Talker identification: effects of masking, hearing loss and age

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Background

Anecdotal reports indicate that listeners with hearing loss, especially older adults, have difficulty identifying who is talking in social communication settings. As noted by Gatehouse & Noble [1], “failures of identification, such as of persons or their mood, may add to a sense of embarrassment and reinforce a desire to avoid social situations, as will the effort needed to engage in conversation”.

There are multiple stages at which hearing loss and age could affect talker identification:

- the acoustic features needed to discriminate and identify voices may be disrupted by hearing loss (particularly in the presence of noise)
- the storage of voice information may be impeded by hearing loss because effortful listening depletes the available cognitive resources
- cognitive limitations in older listeners may impede learning and memory for voices.

The limited data on this issue suggest that older listeners are poorer than younger listeners at categorizing gender [2] and recognizing voices in quiet [3] and in the presence of a competing talker [4]. However, the role of hearing loss is not clear.

Here participants learned to identify talkers on the basis of their voice. They were then tested on their ability to identify these talkers in quiet, and in the presence of masking. Of interest was the ability of listeners to learn to identify the voices, and the extent to which performance was disrupted by masking.

Participants

Four groups (see Fig 1) were recruited across two locations (Boston University and the Medical University of South Carolina).

Younger normal-hearing (YNH: mean age 26, N=8)
Younger hearing-impaired (YHI: mean age 24, N=7)
Older normal-hearing (ONH: mean age 70, N=8)
Older hearing-impaired (OHI: mean age 75, N=8)

Hearing losses were bilateral, symmetric, and sensorineural. HI listeners were provided linear gain according to the NAL-RP prescription rule.

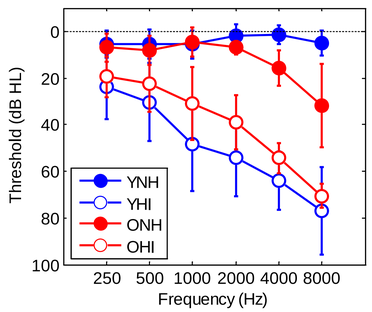

Fig 1. Mean audiograms for each group, averaged over left and right ears.

Materials

Speech materials were drawn from a corpus recorded in the laboratory by 12 male and 12 female talkers. From each set of 12, 4 talkers were chosen arbitrarily to be targets and the remaining 8 were used as maskers (see Fig 2).

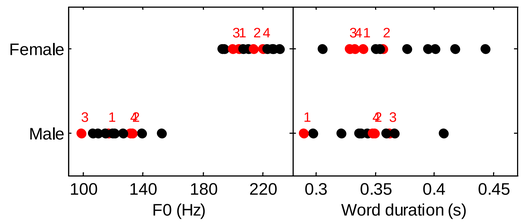

Fig 2. Variation across target (red) and masker (black) talkers in average F0 and word duration.

Phrases were simple questions (e.g. “What is 2 plus 3?”). Different categories of questions were used for training and testing.

During testing, performance was measured (1) in quiet, (2) in the presence of speech-shaped noise (matched to the average spectrum of the male or female voices in the corpus), and (3) in the presence of a single, unlearned, same-sex talker. Masked conditions were tested at four target-to-masker ratios (TMRs).

Procedures

Each listener completed two sessions of 2-3 hours, one with female talkers and one with male talkers (order counterbalanced within groups).

Within each session, training and testing were completed using a protocol adapted from Perrachione et al [5]. Feedback was provided throughout to minimize “forgetting”.

Training	For each of 15 different questions: - 8 “passive” trials - 8 “active” trials
Training Assessment	Mixed block of training questions (120 trials)
Testing 1	Mixed block of untrained questions in QUIET (40 trials) Mixed block of untrained questions in NOISE masker (160 trials) Mixed block of untrained questions in SPEECH masker (160 trials)
Testing 2	As per Testing 1

Results

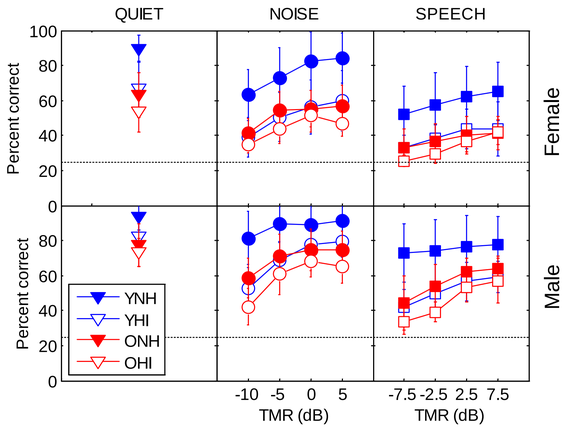

Fig 3. Mean psychometric functions for each group.

Performance varied across the four groups in quiet and in the masked conditions (Fig 3). Scores were lower and psychometric functions were shallower for the speech masker than the noise masker, analogous to typical findings for the task of sentence identification.

Performance in quiet showed substantial individual differences (Fig 4 top). Multiple regression analysis indicated that both age and hearing loss were significant predictors (age more so than hearing loss in this sample).

Age and hearing loss were also significant predictors of performance in noise (Fig 4 middle) and in speech (Fig 4 bottom). However, if quiet scores were included as a predictor, the contribution of age was no longer significant, while the contribution of hearing loss persisted in the male talker condition.

Confusion matrices showed evidence that certain talkers (e.g. female 4, male 3) were more robustly identified than others (Fig 5; refer to Fig 2).

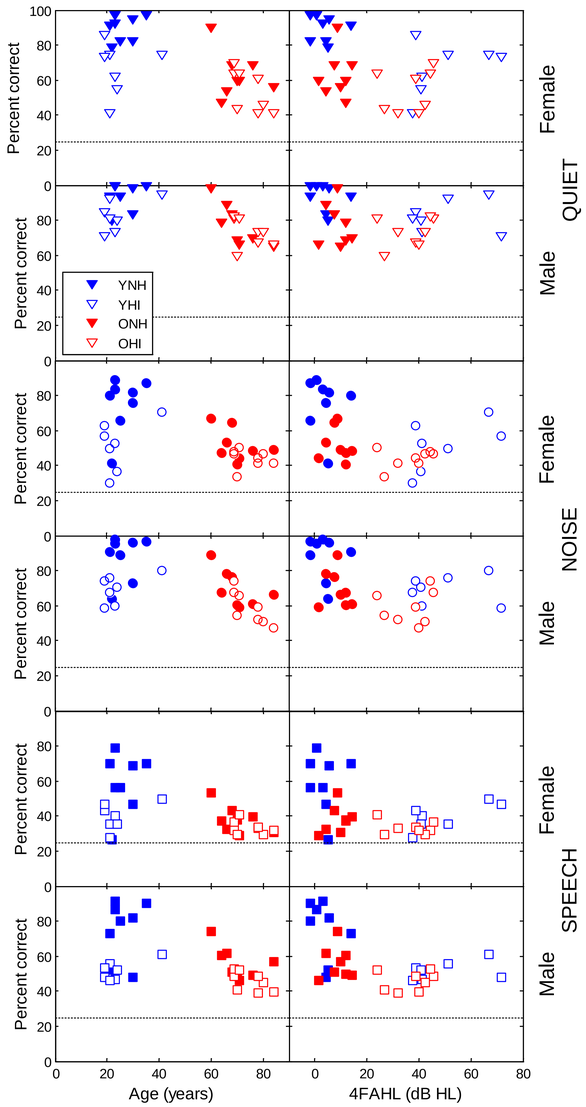

Fig 4. Scatterplots showing scores as a function of age and four-frequency average hearing loss (4FAHL) in quiet (top), and in the presence of noise (middle) or a competing talker (bottom). Masked scores are averaged across TMR.

Conclusions

These findings demonstrate that both age and hearing loss can affect talker identification. The data are consistent with the idea that hearing loss primarily disrupts voice discrimination, while age primarily affects the recall of newly learned voices. Further experiments that examine discrimination and recall independently are needed to confirm these tentative conclusions.

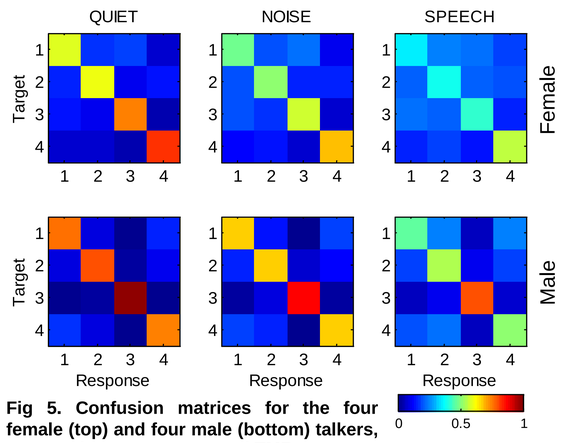

Fig 5. Confusion matrices for the four female (top) and four male (bottom) talkers, averaged across groups and TMRs.

References

1. Gatehouse & Noble (2004). The Speech, Spatial and Qualities of Hearing Scale (SSQ). Int J Audiol 43: 85-99.
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4. Rossi-Katz & Arehart (2009). Message and talker identification in older adults: effects of task, distinctiveness of the talkers' voices, and meaningfulness of the competing message. J Speech Lang Hear Res 52:435-453.
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