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Research Article

Effects of Familiarization on Intelligibility of Dysarthric Speech in Older Adults With and Without Hearing Loss

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Purpose: Familiarization tasks offer a promising platform for listener-targeted remediation of intelligibility disorders associated with dysarthria. To date, the body of work demonstrating improved understanding of dysarthric speech following a familiarization experience has been carried out on younger adults. The primary purpose of the present study was to examine the intelligibility effects of familiarization in older adults.
Method: Nineteen older adults, with and without hearing loss, completed a familiarization protocol consisting of three phases: pretest, familiarization, and posttest. The older adults' initial intelligibility and intelligibility improvement scores were compared with previously reported data collected from 50 younger adults (Borrie, Lansford, & Barrett, 2017a).
Results: Relative to younger adults, initial intelligibility scores were significantly lower for older adults, although additional analysis revealed that the difference was limited to older adults with hearing loss. Key, however, is that irrespective of hearing status, the older and younger adults achieved comparable intelligibility improvement following familiarization (gain of roughly 20 percentage points).
Conclusion: This study extends previous findings of improved intelligibility of dysarthria following familiarization to a group of listeners who are critical to consider in listener-targeted remediation, namely, aging caregivers and/or spouses of individuals with dysarthria.

Dysarthria, a motor speech disorder arising from neurological damage or disease, is broadly characterized by articulatory imprecision, prosodic disturbance, abnormal vocal quality, and/or resonance and often results in intelligibility disorders. Due to the progressive nature of several common causes of dysarthria (e.g., amyotrophic lateral sclerosis and Huntington's disease), some speakers with dysarthria may not be ideal candidates for traditional behavioral intervention approaches that target reduced intelligibility by improving speech production. Further, concomitant physical, cognitive, and memory impairments that regularly arise with progressive neurological disease may greatly reduce an individual's capacity to learn and maintain benefits from traditional speaker-oriented interventions (Duffy, 2013). These limitations have led some to propose an alternate approach, one that targets reduced intelligibility present in dysarthria through interventions that focus on the listener rather than the speaker (e.g., Borrie, McAuliffe, & Liss, 2012; Liss, 2007).

The primary aim of listener-targeted remediation is to offset the intelligibility burden associated with dysarthria from the speaker onto the listener (e.g., caregiver, practitioner, and clinician). Familiarization paradigms offer a promising platform for listener-targeted remediation. Briefly, such paradigms involve a familiarization or exposure experience, in which feedback may or may not be provided, to train listeners with an individual's specific speech pattern (e.g., Borrie, McAuliffe, Liss, Kirk, et al., 2012; Borrie & Schäfer, 2015). Though the precise mechanism underlying improved speech recognition following familiarization is unclear, it is presumed that experience affords listeners an opportunity to retune their stored linguistic representations to facilitate mapping of the degraded acoustic signal (Samuel & Kraljic, 2009). Familiarization tasks have been demonstrated to improve listeners' understanding of foreign-accented (e.g., Bradlow & Bent, 2008; Clarke & Garrett,

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2004; Sidaras, Alexander, & Nygaard, 2009), hearing-impaired (e.g. McGarr, 1983), noise-vocoded (e.g., Davis & Johnsrude, 2007; Loebach, Bent, & Pisoni, 2008), time-compressed (Dupoux & Green, 1997), and, importantly, dysarthric speech (e.g., Borrie, McAuliffe, Liss, Kirk, et al., 2012; Lansford, Borrie, & Bystricky, 2016; Liss, Spitzer, Caviness, & Adler, 2002). This body of evidence demonstrating that prior experience with noncanonical speech facilitates improved recognition of that signal during subsequent encounters supports the continued investigation of listener-targeted remediation approaches for improving intelligibility of dysarthric speech.

To date, much of the work demonstrating improved understanding of dysarthric speech following familiarization has utilized convenience samples of younger, healthy adults with normal hearing recruited from the affiliated universities and the local community (e.g., Borrie, Lansford, & Barrett, 2017a; Lansford et al., 2016; Liss et al., 2002). These studies have allowed researchers to build well-controlled models of how the listener understands and adapts to degraded speech. Diseases resulting in dysarthria (e.g., neurodegenerative disease and stroke), however, often occur later in life. Thus, the older adult population, namely, the aging spouses, friends, and caregivers of individuals with dysarthria, would particularly benefit from familiarization.

There is reason to hypothesize that the significant benefit of familiarization with dysarthric speech achieved by the younger adults studied to date may not be achieved by the aging population. Previous research suggests that understanding spoken language, particularly in difficult listening situations (e.g., speech in noise and foreign-accented speech), may be affected by age-related factors, including hearing loss and declines in cognitive function (e.g., Gordon-Salant & Fitzgibbons, 2004; Gordon-Salant, Yeni-Komshian, & Fitzgibbons, 2010; Wingfield, Tun, & McCoy, 2005). Indeed, relative to younger adults, older adults, with and without hearing loss, experience greater difficulty understanding speech in noise and foreign-accented speech (e.g., Dubno, Dirks, & Morgan, 1984; Gordon-Salant & Fitzgibbons, 1995; Ingvalson, Lansford, Fedorova, & Fernandez, 2017; Schneider, Daneman, Murphy, & See, 2000; Souza, Arehart, Shen, Anderson, & Kates, 2015). In addition, the cognitive mechanisms supporting perception of speech in difficult listening conditions may be different for younger and older adults. For example, Ingvalson et al. (2017) observed that success with understanding accented speech in younger adults was supported by an interaction between processing speed and hearing acuity. However, greater cognitive resources were found to support older adults' perception of accented speech, including verbal working memory, and interactions between hearing acuity and cognitive flexibility, and hearing acuity and inhibitory control.

Previous investigations that compared younger and older adults' perception of dysarthric speech have yielded mixed results, with demonstration of a differential effect of aging on intelligibility in some, but not others (e.g., Dagenais, Adlington, & Evans, 2011; Jones, Mathy, Azuma, & Liss, 2004; McAuliffe, Fletcher, Kerr, O'Beirne, & Anderson, 2017; cf. Dagenais, Watts, Turnage, & Kennedy, 1999; McAuliffe, Wilding, Rickard, & O'Beirne, 2012). A review of this body of work reveals that the hearing status of the older listener participants included in these studies account, at least partially, for the inconsistent findings. Inclusion criteria in the studies that did not demonstrate an age-related effect on intelligibility of dysarthric speech required that all listeners pass a hearing screening at 25 dB in all frequencies (Dagenais et al., 1999; McAuliffe et al., 2012), whereas studies that demonstrated an age-related effect on intelligibility of dysarthric speech, with younger adults achieving significantly higher intelligibility scores than older adults, included an aging population with and without hearing loss (e.g., Dagenais et al., 2011; Jones et al., 2004; McAuliffe et al., 2017). Thus, the methodological differences of the studies conducted to date make it difficult to disentangle the effect of aging from that of hearing acuity on listener intelligibility of dysarthric speech. Despite the equivocal findings in this area, recent work has revealed that even if older adults achieve similar intelligibility scores as younger adults recognizing dysarthric speech, additional cognitive resources may be recruited to complete the task (Ingvalson, Lansford, Fedorova, & Fernandez, in press).

The impact of aging on listener adaptation to dysarthric speech following a familiarization task has not yet been studied. However, age-related differences in perceptual learning have been noted with variation in the learning effect and transfer of perceptual knowledge for foreign-accented and time-compressed speech (Adank & Janse, 2010; Peelle & Wingfield, 2005; Scharenborg & Janse, 2013). Demonstration of improved intelligibility of dysarthric speech following familiarization in older listeners would support the use this listener-targeted approach with the aging population—an important population to study given that the prevalence of acquired neurogenic speech disorders increases with age. Accordingly, the primary aim of the present study was to determine if intelligibility improvements following familiarization with dysarthric speech, consistently shown for younger, healthy adults, could be revealed for older adults. As a secondary aim, we explored issues of hearing acuity in an attempt to elucidate the equivocal findings related to age-related declines in intelligibility of dysarthric speech. Thus, perceptual data collected from older adult listeners for the current project were compared with historical data collected from younger adult listeners, previously reported in Borrie et al. (2017a), to address the following key research questions:

1. Is initial intelligibility of dysarthric speech (i.e., transcription accuracy prior to a familiarization task) differentially impacted by listener age?
2. Is intelligibility improvement following a familiarization task differentially impacted by listener age?
3. How do initial intelligibility and intelligibility improvement scores achieved by older adult listeners with and without hearing loss compare with those achieved by younger adult listeners without hearing loss?

Method

Participants

Twenty older adults (10 women and 10 men) were recruited from the L. L. Schendel Speech and Hearing Clinic, Tallahassee Senior Center, and Westminster Oaks Retirement Community (all located in Tallahassee, FL) to complete the experimental protocol. Of the 20 recruited participants, 19 completed all tasks. Thus, data from 19 participants were included in the present analysis. The participants were aged 60–95 years (M = 70, SD = 8.32) and were all native speakers of American English. As per self-report, participants had no history of speech, language, or cognitive disorders. Of the 19 older adult listeners, three listeners passed the hearing screening at 25 dB for all three frequencies in both ears. Seven passed the hearing screening at 25 dB for the 1000- and 2000-Hz frequencies in both ears, with no more than a 40-dB threshold in the 4000-Hz band (in the worse ear). Of the remaining nine older listeners, four wore hearing aids, and the other five failed the hearing screening with more than a 40-dB threshold for at least one of the three frequencies. To address our research question related to the effect of hearing status on older listeners' ability to understand and adapt to dysarthric speech, we divided the older adult listeners into two, somewhat broad, subgroups based on their hearing ability: (a) listeners with no loss in the lower frequency bands and no more than a mild loss in the 4000-Hz band (hereafter: no hearing loss or No HL; n = 10) and (b) aided and unaided listeners with at least a moderate loss in one or more of the frequency bands (hereafter HL; n = 9). Average hearing thresholds for the No HL and HL groups are presented in Table 1. Participants were remunerated with a $20 gift card for their involvement in the study.

The data collected from the older adult participants were compared with historical younger adult data, previously reported in Borrie et al. (2017a). Full participant details can be found in the previous manuscript, but briefly, the historical dataset was collected from 50 young university students, aged 18–29 years (M = 21.38, SD = 2.35). The younger adults were native speakers of English and passed a hearing screening at 20 dB HL for all frequencies in both ears. In addition, the younger adults reported no history of speech, language, or cognitive disorders.

Data Collection Procedures

Each participant attended a single experimental session held at the L.L. Schendel Speech and Hearing Clinic at Florida State University. Participants were provided with a brief synopsis of the aim of the study as well as the purpose of each task presented. Tasks included a hearing screening, an intelligibility pretest, familiarization, and an intelligibility posttest and were conducted in that order. All data collection was completed by the second author (S.L.) along with one of four graduate research assistants trained on the administration procedure.

Hearing Test

Pure tones were presented through sound-cancelling headphones that could accommodate hearing aids in a quiet environment. Participants with hearing aids were instructed to wear their personal amplification devices during the screening. Tones were presented starting at 25 dB at the frequencies of 1000, 2000, and 4000 Hz. Thresholds were determined using the modified Hughson–Westlake Method (Svensson, Kvaløy, & Berg, 2015). In this method, stimuli are presented in increasing order by fixed steps of 5 dB until there is a response. After a response is elicited, stimuli are decreased in intensity by 5 dB until the person stops responding. The lowest tone presented that elicited a response is then determined to be the threshold.

Intelligibility Pretest

In order to facilitate comparison of older and younger adult listeners' initial intelligibility and intelligibility improvement scores, the stimuli used in the present study were identical to that used in the study with the younger adult listeners (Borrie et al., 2017a). The stimuli included audio-recorded productions of a reading passage and a set of 80 semantically anomalous phrases, collected in the Motor Speech Disorders Laboratory at Arizona State University as part of a larger study (see Liss et al., 2009). Three certified speech-language pathologists, with expertise in assessment and differential diagnosis of motor speech disorders, diagnosed the 84-year-old male speaker with a moderate ataxic dysarthria secondary to cerebellar disease. Perceptually, the speaker's productions were characterized by excess and equal stress (scanning speech), prolonged phonemes and intervals, monotone, monoloudness, and imprecise articulation with irregular articulatory breakdowns.

Twenty semantically anomalous, but syntactically plausible, phrases functioned as the stimuli for the pretest phase of the speech perception and learning test.[1] These low-predictability phrases (e.g., "darker painted baskets" and "career despite research"), developed by Liss and colleagues for studies of perception of dysarthric speech (Liss, Utianski, & Lansford, 2013), reduce the effect of higher level cognitive–linguistic cues on word recognition. The transcription phrases each contained six syllables with alternating metrical stress, ranging in length from three to five mono- and/or disyllabic English words.

The testing protocol was administered via a web-based listener-perception application preloaded on a computer, with volume set to a comfortable loudness level as determined by the participant. Administration of the task followed instructions outlined in previous perceptual learning studies (e.g., Borrie et al., 2017a; Borrie, McAuliffe, Liss, Kirk, et al., 2012). For the pretest, participants were informed that they would hear sentences produced by someone with

[1]In order to establish a *stable* baseline intelligibility score while also limiting the listener's exposure to the speaker's disordered speech pattern, we opted to include a small subset of 20 transcription phrases (vs. 60 phrases used in the posttest) for the pretest transcription task.

Table 1. Hearing threshold means and standard deviations (dB HL) for the 1000-, 2000-, and 4000-Hz frequencies for the older adults, classified according to those with hearing loss and those without.

Frequency	1000 Hz R	2000 Hz R	4000 Hz R	1000 Hz L	2000 Hz L	4000 Hz L
No HL (n = 10)	25.0	25.0	30.5 (4.9)	25.0	25.0	28.5 (3.4)
HL (n = 9)	30.6 (8.2)	37.5 (8.9)	56.3 (13.0)	32.8 (10.0)	37.8 (12.8)	50.6 (15.9)

Note. HL = hearing loss; R = right ear; L = left ear.

a speech disorder and would need to try and figure out what was being said. They were also told that while all the phrases contained real English words, they may not make sense. Each phrase was presented a single time, with no limit on response time. Participants were given the option to independently type their response on the keyboard or, alternatively, verbally state their response and have the researcher do the typing.[2] Participants were encouraged to make a guess even if unsure as to what was said.

Familiarization

An audio-recorded passage in conjunction with an orthographic transcription served as the linguistically rich stimuli for the familiarization phase of the speech perception and learning task. The reading passage was an adapted version of the "Grandfather Passage" by Darley, Aronson, and Brown (1975) and provided both lexical and structural complexity for a brief sample of the speaker's speech (Powell, 2006). The passage contained 35 phrases, ranging in length from three to 12 words with three to 14 syllables per phrase. During the familiarization phase, participants were instructed to listen carefully to the passage reading while following along with the provided orthographic transcription.

Intelligibility Posttest

Immediately following familiarization, participants completed the posttest transcription task, where they heard and transcribed a set of 60 novel transcription phrases. Similar to pretest, the posttest transcription phrases each contained six syllables with alternating metrical stress, ranging in length from three to five mono- and/or disyllabic English words (see Intelligibility Pretest section for more details regarding the transcription phrases).[3] The same procedures and instructions used in the pretest were utilized during the posttest.

Transcript Analysis

Computation of initial intelligibility and intelligibility improvement scores was based on listener transcriptions of the pre- and posttest speech sets. Transcripts were initially analyzed and scored for accuracy by either the second author or one of the four additional research assistants trained on the transcription analysis protocol. After initial analysis, another member of the research team checked for and corrected potential scoring errors. This resulted in a pre- and posttest percentage words correct (PWC) score for each participant. The initial intelligibility score is the pretest PWC score, reflecting a measure of transcription accuracy prior to familiarization. The intelligibility improvement score is then calculated by subtracting the pretest PWC score from the posttest PWC score. Scoring of words correct followed the same procedures outlined in previous studies on perception of dysarthric speech (e.g., Borrie, McAuliffe, Liss, Kirk, et al., 2012; Lansford et al., 2016; Liss et al., 2002). Words were scored as correct if they accurately matched the intended target or differed by one tense (–ed) or plurality (–s). In addition, misspellings, homophones, and substitutions between *a* and *the* were coded as correct.

Results

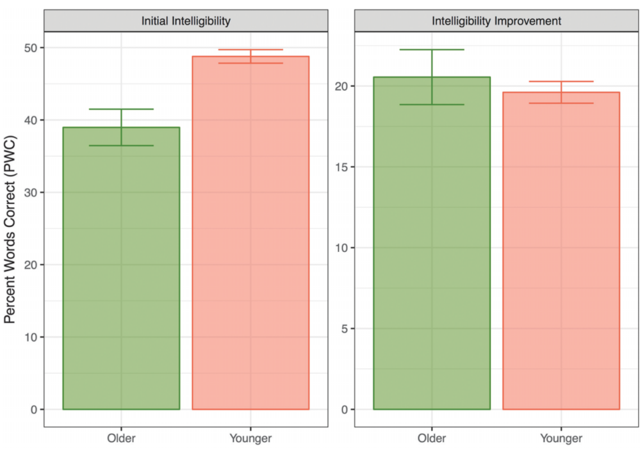
Initial Intelligibility Scores

To capture initial intelligibility of dysarthric speech, pretest PWC scores were derived for each of the older adults (M = 38.97, SD = 10.98) and are illustrated in the left panel of Figure 1. These initial intelligibility scores were compared with those of younger adults (M = 48.78, SD = 6.62; previously reported in Borrie et al., 2017a) to determine the effect of listener age on initial intelligibility of dysarthric speech. Due to the results of Levene's test of homogeneity of variances, $F(1, 67) = 15.709$, $p < .001$, Welch's independent samples t test was conducted to compare the older and younger adult data. The results of this analysis revealed that initial intelligibility of the same speaker with dysarthria was significantly higher for the younger adults as compared with the older adults, $t(23.166) = 4.532$, $p < .001$.

[2]Options were provided due to the older age of participants with varying degrees of typing comfort. Responses were audio-recorded for those participants that opted to provide their response verbally (n = 9) to ensure correct transcription of responses. An independent samples t test revealed that those who typed their responses and those who provided them verbally achieved comparable initial intelligibility scores, $t(17) = 0.021$, $p = .983$, and intelligibility improvement scores, $t(17) = 0.249$, $p = .807$. Thus, for the purposes of the present study, the transcription data collected from the two different methods of data capture were combined.

[3]The pre- and posttest phrase sets were balanced for number of words (M = 4.1 and 3.9 words per phrase, respectively). Additionally, iambic and trochaic stress patterns were equally represented in each phrase set.

Figure 1. Group means of intelligibility outcome measures when categorized according to older adults (n = 19) versus younger (n = 50) adults: The panels reflect a significant group difference in initial intelligibility of dysarthric speech (left) but no difference in intelligibility improvement following familiarization with dysarthric speech (right). Error bars delineate ± 1 standard error of the mean (*SEM*). Younger adult data were from Borrie et al. (2017a).



Intelligibility Improvement Scores

Intelligibility improvement scores (posttest PWC − pretest PWC) were derived for each of the older adults as a measure of learning or adaptation following the familiarization task (M = 20.55, SD = 7.41) and are illustrated in the right panel of Figure 1. These scores were also compared with those of the younger adults (M = 19.61, SD = 4.76; reported originally in Borrie et al., 2017a) using an independent samples t test because parametric assumptions were satisfied for this analysis. The results of this test did not reveal a significant difference between the two age groups, suggesting that the perceptual benefit following familiarization was comparable between the younger and older adults.

Effect of Hearing Status on Initial Intelligibility and Intelligibility Improvement

A final set of analyses was conducted to evaluate how initial intelligibility and intelligibility improvement scores in two groups of older adults, those with and without hearing loss, compare with those of the younger adults without hearing loss. As described in the Method section, the older adults were divided into two subgroups based on their hearing status, those with and without hearing loss (HL vs. No HL). The initial intelligibility scores for the three listener groups (HL, No HL, and younger adults) were compared using a one-way analysis of variance. A significant main effect of listener group was revealed, $F(2, 66) = 14.765$, $p < .001$, and the results of Bonferroni corrected pairwise comparisons revealed that initial intelligibility scores of older adults with hearing loss (M = 33.41, SD = 11.3) were significantly lower than that of both the older adults without hearing loss (M = 43.98, SD = 8.3), p = .01, and the younger adults (M = 48.78, SD = 6.62), $p < .001$. No significant differences between the other groups were revealed.

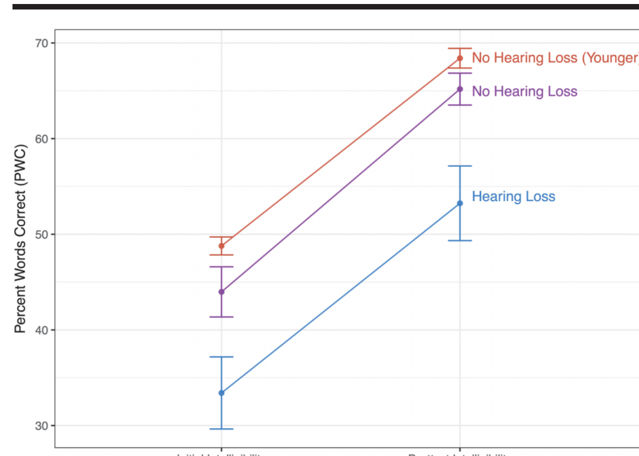
A second analysis of variance was conducted to examine the effect of listener group on intelligibility improvement scores. The results of this analysis did not reach significance, $F(2, 66) = 0.333$, $p = .718$. Thus, older adults with and without hearing loss enjoyed comparable perceptual gains following familiarization as younger adults without hearing loss. This finding is illustrated in Figure 2.

Discussion

Here, we extend findings of improved intelligibility of dysarthric speech following familiarization—consistently demonstrated across a number of studies for younger adults—to a sample of older adults with and without hearing loss. Demonstration of such learning in older adults is important for the extension of familiarization as a means for improving intelligibility of dysarthric speech in the aging population. On average, initial intelligibility demonstrated by the older adults was approximately 10 percentage points lower than that demonstrated by the younger adults, both before and after familiarization. However, and perhaps most importantly, the intelligibility gain postfamiliarization was virtually identical for older and younger adults.

To date, studies examining the effects of familiarization of dysarthric speech in young, healthy adults have regarded hearing loss as an exclusionary criterion. Given that the prevalence of hearing loss increases substantially with age (e.g., Nash et al., 2011), we made the methodological decision to include individuals with hearing loss to address our primary research question related to examining the effects of familiarization in older adults. This methodological decision was supported by a handful of investigations of dysarthric speech perception in older adults, in which mild hearing loss was not considered an exclusionary

Figure 2. Pretest and posttest intelligibility scores, by group, reflect differences in initial intelligibility scores between groups with and without hearing loss but comparable intelligibility improvement scores (slope of connecting line) for all groups.



factor (e.g., Dagenais et al., 2011; McAuliffe et al., 2017). It bears mentioning, however, that inclusion of individuals with hearing loss in some, but not all, studies has complicated our understanding of how older and younger adults process dysarthric speech. The sample recruited for the current work permitted examination of the effects of both age and hearing loss on perception of and adaptation to dysarthric speech. Although older adults, on average, transcribed dysarthric speech less accurately than their younger counterparts, we found that when they were divided into two hearing status groups, this pattern of results only held for the older adults with hearing loss. Thus, the current findings help to clarify previous inconsistencies associated with age-related decreases in perception of dysarthric speech.

Importantly, older adults with and without hearing loss achieved similar gains to intelligibility postfamiliarization. Thus, neither age nor hearing status appeared to affect the listener's ability to learn something useful about the degraded speech during the familiarization task. The present findings are consistent with previous work that examined the effect of listener age on perception of and adaptation to a novel accent following familiarization (Adank & Janse, 2010; Bieber & Gordon-Salant, 2017). Although older adults have been demonstrated to perform less accurately overall relative to their younger counterparts, both age groups demonstrated similar gains to intelligibility of a novel accent following familiarization. Interestingly, however, some evidence suggests that older and younger listeners adapt to degraded speech *differently* than their younger counterparts. For instance, in one study, both older and younger adults were shown to rapidly adapt to a novel accent, however the adaptation effect plateaued more quickly for older adults (Adank & Janse, 2010). In a similar manner, Peele and Wingfield (2005) revealed a rapidly occurring adaptation plateau for time-compressed speech in older adults, relative to younger adults, but also found that younger adults generalized their adaptation to an untrained speech rate, whereas older adults did not. Taken together, it has been argued that though older and younger adults may enjoy similar immediate adaptation benefits secondary to familiarization, overall capacity and transfer of learning may decline with age (Peele & Wingfield, 2005).

Limitations

The present study employed a commonly used three-phase familiarization protocol, wherein the participants completed a pretest intelligibility task, an explicit familiarization task,[4] and a posttest intelligibility task (see Borrie et al., 2017a; Borrie, Lansford, & Barrett, 2017b; Borrie & Schäfer, 2015). This three-phase design permits a within-subject analysis of intelligibility improvement subsequent to familiarization. Due to this methodological decision, it could be suggested that the pretest transcription task, and not the explicit familiarization task, was responsible for the intelligibility improvement from pretest to posttest. However, two recent studies using either identical or very similar stimuli sets have included control conditions—one in which a group of participants was trained on the same stimuli produced by an age- and gender-matched neurologically healthy speaker (Borrie et al., 2017b), and the other where a group of participants received no familiarization (Borrie & Schäfer, 2015). In both studies, there was no significant difference between pretest and posttest PWC scores for the control condition. Thus, current evidence supports that the intelligibility improvement observed following an explicit familiarization experience with dysarthric speech could be attributed to the familiarization task rather than the pretest phase of the protocol. Given this, a control condition was not deemed necessary for the purposes of the present study. However, we acknowledge that the explicit familiarization task utilized in our current and previous work is brief and that the gains to intelligibility could be optimized if a lengthier and perhaps deeper familiarization task were utilized. It remains for future work to evaluate how familiarization material/task, dose, and feedback frequency might enhance the learning experience.

The stimuli utilized in the present study featured speech samples from a single individual diagnosed with a moderate ataxic dysarthria. Although this aided in experimental control of potential sources of variability and is experimentally well justified (see Borrie et al., 2017a; Borrie & Schäfer, 2015), there may be some theoretical limitations associated with the use of a single speaker. However, if familiarization were to be become a viable means for improving a caregiver's ability to understand the speech of an individual with dysarthria, familiarization would likely be focused on that individual's speech. Thus, the methodological decision to concentrate familiarization on a single speaker in our laboratory studies is well justified by the clinical application of listener-targeted remediation. Further, perceptual learning has been observed for a moderate hypokinetic dysarthria (Borrie, McAuliffe, Liss, Kirk, et al., 2012) and a moderate spastic dysarthria (Borrie & Schäfer, 2015), suggesting that the current results may be observed with different types of dysarthria. They may not, however, be observed with different severities of dysarthria. Exploring the impact of severity on both older and younger adults' ability to adapt to dysarthric speech serves as an important future direction for this work.

Another limitation of the current design was that a convenience sample of older adult listeners was utilized. Recruitment efforts were centered on the Florida State University community and two active recreation/living senior centers, and any listener meeting the inclusionary criteria was permitted to participate. An unintended consequence of our recruitment efforts was that the sample of listeners was highly educated. Of the 19 participants, only

[4]Explicit familiarization methods provide the listener either written or somatosensory (e.g., arising from vocal imitation) feedback and have been consistently demonstrated to result in greater intelligibility gains postfamiliarization than passive methods that provide no feedback (Borrie, McAuliffe, Liss, Kirk, et al., 2012; Borrie & Schäfer, 2015; Davis & Johnsrude, 2007). See Borrie, McAuliffe, Liss, Kirk, et al. (2012) for an in-depth discussion of explicit and passive familiarization methods.

one participant had an education level below that of a bachelor's degree. The remaining participants' education levels ranged from bachelor's to doctoral degrees. Thus, it is likely that this sample is not fully representative of the population of older listeners. Due to known relationships between listeners' age, higher level cognitive functioning, and perception of degraded speech (e.g., Ingvalson et al., 2017; McAuliffe, Gibson, Kerr, Anderson, & LaShell, 2013), the current results should be interpreted with some caution. Moving forward with this line of research, a broader sample of participants with varying degrees of education, cognitive functioning, and cultural backgrounds should be recruited.

Clinical Implications and Conclusions

Although preliminary, these findings aid in establishing the ecological validity of familiarization as a listener-based means for treating intelligibility impairment in dysarthria. There is currently strong evidence suggesting the benefit of listener-targeted perceptual learning paradigms as a clinical intervention tool in younger adults (Borrie, McAuliffe, Liss, O'Beirne, & Anderson, 2013; Borrie, McAuliffe, Liss, Kirk, et al., 2012; Borrie & Schäfer, 2015; Lansford et al., 2016). The present study supports and extends previous findings of improved intelligibility of dysarthric speech following familiarization to a group of listeners who are critical to consider in listener-targeted remediation, namely, aging caregivers and/or spouses of individuals with dysarthria. With intervention focused on the primary communication partners (e.g., caregivers, family members, and friends), a potential lessening of the challenges placed on both speaker and listener during communication may be achieved. To continue the advancement of familiarization as a listener-targeted treatment option, future work should evaluate the factors contributing to optimal perceptual outcomes and maintenance, such as the nature of the familiarization material/task, dose, and feedback frequency.

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