults, but not for older adults with hearing loss (Table 2). For younger and older adults in noise, emotion identification accuracy was better in Happy/Sad conditions than in the Disgust condition ($p$'s < 0.05).

**Table 2:** F-values from ANOVAs for emotion identification accuracy. Symbols legend is identical to that of Table 1.

| | Y Quiet | Y Noise | ON Quiet | OH Quiet |
|---|---|---|---|---|
| Emotion | $4.71^{\times}$ | 6.79** | 7.17** | $1.86^{ns}$ |
| HA use | - | - | - | 6.33* |
| Emotion x HA | - | - | - | $0.44^{ns}$ |

## 4 Discussion

Without hearing aids, older adults with hearing loss performed worse than normal-hearing older adults on both word recognition and emotion identification. The use of hearing aids improved performance on both tasks, but much more so for word recognition (24 percentage points) than for emotion identification (6 percentage points). It may be concluded that hearing aid processing benefits word recognition by restoring the audibility of speech cues, but without much benefit to the perception of cues for vocal emotion. Another possibility is that listeners with hearing loss no longer attend to the same emotion cues as normal-hearing listeners or process them in the same way. Listeners with hearing loss were somewhat like listeners with normal hearing in that they found words to be more intelligible if spoken in the Neutral condition than in the Happy or Sad conditions. Unlike normal-hearing listeners, however, the type of emotion did not affect their emotion identification performance. Future directions may include measuring the output of hearing aids to determine how hearing aid processing affects cues for emotion in the speech signal, and determining which hearing aid settings work best for emotion recognition without compromising intelligibility.

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