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The Effects of Age and Gender on Lipreading Abilities

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Abstract

Age-related declines for many sensory and cognitive abilities are greater for males than for females. The primary purpose of the present investigation was to consider whether age-related changes in lipreading abilities are similar for men and women by comparing the lipreading abilities of separate groups of younger and older adults. Older females, older males, younger females and younger males completed vision-only speech recognition tests of: (1) 13 consonants in a vocalic /i/-C-/i/ environment; (2) words in a carrier phrase; and (3) meaningful sentences. In addition to percent correct performance, consonant data were analyzed for performance within viseme categories. The results suggest that while older adults do not lipread as well as younger adults, the difference between older and younger participants was comparable across gender. We also found no differences in the lipreading abilities of males and females, regardless of stimulus type (i.e., consonants, words, sentences), a finding that differs from some reports by previous investigators (e.g., Dancer, Krain, Thompson, Davis, & Glenn, 1994).

Sumario

El deterioro relacionado con la edad de muchas habilidades sensoriales y cognitivas es mayor para los hombres que para las mujeres. El propósito primario de la presente investigación fue considerar si los cambios relacionados con la edad en la habilidad de leer los labios eran similares para hombre y mujeres, comparando las habilidades de lectura labial de grupos separados de adultos jóvenes y viejos. Mujeres viejas, hombres viejos, mujeres jóvenes y hombres jóvenes completaron pruebas de reconocimiento del lenguaje únicamente por medio de la visión de: (1) 13 consonantes en un ambiente vocálico /i/-C-/i/; (2) de palabras en una frase portadora; y (3) de frases significativas. Además del porcentaje correcto de desempeño, los datos de las consonantes se analizaron en cuanto a desempeño dentro de las categorías de visemas. Los resultados sugieren que mientras los adultos más viejos no leen los labios tan bien como los adultos más jóvenes, las diferencias entre participantes más viejos y más jóvenes fueron comparables entre los géneros. Tampoco encontramos diferencias en las habilidades de lectura labial de hombres y mujeres, sin importar el tipo de estímulo (p.e., consonantes, palabras, frases), un hallazgo que difiere con algunos reportes de investigadores previos (p.e., Dancer, Krain, Thompson, Davis, & Glenn, 1994).

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In recent years, several investigators have suggested that gender differences should be considered when designing an audiologic rehabilitation plan for older adults because men and women appear to differ in at least some of their intervention needs. As examples, males and females diverge in their adjustment to hearing loss (Garstecki & Erler, 1995, 1998, 1999), in their ability to manipulate hearing aids (Meredith & Stephens, 1993), and in their willingness to try amplification (Garstecki & Erler, 1998).

In the present study, we considered gender differences in lipreading, with a particular emphasis on whether differences between men's and women's ability to lipread are similar for older and younger adults. The term "lipreading" as we use it here refers to the act of recognizing speech using only the visual signal (see Tye-Murray, 2004).

Although age-related deficits in lipreading have not been studied extensively, the extant literature suggests that people become less adept at recognizing speech in a vision-only condition as they age (Honneil, Dancer, & Gentry, 1991; Dancer, Krain, Thompson, Davis, & Glenn, 1994; Sommers, Tye-Murray, & Spehar, 2005). Furthermore, there is some evidence that women are better lipreaders than men (Johnson, Hicks, Goldberg, & Myslobodosky, 1988; Dancer et al., 1994; Daly, Bench & Chappell, 1996; Watson, Qui, Chamberlain, & Li, 1996). To our knowledge, however, only one study (Dancer et al., 1994) has investigated whether aging affects the magnitude of gender differences in lipreading. Dancer et al. compared lipreading performance for CID everyday sentences in 5 groups of 10 participants each (5 males, 5 females) stratified in age across 5 decades (e.g., 20-29, 30-39, 40-49, 50-59, and 60-69). The participants who were 59 yrs and younger had normal hearing while the participants who were 60 yrs and older had a pure-tone-average (PTA = average thresholds for 500 Hz, 1000 Hz, and 2000 Hz) of 30 dB or better. Comparison across the two extreme groups (20-29 versus 60-69) indicated that older adults were poorer lipreaders than young adults and that females tended to have higher lipreading scores than males. Although there was a slight trend for smaller age differences in females than in males, overall performance for the older adults was at floor, making it difficult to interpret interactions between age and gender.

One reason to suspect that men might demonstrate more rapid declines in their lipreading abilities than women is that they show a greater decline in their auditory skills. Previous investigators have found that men decline more rapidly than women in their auditory sensitivity and in their ability to recognize words in an auditory-only condition (e.g., Eisdorfer & Wilkie, 1972; Jerger, 1973; Milne, 1977; Royster, Royster, & Thomas, 1980; Gates, Cooper, Kannel, & Miller, 1990; Morrell et al., 1996). It is possible that the perceptual systems of males are more susceptible to the aging process than are those of women. The fact that age-related cognitive declines are often greater for males than for females (Feinson, 1987; Jerger, Chmiel, Allen, & Wilson, 1994; Morrell, Gordon-Salant, Pearson, Brant, & Fozard, 1996; Meinz & Salthouse, 1998) lends support to this suggestion, indicating that men are more susceptible to age-related declines in general than are women. In this experiment, we were concerned with how vision-only speech recognition changes as a function of age, even when auditory skills remain intact. Specifically, we sought to determine whether older men and women who retain good hearing acuity also retain good visual-only speech recognition skills.

Figure 1 depicts three possible scenarios of how age might affect lipreading performance for the two genders. Based on the literature reviewed above, each panel in Figure 1 indicates that younger adult females are better lipreaders than their age-matched male counterparts and that aging decreases lipreading performance. The panel on the far left (panel A) indicates the pattern of results that would be observed if aging has comparable effects on men and women. In this scenario, women start out as better lipreaders than men and demonstrate comparable change as a function of age. Panel B indicates the set of results that would be obtained if aging has greater effects on men than on women. In this scenario, women start out as better lipreaders and this gender difference increases with aging. Finally, panel C indicates the set of results that would be obtained if aging has greater effects on women than on men. In this scenario, women start out as better lipreaders but show greater declines as a function of age.

In the present investigation we extended the results of Dancer et al. (1994) and determined which of the three scenarios presented in Figure 1 might best characterize the way in which gender and age interact with lipreading performance. Dancer et al. evaluated only 5 older males and 5 older females (over the age of 60 yrs), and

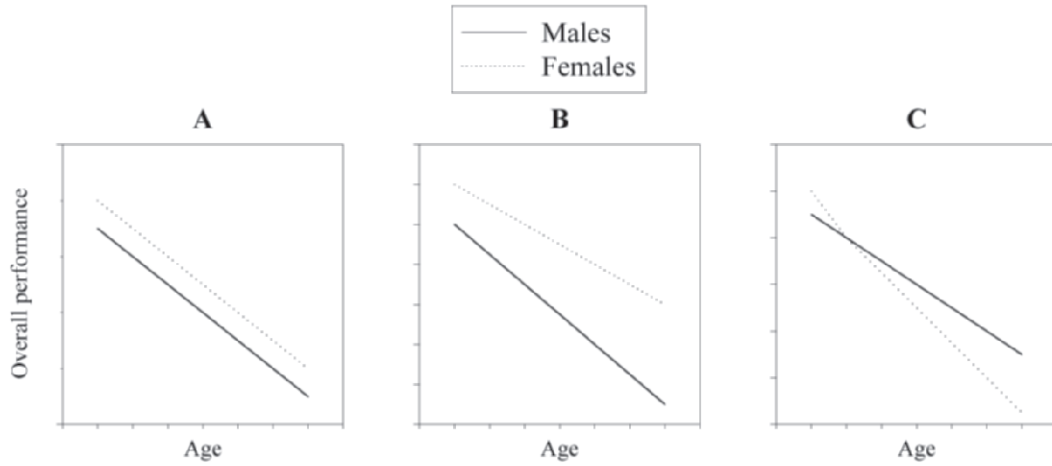

Figure 1. Three potential patterns of results for the current study. The reduced performance for older adults in all three panels reflects previous findings that older adults are poorer lipreaders than are younger adults. The difference between males and females in each panel reflects a general trend in the literature for men to exhibit poorer lipreading than women.

their conclusions were limited by a floor performance on the sentence testing. We tested a large number of participants and used an array of speech stimuli. Previous work from our laboratory (Sommers et al., 2005) has demonstrated that older adults can obtain above-floor performance for both consonants and words. We therefore tested older and younger men and women on lipreading performance for consonants (in a vowel-consonant-vowel environment), words (in a standard carrier phrase), and sentences. Based on previous findings of greater sensory and cognitive declines for men than for women, the working hypothesis for the current study is represented by panel B in Figure 1, where gender differences increase for older compared with younger adults.

METHODS

Participants

One hundred and twenty-two adults participated in the investigation (82 of these subjects are reported in Sommers et al., 2005). Thirty-six were older females (OF, mean age 73.0 yrs, range = 65-80, SD = 4.1), 32 were younger females (YF, mean age 21.7 yrs, range 18-25, SD = 1.9), 24 were older males (OM, mean age 73.0, range = 65-85, SD = 5.4), and 30 were younger males (YM, mean age 20.7 yrs, range = 18-27, SD = 2.1). The younger participants were all students at Washington University and were recruited through posted advertisements. The older participants were community-dwelling residents recruited either through the database maintained by the Aging and Development Program at Washington University or the database maintained by the Volunteers for Health at Washington University School of Medicine. Mean years of education for the four groups was as follows: OF = 13.4 yrs, SD = 2.2; OM = 15.5 yrs, SD = 3.1; YF = 15.4 yrs, SD = 1.6; YM = 14.2, SD = 1.5. A two-way analysis of variance (ANOVA), with the independent variables of age group and gender, indicated no significant differences in years of education for either age group or gender. All participants reported that English was their first language and that they had never participated in lipreading training. Participants received $10/hr for taking part in the experiment.

To exclude older participants with either mild cognitive impairment or who were experiencing the initial stages of a dementing illness, all older participants had to score a minimum of 24 (out of 30) on the Mini Mental Status Exam (Folstein et al., 1975). In addition, participants who reported a history of central nervous system (CNS) disorder or who were currently taking drugs that affect CNS function were excused from the experimental protocol. Verbal abilities were screened with the Wechsler Adult Intelligence Scale (WAIS) vocabulary subtest, which has a maximum score of 66. Mean scores for the four groups were: OF = 45.3 (SD = 8.3), YF = 55.7 (SD = 4.4), OM = 50.4 (SD = 8.3), and YM = 53.1 (SD = 6.0). A two-way ANOVA with the independent variables of age group and gender revealed that younger adults had significantly higher WAIS vocabulary scores than older adults ($F(1,101) = 21.38$, $p < .001$) but there was no significant difference in WAIS scores for gender ($F(1, 101) = .783$, $p = .378$). The main effect of age, however, must be considered in light of a significant interaction between age and gender ($F(1, 101) = 7.59$, $p < .001$). Post-hoc comparisons with a Bonferroni correction for multiple comparisons indicated that WAIS vocabulary scores did not differ significantly between older and younger males ($p = .27$) but that younger females had higher vocabulary scores than older females ($p < .001$).

All participants were screened for visual acuity and visual contrast sensitivity. Visual acuity was measured using a Snellen eye chart (Wade & Swanston, 2001) and contrast sensitivity was measured using the Pelli-Robson Contrast Sensitivity Chart (Pelli et al., 1998). If participants reported that they wore corrective lenses (glasses or contacts), testing was conducted with those in place. Only participants who had normal or corrected visual acuity equal to or better than 20/40 and contrast sensitivity equal to or better than 1.8 were included.

All participants reported having normal hearing. Of the 122 people who participated in the study, all of the older adults (54) and 43 of the younger (31 female, 12 males) were screened to exclude hearing losses above a PTA of 25 dB HL and an inter-octave slope of greater than 15 dB. Individuals with asymmetric hearing losses (defined as greater than a 15-dB difference in thresholds between the two ears for each frequency tested) were also excluded. Mean PTA were: OF = 13.6 dB HL (SD = 6.0), YF = 1.0 dB HL (SD = 4.2), OM = 14.6 dB HL (SD = 6.6), and YM = 2.0 dB HL (SD = 6.1). A two-way ANOVA with the independent variables of age group and gender revealed that PTAs were higher for older than for younger adults ($F(1, 99) = 106.19$, $p < .001$). No significant differences in PTAs were observed for gender ($F(1,99) = .736$, $p = .393$), and the interaction between gender and age ($F(1, 98) = .001$, $p = .993$) was also not significant.

As noted, a significant number of young adults (25) did not have hearing screenings. These individuals were tested as part of a different study on lipreading that did not require information regarding hearing status. Although all of the participants indicated that they had normal hearing and had never been diagnosed with a hearing-related problem, it is possible that one or more may have had an undiagnosed mild hearing loss. Therefore, all of the analyses reported below were conducted first using the subset of participants who had hearing data available (n =97) and then again with the full complement of 122 participants. In no case did the pattern of results or level of significance differ between the full set of 122 participants and the subset of 97 with complete hearing data. This similarity was not surprising, given that the two samples both included young adults who reported no hearing problems and no history of audiological difficulties. In the remainder of the analyses we report data for the full set of participants because of the increased statistical power and its importance in evaluating potential null results.

Stimuli and Procedures

Participants were tested in a sound-treated room. Stimuli were presented via a PC (Dell 420) equipped with a Matrox (Millennium G400 Flex) 3D video card. Video configuration was in dual screen mode so that stimuli could be presented to participants in the test booth while the experimenter monitored session progress. The test stimuli consisted of consonants, words, and sentences. The word and sentence tests, described below, contained vocabulary that would be familiar to the participants. Some of the subjects were tested as a part of a larger experiment to assess age differences in auditory-visual speech perception that required testing visual-only performance in a background of babble. Thus, to equate testing conditions across all participants (including those not tested as part of the larger study) we measured lipreading performance for all conditions in the presence of a 6-talker background babble that had an average level of 67 dB SPL. It is important to note that only the multi-talker babble was presented as an auditory stimulus (i.e., there was no auditory presentation of the stimulus). In a pilot study, we addressed the issue of whether lipreading performance would be affected by background speech babble differentially for older and younger lipreaders by comparing the lipreading performance of 42 older adults and 26 younger adults (all of whom met the subject criteria described above) in quiet versus six-talker babble using the same word test and a similar sentence test, the City University of New York (CUNY) sentence test (Boothroyd, Hanin, & Hnath-Chisholm, 1985) and the same procedures as used in the main experiment. Both groups in the pilot study demonstrated poorer lipreading performance for items presented in background speech babble than for stimuli presented in quiet. (Similar findings for younger adults have been reported by Markides, 1989, although Brungart & Simpson, 2005, and Lyxell & Ronnberg, 1993, showed that a background narrative by a single talker had no effect on adults' lipreading performance, where participants' ages ranged from 21 to 55 yrs). Importantly for the present study, no significant interactions with age were revealed in the pilot experiment for either words ($F(2, 67) = 1.045$, $p = .355$) or sentences ($F(2, 67) = .354$, $p = .703$). These findings indicate that older and younger adults have comparable susceptibility to the presence of background noise when they attempt to lipread.

Consonants

Participants viewed 42 repetitions of 13 consonants (a total of 546 stimuli) in an /i/-C-/i/ context, in a closed-set format. The consonants were: m, n, p, b, sh, t, d, g, f, v, z, s, and k (e.g., participants saw an individual saying the stimuli "eemee," "eenee," etc.). The stimuli were all spoken by a young adult male talker who had a Midwest American dialect. The head and shoulders of the talker were filmed with high-intensity studio lighting before a neutral background. The resultant image afforded a clear view of the speaker's face, mouth, tongue, and teeth. The items came from existing Laserdisc recordings of the Iowa Consonant Test (see Tyler, Preece, & Tye-Murray, 1986, for additional details). They were digitized by connecting the output of the Laserdisc player (Laservision LD-V8000) into a commercially available PCI interface card for digitization (Matrox RT2000). Video capture was 24-bit, 720x480 in NTSC-standard 4:3 aspect ratio and 29.97 frames per second to best match the original analog version.

During a test session, a participant was seated in the sound-treated room within arm's distance of a touch screen monitor (ELO ETC-170C). The talker's head and shoulders appeared on the screen and the talker articulated a stimulus. Immediately after stimulus presentation, a closed-set of the thirteen consonant choices appeared on the monitor (e.g., participants saw "eebee" as one of the response choices). Participants were asked to respond by touching the response area containing the consonant they perceived. Prior to testing, participants received each test consonant in practice, with both the visual and the corresponding auditory signal. Testing did not commence until a participant was able to identify all 13 consonants in an audiovisual condition. Younger and older adults required similar amounts of practice to meet this criterion. No feedback was provided during testing.

Words

Words from the analog recordings of the Children's Auditory Visual Enhancement Test (CAVET; Tye-Murray & Geers, 2001) were digitized using the same equipment and procedures as for the consonant stimuli. The CAVET consists of three lists of 20 words and a practice list of three words. The stimulus words have between one and three syllables, and are embedded in the carrier phrase, "Say the word…" Stimulus selection for the CAVET was based on two considerations. First, the words were selected based on a survey of elementary school teachers who work in an oral deaf school to be within the vocabulary of a typical fourth grader who has hearing loss. Thus, all of the words were likely to be highly familiar to our younger and older adults who have normal hearing. Second, the CAVET was developed to avoid the problem of floor performance that can occur on tests of visual-only lipreading. The items were selected such that half of the target words in each list can be considered relatively easy to lipread (e.g., basketball) while the remaining half are more difficult to identify in a vision-only condition (e.g., hill). Briefly, the distinction between easy and hard words was based on findings from Tye-Murray and Geers (2001) in which they tested 100 undergraduate students' ability to lipread the stimulus items. Subsequent research with the CAVET (Spehar, Tye-Murray & Sommers, 2004) has shown that mean percent correct for the items designated as "easy" words was 48%, compared with 15% for items designated as "hard" words. List equivalency was also assessed during test development, with scores on the three lists of 35% (SD=12), 38% (SD=10), and 31% (SD=13), for lists A, B, and C respectively, when tested in the vision-only condition (see Tye-Murray & Geers, 2001, for additional details on test development). Additionally, in the current investigation, a two-way ANOVA with age and presentation list as independent variables was used to compare scores across the three lists (List A, n = 21 older and 19 young; List B, n = 19 older and 22 young; List C, n = 20 older and 21 young) and no differences in performance were observed across lists ($F(2, 116) = .449$, $p = .634$). Lists were counterbalanced such that approximately an equal number of participants in each of the age/gender conditions (OF, YF, OM, YM) viewed each of the three lists. Based on the absence of list differences and the counterbalancing of lists across participant groups, all subsequent analyses were conducted with scores combined across lists. All items were spoken by a young female talker who had a Midwest American dialect. As with the consonants, participants viewed the head and shoulders of the talker, filmed with high-intensity studio lighting before a neutral background.

Participants were tested in the same room as for the consonants, with the same equipment. They were instructed to repeat the word aloud after the talker spoke it. Guessing was encouraged. In order for a response to be scored as correct, a participant had to say the word verbatim.

Sentences

Sentence stimuli were digitized from the Laserdisc recording of the Iowa Sentence Test (Tyler et al., 1986) using the same equipment and procedures as for the consonants and words. The original version of the Iowa Sentence Test is comprised of 100 sentences, spoken by a total of 20 adult talkers with a Midwest American dialect (10 female, 10 male), with each talker speaking five sentences. The vocabulary was selected from the sentence lists developed by Bench and Bamford (1979), who included only common-usage words that had been shown to be familiar to children who have significant hearing loss. Lighting and background conditions were similar to those used for the consonants (also see Tyler et al., 1986). We created five lists of 20 sentences each, such that each list included one sentence spoken by each of the 20 talkers and each list included approximately the same number of words. Thus, within a list, participants saw a new talker on every trial. Two of the lists were used for practice while the remaining three were used for testing. Lists were counterbalanced across the four subject groups. An approximately equal number of participants in each group viewed each list. Similar to the CAVET scores, results of a one-way ANOVA comparing performance on each list (List A, n = 41; List B, n=39; List C, n=42) failed to find a significant difference between lists ($F(2,119) = .816$, $p = .445$). Therefore, presentation list was not considered in the comparison of group scores for the sentence material. Testing occurred in the same sound-treated booth and with the same equipment as for the consonants and words. Participants were asked to repeat the sentence and were encouraged to guess if they were unsure of an item. Scoring was based on 5-7 key words in each sentence and responses had to be verbatim in order to be counted as correct.

RESULTS

In this section, we first present findings for overall accuracy (i.e., percent correct consonants, words, and sentences) followed by a more detailed analysis based on visemes (i.e., speech elements that look identical when lipreading) for the consonants. Figure 2 displays percent correct identification for each stimulus type as a function of gender and age group. Because of differences in presentation format, response format, and number of talkers for each stimulus type, separate analyses were conducted for the consonants, words and sentences.

Consonants

A two-way ANOVA with age (young versus old) and gender (male versus female) as independent-measures variables was performed on the consonant data. Young adults performed significantly better than older adults ($F(1, 118) = 38.8$, $p < .001$), but no difference was observed between male and female performance ($F(1, 118) = 2.4$, $p = .127$). The interaction between age and gender was not significant ($F(1, 118) < 1$, $p = .92$), indicating that males and females showed the same decline in lipreading performance as a function of age.

Words

Results for lipreading words in a carrier phrase were similar to the findings with consonants. Older adults performed significantly poorer than young adults ($F(1, 118) = 24.4$, $p < .001$), but no difference was observed between performance for males and females ($F(1, 118) = 3.6$, $p = .06$) and the interaction of age and gender was not significant ($F(1, 118) < 1$, $p = .63$).

Sentences

The findings for the sentence test also paralleled the results for consonants and words, with significant effects of age ($F(1, 118) = 21.3$, $p < .001$) but no significant effect of gender ($F(1, 118) = 1.374$, $p = .244$) and no age x gender interaction $F(1, 118) < 1$, $p =.36$). The sentence data, however, need to be interpreted somewhat cautiously as overall performance levels were near floor.

Some English consonants are homophenous and cannot be distinguished in visual-only formats (Erber, 1974; Lesner, Sandridge, & Kricos, 1987). Therefore, it may be more appropriate to analyze lipreading performance for consonants in the /i/-C-/i/ context according to viseme categories (groups of phonemes, such as /f/ and /v/ that are indistinguishable based on visual-only information because they appear similar on the face and lips). We thus analyzed the consonant data[1] for age group and gender differences as a function of viseme groups. One difficulty in obtaining measures based on viseme categories is that a number of factors, including talker characteristics, speaking rate, vowel context, and speaking style, can significantly influence the number of distinguishable viseme categories (see Kricos & Lesner, 1982, 1985, for evidence that talker differences can dramatically affect the number of available viseme categories). In the current study, viseme groups were first established based on the categories identified by Lesner et al. (1987). For the 13 consonants tested, this categorization produced four groups of visemes: Group 1 consisted of /b/, /p/, and /m/; Group 2 consisted of /v/ and /f/; Group 3 consisted of /n/, /d/, /t/, /s/, /z/, /k/, and /g/; Group 4 had only one member, /ʃ/.

Figure 3 displays percent correct identification for each viseme group as a function of gender and age group. Scores in each group were first analyzed using a three-way ANOVA with age group, gender, and viseme group included as independent variables. Results were similar to the results with the overall V-only phoneme (consonant) scores, whereby young adults performed significantly better than older adults ($F(1, 472) = 65.6, p<.001$), but there was no main effect for gender ($F(1, 472) = 2.2, p=.137$). The ANOVA also indicated a difference between viseme groups ($F(3, 472) = 70.1, p<.001$), suggesting that some visemes are easier to identify than others. Further, the two-way interaction between age group and viseme group ($F(3, 472) = 30.7, p=.001$), along with the three-way interaction between age group, gender, and viseme group ($F(3, 472) = 3.7, p=.011$), both reached significance.

For further analysis, each of the four viseme categories was analyzed for age and gender differences using a separate two-way ANOVA similar to the consonant analysis described above (i.e., with age and gender as independent-measures variables). Results indicated that young adults performed significantly better than older adults in recognizing three of the four viseme types: /b/, /p/, and /m/ ($F (1, 118) = 6.7, p = .010$); /n/, /d/, /t/, /s/, /z/, /k/, and /g/ ($F (1, 118) = 28.1, p < .001$); and /ʃ/ ($F (1, 118) = 44.5, p < .001$). One exception to this pattern was that the /v/ and /f/ viseme group did not show an age-related difference ($F (1, 118) = 1.029, p = .313$). This category was the easiest for all groups (M = 52.1%), suggesting that age differences in lipreading, at least based on viseme analyses, may emerge only for more difficult visual-only discriminations. The only significant interaction that was obtained across the four viseme categories was that for the single-member viseme group (/ʃ/) a significant interaction between age and gender was observed ($F (1, 118) = 4.1, p = .045$). Post-hoc analysis using a Bonferroni/ Dunn correction for multiple comparisons indicated that the interaction was due to a larger age-related difference between the females than among the males.

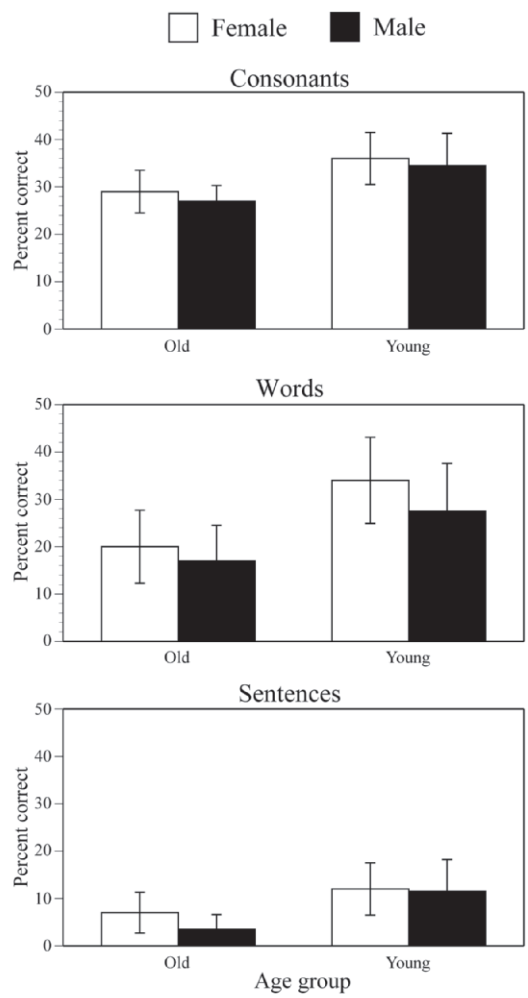

Figure 2. (*Top*): Mean percent correct visual-only consonant identification for older and younger females and older and younger males. Note that all stimuli were spoken by a single male talker and responses were made based on a 13-item closed set format. (*Middle*): Same as the top panel except data are for words presented in a carrier phrase, response format was open set, and a single female talker presented all of the items. (*Bottom*): Same as middle panel except data are for key word identification and stimuli were spoken

One potential concern in applying the viseme categorization scheme from Lesner et al. (1987) to the current data is that Lesner et al. based their groupings on consonant confusions obtained in an /a/-C-/a/ context, whereas our results were obtained in an /i/-C-/i/ environment. To determine if the Lesner et al. scheme was appropriate for the current data, we conducted a hierarchical cluster analysis (nearest neighbor method, based on squared Euclidean distance) on the consonant confusion data obtained from our older and younger participants. Separate analyses were conducted for older and younger adults to allow for the possibility that age would alter viseme clustering. In all cases, viseme clustering was identical for older and younger adults. Results from the cluster analysis suggested that a four-category solution supported the categorization scheme of Lesner et al. (1987) for the current data. In the six-category solution, however, the largest cluster (n,d,t,s,z,k,g) was sub-divided into three separate categories consisting of /n,d,t /, /s,z/, and /k,g/.

Figure 4 displays percent correct visemes for the subgroups /n,d,t/, /s,z/, and /k,g/. An ANOVA conducted on the data from the 3 viseme categories displayed in Figure 4 indicated a pattern of findings similar to that observed in the four-category solution. Specifically, performance differed significantly for the three viseme groups ($F(2, 236) = 123.7$, $p < .001$). Post-hoc comparisons with a Bonferroni correction for multiple comparisons indicated that scores for the /s,z/ group were significantly higher than for the /n,d,t/ group, which in turn were significantly higher than for the /k,g/ group ($p < .001$ for all comparisons). As with the four-category analysis, older adults performed significantly worse than young adults ($F(1,118) = 27.4$, $p < .001$), but scores did not differ for males and females. Only one interaction, between age and viseme reached significance ($F(2, 236) = 6.1$, $p < .01$). Pairwise comparisons with a Bonferroni correction for multiple comparisons indicated that older adults performed significantly poorer than young adults for the /n,d,t/ and /k,g/ groups ($p < .001$ for both comparisons), but not for the /s,z/ category. Note that, consistent with the viseme analysis for all stimuli, significant age differences were again found only for the more difficult discriminations (scores for both the /n,d,t/ and /s,z/ groups were significantly lower than for the /s,z/ group).

DISCUSSION

The primary goal of the present investigation was to determine whether age-related changes in lipreading abilities are similar for men and women who retain normal hearing acuity. The findings suggest that whereas both older adult males and females performed less

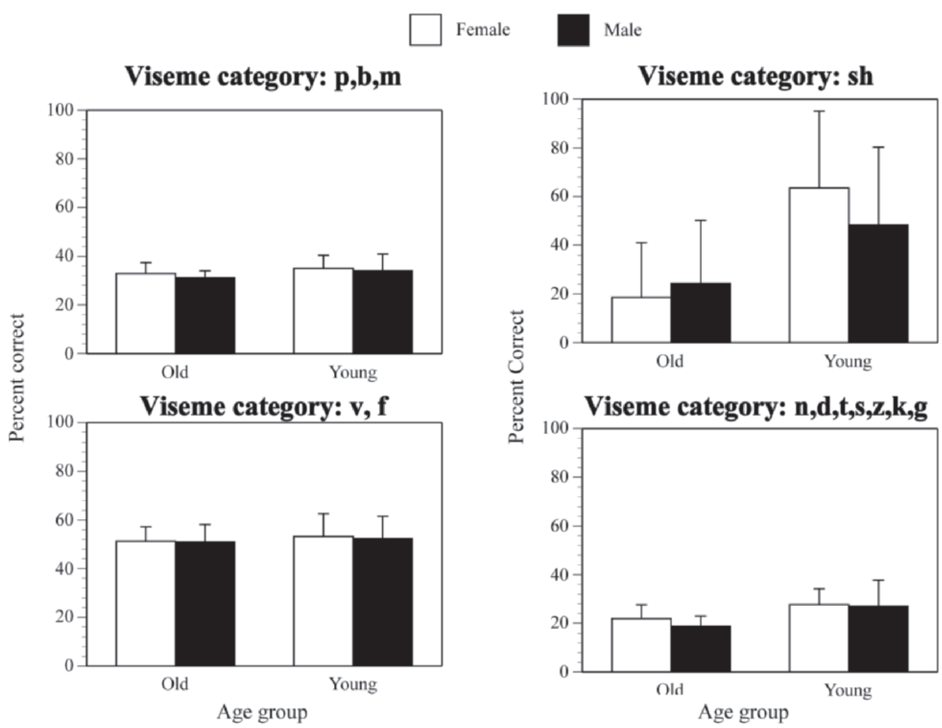

Figure 3. Means and standard deviations for older and younger females and older and younger males for the four consonant viseme categories. Error bars indicate standard deviation.

well than their younger counterparts, the differences between younger and older adults did not vary with gender. In future investigations, it will be worthwhile to examine older individuals who have incurred age-related hearing loss and to test lipreading skills in quiet instead of in the presence of babble. It is possible that older women and men with presbycusic hearing loss might differ in their lipreading skills and/or in their susceptibility to interference from the presence of background noise.

None of the gender differences reached statistical significance, although there was a slight trend for females to perform better than males on the lipreading tasks. This finding stands in contrast to previous results (Dancer et al., 1994; Johnson et. al, 1988). Johnson et al. (1988), for instance, compared lipreading performance for young adult males and females using consonants (presented in an /a/-C-/a/ environment), isolated words, and common phrases. With the exception of isolated words (where performance was near ceiling for both men and women), Johnson et al. found better lipreading performance in females than in males. One explanation for the discrepancy between previous findings and the current results is that there may indeed exist a gender difference, but the difference is slight. For example, Johnson et al. reported a difference of approximately 13% between young males and females lipreading isolated words, whereas in the current study young females scored approximately 8% higher than young males for words in a carrier phrase. Variability, as assessed with standard deviations, however, was considerably lower both for males and females in the Johnson et al. experiment than in the present investigation, suggesting that high variability contributed to the absence of significant gender differences in the present study. In sum, it may be that the difference between the two genders is subtle and difficult to detect given the extensive variability associated with measures of lipreading.

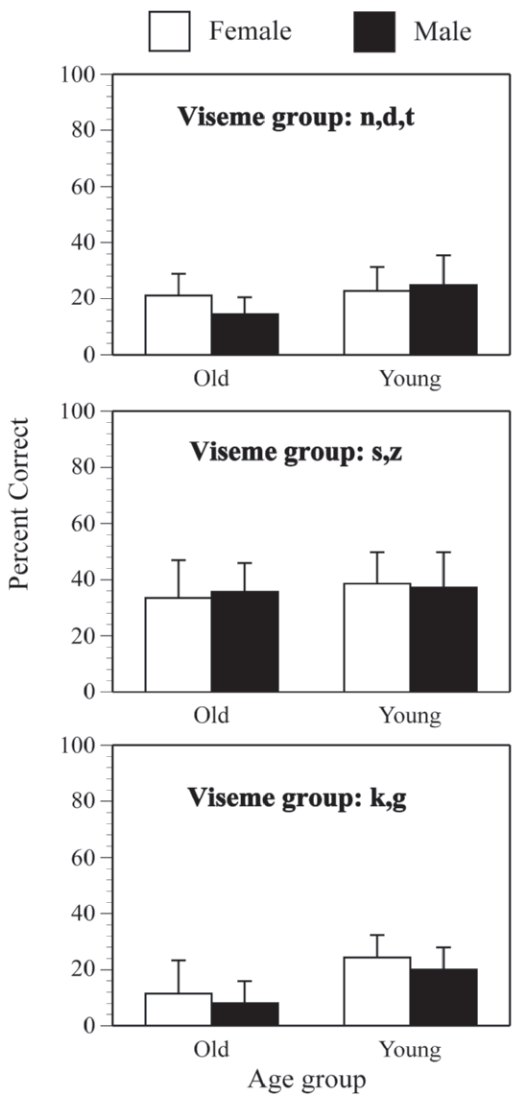

Figure 4. Same as Figure 3 except that means and standard deviations are for the new viseme categories to emerge from a hierarchical cluster analysis using six, rather than four viseme categories.

Although data from Dancer et al. (1994) indicated a trend for greater age-related declines in lipreading sentences for males than for females, both their results and the sentence findings from the current study are limited by near-floor level performance for all participants. Thus, to our knowledge, the current findings for consonants and words, indicating similar age-related declines for males and females, represent the first demonstration that aging does not differentially affect lipreading abilities for men and women under conditions that produce a good range of performance levels.

Finally, the present results suggest that audiologic rehabilitation interventions for older men and women should include similar content in terms of lipreading. Any differences in approach for gender might focus instead on known gender-related differences (Garstecki & Erler, 1995, 1998, 1999; Meredith & Stephens, 1993; Garstecki & Erler, 1998). Overall, however, the counseling component of the intervention program might explain to older persons that aging is often accompanied by a decrease in lipreading ability. As such, everyday conversation might be more difficult both because one's hearing has declined as well as one's ability to extract speech information by watching the talker's face.

NOTE

1. To our knowledge there is no validated system for categorizing visemes within words presented in a carrier phrase or within sentences. Therefore, viseme analyses were restricted to the consonant data.

REFERENCES

Bench J, Bamford J. (1979) *Speechreading Tests and the Spoken Language of Hearing-Impaired Children*. London: Academic Press.

Boothroyd A, Hanin L, Hnath-Chisholm T. (1985) *The CUNY Sentence Test*. New York: City University of New York.

Brungart DS, Simpson BD. (2005) Interference from audio distracters during speechreading. *J Acoust Soc Am* 118:3889–3902.

Daly N, Bench J, Chappell H. (1996) Gender differences in speechreadability. *J Acad Rehabil Audiol* 29:27–40.

Dancer J, Krain M, Thompson C, Davis P, Glenn J. (1994) A cross-sectional investigation of speechreading in adults: effects of age, gender, practice, and education. *Volta Rev* 96:31–40.

Eisdorfer C, Wilkie F. (1972) Auditory changes in the aged: a follow-up study. *J Am Geriatr Soc* 20:377–382.

Erber NP. (1974) Visual perception of speech by deaf children: recent developments and continuing needs. *J Speech Hear Disord* 39:178–185.

Feinson MC. (1987) Mental health and aging: are there gender differences? *Gerontologist* 27:703–711.

Folstein MF, Folstein SE, McHugh PR. (1975) Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. *J Psych Res* 12:189–198.

Garstecki DC, Erler SF. (1995) Older women and hearing. *Am J Audiol* 4:41–46.

Garstecki DC, Erler SF. (1998) Hearing loss, control, and demographic factors influencing hearing aid use among older adults. *J Speech Lang Hear Res* 41:527–537.

Garstecki DC, Erler SF. (1999) Older adult performance on the Communication Profile for the Hearing Impaired: gender difference. *J Speech Lang Hear Res* 42:785–796.

Gates GA, Cooper JC, Kannel WB, Miller NJ. (1990) Hearing in the elderly: the Framingham Cohort, 1983–1985. *Ear Hear* 11:247–256.

Honneil S, Dancer J, Gentry B. (1991) Age and speechreading performance in relation to percent correct, eyeblinks, and written responses. *Volta Rev* May:207–212.

Jerger J. (1973) Audiological findings in aging. *Ad Otorhinolaryngol* 20:115–124.

Jerger J, Chmiel R, Allen J, Wilson A. (1994) Effects of age and gender on dichotic sentence identification. *Ear Hear* 15:274–286.

Johnson FM, Hicks LH, Goldberg T, Myslobodosky MS. (1988) Sex differences in lipreading. *Bull Psychon Soc* 26:106–108.

Kricos PB, Lesner SA. (1982) Differences in visual intelligibility across talkers. *Volta Rev* 84:219–225.

Kricos PB, Lesner SA. (1985) Effect of talker differences on the speechreading of hearing-impaired teenagers. *Volta Rev* 87:5–14

Lesner K, Sandridge S, Kricos P. (1987) Training influences on visual consonant and sentence recognition. *Ear Hear* 8:283–287.

Lyxell B, Ronnberg J. (1993) The effects of background noise and working memory capacity on speechreading performance. *Scand Audiol* 22(2):67–70.

Markides A. (1989) Background noise and lip-reading ability. *Br Audiol* 23:251–253.

Meinz EJ, Salthouse TA. (1998) Is age kinder to females than to males? *Psychon Bull Rev* 5:56–70.

Meredith R, Stephens D. (1993) In-the-ear and behind-the-ear hearing aids in the elderly. *Scand Audiol* 22:211–216.

Milne JS. (1977) A longitudinal study of hearing loss in older people. *Br J Audiol* 11:7–14.

Morrell CH, Gordon-Salant S, Pearson JD, Brant LJ, Fozard JL. (1996) Age- and gender-specific reference ranges for hearing level and longitudinal changes in hearing level. *J Acoust Soc Am* 100:1949–1967.

Pelli D, Robson J, Wilkins A. (1998) The design of a new letter chart for measuring contrast sensitivity. *Clin Vis Sci* 2:187–199.

Royster LH, Royster JD, Thomas WG. (1980) Representative hearing levels by race and sex in North Carolina industry. *J Acoust Soc Am* 68:551–566.

Sommers M, Tye-Murray N, Spehar B. (2005) Auditory-visual speech perception and auditory-visual enhancement in normal-hearing younger and older adults. *Ear Hear* 26:263–275.

Spehar BP, Tye-Murray N, Sommers MS. (2004) Time-compressed visual speech and age: a first report. *Ear Hear* 25:565–557.

Tye-Murray N. (2004) *Foundations of Audiologic Rehabilitation: Children, Adults, and Their Family Members*. 2nd edition. New York: Thompson Delmar Learning.

Tye-Murray N, Geers A. (2001) *Children's Audio-visual Enhancement Test (CAVET)*. St. Louis, MO: Central Institute for the Deaf.

Tyler R S, Preece J, Tye-Murray N. (1986) *The Iowa Laser Videodisk Tests*. Iowa City, IA: University of Iowa Hospitals.

Wade NJ, Swanston MT. (2001) *Visual Perception: An Introduction*. 2nd edition. Philadelphia: Psychology Press.

Watson CS, Qui WW, Chamberlain MM, Li X. (1996) Auditory and visual speech perception: confirmation of a modality-independent source of individual differences in speech recognition. *J Acoust Soc Am* 100:1153–1162.