Short-term adaptation to accented English by younger and older adults

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Abstract: This study examined the effects of age and hearing loss on short-term adaptation to accented speech. Data from younger and older listeners in a prior investigation [Gordon-Salant *et al.* (2010). J. Acoust. Soc. Am. **128**, 444–455] were re-analyzed to examine changes in recognition over four administrations of equivalent lists of English stimuli recorded by native speakers of Spanish and English. Results showed improvement in recognition scores over four list administrations for the accented stimuli but not for the native English stimuli. Group effects emerged but were not involved in any interactions, suggesting that short-term adaptation to accented speech is preserved with aging and with hearing loss.

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1. Introduction

In a recent study (Gordon-Salant *et al.*, 2010), recognition of Spanish-accented English was examined for words and sentences presented in quiet to younger and older adults with normal hearing and to older adults with hearing loss. The findings showed a significant main effect of accent for both words and sentences, in which all listener groups exhibited significantly poorer scores with increasing speaker accent. In addition, older hearing-impaired listeners performed more poorly than the two groups of normal-hearing listeners, indicating a significant hearing loss effect. The stimuli used in this study consisted of four lists of words and four lists of sentences that were presented in randomized order. The lists included words with specific phonetic contrasts that frequently are mispronounced in Spanish-accented English (Gordon-Salant *et al.*, 2010). An equal distribution of these phonetic contrasts appeared in the initial and final consonants, as well as the vowels, across the four lists. Analyses of the recognition performance of 15 young normal-hearing listeners established that the four lists of word and sentence stimuli produced by each of the talkers were equivalent. The use of four equivalent stimulus lists of each stimulus type provided data that could be re-analyzed to determine if there was a short-term improvement, or adaptation, to accented English over time, and if the magnitude of possible improvement varied for listeners as a function of age and hearing status.

One observation of the participants in the original study was that listening to accented English became easier as the study progressed. Previous studies have shown that young listeners with normal hearing demonstrate rapid improvements in recognition of accented English

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(e.g., Bradlow and Bent, 2008) and rapid increments in processing speed for accented English following brief exposure to accented speech (Clarke and Garrett, 2004). This rapid improvement in perceiving accented English undoubtedly promotes effective communication with nonnative speakers of English. However, as reported in a previous study (Gordon-Salant *et al.* 2010), older listeners with hearing loss exhibit considerable difficulty understanding accented English. If these listeners also experience rapid adaptation to accented English, then potential communication problems with accented talkers may be minimized. To date, short-term learning of accented English has not been examined in older hearing-impaired listeners. The distortion imposed by hearing loss coupled with acoustic alterations in speech that accompany accent, could combine to severely reduce initial levels of performance by hearing-impaired listeners. However, with continued exposure over time to accented speech, they may learn to derive meaning from the altered stimuli and hence understand the altered speech patterns with a greater degree of accuracy. Thus, it might be anticipated that listeners with hearing loss would exhibit more rapid short-term improvement than those with normal hearing.

It is also possible that older people (with and without hearing loss) experience more difficulty understanding accented speech than younger people because of cognitive decline. Some cognitive abilities are known to decline with advancing age that have potential import for understanding accented English, including speed of information processing (Salthouse, 1996), working memory capacity (Zacks *et al.*, 2000), and attentional resources (McDowd and Shaw, 2000). If such cognitive domains are diminished among older people, then it could be predicted that older listeners may require a longer time to adjust to accented English compared to younger listeners with normal hearing. Two recent studies investigated the effect of listener age on short-term adaptation to another form of altered speech, time-compressed speech (Peelle and Wingfield, 2005; Golumb *et al.*, 2007). Contrary to expectation, the results generally showed that older listeners adapt to time-compressed speech at a rate that is comparable to younger listeners in both ideal and interrupted training sessions. The goal of the current study is to determine the extent to which age and hearing loss influence adaptation to accented English.

2. Method and results of previous study

Data collected in a previous experiment were re-examined to permit an initial assessment of short-term adaptation to Spanish-accented English by younger and older listeners with normal hearing and older listeners with hearing loss (Gordon-Salant *et al.*, 2010). The method used in the original experiment is summarized below. Participants were native speakers of English who were assigned to one of three groups (n = 15/group) on the basis of age and hearing status: young normal-hearing listeners (18–30 years, pure tone thresholds ≤20 dB HL, 250–4000 Hz, re: ANSI, 2004), older normal-hearing listeners (66–81 years, pure tone thresholds ≤20 dB HL, 250–4000 Hz, re: ANSI, 2004), and older hearing-impaired listeners (65–81 years; with mild-to-moderate sloping sensorineural hearing losses, typical of age-related threshold patterns observed with presbycusis). The main selection criterion for the hearing-impaired listeners was that thresholds at 4000 Hz were between 40 and 70 dB HL. In general, the pure-tone thresholds of this older hearing-impaired group ranged from 10–45 dB HL from 250–500 Hz, from 10–65 dB HL from 1000–2000 Hz, and from 45–70 dB HL at 4000 Hz, re: ANSI, 2004).

Stimuli were 4 lists of 40 monosyllabic words, with the same words appearing as the final word in 4 lists of 40 low-context sentences (the stimuli are available upon request from the first author). Each of these stimuli was spoken by a native speaker of American English, a native speaker of Spanish with a mild accent, and a native speaker of Spanish with a moderate accent (all speakers were male). The order of speech material (words, sentences), speakers (native, mild accent, moderate accent), and lists (1, 2, 3, 4) was randomized over listeners. Stimuli were presented monaurally through an insert earphone at a level of 85 dB SPL in quiet. Listeners were asked to write down the words or sentences they heard. All testing was conducted in a sound-attenuating chamber on two separate days (one day for words and a second day for sentences), usually separated by two weeks.

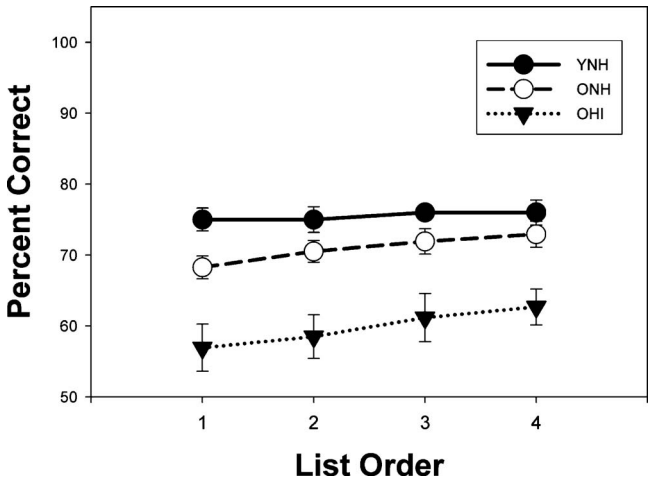

Fig. 1. Percent correct recognition of words and sentences (collapsed) for the Spanish-accented speaker, by three listener groups (YNH=Young Normal Hearing, ONH=Older Normal Hearing, OHI=Older Hearing-Impaired). Error bars reflect one standard error of the mean.

3. New analysis

Percent correct scores for each list of each speech material (words and last words in sentences) and talker condition were transformed to arc-sine units prior to statistical analyses. Data were re-organized according to the order of list presentation to a given listener, separately for each speech material (words or sentences) and speaker. For brevity, only data for the native speaker and moderately accented speaker are presented. Improvement in recognition for the accented speaker would indicate both adaptation to accent and adaptation to the task. However, it was assumed that larger improvements for the accented speaker than the native speaker would suggest adaptation to the accent.

Results for the native English speaker were analyzed with a split-plot factorial design with one between-subjects factor (group) and two within-subjects factors (speech material, list order). Statistical analyses showed a significant main effect of listener group $[F(2,42)=15.29,\ p<0.01]$. None of the other main effects nor interactions was significant. Post-hoc multiple comparison testing (Bonferroni) revealed that the recognition scores were significantly lower for the older hearing-impaired listeners compared to the two groups of listeners with normal hearing. The lack of a list order effect confirmed that there was no short-term adaptation to words and sentences spoken by the native English speaker. It could be argued that for the young normal-hearing listeners, a ceiling effect may have been operating. However, ceiling effects likely did not operate for the older normal-hearing and older hearing-impaired listeners, because their scores ranged from 93%–94% correct and 82%–83.5% correct, respectively.

For the accented speaker, recognition scores of the three listener groups appear to improve over the course of administration of multiple lists, as shown in Fig. 1. Statistical analyses revealed significant main effects of group $[F(2,42)=16.96,\ p<0.01]$ and list order $[F(3,126)=5.77,\ p<0.01]$. None of the other effects was significant. Post-hoc multiple comparison testing (Bonferroni) of the group effect revealed that the older hearing-impaired listeners exhibited lower recognition scores than the two groups of normal-hearing listeners ($p<0.01$, both comparisons). There were no significant differences in performance between the younger and older groups with normal hearing. Paired-sample t-testing was conducted for data collapsed across the two speech materials and three groups to examine the improvement from the first list administered to each subsequent list, the second list administered to each subsequent list, and the third list adminis-

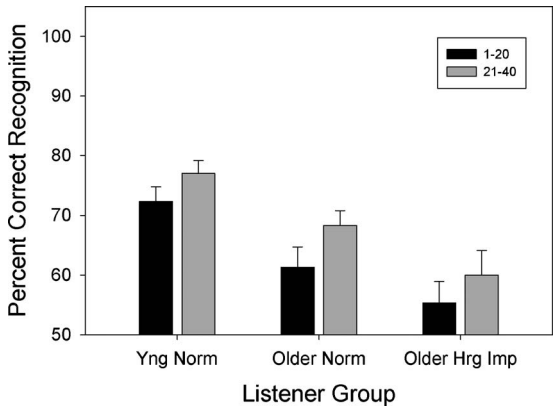

Fig. 2. Percent correct recognition for the first half (items 1–20) vs. second half (items 21–40) of the first list administered for the Spanish-accented speaker, by the three listener groups. Error bars reflect one standard error of the mean.

tered to the final list. The alpha level was adjusted with the Bonferroni correction. Results revealed significant improvements in performance from list 1 to list 3 and list 1 to 4 ($p < 0.008$, both comparisons).

A second approach to data analysis examined short-term learning within the first list administered to the listeners, regardless of speech material. Separate analyses were conducted for the accented and unaccented stimuli. Figure 2 shows the percent correct recognition scores for the first half (items 1–20) vs. second half (items 21–40) of the initial stimulus list spoken by the accented speaker, separately for each listener group. Statistical analysis revealed significant main effects of stimulus order $[F(1,42)=7.30,\ p<0.05]$ and group $[F(2,42)=11.58,\ p<0.01]$, with no interactions between these effects. Comparison of the mean data indicates that all listeners exhibited higher scores on the second half compared to the first half of the first list administered. Hence, all listener groups exhibited short-term adaptation to the moderately accented talker's speech following exposure to the first 20 sentences on the list. Multiple comparison testing of the group effect (Bonferroni) showed that the young normal-hearing listeners exhibited higher recognition scores than the two older groups, indicating an age effect for the first list administered. For the stimuli spoken by the native English speaker, a statistical analysis was conducted to compare recognition of the first half vs. the second half of the initial list heard by each listener. The results revealed a significant main effect of group $[F(2,42)=8.36,\ p<0.01]$, but the main effect of stimulus order was not significant ($p > 0.05$). No other effects were significant. Post-hoc testing (Bonferroni) indicated that the young normal-hearing listeners performed significantly better than the older hearing-impaired listeners. Thus, short-term adaptation was observed only for the accented stimuli, and not the unaccented stimuli.

4. Discussion

The current findings indicate that listeners improve their recognition of stimuli spoken by a moderately accented talker over the course of four administrations of stimulus lists. Moreover, some short-term adaptation to accented English is evident following exposure to 20 words or sentences. The three listener groups exhibited the same pattern of improvement, because the main effects of stimulus order were not involved in any interactions with listener group. The results are offered as evidence that younger and older listeners with normal hearing, as well as older listeners with hearing loss, are able to adapt to the accent of a native speaker of Spanish within a reasonably brief period of time. Because an effect of list order was not observed for stimuli spoken by the native speaker of English, the improvements observed with exposure to accented English are not interpreted as reflecting a practice effect for the task. Rather, the results suggest that adults, regardless of age and hearing status (normal hearing vs. mild-to-

moderate hearing loss), are able to learn the patterns of a Spanish-accented English speaker to obtain modest improvements in recognition within a short period of time. Additional investigation is required to establish whether this adaptation generalizes to other native speakers of Spanish. The current findings extend the results reported by others (Clarke and Garrett, 2004) of listeners' ability to adapt to accented English over a brief period of time, to older listeners with normal hearing and with hearing loss. The findings are also consistent with the observation, shown previously for time-compressed speech (e.g., Peelle and Wingfield, 2005), that short-term adaptation to distorted speech is preserved across the lifespan.

Acknowledgments

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