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Age-Related Deficits in Auditory Confrontation Naming

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Abstract

The naming of manipulable objects in older and younger adults was evaluated across auditory, visual, and multisensory conditions. Older adults were less accurate and slower in naming across conditions, and all subjects were more impaired and slower to name action sounds than pictures or audiovisual combinations. Moreover, there was a sensory by age group interaction, revealing lower accuracy and increased latencies in auditory naming for older adults unrelated to hearing insensitivity but modest improvement to multisensory cues. These findings support age-related deficits in object action naming and suggest that auditory confrontation naming may be more sensitive than visual naming.

Keywords

auditory naming; naming environmental sounds; multisensory naming

There is extensive literature providing evidence of age-related difficulties in naming (Burke, Worthley, & Martin, 1998; Connor, Spiro, Obler, & Albert, 2004; Feyereisen, 1997; Goodglass, 1980), although some studies have also reported either no age-associated difficulties or a significant age-related trend (Burke et al., 1998; Goodglass, 1980; Goulet, Ska, & Kahn, 1994). A few studies have reported that word-finding ability in older adults even exceeds that of young subjects (A. S. Brown & Nix, 1996; Rastle & Burke, 1996). In general, complaints of word-finding difficulties in older adults have been reported as common cognitive symptoms (Connor et al., 2004; Lovelace & Twohig, 1990). Moreover, naming deficits in advanced age may predict further cognitive decline in a subgroup of individuals who may be at risk for developing Alzheimer's dementia (AD; De Jager, Blackwell, Budge, & Sahakian, 2005; Jeon & Lee, 2009). However, some investigators conceptualize increased naming difficulties as a part of normal aging that cannot be fully explained by inclusion of subjects with early dementia (Mackay, Connor, & Storandt, 2005).

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Because studies documenting word retrieval difficulties in aging have used limited naming batteries, it has remained unclear if naming difficulties are part of aging or a precursor to accelerated age-associated cognitive decline.

Word-finding difficulties in older adults provide valuable information about the aging process, as they represent phonological retrieval difficulties with accurate access to semantic information (Shafto, Burke, Stamatakis, Tarn, & Tyler, 2007). This is in contrast to other aspects of language that do not appear to change with normal aging until after the age of 75 (Burke & Shafto, 2008). Older adults display relatively stable meaning of words in vocabulary and semantic retrieval during the processing of single words or sentences (Burke, 1997; Mayr & Kliegl, 2000; Taylor & Burke, 2002). Conversely, they report more tip-of-the-tongue states than young adults, with reduced phonological information about the target word and other related words demonstrating asymmetric aging effects on phonological versus semantic processes (Shafto et al., 2007; Taylor & Burke, 2002). It is unclear why phonological processes are more vulnerable than semantic representations to aging deficits, although it has been suggested that this might be related to greater redundancy in the representation of meaning than the representation of sound (Burke & MacKay, 1997; Burke, MacKay, Worthley, & Wade, 1991).

There has been some indication that retrieval of proper names (people or places) is disproportionately affected by advanced age compared to common names (objects) (Evrard, 2002). However, this dissociation was not supported by a direct comparison of naming to pictures of objects versus people (Maylor, 1995), although there is some evidence for subtle age-related decline in object naming (Connor et al., 2004). Moreover, object naming has also been reported to be better preserved than action naming in amnestic patients, with some indication that action naming is subserved by different neural mechanisms (Liljeström et al., 2008). Several different models have been proposed to explain differences between action naming and object naming, including dissociation of neural substrates for syntactic properties, semantic properties of categories, or sensorimotor dimensions such as manipulability (Caramazza & Hillis, 1991; Damasio & Tranel, 1993). The sensorimotor hypothesis implies that semantic networks active during perception may be stored according to dimensions such as manipulability of tools (Chao & Martin, 2000). However, most studies have evaluated either pictures of manipulable tools or words, with no investigation of how auditory perception of action sound may influence object action lexical retrieval, given the saliency of sound in movement.

Previous findings suggest that normal aging may be associated with decreased naming ability across sensory modalities, with an underlying common cause in retrieving stored lexical information. However, most experimental paradigms evaluating word retrieval difficulties have relied on picture and/or word tasks (Kaplan, Goodglass, & Weintraub, 1983), and there have been few attempts to evaluate how aging influences processing of sound. Findings of impaired recognition of meaningful sounds and auditory processing deficits in AD suggest that naming by auditory features may be impaired sooner than visual naming (Jeon & Lee, 2009; Rapcsak, Kentros, & Rubens, 1989). This auditory dysfunction is believed to be related to structural changes in the auditory pathways associated with AD pathology, which is in close proximity to medial temporal structures underlying memory

impairment, the hallmark feature of AD (Dublin, 1986; Kurylo, Corkin, Allard, Zatorre, & Growdon, 1993; Sinha, Hollen, Rodriguez, & Miller, 1993). Therefore, it is conceivable that auditory confrontation naming may be even more sensitive to age-related declines than commonly implemented visual confrontation naming tests (Jeon & Lee, 2009). However, it is unclear whether auditory naming declines are representative of normal aging or indicative of the onset of a neurodegenerative process. The purpose of this study was to examine the naming performance of older healthy adults relative to younger adults across sensory modalities. Subjects were asked to name manipulable objects in visual picture and auditory sound conditions and multisensory audiovisual presentations to determine whether this facilitated naming in older adults.

Method

Participants

Participants were 135 healthy adults (71 women and 54 men) ages 20–85, who were selected from a larger neuropsychological study. Subjects were screened for dementia with the Mini-Mental Status Examination (Folstein, Folstein, & McHugh, 1975) and a full neuropsychological battery; they were included in the study if they displayed normal cognitive performance (within 1 *SD* of the mean) and they were functionally independent. For comparison of age-related naming performances, the participants were recruited into one of two age groups: younger ($n = 71$ for 20–35 years of age) and older ($n = 64$ for 60–85 years of age) adults. Subjects were healthy (no chronic or serious medical conditions) and excluded on the basis of the presence of neurological or psychiatric disease, including depression and substance abuse. All subjects were native English speakers, strongly right-hand dominant as determined by the Edinburgh Handedness Inventory (Oldfield, 1971), and free of language impairments. Younger and older subjects were matched on education and verbal intelligence, as estimated by the American National Adult Reading Test (Grober & Sliwinski, 1991), and were screened for the presence of anomia with the Boston Naming Test (Kaplan et al., 1983; see Table 1).

Hearing Screening

All subjects were screened with the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982), and an audiometer screening was administered to 117 of the 135 subjects, resulting in exclusion of 10 older subjects. Of the remaining 125 participants (younger, $n = 61$; older, $n = 64$), 18 did not receive an audiology screening (14 younger; four older), but none of these subjects endorsed any subjective complaints on the hearing inventory. The hearing screening and threshold tests were conducted initially at 25 dB for the right ear, followed by the left ear, at 250, 500, 1000, 2000, 4000, and 8000 Hz. Participants were excluded if the average threshold level was greater than 41 dB or if there was a greater than 30-dB difference between the ears at any frequency level, similar to criteria in other studies (Fabiani, Kazmerski, Cycowicz, & Friedman, 1996).

Auditory and Visual Stimuli

Twenty-five common man-made objects (e.g., toothbrush, saw, zipper, telephone) were used for the battery. Visual pictures depicting the 25 objects were static color photographs of the

objects and did not contain any images of motion. Digitized sounds for the objects were obtained from three websites (<http://www.findsounds.com/types.htm>; <http://www.grsites.com/sounds>; <http://www.cofc.edu/~marcellm/confrontation%20sound%20naming/ziped.htm>) and a compact disc (*300 Spectacular Sound Effects*, 1994). Sounds were edited in Adobe Audition (Version 2.0), using the root-mean-square (RMS) normalization loudness function for equivalence. The mean name agreement for the objects in the battery (percentage of dominant name produced to pictorial items) was 1.07 (range: 0.7 to 2.7), with 1.19 mean alternative responses (range: one to two responses) from the International Picture Naming Project at the Center for Research and Language, University of California, San Diego. The objects had the following normative properties: mean verbal frequency of 11.14 (out of 14,529 occurrences for Brown frequency; G. D. A. Brown, 1984), mean familiarity of 563.5 (out of 9,392 occurrences), mean written frequency of 66.5 (out of 29,778 occurrences for the Kucera-Francis written frequency; Kucera & Francis, 1967) as derived from the MRC Psycholinguistic Database output (Coltheart, 1981; Wilson, 1988).

Behavioral Paradigm

The subjects engaged in a naming paradigm under auditory, visual, and multisensory (auditory–visual) presentations. The subjects were instructed to provide the specific name of the object as quickly as possible, although they were told that accuracy was more important. Each naming battery was presented in a counterbalanced order across subjects, and all possible orders were repeated several times for each group. All stimuli were presented with the Presentation stimulus delivery software program (Version 10.1). When auditory–visual (multisensory) stimulus items were presented together, they were presented simultaneously. Object sounds and images were presented via a Dell laptop; Koss headphones and amplifier were used for presentation of the auditory stimuli and provided a frequency response of 20 Hz to 30,000 Hz and sensitivity of 105 dB. Subjects were provided a 4-s maximum for stimulus presentation, but responses preceding 4 s were recorded and thus shortened the time of stimulus presentation. The stimulus was withdrawn even when subjects did not respond within the 4-s stimulus presentation, although they were allowed up to 25 s to produce a response while looking at a blank computer screen. Ambiguous or nonspecific responses (naming a general class of object) were queried for further information and marked as correct if the second response was accurate. Similarly, self-corrections were scored as correct if the subject corrected the response prior to presentation of the next stimulus item. Reaction times were measured from stimulus presentation to first response generation. Response accuracy and reaction times in milliseconds were collected by the experimenter hitting a key on the keyboard following a subject's response.

Results

Naming Accuracy

Univariate tests revealed a significant between-subjects effect of age group for naming accuracy, $F(1, 123) = 52.42, p < .001$, and within-subjects effects for changes in naming accuracy across sensory conditions, $F(2, 246) = 263.31, p < .001$. Younger adults had better naming collapsed across sensory cue conditions ($M_{\text{young}} = 93.2\%$) than older adults ($M_{\text{older}} = 85.1\%$; see Table 1). Pairwise comparisons with Bonferroni correction revealed that

naming accuracy in the auditory condition ($M_{\text{auditory}} = 75.4\%$) was significantly lower than naming in the visual ($M_{\text{visual}} = 95.7\%$) and multisensory conditions ($M_{\text{multi}} = 96.4\%$, $p < .001$; see Table 1 for means). However, there was no significant difference between naming in the visual and multisensory conditions ($p = .085$). There was a significant Age Group $\times$ Sensory Condition interaction for accuracy, $F(2, 246) = 51.11$, $p < .001$. The older adults displayed a larger difference in accuracy between sensory cue conditions than younger adults. Age group differences in naming accuracy were different between auditory and visual conditions, $F(1, 123) = 47.4$, $p < .001$, and auditory and multisensory conditions, $F(1, 123) = 58.11$, $p < .001$. There was also an age group difference between visual and multisensory conditions, $F(1, 123) = 4.93$, $p < .05$, although the size of the differences was much less. Older adults displayed a much greater difference between the auditory condition and the visual and multisensory conditions than younger adults. Also, for older adults naming accuracy was significantly different between visual and multisensory conditions, consistent with a slight improvement in naming to multisensory cues.

Reaction Times for Correctly Named Items

The within-subjects effect was significant for a Sensory Cue Condition $\times$ Age Group interaction for reaction times for accurately named items, $F(2, 246) = 13.26$, $p < .001$. The age groups were significantly different in reaction times between the auditory and visual conditions, $F(1, 123) = 17.76$, $p < .01$, and the auditory and multisensory conditions, $F(1, 123) = 11.29$, $p < .01$ (see Table 1; Figure 1). However, there was no significant age group difference in reaction times between the visual and multisensory conditions, $F(1, 123) = 2.93$, $p = .09$. These results reveal much longer reaction times for older subjects across conditions, particularly for the auditory condition relative to the other conditions, when compared with younger subjects. These findings suggest that there are increased auditory processing demands for older adults even when accuracy is controlled.

Control Analyses

Audiometric analyses—Differences between the left and right ears were computed for each subject at frequency levels of 250, 500, 1,000, 2,000, and 4,000 Hz. Age group comparisons revealed differences between the two age groups at 250 Hz, $F(1, 105) = 4.58$, $p < .05$, and 1,000 Hz, $F(1, 105) = 6.43$, $p < .05$, but not at 500, 2,000, or 4,000 Hz. At 200 Hz, younger adults had greater asymmetry between the ears (-1.52) compared with older adults (0.54), whereas at 1,000 Hz older adults had greater asymmetry (2.32) than younger adults (0.0). Difference values at 200 and 1,000 Hz did not significantly adjust the variance in auditory naming between age groups, and a significant between-group effect remained, $F(3, 103) = 41.06$, $p < .0001$.

Item analyses of naming latencies—We conducted additional analyses to examine the credibility of the interaction because it was limited by ceiling effects for the visual condition in younger subjects. Object naming latencies were ordered in the visual and auditory conditions for the young adults. In the young subjects, difficult items with latency of rank orders of 23, 22, 21 and 14 in the visual condition overlapped with easy rank orders of 11, 5, 6, and 4 in the auditory condition, respectively. These same items produced visual-auditory differences in the older adults. Differences in mean reaction times between visual and

auditory conditions approached significance for young adults ($t = -3.11, p = .053$) but were highly significant between conditions for older adults ($t = -6.33, p = .008$). Although younger and older adults did not differ in reaction times for these items in the visual condition ($t = -1.59, p = .209; M_{\text{younger}} = 1,954.13; M_{\text{older}} = 2,349.63$), they did differ in reaction times in the auditory condition ($t = -6.11, p = .009; M_{\text{younger}} = 2,413.82; M_{\text{older}} = 3,364.57$), supporting the interaction.

Accuracy analyses for the first block of stimulus items—To evaluate the influence of counterbalancing, we analyzed the first block of each condition as a control analysis. Older adults' auditory naming accuracy was lower than that of younger adults, irrespective of the first block order (see Table 1). Between-group differences for visual naming were present for the auditory first block condition and approached significance for the visual first condition (see Table 1). There was also a difference between groups for subjects that received the multisensory condition first.

Discussion

This study evaluated differences in naming performance across different sensory modalities in older healthy adults (60–85 years) relative to younger adults (20–35 years). We hypothesized that there may be differences in naming of manipulable objects across sensory modalities in visual, auditory nonlinguistic, and multisensory (visual–auditory) domains. Specifically, we tested the hypothesis that auditory confrontation naming of sounds of manipulable objects may be more susceptible to age-related decline. Because older adults frequently experience hearing loss, we performed an audiometric evaluation to control for hearing insensitivity. Furthermore, because older subjects with neurodegenerative disorders may be more likely to experience auditory processing and naming deficits (Jeon & Lee, 2009; Rapcsak et al., 1989), we excluded subjects with demonstrated cognitive compromise by using stringent cutoffs.

The results of this investigation indicate that naming performance varied across age groups, such that the older subjects were less accurate and produced slower responses in naming across sensory conditions. There was also a sensory condition effect, whereby all subjects (collapsed across age groups) produced less accurate and slower naming responses in the auditory condition compared with visual and multisensory conditions. The accuracy was not significantly different between visual and multisensory conditions, although reaction times for multisensory cues were longer than those for visual cues. These results support differences in naming of action objects on the basis of advanced age, as well as different sensory modalities. Although the accuracy for all subjects was lower in the auditory condition and required greater time for processing, the magnitude of the difference was greater for older subjects. Older subjects had much lower accuracy when naming to environmental sounds than when naming to visual pictures or with multisensory cues. Also, older subjects improved their naming accuracy slightly in the multisensory condition, suggesting that multisensory enrichment may facilitate lexical retrieval in older adults. Older adults' auditory naming accuracy was significantly lower than that of younger adults, irrespective of which condition was presented in the first block. The order of the first block of stimulus items did influence the results in a way that suggests that subjects who received

the multisensory block first benefited primarily in the visual domain and vice versa. However, block order had little influence on the auditory condition results, conceivably because subjects rely more heavily on pictorial cues in both the visual and multisensory conditions.

Furthermore, much longer reaction times were evident for older subjects in the auditory condition for correct items, suggesting that auditory processing requirements for older adults are greater and that the speed of processing is not compromised because of inaccuracy. However, the interaction for naming accuracy is somewhat limited by the ceiling effect of the visual condition in younger adults and should be considered in the interpretation. Although the latency in auditory naming supports this interaction, it also demonstrates that not only older adults but also young adults produced delayed naming latencies in the auditory condition. To further evaluate the credibility of this interaction, we ordered object naming latencies in the visual and auditory conditions for the young adults. Difficult visual items that overlapped with easy auditory items in young subjects were evaluated, and these same items produced visual–auditory differences in older adults, providing support for the interaction.

Age-associated auditory processing difficulties are common and appear to be distinct from loss in hearing sensitivity. This is supported by our results, which demonstrate differences in hearing sensitivity at specific frequencies and naming between younger and older adults, although differences in hearing sensitivity could not account for the differences in auditory naming between the groups when performance on the audiometric evaluation was used as covariate. It has been reported that auditory functioning in normal aging may predict decline in memory functioning by as much as 6 years and that central auditory dysfunction precedes the onset of clinical dementia in individuals with AD (Gates, Beiser, Rees, D'Agostino, & Wolf, 2002; Gates et al., 1995; Valentijn et al., 2005). This auditory dysfunction is believed to be related to structural changes in the auditory pathways associated with AD pathology, which are in close proximity to medial temporal structures underlying memory impairment, the hallmark feature of AD (Dublin, 1986; Kurylo et al., 1993; Sinha et al., 1993). Because we excluded subjects with cognitive difficulties, our findings cannot shed light on the relationship between memory decline and auditory naming deficits. However, based on the neuropathological premise of susceptible brain regions in advanced age, it is conceivable that auditory confrontation naming may be even more sensitive to age-related declines than commonly implemented visual confrontation naming tests.

Our results are not completely consistent with the few previous investigations that compared younger or older healthy adults in the processing of nonverbal sounds. However, there is a lack of studies addressing lexical retrieval in auditory naming, and there are no studies evaluating multisensory processing in naming. Also, most studies have used a mixture of manipulable and nonmanipulable objects; previous work suggests that there may be increased difficulty in naming action objects compared to other common objects and describing different neural pathways for action (Chao & Martin, 2000; Liljeström, Hultén, Parkkonen, & Salmelin, 2009; Liljeström et al., 2008). Previous comparisons of auditory processing have failed to demonstrate greater impairment in auditory nonlinguistic naming in older adults and have reported more rapid processing of nonverbal sounds for accurate

items by both younger and older adults (Saygin, Dick, & Bates, 2005; Taylor & Burke, 2002). This is in direct contrast to our findings of slower responses by older subjects for naming of environmental sounds, even when accuracy is taken into consideration. These differences are likely explained by differences in task demands of object recognition and matching versus the lexical retrieval demands of our study. Moreover, our study design does not allow for identification of the specific stage of difficulty experienced by older adults during auditory confrontation naming. Successful naming of auditory cues requires the usual stages of accurate retrieval of semantic and word-form information, but it requires auditory recognition as well (Goral, Spiro, Albert, Obler, & Connor, 2007). Because our study design does not isolate auditory recognition functions, future studies should closely evaluate each stage of the auditory naming process to determine the specific age-related deficit.

In conclusion, this study suggests that older individuals display declines in speed of processing environmental sounds and in the accuracy of auditory confrontation naming. These findings suggest that auditory confrontation naming batteries may provide increased sensitivity, and multisensory cues may facilitate lexical retrieval. Future studies should evaluate the relationship between auditory naming and other cognitive functions and delineate the neural mechanisms that subserve sound versus picture naming.

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Figure 1.
Mean reaction times (milliseconds) for correctly named items.

Table 1
Means, Standard Errors, and Between-Group Significance Across Conditions and for the First Block

Variable	Younger			Older			F	P	η ²
	M	SE		M	SE				
Screening measures									
Age	26.9	0.49		69.8	0.83	1,916.03	.0001	***	.94
Education	17.08	0.19		17.15	0.31	0.034	.854		.00
MMSE	29.5	0.09		29.16	0.12	6.08	.015	*	.05
AMNART	122.6	0.59		123.46	0.54	1.15	.287		.01
Edinburgh HQ	81.39	1.47		76.61	4.12	1.15	.285		.01
BNT	55.74	0.35		56.36	0.27	1.29	.257		.03
Naming accuracy									
Auditory	84.8	1.97		65.98	1.92	61.81	.0001	***	.33
Visual	96.69	0.69		94.59	0.67	9.72	.002	**	.07
Multisensory	97.06	0.63		95.67	0.61	2.76	.098		.02
Reaction times (ms)									
Auditory	2,815.35	140.4		3,898.18	137.1	30.46	.0001	***	.19
Visual	1,555.46	48.78		1,833.97	47.63	16.69	.0001	***	.12
Multisensory	1,666.19	60.22		2,105.56	58.79	27.26	.0001	***	.18
First block accuracy									
Auditory first									
Auditory	79.14	1.95		56.65	2.39	48.43	.0001	***	.44
Visual	97.43	0.75		94.49	1.04	4.64	.035	*	.07
Multisensory	97.14	0.94		95.89	0.84	0.975	.327		.02
Visual first									
Auditory	89.75	1.5		76.0	3.63	13.43	.001	**	.32
Visual	95.75	0.93		92.3	1.59	3.75	.063		.12
Multisensory	96.5	1.15		96.57	0.92	0.002	.962		.00
Multisensory first									
Auditory	92.0	2.22		78.46	3.4	11.9	.002	**	.30

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Variable	Younger		Older		F	P	η^2
	M	SE	M	SE			
Visual	97.65	0.69	95.69	1.39	1.82	.188	.06
Multisensory	97.42	0.68	94.15	1.4	5.05	.033*	.15

Note. Significant *p* values are bolded. MMSE = Mini-Mental Status Examination, maximum score of 30; AMNART = American New Adult Reading Test with IQ equivalency; Edinburgh HQ = Edinburgh Handedness Quotient > +60 as strongly right hand dominant; BNT = Boston Naming Test, 60 total items; accuracy = percentage correct.

* *p* < .05.
** *p* < .01.
*** *p* < .001.