Hearing loss and cognitive-communication test performance of long-term care residents with dementia: Effects of amplification

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Abstract

Purpose: The study aims were: 1) to explore the relationship between hearing loss and cognitive-communication performance of individuals with dementia, and 2) to determine if hearing loss is accurately identified by long-term care (LTC) staff. The research questions were: 1) What is the effect of amplification on cognitive-communication test performance of LTC residents with early to middle-stage dementia and mild-to-moderate hearing loss? 2) What is the relationship between measured hearing ability and hearing ability recorded by staff using Resident Assessment Instrument-Minimum Data Set 2.0 (RAI-MDS)?

Method: Thirty-one residents from five long-term care facilities participated in this quasi-experimental cross-over study. Residents participated in cognitive-communication testing with and without amplification. RAI-MDS ratings of participants' hearing were compared to audiological assessment results.

Results: Participants' Speech Intelligibility Index scores significantly improved with amplification; however, participants did not demonstrate significant improvement in cognitive-communication test scores with amplification. A significant correlation was found between participants' average pure-tone thresholds and RAI-MDS ratings of hearing, yet misclassification of hearing loss occurred for 44% of participants.

Conclusions: Measuring short-term improvement of performance-based cognitive-communication may not be the most effective means to assess amplification for individuals with dementia. Hearing screenings and staff education remain necessary to promote hearing health for LTC residents.

The prevalence of Alzheimer's disease and other dementias is increasing each year. In the absence of a cure for most common forms of dementia, researchers continue to focus on strategies to minimize the adverse effects of related health conditions or environmental factors that may contribute to excess disability in dementia (Slaughter & Bankes, 2007). Hearing loss is one such condition that may exacerbate cognitive-communication disability. However, the relationship between hearing loss and cognitive-communication abilities in individuals with dementia remains unclear.

Based on several studies, researchers have concluded that individuals with dementia and hearing loss have poorer cognitive function than those with dementia and normal hearing (Peters, Potter & Scholer, 1988; Uhlmann, Larson & Koepsell, 1986; Uhlmann, Teri, Rees, Mozlowski & Larson, 1989; Weinstein & Amsel, 1986), yet the reason behind this reduced functioning, or excess disability, is speculative. In some of the earliest work on the topic, Weinstein and Amsel (1986) administered the *Mini-Mental State Examination* (MMSE; Folstein, Folstein & McHugh, 1975) to individuals with dementia and hearing loss under two conditions, with and without amplification, and reported an improvement in MMSE scores when amplification was provided to participants. They concluded that poorer cognitive test performance among individuals with dementia and hearing loss is likely an artifact of cognitive test administration; individuals with dementia and hearing loss cannot hear test instructions and therefore perform poorly. In a subsequent study to address the issue raised by Weinstein and Amsel (1986), Uhlmann et al. (1989) administered the MMSE in its standard form and in a written, hearing-free form (Gallacher, 2004) to two groups of participants with dementia: those with hearing loss and those with normal hearing. They found that participants with dementia and hearing loss performed significantly lower on both forms of the MMSE as compared to participants with dementia and normal hearing. They concluded that the relationship between hearing loss and diminished cognitive test performance in dementia is not simply a result of participants being unable to hear test instructions. In both studies, however, the outcome measures were limited to the MMSE, restricting the degree to which findings can be generalized to cognition and communication functioning more broadly.

In the literature involving typically aging older adults, the findings on this topic are likewise mixed, varying across study samples and data collection methods. For example, Mulrow et al. (1990) found an improvement in general cognitive function among older adults with hearing loss at 6 months post-hearing aid fitting. In contrast, Van Hooren et al (2005) found that when typically aging older adults with hearing loss were provided with hearing aids, they did not exhibit improved performance on cognitive tests one year later, even in the presence of improved hearing acuity. Recently, MacDonald et al. (2012) conducted a randomized controlled trial on the effects of amplification on cognitive screening test scores (MMSE and *The Abbreviated Mental Test*, Jitapunkul, Pillay & Ebrahim, 1991) for 192 older adult patients admitted to acute assessment units of hospitals in the United Kingdom. They found significant positive effects on MMSE scores when patients were provided with amplification and tested on consecutive days. However, patients' hearing loss was not quantified objectively, and was judged based on self-assessment.

Although a growing body of research has been devoted to the relationship between hearing loss, typical aging and cognition (see Humes & Dubno, 2010; Lin, 2011), relatively less attention has been paid to hearing loss and its impact on cognition and communication in people living with dementia. The prevalence of hearing loss is high among individuals with dementia in long-term care (LTC) settings, and it is often under-identified (Hopper, Bayles, Harris &

Holland, 2001; Hopper & Hinton, 2012; Miller, Brunworth, Brunworth, Hagan & Morley, 1995) and under-treated (Hopper et al., 2001; Cohen-Mansfield & Taylor, 2004). Because awareness of hearing loss is necessary for interventions and accommodations, identification of hearing loss among LTC residents with dementia was also of interest in this study.

Purpose of the study

The aims of this study were: 1) to explore the relationship between hearing loss and cognitive-communication test performance of individuals with dementia, and 2) to determine if hearing loss is accurately identified by LTC staff using the RAI-MDS. Thus, the following research questions were posed: (1) What is the effect of amplification on cognitive-communication test performance of participants with early to middle-stage dementia and mild-to-moderate hearing loss? (2) What is the relationship between measured hearing ability and hearing ability as recorded by LTC staff using the Resident Assessment Instrument – Minimum Data Set 2.0 (RAI-MDS; Hirdes et al., 1999)? Health care aides' perspectives on hearing loss among residents with dementia and the relevance of hearing loss for day-to-day care were also explored using qualitative methods, with findings reported in a separate paper (see Slaughter, Hopper, Ickert & Erin, 2014).

Method

Research Design and General Procedures

Research Question 1: A quasi-experimental repeated measures cross-over research design was used. A single group of participants completed cognitive-communication tasks in two conditions: with amplification (intervention/aided) and without (control/unaided). The order of presentation of the two conditions was counterbalanced across participants (Portney & Watkins, 2000). A power analysis was conducted to ensure an adequate sample size to detect a difference between treatment conditions, should one exist. Using the primary outcome variable (total score on the *Functional Linguistic Communication Inventory; FLCI*; Bayles & Tomoeda, 1994), a sample size of 30 was estimated to be necessary to detect a moderate treatment effect size (0.65; Cohen, 1988) with 80% power and 95% confidence (Portney & Walkins, 2000).

Research Question 2: A retrospective health record review was conducted for each participant to access hearing data from the most recent RAI-MDS assessment. Each participant's hearing ability, as measured by an audiologist, was compared to RAI-MDS ratings completed by healthcare staff. These ratings were unknown to researchers until after audiological testing was completed.

Participants

Thirty one individuals (18 females) with dementia residing in five LTC facilities participated in the study. Residents were eligible to participate if they met the following inclusion criteria: 1) had a diagnosis by a physician of Alzheimer's disease, vascular dementia, or mixed dementia; 2) were literate, fluent speakers of English; 3) had visual function sufficient to read 24-28 point font, as determined using the Vision and Literacy Screening subtest of the *Arizona Battery for Communication Disorders of Dementia* (ABCD; Bayles & Tomoeda, 1993), and, 4) presented with a mild-to-moderate hearing impairment (see the *Audiological Assessment* section that follows for procedural details on the assessment). Nineteen participants had mild hearing loss, defined as a pure tone threshold average (PTA of .5, 1, 2, and 4KHz) of 25.1 to 44.9 dB in the better ear (M = 36.87, SD = 5.46) and 12 had moderate hearing loss (PTA = 45 to 64.9 dB better ear) (M = 52.74, SD = 5.43) (see Table 1 for participant characteristics). Participants were excluded if they had a diagnosis of fronto-temporal or Lewy body dementia, as these types of dementia often have variable presentation patterns and tend to progress differently from Alzheimer disease.

Recruitment of residents with dementia involved integration of several ethical considerations (Slaughter, Cole, Jennings & Reimer, 2007; Tricouncil, 2010) and based on the successful strategy used in previous studies conducted by Slaughter, Eliasziw, Morgan & Drummond (2010) and Slaughter et al. (2015). Informed consent was obtained from authorized representatives of all residents (Tri-Council, 2010). With the necessary Human Research Ethics Board approval from the University of Alberta (approval # Pro00016876) and the support of senior administrators in the LTC facilities, nursing unit managers or designates identified residents who met study inclusion criteria. A LTC staff member then contacted residents' authorized representatives/family members using a standard script to obtain permission for researchers to contact them to explain the study (n = 99; see Figure 1 for details on enrollment). The researchers obtained written informed consent for participation from representatives/family members (n=68), and further assent to participate was sought directly from LTC residents (Slaughter et al., 2007). A researcher reviewed the health records of all 68 participants with a signed consent form to ensure that they met inclusion criteria; participants' co-morbidities, medications, date of birth and date of admission were also documented. All residents who met criteria for inclusion in the study were then referred to the audiologist for assessment (n = 65).

Audiological Assessment. The audiologist first performed otoscopy on all participants who met inclusion criteria for participation. Wax removal was necessary for 16 participants before testing could be completed. The same audiologist then conducted a hearing assessment where thresholds at .25, .5, 1, 2, 3, 4, 6 and 8 kHz were measured by air conduction for both ears using a calibrated AD226 diagnostic audiometer (Interacoustics, Assens, Denmark). Audiometric testing was conducted on-site at the LTC facilities using ER-3A insert earphones in a quiet room with a measured ambient noise level of no more than 45 dBA (using the Audioscan Verifit as a sound level meter). Ambient noise was assessed at the beginning of the testing session only and did not include assessment per octave band. The thresholds were entered into an Audioscan Verifit and an individual real ear to coupler difference curve was measured to convert the HL values to real ear SPL (Audioscan, Dorchester, Canada) and Desired Sensation Level (Scollie et al., 2005). Prescriptive targets for adults were automatically generated for each individual's hearing loss. These targets use the individual's hearing thresholds and their unique ear acoustics (as measured with a probe microphone) to set the audibility goals for each participant.

Amplification. The Sennheiser model A200 assistive listening device (ALD; Sennheiser, Montreal, Canada) was used to provide amplification to participants during cognitive-communication testing. This ALD is a stereo personal sound amplifier with headphones and two integrated microphones. The audiologist adjusted the volume control of the ALD to best approximate the output targets generated by the Verifit while the participant wore the ALD. To make these adjustments, a real ear probe microphone was placed into each user's ear canal and the sound pressure level (SPL) of the ALD was measured. Although the ALD did not have specific frequency shaping options, it was possible to cover a port with tape to alter the shape of the response broadly. This covering was done as needed in conjunction with volume adjustments to best approximate targets. Speech signals were presented from the front, at approximately 1 meter away, at 55, 65 and 75 dB SPL (soft, average and loud speech) from the Verifit to ensure that the ALD was providing a reasonable output as close to prescriptive targets as possible (according to Desired Sensation Level (DSL) m[i/o]). The audiologist also ran a 90 dB pure tone sweep to record the maximum power output of the ALD on each user. These data were then used to generate Speech Intelligibility Index (SII) ratings, allowing the researchers to calculate the percentage of speech sounds that were audible and usable with the ALD for each of the input conditions (55, 65 and 75 dB SPL). There is a strong positive correlation between SII values and speech intelligibility performance (ANSI, S3.5, 1997). There are different performance/intensity functions for different stimuli materials (e.g., sentence versus words). For words in isolation, like those used in the speech recognition test in this study, and SII value of 0.5 would be expected to equate to approximately 70% word recognition. If the resident was able to participate in the assessment and results showed the presence of a mild-to-moderate hearing loss, then the resident was eligible to participate in the cognitive-communication testing under aided and unaided conditions.

Aided and Unaided Cognitive-Communication Assessment Conditions. Participants were tested twice, with and without amplification, between four and 14 days apart (average days between testing = 6.28, SD = 2.0). For consistency of amplification, all participants, regardless of hearing aid use, were tested using the ALD. To control for voice loudness within sessions and across conditions, a sound level meter was used to monitor the live-voice presentation level of the stimuli at 65 dB SPL, ± 5 dB SPL.

Upon providing assent to the researcher, participants engaged in a video-taped cognitive-communication assessment, conducted in the same quiet room in which the audiological assessment took place. The researcher ensured that each resident had glasses if needed, and if participants wore hearing aids, the researcher ensured they were removed before testing (n = 13; see Table 1). Participants were tested individually. If participants were completing their aided assessment, the researcher would place the ALD on the participant, and adjust the ALD to the volume setting specified by the audiologist.

To characterize participants' cognitive functioning, scores from the most recently administered MDS-Cognitive Performance Scale (Hartmaier et al., 1995; Morris et al., 1994) were collected from residents' health records. This measure, which is derived from five MDS items, provides a functional view of cognitive performance and corresponds to other standardized measures of cognition such as the MMSE (Hartmaier et al., 1995). The scores on the MDS Cognitive Performance Scale are ordinal, and range from 0 (Intact) to 6 (Very Severe Impairment).

Several tests were administered to participants and served as dependent measures of cognitive-communication ability in the aided and unaided testing conditions. Assessments were selected to represent different aspects of cognition and communication at the impairment and activity levels of functioning, according to the International Classification of Functioning, Disability and Health (ICF; World Health Organization, 2001). Further, test selection involved consideration of the degree to which participants would have to rely on hearing to complete the tests. The final test battery was administered twice, once in the aided and once in the unaided conditions.

1. Four subtests of the *Functional Linguistic Communication Inventory* (FLCI; Bayles & Tomoeda, 1994) were administered. The FLCI is a standardized communication test battery designed for individuals with middle to late-stage dementia and consists of 10 subtests. For the purposes of the current study, we administered (1) greeting and naming, (2) writing, (3) reminiscing, and (4) conversation. The total possible score for the four subtests was 36.
2. Past Memory Axis - *Brief Cognitive Rating Scale* (Reisberg, Schneck, Ferris, Schwartz & de Leon, 1983). The BCRS was developed to assess cognitive decline in

five domains or axes of function, each scored on a scale of 1 to 7. The axes were developed based on other rating instruments and clinical experience. The average performance across the five axes provides the individual's Global Deterioration Scale score (GDS; Reisberg, Ferris, de Leon, & Crook, 1982). For this study, only Axis 3: Past Memory, was used. It comprises 8 questions (e.g., Where were you born?), yielding 8 total points, and is a measure of ability to respond to conversational questions that does not place a heavy load on recent episodic memory.

3. Story-Retelling Task – Immediate Recall Condition – Story retelling tests are used to evaluate verbal working and episodic memory abilities. The examiner tells the story to the participant who then attempts to retell or recall the story immediately after hearing it and again after a short (10-15 minute) delay. In this study, we used only scores on the immediate recall task to reduce demands on impaired episodic memory and avoid floor effects in the testing. Scores are calculated based on number of correct content units that participants identify in the re-telling of the story to the examiner (out of a possible 17). Two versions of the test were used to control for repeated testing effects with the aided and unaided conditions. One story was from the ABCD and one was from Mahendra, Bayles and Harris (2005). The stories are equivalent in syntactic and semantic complexity, as well as vocabulary level (Mahendra et al., 2005) and narrative structure. An even distribution of the four testing situations was ensured across participants and sites (see Figure 1).

4. Word recognition testing – The ability to recognize and repeat spoken words was tested using Isophonemic Word Lists (Boothroyd, 1968). Each of 15 parallel lists contains 10 words consisting of the same set of 30 phonemes, 10 vowels and 20

consonants. Two randomly selected lists were administered during each of the aided and unaided conditions. To minimize response burden and frustration from repeated failure, word recognition testing was discontinued after the participant failed to repeat 3 words in each list. Scoring was continuous for analysis purposes; percentage correct was calculated based on the number of correct responses divided by the number of words presented.

5. Clock Drawing Test – Executive functions, visuospatial abilities and semantic memory were assessed using the Clock Drawing Test. The instructions and scoring system from the *Cognitive Linguistic Quick Test* (Helm-Estabrooks, 2001) were used (maximum possible score was 13). Residents were provided with a standard letter sized sheet of paper with a large circle in the center. Written instructions at the top of page stated: *Draw a Clock. Put in all the numbers. Set the hands to "ten minutes after eleven." Be careful. Be neat.* These instructions were read to the participant once, and the person was given 3 minutes to complete the task. Instructions were repeated once, upon request. Prompts such as "Is that all?" and "Are you finished?" were used to encourage the participant to continue. This test does not rely heavily on spoken language for completion, relative to the other tasks in the test battery.

Measurement reliability. The researcher scored tasks throughout the assessment. Another researcher who watched the test session videos checked all data independently. Researchers were not blinded to study condition during scoring. Discrepancies in scoring were noted on 1.7% of the scored task items and were resolved by consensus.

Data Analysis

Research Question 1: To determine differences between cognitive-communication test performance as a function of amplification condition (with or without), repeated measures *t*-tests were conducted. The SII, or percentage of speech sounds that were audible to the participants when using the ALD, was determined during audiological testing. SIIs with amplification with the ALD and without, at the input intensities of 55, 65 and 75 dB SPL, were also compared using t-tests.

Research Question 2: A comparison was made between RAI-MDS ratings on item 1 (Hearing) in section C (0 = hears adequately, 1 = minimal difficulty, 2 = hears in special situation only, and 3 = highly impaired/absence of useful hearing) and PTA thresholds for all participants (unaided), according to mild (25 to 44.9 dB HL) and moderate (45 to 64.9 dB HL) impairment classifications. An intraclass correlation coefficient (ICC) was calculated.

Results

Research Question 1: The results of the analyses are found in Table 2. With the use of an adjusted alpha level to control for multiple comparisons (Bonferroni correction), no statistically significant differences were found in the cognitive-communication test scores between the aided and unaided conditions.

SII scores (in percentages) were statistically significantly higher when the participants were fitted with the ALD at all input intensities (see Table 3). It should be noted that whereas the SII scores were significantly higher with the ALD, not all speech sounds were audible for these listeners even with a loud input of 75 dB. This situation reflects the inability of the audiologist to alter the frequency response/compression parameters of the ALD to adequately meet DSL targets. DSL targets, if matched, would have yielded higher SII values.

Research Question 2: RAI-MDS data were available for 25 of the 31 participants because six residents resided in facilities that did not gather RAI-MDS data. The cross tabulation of the RAI-MDS ratings with PTAs are described in Table 4. A significant ICC was found between the PTA category and the RAI-MDS rating (R = 0.286, p = .015). When examined at the individual level, 11 of 25 participants (44%) had hearing loss that was either unidentified (n=7) or underestimated (n=4) based on staff ratings on the RAI-MDS.

Discussion

LTC residents with early to middle-stage dementia and mild-to-moderate hearing loss did not exhibit improved cognitive-communication test scores when provided with amplification from an ALD. This finding is likely related to methodological limitations of the current study and the interaction of sensory and cognitive declines experienced by the participants with dementia.

A prominent consideration in interpretation of the results is the condition under which cognitive-communication testing occurred. Conditions were highly controlled and might be considered ‘ideal’ for listening. The outcome measures were carefully selected to be standardized in their administration, the testing environment was quiet, the instructions were presented face-to-face in a well-lit room, and voice loudness levels were monitored throughout cognitive-communication testing. Presenting the stimuli face-to-face may have attenuated potential differences between the testing conditions as participants had access to supplemental visual speech information, which would not have occurred if the examiner’s face could not be seen during testing. It is perhaps unsurprising then, that individuals with mild hearing loss (n = 19) did not experience significant benefits of amplification under these supportive conditions.

Yet it would be erroneous to conclude that mild hearing loss does not affect cognition or communication in individuals with dementia under usual circumstances.

It is well known that even mild sensorineural hearing loss can have a significant negative effect on spoken language comprehension in everyday life in which settings are often noisy, many people are talking, people have accents or speak quickly, and topics are unfamiliar (Pichora-Fuller, 2014). In addition to reduced information coming in through the perceptual channel, an added problem in such environments is the superimposition of effortful listening that consumes cognitive resources that could instead be allocated to language processing and memory functions (Pichora-Fuller, Schneider & Daneman; 1995). Typically aging older adults with mild hearing loss have difficulty communicating in such contexts; it is reasonable to assume that individuals with dementia and hearing loss are disadvantaged to a similar or greater extent. Nevertheless, this conclusion remains to be tested empirically.

One might hypothesize that moderate levels of hearing loss would affect cognitive-communication test performance of individuals with dementia even in ideal listening conditions. Unfortunately the sample size of the remaining 12 residents with moderate hearing loss was likely too small to allow detection of any statistically significant difference in test performance between aided and unaided conditions. In fact, the alpha level used in this study was conservative (.008) to control for Type I error rate associated with multiple comparisons in the same study sample. Thus, despite an a priori power analysis, the study may have lacked statistical power to detect differences that existed between participant performance in aided and unaided conditions.

The participant sample varied in degree of hearing loss and severity of dementia, both of which may have been effect modifiers influencing the ability to detect a difference between conditions (Aschengrau & Seage, 2008). As has been noted in research involving typically aging older adults, future research designs should involve stratification of a larger sample of participants according to cognitive impairment (or dementia severity) to determine whether the benefit of amplification differs as a function of cognitive status (Gatehouse, Naylor & Elberling, 2003; Lunner, 2003).

Another possible effect modifier is the participants' history of hearing aid use. Thirteen of the participants were noted to have used hearing aids at the time of the study or in the past. Because these participants did not wear their hearing aids during either test condition (with the ALD or without), they would be disadvantaged as they would be used to listening with their aids. Similarly, those participants who were not hearing aid users would also be disadvantaged during the aided condition because they would not be used to listening to amplified speech. Unfortunately, the contributions of hearing aid use to cognitive-communication test performance in this study are unclear. Researchers were unable to collect detailed information on hearing aid use by the 13 participants who were described as hearing aid users. Because hearing aid use among LTC residents is affected by several institutional and individual variables (Cohen-Mansfield & Taylor, 2004), it cannot be assumed that the participants in this study were regularly using their hearing aids at the time of study. Hearing aids of adults in long-term care are often not in working order, are lost or are unused even when residents are described or classified as current hearing aid users (Cohen-Mansfield & Taylor, 2004; Thibodeau & Schmitt, 1988). The situation is likely worse for residents with dementia, although hearing aid research focused solely on residents with cognitive impairment is scarce.

With regard to research question 2, the finding that RAI-MDS ratings were significantly related to residents' actual hearing ability as measured by pure-tone audiometry was positive.

This finding suggests that health care staff completing the RAI-MDS assessments were able to recognize hearing loss even among residents with early to middle stage dementia, and that they were able to distinguish between cognitive-communication limitations caused by dementia and those caused by hearing loss. However, variance in the data was apparent at an individual level, with almost half of the 25 residents misclassified as to the presence or severity of their hearing loss. This finding underscores the importance of hearing screenings for LTC residents to ensure detection of hearing loss and referral for audiological assessment as indicated. Further, education in hearing health for LTC residents with dementia remains an important and necessary endeavor for communication professionals.

Clinical Implications

The results of this study suggest that simply providing amplification to individuals with dementia and hearing loss may not be sufficient to produce significant changes in cognitive-communication test performance over a short time period under ideal listening conditions. This finding is important in that it extends the current state of knowledge related to the relationship between hearing loss and cognitive test performance of individuals with dementia. Further, from a clinical standpoint, the results support the need for holistic, systematic approaches to hearing intervention and outcome assessment for adults with hearing loss and dementia. As noted by Sweetow & Sabes (2007), there is more to communication than access to acoustic information. The intervention used in this study was impairment-based, designed to improve audibility, and was effective in reducing hearing impairment. However, audiologists and speech-language pathologists have long recognized that approaches to aural rehabilitation must include consideration of activity/participation levels of functioning and environmental factors that hinder or facilitate hearing and communication (Hickson & Scarinci, 2007). LTC residents often spend much of their time in shared or common spaces, such as dining rooms, that represent challenging listening environments. An important direction for future research is to determining the types of activity/participation hearing outcome measures that are most sensitive to change as a result of the treatment of hearing loss for people with dementia.

Another notable result is that all participants in this study tolerated the ALD during the cognitive testing. There are few studies in which researchers have investigated the use of hearing technologies for individuals with dementia (Pichora Fuller, Dupuis, Reed & Lemke, 2013). Thus, the current study results add to the literature in this area, and are consistent with positive reports from other studies in which hearing aids were successfully used by individuals with dementia (Allen et al., 2003; Durrant, Palmer & Lunner, 2005; Palmer, Adams, Durrant, Bourgeois & Rossi, 1999). Although none of these teams found significant improvement in cognitive abilities of individuals with dementia, Palmer et al. found that the use of hearing aids resulted in a reduction in responsive or problematic behaviors for an individual with dementia and hearing loss. Audiologists should, therefore, continue to explore options for amplification with clients who have dementia and hearing loss.

In terms of audiological assessment in LTC facilities, the importance of otoscopy and cerumen management cannot be overstated. The current study findings are consistent with those of other researchers who reported a high prevalence of impacted cerumen in geriatric hospital in-patients (Allen et al., 2003; Lewis-Culliman & Janken, 1990). These researchers found that removal of cerumen resulted in a significant improvement in hearing. Conductive hearing losses caused by ear wax are generally easily treated by healthcare professionals, and were well-tolerated by the participants with dementia in the current study.

The hearing health of individuals with dementia in LTC settings is an interdisciplinary team issue. Speech-language pathologists and audiologists have crucial roles to play in educating other healthcare professionals about hearing loss and its treatment, including, but not limited to, amplification. The authors of the current study represent multiple disciplines including speech-language pathology, nursing, audiology and sociology. In clinical contexts, aural rehabilitation programs should involve all members of the health care team, including individuals with dementia and their family members, if these programs are to have a significant, lasting impact in LTC settings.

In conclusion, the important learnings from this study extend beyond the statistical analysis of performance differences between cognitive-communication testing conditions as a function of amplification. People with dementia are under-represented in speech, language and hearing research, despite the fact that the prevalence rates of dementia and of hearing loss are growing. The challenges of conducting applied research in hearing and communication for people with mild to moderate dementia must be addressed and overcome if hearing health of this group of vulnerable individuals is to be a priority.

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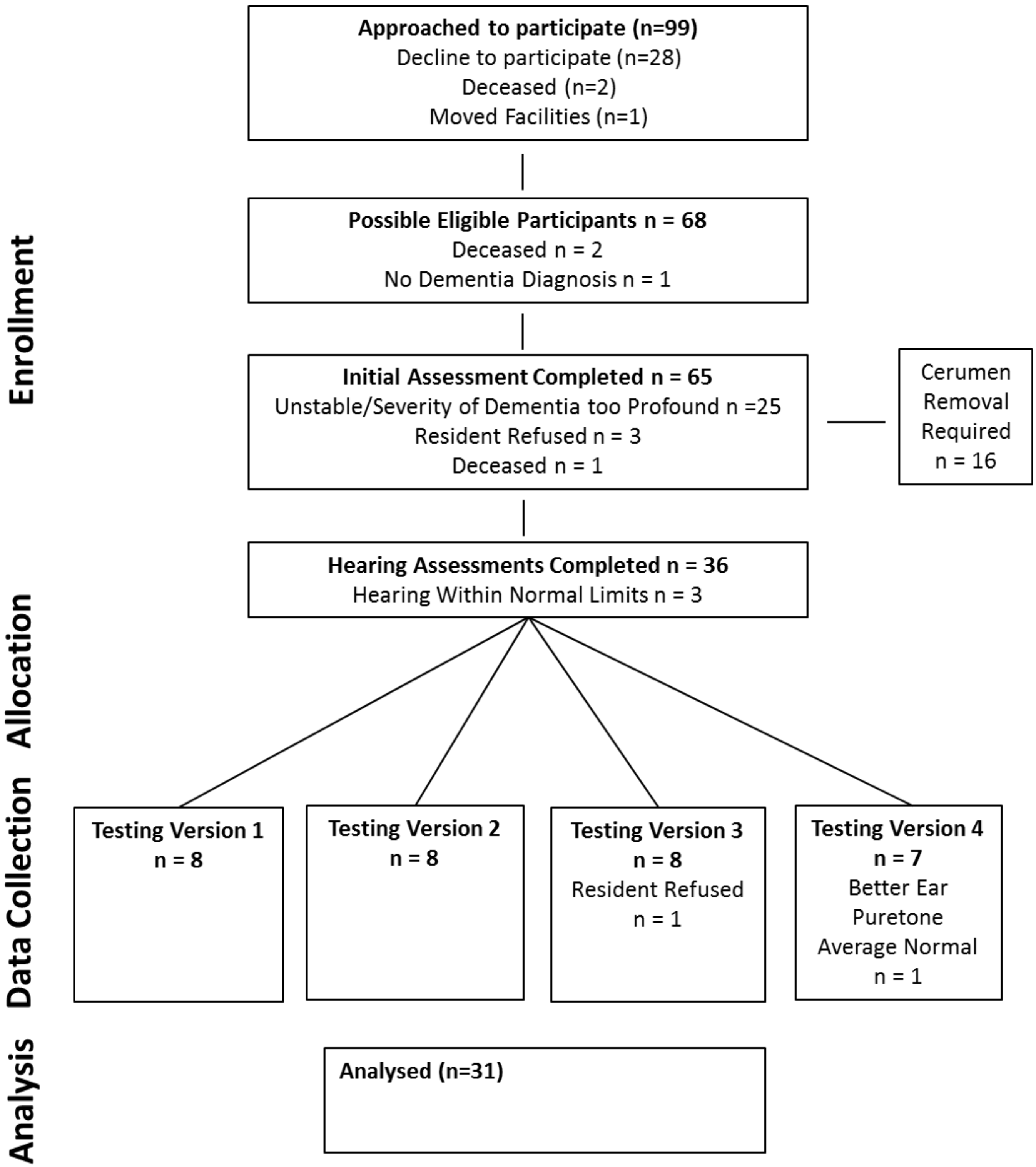

Fig. 1. Flow diagram of participant progress through trial phases.

Table 1

Resident Characteristics (n = 31)

Variable	n (%)
Female	18 (58.1)
English as first language	27 (87.1)
Cognitive Impairment (Cognitive Performance Scale: 0-6)	
Mild Impairment (2)	7 (22.6)
Moderate Impairment (3)	13 (41.9)
Moderate/Severe Impairment (4)	2 (6.5)
Severe Impairment (5)	3 (9.7)
Missing	6 (19.4)
Dementia Diagnosis	
Unspecified	15 (48.4)
Alzheimer's Disease	8 (25.8)
Vascular	5 (16.1)
Mixed	3 (9.7)
Hearing Impairment (Based on Better Ear PTA)	
Mild PTA (26 – 45 dB)	19 (61.3)
Moderate PTA (46 – 65 dB)	12 (38.7)
Hearing Aid Use	
Mild Impairment	6 (31.6)
Moderate Impairment	7 (58.3)
	mean (SD)

Age (All Residents)	88.0 (4.37)
Residents with Mild Hearing Impairment	86.9 (4.2)
Residents with Moderate Hearing Impairment	89.7 (4.3)

Table 2

Mean Differences of Primary Outcomes by Aided and Unaided Testing Conditions (n = 31)

Variable	Unaided Mean (SD)	Aided Mean (SD)	p-value
Story Retell – Immediate Recall	4.06 (4.54)	4.29 (4.56)	.575
Global Deterioration Scale (Conversation Only)	5.63 (2.14)	5.80 (2.07)	.502
FLCI Greeting & Naming	10.50 (2.61)	10.73 (2.92)	.394
FLCI Conversation	2.68 (1.11)	2.94 (1.03)	.199
FLCI Reminiscing	4.10 (1.64)	3.71 (1.81)	.056
FLCI Writing	5.00 (3.24)	5.87 (3.42)	.011*
FLCI Total	22.52 (6.85)	23.45 (7.46)	.168
Clock Drawing	5.52 (3.97)	5.58 (3.72)	.895
Boothroyd Word Recognition	0.57 (0.27)	0.68 (0.23)	.014*

*NS after Bonferroni correction (.05/9 = .005)

Table 3

Mean Differences of Speech Intelligibility Index by Aided and Unaided Conditions (n = 28)

Variable	Unaided Mean (SD)	Aided Mean (SD)	p-value
SII 55	23.5 (16.5)	45.4 (16.9)	<.001
SII 65	43.9 (22.1)	62.8 (16.7)	<.001
SII 75	66.54 (20.3)	74.7 (11.9)	<.001

Table 4

*Better Ear Pure-tone threshold average (PTA) compared to RAI-MDS Hearing Rating (n = 25)**

	n (%)				
Better Ear PTA	Hears Adequately	Minimal Difficulty	Hears in Special Situations	Highly Impaired	Total
Mild	6 (24.0)	6 (24.0)	2 (8.0)	0 (0)	14 (56.0)
Moderate	1 (4.0)	4 (16.0)	4 (16.0)	2 (8.0)	11(44.0)
Total	7 (28.0)	10 (40.0)	6 (24.0)	2 (8.0)	25 (100)

*RAI-MDS data unavailable for 6 participants