Age Effects in Processing Bilinguals' Accented Speech

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1.0 Introduction

Older adults often complain about difficulty understanding distorted speech, such as synthetic voices on telephones, answering-machine messages that are "too-fast", and movies with actors speaking dialects of English different from their own. Younger adults (college-students) have been reported to complain about difficulties understanding teaching assistants with "foreign" accented speech (e.g., Brown, 1992; Norris, 1991). Speech spoken by bilingual speakers with non-native accents is prevalent in many settings and likely to be experienced by the young and old listeners alike. We ask whether older adult listeners are disproportionately affected, relative to younger adults, by bilinguals' accented speech.

One might expect that older adults have more difficulty than younger adults in processing accented speech because older listeners have been documented to have more difficulty with other forms of distorted speech, namely speech-in-noise, reverberant speech, and time-compressed speech, as will be discussed further (see also Wingfield & Stine-Morrow, 2000 and Schneider & Pichora-Fuller, 2000). Obler et al. (1985) showed that older monolingual adults (in their 70s) perform significantly worse than younger monolingual adults (aged 30-69) when reporting the final word of Speech Perception in Noise test (Kalikow et al., 1977) sentences under low stimulus-to-noise ratios. Pichora-Fuller et al. (1995) reported a similar finding. They demonstrated that older participants found it significantly more difficult than younger adults to filter the signal from the noise. When the noise level was low, older adults performed at ceiling on word-recognition tasks, but when the noise level was high, even participants with near-normal hearing sensitivity experienced difficulty with the task.

Tun (1998) added temporal distortion to the speech-in-noise component to test the effects of speech rate, level of noise, and predictability of the material. Speech rate, level of noise, and predictability of the material were varied while comparing across two groups of listeners: young (17-21 years old) and old (64-78 years old) in a sentence-repetition task. She found that for all participants, faster speech and lower signal-to-noise ratios yielded poorer performance. Moreover, there was a significant interaction between the two variables such that performance was most affected at fastest presentation at the highest noise level. While the older adults performed less well than the younger group overall, smaller differences were detected at the extreme ends of the difficulty continuum, i.e., at high noise levels (when performance was generally poor) and at low noise levels (when performance was usually good). Most differences between the two groups were found at rate and noise levels along the mid-range of the continuum. Note that neither the processing speed, nor the hearing sensitivity of the subjects, appeared to account for the results observed.

Other studies of speeded speech have demonstrated differential effects on older as compared to younger presumably monolingual adults. Using a time-compression technique, Gordon-Salant and Fitzgibbons found that normal-hearing older adults showed poorer performance on the Speech-in-noise (SPIN) test (Gordon-Salant and Fitzgibbons, 1993) and poorer recognition scores for sentences and phrases (Gordon-Salant and Fitzgibbons, 2001), when the material was presented at a fast (time-compressed) rate compared to normal (non-compressed) rate. Vaughan and Letowski (1997) also used a time-compression paradigm but found that their older participants did not differ from the younger participants on a sentence-repetition task, even at the fastest presentation condition. However, the older adults did experience greater difficulty than the younger participants at the fastest speech rate when they were required to make inferences from the spoken paragraph-level material. Age-related

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difficulties associated with fast rate of speech were also documented by Stine et al. (1986). They found that older adults demonstrated a disproportionate decline, compared to younger adults, in performance on a recall task when the stimulus material was presented at speeded rates. Bergman (1980) reported that older participants evidenced difficulty not only with speeded speech but also with slowed speech (and noted that the problems for older participants were even more evident among bilinguals, even those who had been in the United States for most of their adult lives).

In addition to speech-in-noise and temporally-distorted speech, reverberant speech has been demonstrated to incur auditory-processing difficulties for the older, albeit to a relatively lesser extent. Gordon-Salant and Fitzgibbons (1999) found that older adults (65-76 years) experienced proportionately greater difficulties than the young subjects (18-40 years) only at the higher level of reverberation (0.6 seconds), but not at a lower reverberation time (0.4 seconds), as reflected by the relatively poorer speech recognition scores compared to those of the young adults. These age effects were found independently of effects related to peripheral hearing loss. From these studies it appears that the rapidity, distortion of the temporal order, and/or reverberation of the signal cause perceptual breakdown among the older adults.

All speech may be considered to be spoken with an individual or regional accent. Here we focus on the accented speech of bilinguals, those with that recognizably non-native accent that, one might argue, contains aspects of "noise" overlay and aspects of temporal distortion relative to what we will call 'unaccented' speech, that is, the speech of native speakers. Spectral and temporal deviations from the norm are reported in the speech of bilingual accented speakers at the segmental as well as at the suprasegmental levels and these deviations contribute to the perceived accent (Flege, 1984, 1988; Port and Mitleb, 1983; Shah, 2002).

One reason to speculate that older adults have disproportionate difficulty with accented speech derives from a pilot study we conducted (Shah, DeSanti, and Obler, 1997). We presented sentences for repetition to five healthy monolingual English-speaking adults, and seven patients with Alzheimer's dementia (three with mild impairment and four with moderately-severe impairment). While the healthy adults as a group (mean 64.6 years) did not have significant difficulty with repeating the sentences presented in the unaccented condition, they showed considerable variability in their scores in the accented condition. Indeed there was overlap between the group of normal adults and the mildly demented patients. The three normal adults who performed at the level of the mildly demented group were aged 74, 71, and 49 years respectively. Since the third participant who performed at the level of the demented group was relatively young (49-years old), the hypothesis of age-related processing deficit for accented speech remains inconclusive. These substantial individual differences among the healthy adults need to be tested in a larger sample.

We are aware of only two studies that have tested the hypothesis that processing bilinguals' 'foreign'-accented English is difficult for older adults. The first is that of Burda (2000). Measures of intelligibility, comprehensibility, and accent ratings were obtained from listeners who were monolingual native speakers of English in three age groups (20-39, 40-59, and 60 years or older). Participants listened to words, sentences, and paragraphs produced by a native speaker of English, a native speaker of Taiwanese, and a native speaker of Spanish. Burda measured intelligibility (defined as participants' ability to write down words and sentences they heard) and comprehensibility (defined as participants' accuracy in answering questions based on sentences and paragraphs they heard). Participants also rated, on a 7-point scale, how comprehensible statements they heard were as well as how accented they thought each statement was.

Burda's results showed that the mean scores of the oldest group were the lowest of the three participant groups on each of the three tasks. For all participants, accented speech was more difficult to process than unaccented speech. However, no interaction was found between the age of the listeners and the accentedness of the stimulus materials. The findings suggest that although aging was associated with a general decline in performance across tasks used in the study, the older adults did not have a disproportionately greater difficulty with the accented material than did the younger adults. This was evident in the lack of interaction between each of the dependent measures and age; therefore, the study's statistics do not support the author's conclusion that "the older individuals had significantly greater difficulty in understanding individuals with accented speech" (Burda, 2000, p. 74), if by that phrasing we are to infer "significantly greater difficulty compared to younger

individuals". Moreover, with respect to self-reported difficulty, there were no significant differences among the three age-groups.

The second study of aging monolingual listeners' abilities listening to accented English is that of Galletta (2003). Galletta used the words and sentences from the Revised Speech Perception in Noise (SPIN; Bilger, no date) stimuli to test 54 monolingual English-speaking participants aged 20 to 81 years old. Bilingual-accented materials in her study were recorded from six speakers: two Chinese-English speakers and two Portuguese-English speakers, as well as two matched monolingual speakers of Standard American English. As in Burda, with advancing age, poorer performance was seen in repeating either single words or the final words of the SPIN sentences, especially those in which the final word was not predictable by the context of the preceding sentence. While Galletta performed complete audiological examinations of her participants, she was unable to statistically distinguish the effects of age-related hearing loss from those of difficulty processing accented speech, because none of her younger adults had any hearing loss, whereas most of her oldest participants did. She was able to rule out education, working memory, attention, and prior exposure to accented speech as explanations for the poorer performance of older adults, relative to younger adults, on both accented and unaccented speech. Moreover, among the oldest participants, three stood out as having particularly good speech-recognition abilities, and two of these had the poorer hearing common to her oldest adults.

Thus the question of to what extent bilinguals' accented speech may pose a disproportionate disadvantage to older adults remains unanswered so far and is the focus of the present study. We ruled out hearing problems in our older subjects to eliminate the potential confound of age-related hearing impairment that has been reported to interact with speech recognition (Schneider et al., 2000). We also included both high- and low-probability sentences, as several studies (e.g. Obler et al., 1985; Kemper et al., 1996, Galletta, 2003) show that lack of redundancy or predictability diminishes older adults' comprehension of spoken materials.

2.0 Methods

2.1 Monolingual listeners

Two groups of monolingual listeners participated in this study. They were recruited from Molloy College, Rockville Centre, New York and the Leonard Sandel Senior Center, Rockville Centre, New York. Group OA, 14 older individuals, ranged in age from 62-92 years old (mean 75.7). Group YA, 13 younger participants, ranged in age from 17-25 years old, with a mean of 21.1. Group OA consisted of individuals whose highest level of education ranged from completion of the 8th grade through advanced graduate study (mean 13 years). Individuals in Group YA had completed education from the 10th grade through two years of law school (mean 14 years). Mean education levels did not differ significantly between the two groups. All participants were native English speakers with no known neurological conditions or hearing problems. None of the participants had prior exposure to Croatian accent (the first language of the nonnative speaker of English employed in this study).

In an effort to exclude older adults with a hearing loss, participants over the age of 60 were asked to complete the Hearing Handicap Inventory for the Older-Screening Version (Ventry and Weinstein, 1983). Only those individuals who passed the screening with a score of 8 or less out of a total possible 40 were included in the study.

2.2 Stimuli

The sixteen low- and high-probability phrases and sentences from the Repetition section of the Boston Diagnostic Aphasia Examination (BDAE 2nd Edition; Goodglass and Kaplan, 1983), and 16 new phrases and sentences (comparable to BDAE sentences) were used as stimuli. The new sentences were constructed to match the BDAE sentences in terms of grammatical structure, frequency of occurrence of words (Francis and Kučera, 1982), syllable length of words, and semantic structure.

The complete list of sentences (n = 32) was recorded by two speakers (see below). The tape was made such that the intensity of each stimulus was monitored and recorded at similar levels. The stimuli were recorded on a Marantz tape-recorder (Model PMD 420), using an external microphone

(Electrovoice Dynamic omnidirectional 635 A). The sentences were subsequently digitized and edited: extraneous noise was removed, as were extra spaces and pauses, and inter-stimulus intervals were equated. Matching of intensity was done for each sentence and each speaker by scaling all the sentences to a level of 70dB. Four tapes were created, counterbalancing blocks of 16 accented and 16 unaccented sentences. One block contained the set of high-probability phrases and sentences from the BDAE (in an order of presentation ranging from short to long phrase/sentence-length) first and then the set of low-probability BDAE phrases and sentences (also ranging from short to long). The other block was similarly structured, but differed in content as it comprised the newly constructed sentences (matched to BDAE).

2.3 Procedures

2.3.1 Selection of accented speakers:

Our goal was to select one bilingual, nonnative speaker of English who spoke English with a pronounced foreign accent that listeners were not likely to be familiar with and a matched speaker of Standard American English. Five native speakers and five nonnative speakers were preliminarily taped reading the stimulus sentences. The recording of each of these speakers was played to three native American-English-speaking judges. These judges rated the stimuli using a Likert scale of 0-4, 0 being "native-like" and 4 being "highly accented" for each of the speakers. A nonnative speaker, judged by these listeners to be with a moderate accent (average 2) was selected as the speaker for the accented English sections of the experiment. This speaker spoke English with a Croatian accent. The standard American-English speaker selected was one adjudged on the same Likert scale (average score 0), by the same three native American-English speakers. These two speakers were matched in gender, approximate age, average intensity and average pitch of their voices.

2.3.2 Listening Task:

Each participant was individually tested in a quiet room in a session lasting approximately 30 minutes. Prior to the experimental task, individuals were asked to sign a consent form and fill out a background information questionnaire. The stimuli were presented over Telephonics 296D200 earphones, using a Marantz PMD 201 portable cassette recorder. Participants were instructed to listen to each sentence and repeat exactly what they heard. It was explained that some of the sentences would be more difficult to understand and some would be easier. Responses were audio-taped using a voice-activated microphone worn on the collar and a SONY TCM-354 V cassette-recorder. The examiner sat to the left and slightly behind the participant as he or she was listening to the tape. Effectively, half of the participants in each age group heard a block of 16 accented sentences first; the other half heard the unaccented block first. Each participant heard each sentence once, either in the accented or the unaccented condition.

3.0 Results

One of the authors (a trained speech-language pathologist) scored participants' responses as they performed the task, recording onto a scoring sheet each word produced. The number of target words correctly produced in each sentence by each participant was tabulated. Errors were identified as words that were omitted or substituted for by another word (including phoneme substitutions and omissions). Non-target additions were not included as errors.

As a measure of inter-rater reliability, another author (a trained linguist) listened to the eight longest sentences (every fourth sentence in the list) for half the participants in each age group. The total of 120 target sentences yielded 883 words judged by both raters. Of these, differences obtained on 23 words, i.e. on 2.6%, resulting in an inter-rater reliability score of 97.4%.

The numbers of correct words for the accented and the unaccented sentences were tabulated for each participant, group means were obtained, and percent accuracy was calculated for each group. Accuracy results in each condition for each group (means and standard deviations) are presented in Table 1.

These scores were subjected to a repeated-measures ANOVA in which the groups of participants were taken as the independent variable and the percent correct for accented words and percent correct for unaccented words were taken as the dependent variables. A significant main effect of accentedness was found across the groups ($F = 235.86$, $p < 0.01$). This result suggests that accented speech was significantly more difficult than unaccented speech for both groups (mean percent correct for accented items overall was 65.33% and mean percent correct for the unaccented items was 92.69%). There was also a significant main effect of age ($F = 6.49$, $p < 0.05$). Mean scores were calculated for both accented and unaccented conditions together for each age group. The mean scores suggest that the older group performed worse (combined mean = 152) than the younger group (combined mean = 166). However, there was no interaction between accentedness and age group ($F = .044$, $p > .1$). This lack of interaction was maintained even after the removal of two apparent outliers in the younger group who may have lowered the scores and brought the younger-group means closer to the means of the older group.

Planned comparisons of the two age groups in each presentation condition (unaccented and accented) revealed that the difference between the two groups in the accented condition failed to reach significance ($F = 2.55$, $p = .122$). In the unaccented condition, in contrast, the difference between the two groups was found to be significant ($F = 7.65$, $p = .01$). This is surprising given the lack of group by accentedness interaction; it may be that with larger numbers of participants in each age group, the difference between the two groups in the accented condition would have reached statistical significance.

When we assessed the effect of probability of the sentences, we found a main effect of probability but a lack of significant interaction between probability and accentedness and probability and age group. That is, the high-probability items were easier than the low-probability items in both the unaccented and the accented conditions, for both groups.

4.0 Discussion

Results of this study concur with those of Burda (2000) and Galletta (2003) and indicate that, while older adults do have difficulty processing bilinguals' accented speech relative to unaccented speech, their difficulty is not disproportionate to that experienced by younger adults in the same conditions.

Note that we did find, as have previous studies of language processing, a significant main effect for age; our older participants had greater difficulty with this repetition task overall than did our younger participants. The greater difficulty, however, was more prominent for the unaccented speech as compared to the accented speech. It is interesting to consider why, while there was no significant difference between the two groups in the accented condition, the difference between the two groups only reached statistical significance in the unaccented condition. An uninteresting explanation would be that our population sample was too small; replication with a larger participant pool is thus warranted. Linked to this explanation is the greater degree of interindividual variability consistently associated with advancing age in cognitive studies. Since previous research has indicated sizable individual differences in ability to process accented speech (Shah et al., 1997, Galletta, 2003), the two sources of added variability may mask the significance of minor age-related differences in processing bilinguals' accented speech by the elderly. An interesting possibility lies in that fact that other studies have found that speech-processing differences between younger and older adult participants were least evident in very easy or very difficult conditions (e.g., Tun, 1998). Thus we suggest that the lack of interaction between age and the accented conditions in our study resulted from the fact that the accented materials were markedly difficult for all participants.

Why, then, have we heard more older adults than younger adults complain of difficulty understanding the speech of accented speakers? We posit that the level of difficulty added by listening to speech with an unfamiliar accent, which in fact affects adults of every age, brings comprehension below an acceptable threshold for these elderly, and thus they are no longer able to comprehend enough of the input to feel that have succeeded in listening.

Recall that we, like Burda and Galletta, had predicted that our older monolingual listeners would find listening to the accented English of non-balanced bilinguals particularly difficult, relative to younger adult listeners. Listening and making sense of accented speech, we had assumed, requires

hearers to transform the input into representations that they have 'listed' in their mental grammars and lexicons in 'unaccented' form. For example, monolingual English speakers have in their representational phonemic inventories a range of sounds that will get 'heard' as /l/, and another that will get 'heard' as /r/. The first time an accented bilingual appears to say 'steel' for 'steer', the listener will need to observe that the former doesn't make sense in context, but that the latter includes the perceptually-close phoneme and would make sense. Two possibilities arise for the listener; always considering both items of a minimal pair including the phonemes when one is 'heard' (e.g., pear/pail, snair/snail, flee/free) or developing the ability to perceive differences that the accented speaker may make that use different boundaries from those usually employed by the listener when listening to other 'unaccented' speakers. In either case, over a certain interval of exposure to a given bilingual speaker, one might expect listeners, perhaps some more than others, to devise temporary rules for making such a transformation consistently for a given speaker, in the same way listeners quickly compensate when listening to lisped speech, speech after dental procedures, speech in noise, etc. It is clear from our data that making such transformations is not easy on a task like the current one. However, because our older listeners did not perform significantly worse than our younger listeners, we conclude that, unlike those cognitive procedures that do decline with advancing age, the ability to transform bilinguals' accented speech appears not to decline.

For bilingual speakers who have a distinct non-native accent, we conclude, working to master a more native-like pronunciation can affect listeners' ability to comprehend their speech. This holds true particularly if the content of their talk will not be redundant, and if their listeners are likely to have difficulties hearing them, such as those associated with advanced age and hearing loss, noisy environment, and accented speech.

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Table 1. Group Means and Standard Deviations of Correct Responses (Words)

Groups	Accented Condition		Unaccented Condition	
	Mean	Standard Deviation	Means	Standard Deviation
Young	68.22	7.27	96.77	3.93
Old	62.64	10.46	88.88	9.60

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