Published in final edited form as:

Ear Hear. 2012 March ; 32(2): 250–256. doi:10.1097/AUD.0b013e31822f680f.

Word Recognition Within a Linguistic Context: Effects of Age, Hearing Acuity, Verbal Ability and Cognitive Function

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Abstract

Objective—Participants in traditional studies of the effects of context on spoken word recognition have been university undergraduates. When older adults have been included, they have typically been matched with these young adults for verbal ability or years of education. Although this may be a good strategy for eliminating confounding variables, it is not clear how results of these studies may extend to the general population of young and older adults. The objective of this study was to examine the effects of adult age, hearing acuity, verbal ability and cognitive function on the use of linguistic context in spoken word recognition.

Design—Fifty-three adults, aged 19 to 89, heard short sentences in which the final word was masked by multitalker babble. The level of babble was progressively reduced in 2 dB steps until the sentence-final word could be correctly identified. Published norms were used to construct sets of sentences in which the same word could be heard with three levels of predictability (low, medium, high) based on the linguistic context. In a fourth condition (no context) the words were preceded by a neutral carrier phrase. Participants received tests of verbal ability, with an emphasis on vocabulary knowledge, a brief test battery to assess cognitive function, and an assessment of hearing acuity based on pure-tone thresholds. Participants' hearing acuity ranged from normal acuity to moderate hearing loss.

Results—Results showed that the signal-to-noise ratio necessary for correct word recognition varied inversely with the probability of that word occurring in the sentence context. Hearing loss had a significant effect on word recognition for words heard in a neutral context, but the effect of hearing acuity diminished progressively with increasing contextual probability of the target word. Hierarchical multiple regressions showed that hearing acuity accounted for a significant amount of the variance at the lowest three levels of contextual probability but not at the highest probability level tested. Cognitive function contributed significantly to the obtained variance in word recognition performance at all levels of contextual probability tested. Moreover, participant age accounted for a significant amount of variance even after hearing acuity and cognitive function were taken into account. Verbal ability in the range represented by the test participants did not contribute significantly to recognition performance in any of the context conditions.

Conclusions—Peripheral hearing acuity accounted for only a part of the variance in word recognition accuracy, with significant variance also contributed by individual differences in cognitive function and participant age. Results showed the ability to use linguistic context to aid spoken word recognition is sufficiently robust that a relatively wide range in verbal ability among native English speakers had no effect on recognition performance.

Keywords

word recognition; linguistic context; adult aging; hearing acuity; cognitive ability

Numerous studies over the past 60 years have affirmed the fundamental principle in perception that, the higher the probability of occurrence of a stimulus, the less sensory information will be needed for its correct recognition (Howes 1954). For linguistic material this principal has been frequently demonstrated using the so-called ‘cloze’ procedure (Taylor 1953), in which the transitional probability of a word in a sentence context is estimated by the percentage of individuals who give that word when asked to complete a sentence with what they believe would be the most likely final word (e.g., “He mailed a letter without a ____.”).

Whether measured by the minimum exposure duration necessary to recognize a written word, or the minimum signal to noise ratio necessary to recognize a spoken word, the amount or clarity of the stimulus necessary for its recognition has been shown to be inversely proportional to the logarithm of its probability in that linguistic context (Tulving & Gold 1963; Morton 1964, 1969; see also Black 1952; Bruce 1958). This general principle holds for older as well as for younger adults for both written (Madden 1988), and spoken words (Wingfield et al. 1991; Perry & Wingfield 1994), and for older adults with reduced hearing acuity (Pichora-Fuller et al. 1995; Dubno et al. 2000; Grant & Seitz 2000). It is also embodied in the SPIN test and related speech-in-noise tests used in audiometric assessment, where intelligibility is recorded for words presented in background noise with or without a constraining linguistic context (Kalikow et al. 1977; Wilson et al. 2007).

Historically, the initial studies of the facilitating effects of a linguistic context on word recognition were conducted on college students as a population of convenience for university-based research. In cognitive aging research this tradition has largely still been followed, with university undergraduates representing the young adults, compared to an older adult cohort matched for education and verbal ability (cf., Park & Schwarz 2000; Craik & Salthouse 2007). On the other hand, many studies of aging, hearing acuity, and speech recognition give no demographic information at all, beyond age and hearing acuity. Pichora-Fuller and Souza (2003) have made a specific note of this inattention to factors beyond age and hearing acuity, pointing out that most research on speech perception with older adults has used well-educated, self-selected volunteers. As they indicate, this is a good strategy for eliminating confounding variables such as linguistic ability and educational achievement, but it is not clear to what extent such studies fairly describe the general population of older, or we might add, younger adults as well (Pichora-Fuller & Souza 1963, pg. 2S14).

The purpose of this study was to explore the effects of adult aging and hearing acuity on the use of linguistic context in spoken word recognition using native English-speaking participants with a far wider range of educational achievement and vocabulary knowledge than is typically found in such studies. There is no suggestion that participants with this demographic range will not spontaneously employ linguistic context in spoken word recognition. Rather, our question is how hearing acuity, age, and verbal and cognitive ability may contribute to word recognition data when words are heard in the absence of a linguistic context, or when heard preceded by varying degrees of contextual constraint.

METHOD

Participants

The participants were 53 adults, 29 women and 24 men, with ages ranging from 19 to 89 years ($M = 56.1$ years, $SD = 21.7$). The participants were recruited through the audiology department at the Boston Medical Center and chosen to represent a range in chronological age, auditory acuity and years of formal education. All reported English as their first language but the group varied widely in levels of education, ranging from a low of 4 years to a high of 19 years of formal education ($M = 14.7$ years, $SD = 3.3$). All participants reported themselves to be in good health, with no history of stroke, Parkinson's disease, or other neurological involvement that might compromise their ability to perform the research task.

Hearing Acuity—Audiometric evaluation was carried out for each participant using a GSI 61 clinical audiometer (Grason-Stadler, Inc., Madison, WI) by way of standard audiometric techniques in a sound-attenuated testing room. Distortion-product otoacoustic emissions (DPOAEs) were obtained using the AuDx (Bio-logic Systems Corp., Mundelein, IL) to help confirm a cochlear locus when hearing loss was present and to reject participants with possible auditory neuropathy (Starr et al. 1996). Participants' hearing acuity ranged from 2 dB HL to 60 dB HL in the better ear based on their high-frequency pure-tone average (HFPTA) across 1000, 2000, and 4,000 Hz, a frequency range known to be a good predictor of perceptual performance for speech (Humes 1996). None of the participants wore hearing aids on a regular basis and all testing was conducted unaided.

Verbal Ability—We used two tests of verbal ability, which is commonly assumed to represent crystallized knowledge, a form of mental ability based on experiential and accumulated knowledge (Baltes et al. 1999). The first test of verbal ability was the vocabulary subtest from the Wechsler Adult Intelligence Scale -III (WAIS; Wechsler 1997), in which participants are scored for their ability to define 33 presented words. The second was the Wechsler Test of Adult Reading (WTAR; Wechsler 2001), a read-aloud test for 50 words whose pronunciation differs from their grapheme, requiring the participant to rely on word-knowledge rather than standard pronunciation rules. The WAIS vocabulary raw scores ranged from 14 to 70 ($M = 48.13$, $SD = 16.45$). Scaled scores ranged from 4 to 19, representing a range of greater than 3 standard deviations (SD) above, to 2 SD below the mean, based on a normative sample (Wechsler 1997). The WTAR also showed a wide range ($M = 36.22$, $SD = 13.35$). Standard scores ranged from 61 to 126, reflecting 56% of the participants falling within 90% of the predicted interval for their age and education levels and the remainder scoring above or below this score (Wechsler 2001). In order to create a more stable estimate of verbal ability, the raw scores on each of the two verbal tests were converted to z-scores and averaged to give a composite score with good reliability (Cronbach's $\alpha = .947$).

Cognitive Function—All participants also received a series of cognitive tests based on an in-person version of the cognitive battery developed by Tun and Lachman (2006). These were administered as tests of fluid cognitive ability, which reflects the capacity to rapidly process and integrate new information (Baltes et al. 1999). This included a test of *episodic memory*, based on the number of words that could be correctly recalled from a list of 15 common nouns, presented at a rate of 1 word per second. Testing was conducted immediately after presentation ($M = 6.16$ words, $SD = 1.67$), and after a 15-minute delay ($M = 3.78$ words, $SD = 2.41$). *Working memory* was assessed by the backward digit span from the WAIS III (Wechsler, 1997), in which sets of 2 to 8 digits, presented at a rate of 1 digit per second, were to be recalled in the reverse order from which they were heard. The score was represented by the longest string correctly reported; the group mean was 2.83 ($SD =$

1.80). *Speed of processing* was assessed by a backward counting task, which involved counting backwards from 100 by ones as quickly as possible in 30 seconds. Scoring was based on the number of digits correctly reported, minus repetitions (Tun & Lachman 2006); the group mean was 30.91 ($SD = 11.09$). A composite cognitive score for each participant was computed as the average of the standardized scores across the cognitive battery, which gave good measurement reliability (Cronbach's $\alpha = .742$).

Although verbal and general cognitive ability can be distinguished conceptually as crystallized versus fluid abilities (Horn 1982), there is often a positive correlation between the two (van der Maas et al. 2006). As we shall see, this was also true in the present case. Nevertheless, a principle components analysis with direct oblimin rotation conducted on our crystallized (verbal knowledge) and fluid (cognitive) measures supported the breakdown of these two factors with an eigenvalue greater than one (Basilevsky, 2008). Together these factors accounted for 76% of the variance.

Stimulus Materials

The stimuli consisted of 20 one- and two-syllable target words, each of which was recorded by a single speaker in the absence of a surrounding context that might affect coarticulation. Each target word was then spliced into three different sentence contexts that varied in the probability to which they predicted the target word based on the 'cloze' procedure (Bloom & Fischler 1980). The stimuli were checked against those collected by Lahar et al. (2004) to avoid stimulus combinations that might be age-cohort specific. The range of transitional probabilities were binned into three response-probability categories: a *low predictability* context, which we defined as a contextual probability of .02 to .05 ($M = .03$; e.g., "The cigar burned a hole in the FLOOR" [$p = .03$], a *medium predictability* context of .09 to .21 ($M = .13$; e.g., "The boys helped Jane wax her FLOOR" [$p = .10$] and a *high predictability* context of .25 to .85 ($M = .53$; e.g., "Some of the ashes dropped on the FLOOR [$p = .43$]). Each of the target words was also presented in a *No Context* condition in which the target word was preceded by the neutral carrier phrase, "The word is...." All of the sentences had simple syntactic forms as in the above examples, and all of the target words were common words with high frequencies of occurrence in English based on published norms (Francis & Kucera 1982).

All stimuli were recorded by the same female speaker of American English who had recorded the target words, with the sentences and neutral carrier phrase recorded at a comfortable speaking rate of approximately 176 words per minute. These renderings were recorded onto computer sound files using SoundEdit software (Macromedia, Inc., San Francisco, CA) for the Macintosh computer (Apple, Cupertino, CA), that digitized (16-bit) at a sampling rate of 44,000 Hz. Recordings were normalized to insure an even RMS amplitude level across context conditions. Computer editing was used to splice the single rendering of each target word onto each of its four sentence context conditions to insure that any performance differences for a given target word would not be due to accidental differences in the way in which the target word had been uttered. In presentation, to be described below, the context sentences were always presented in a silent background, with the target word noise-masked to varying degrees. Target words were always the final words of the sentences.

Procedures

Each participant heard each of the 20 target words in only one of its four context conditions, with the particular sentence and target word combinations varied across participants. Sentences representing the four context conditions were randomly intermixed for each participant. Participants were told that they would be hearing a series of sentences in which

the last word of the sentence would be overlaid by a masking noise that would make it difficult for the word to be recognized. If they were unable to identify the last word of the sentence (the target word), the sentence would be presented again, but this time with the level of the noise masking over the target word reduced. If still unable to identify the target word the procedure would continue, with the sound level of the masking over the target word incrementally reduced until it could be correctly identified. Once the target word was correctly identified the next sentence with its masked sentence-final target word would be presented using the same procedures. Participants were encouraged to attempt a response on every presentation, even if unsure, but not to guess wildly. (A preliminary analysis of data showed that two of the 20 target words, “road” and “work,” were outliers in recognition performance; these words were dropped from final analyses.)

The speech signal, both context sentences and target words, was presented at 65 dB HL, a sound level confirmed by pretest to be intelligible for similar materials for all participants. On the initial presentation of each sentence, the masking stimulus was set at 10 dB above the level of the sentence-final target word, representing a signal to noise ratio (SNR) of -10 dB. The masking stimulus used was 20-talker babble (Auditek, St. Louis, MO). On each subsequent presentation the masking level was reduced by 2 dB until the word was correctly identified.

The recognition threshold for each word was defined as the lowest SNR that allowed the word to be correctly identified in that sentence context. Stimuli were presented binaurally over Eartone 3A (E-A-R Auditory Systems, Aero Company, Indianapolis, IN) insert earphones via a Grason Stadler GS 61 clinical audiometer using Psyscope presentation software (Cohen et al. 1993). Informed consent was obtained following protocols approved by both Brandeis University and Boston Medical Center Institutional Review Boards.

RESULTS

To give an overall picture of the effects of hearing acuity on the utilization of linguistic context on word recognition, the 53 participants were divided into three groups based on hearing acuity: those with good hearing acuity (HFPTAs better than 15 dB HL), those with a slight-to-mild hearing loss (HFPTAs from 16 – 40 dB HL) and those with moderate hearing loss (HFPTAs from 41 – 60 dB HL) (Katz, 2002). Descriptive data for each of the three acuity groups are given in Table 1. The three groups did not differ significantly in mean age, $F(2,50) < 1.0$, years of formal education, $F(2,50) < 1.0$, verbal ability scores, $F(2,50) < 1.0$, or cognitive test scores, $F(2,50) = 3.06$, *n.s.* It can be seen, however, that there was substantial within-group variability, a point to which we will return in a subsequent section.

Figure 1 shows mean recognition thresholds represented as the minimum SNR allowing for correct word recognition for each of the four context conditions (no context, low context, medium context, high context). These data were analyzed with a 3 (Hearing acuity group) X 4 (Context condition) mixed-design analysis of variance (ANOVA), with context condition as a within participants variable and hearing group as between participants. The general decline in recognition threshold with increasing contextual constraint seen in Figure 1 was supported by a significant main effect of context level, $F(3, 153) = 63.40$, $p < .001$, $\eta_p^2 = .57$. There was also a significant main effect of hearing acuity group, $F(2,51) = 6.23$, $p < .01$, $\eta_p^2 = .20$. As implied by visual inspection of Figure 1, paired comparison testing confirmed a significant difference in recognition thresholds between each of the three acuity groups when words were presented without contextual support in the No Context condition ($p < .05$ or better in all cases). The tendency for these differences to diminish with increasing contextual constraints was confirmed by a significant Hearing acuity X Context level interaction, $F(6, 153) = 3.10$, $p < .01$, $\eta_p^2 = .11$.

Although examinations of the effects of hearing acuity on word recognition often use the extreme contrast of words heard with a neutral context versus those heard with high context (e.g., Dubno et al. 2000; Grant & Seitz, 2000; Pichora-Fuller et al. 1995), the effects of linguistic context are known to be graded within these two extremes (Tulving & Gold 1963; Morton 1964), as was the case for these data. A calculation for each participant of the best-fitting slope of the recognition thresholds across the log-transformed transitional probabilities of the target words, showed the slope (m) to be significant but relatively slight for the listeners with good hearing acuity ($m = -1.38$), slightly greater for those with a slight-to-mild hearing loss ($m = -1.77$), and steeper for those with a moderate hearing loss ($m = -2.48$). A univariate ANOVA conducted on these slopes showed a significant effect of hearing acuity group, $F(2, 51) = 3.48$, $p < .05$, $\eta_p^2 = .12$. (For this analysis the probability of the words in the No Context condition was approximated using their relative frequency of occurrence in published word counts [Francis & Kucera 1982]).

Effects of Hearing Acuity, Age, Cognitive Function, and Verbal Ability

Although Figure 1 shows clear effects of hearing acuity on word recognition thresholds, the error bars indicated considerable variability around the plotted means. To explore the factors that led to this variability we carried out hierarchical multiple regression analyses for each level of context. This separation was predicated on the possibility that the factors that affect one level of context (e.g., the No Context condition) need not necessarily have an equivalent effect when increasing contextual constraints are present. The dependent variable in each case was the recognition threshold represented by the lowest SNR that allowed a target word to be reported correctly. Predictor variables were entered into the model in blocks, in the following order: (a) hearing acuity represented by the better ear HFPTA, (b) cognitive ability, represented as a z-score composite of the individuals' episodic memory, working memory, and processing speed measures, (c) verbal ability represented as a z-score composite of WAIS vocabulary and WTAR scores, and (d) participants' chronological age in years. This order was selected so as to show the contribution of cognitive and verbal ability after statistically controlling for hearing acuity, and finally to determine if age contributed unique variance after accounting for hearing acuity, cognitive, and verbal abilities.

The results of the regression analyses are shown in Table 2. For each predictor variable in each context condition we show the R^2 , which represents the cumulative contribution of each variable along with the previously entered variables, and the change in R^2 , which shows the contribution of each variable at each step. The next column shows the level of significance for each variable, and the final column the standardized regression coefficient. The regression analyses show that for all levels of context except for the High Context condition, hearing acuity and cognitive test scores contributed significant variance to the word recognition thresholds, with age showing a significant contribution even after hearing acuity and cognitive ability had been entered into the analysis. In the High Context condition hearing acuity, unlike cognitive test scores and age, no longer played a role in recognition thresholds. It is notable that verbal ability in the range represented by this participant sample did not contribute significant variance under any context condition. (Years of formal education entered into this analysis also failed to show a significant contribution to recognition performance for any of the context conditions.)

Relation Among Predictor Variables

As indicated previously, there was a significant correlation between participants' cognitive and verbal ability composite scores. This can be seen in Table 3, which shows Pearson correlations among our predictor variables. As would be expected from the literature, there was also a significant correlation between age and cognitive test performance, but not

between age and verbal ability, the latter being considered a crystallized ability that remains generally stable in adult aging (Horn, 1982). Less expected was the appearance of a relationship between hearing acuity and cognitive function, a relationship that typically begins to appear only among the oldest old (Baltes & Lindenberger 1997). The fact that our regression data showed cognitive ability to emerge as a significant predictor of word recognition even after statistically controlling for hearing acuity, however, further strengthens the case for the importance of cognitive ability on word recognition.

In view of the relationship shown in Table 3 between verbal and cognitive ability scores, we also conducted a stepwise regression with verbal ability entered after hearing acuity and before cognitive ability. This additional analysis was conducted in order to confirm that a potential predictive power of verbal ability on recognition performance was not being obscured by cognitive ability. This procedure did not change the pattern reported in the initial regression, with verbal ability still failing to make a significant contribution to the variance in any of the context conditions, while general cognitive ability still emerged as a significant predictor in each context condition (all $p < .01$).

DISCUSSION

Outside of the psychophysical laboratory or audiometric testing environments it is rare that spoken words are encountered in a total absence of context. In its conventional usage, “context” refers to the embedding of a stimulus in some contiguous material whose presence directly operates to reduce the level of uncertainty for the occurrence of the stimulus. Well over a century ago, James McKeen Cattell observed that a word presented in the context of a sentence, or a letter in the context of a word, could be read faster than when presented without such contextual constraints (Cattell 1886). It was subsequently confirmed for young adults that auditory intelligibility for spoken words is also facilitated by the word’s probability of occurrence, whether the contextual probability was manipulated with a sentence context, word associations, or the provision of a category description for the target word (Black 1952; Bruce 1958; Rubenstein & Pollack 1963). In the case of older adults, it has been demonstrated that word recognition is facilitated by sentence context to an equal or greater degree than for young adults (cf. Cohen & Faulkner 1983; Dubno et al., 2000; Wingfield et al 1991; Perry & Wingfield 1994).

This general principle of contextual facilitation has been affirmed in previous studies with young and older adults with good and with poor hearing acuity for words presented with versus without a supportive linguistic context (e.g., Pichora-Fuller et al. 1995; Dubno et al. 2000; Grant & Seitz 2000). In addition, we show here that the effect of context on recognition thresholds for words in noise is an incrementally graded one across the range of probabilities tested, with this effect especially prominent for the participants with hearing loss in the moderate range.

The importance of sensory-cognitive interactions in speech recognition in adult aging and hearing loss has gained increasing attention in the literature at both the behavioral (Stewart & Wingfield 2009; Wingfield 1996; Humes 1996, 2005; Wingfield & Tun 2001; Schneider & Pichora-Fuller 2000; Pichora-Fuller 2003; Arlinger et al. 2009) and in auditory physiology (e.g., Anderson & Kraus 2010, pg. 582). It is noteworthy, and clinically important, that the regression analyses showed that while age and cognitive test scores contributed significant variance to recognition thresholds in all of the contextual conditions tested, hearing acuity ceased to be a significant contributor to recognition thresholds in the High Context condition. That is, even with a moderate hearing loss, a strong linguistic context has such powerful effects on boosting recognition that it can virtually over-ride differences among listeners in hearing acuity. This is a finding consistent with the

previously noted principle that the more probable a stimulus is in a particular context, the less sensory information will be needed for its correct identification (Morton 1969; see also the discussion in Boothroyd 2010). It is noteworthy that the contextual probability of the target words in the High Context condition averaged only .53, and in no case exceeded .85, a level well below that of absolute certainty.

The fact that the regression analysis showed age to contribute significantly to recognition thresholds even after the variance due to hearing acuity and cognitive test scores was taken into account raises two non-exclusive possibilities. The first is that the cognitive tests that we employed may not have captured all of the aspects of age-related differences in cognitive ability that might bear on performance. The second is that differences in speech understanding in older adults can occur beyond reductions in peripheral acuity as measured by pure-tone thresholds (Humes 1996; Divenyi et al. 2005; Cox et al. 2008).

Our present results emphasize the importance of cognitive function to auditory performance (Humes 2005; van Rooij & Plomp, 1990), showing in addition, that as the degree of contextual support from a linguistic context increases, the relative contributions of cognitive ability and hearing acuity exchange places. Specifically, in a neutral context we see a large role for hearing acuity on word recognition and a modest role for cognitive ability. By contrast, in the highest context condition hearing acuity was no longer a significant predictor, but general cognitive ability played a significant role. These findings underscore the need to take into account the full interplay of individual differences in cognitive ability and constraints of linguistic context, as well as hearing acuity, even in a task as straightforward as word recognition.

The ability to utilize a linguistic context depends on both comprehending the meaning of the utterance and a developing sense of the likelihood of the sentence-final target word based on this understanding. Because of this, comprehension is slowed and comprehension errors occur for sentences spoken with complex syntax, with this complexity effect amplified in older adults and for those with reduced hearing acuity (Wingfield et al. 2006; Stewart & Wingfield 2009). In the present study we took care to use canonical syntactic forms for the context sentences and target words with common usage in American English. Further, although our participants represented a range of scores in tests of verbal ability, all reported English as their first language. With these caveats, however, our present findings suggest that the value of linguistic context in facilitating word recognition is a robust one that operates similarly within a wide range of individual differences in verbal ability among native English speakers.

Acknowledgments

This work was supported by NIH Grant AG019714 from the National Institute on Aging. We thank Nicole Amichetti for assistance of preparation of this manuscript.

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Figure 1.

Mean word recognition thresholds represented by the minimum signal-to-noise ratio (SNR) necessary for correct word recognition as a function of the probability of the target word based on the degree of linguistic context. Error bars represent one standard error.

Table 1

Participant Characteristics

Participant Characteristics	Group					
	Good Hearing Acuity (N=16)		Slight-to-Mild Hearing Loss (N=22)		Moderate Hearing Loss (N=15)	
	M	(SD)	M	(SD)	M	(SD)
Age (years)	54.2	(19.0)	55	(21.2)	59.7	(26.0)
Education (years)	14.4	(2.8)	14.5	(4.0)	15.1	(3.0)
Composite Verbal (Z Scores)	-0.03	(1.1)	-0.01	(.93)	0.09	(.97)
Composite Cognitive (Z Scores)	0.2	(.71)	0.05	(.68)	-0.37	(.58)
Better Ear PTA (dB HL)	9.7	(3.9)	27.8	(7.7)	47.3	(5.6)

Note: HFPTA =High Frequency Pure Tone Average (1,000, 2,000, 4,000)

Table 2

Summary of Hierarchical Regression Analyses

Context Condition	Predictor Variable	R ²	Change in R ²	p Value [*]	Beta ^{**}
Neutral	Hearing (PTA)	0.28	0.28	<0.001	.44
	Cognitive Ability	0.39	0.11	<0.01	-.23
	Verbal Ability	0.40	0.00	n.s.	.00
	Age	0.45	0.05	<0.05	.27
Low	Hearing (PTA)	0.07	0.07	<0.05	.18
	Cognitive Ability	0.22	0.14	<0.01	-.26
	Verbal Ability	0.23	0.01	n.s.	.03
	Age	0.32	0.08	<0.05	.34
Medium	Hearing (PTA)	0.05	0.07	<0.05	.16
	Cognitive Ability	0.21	0.17	<0.01	-.29
	Verbal Ability	0.21	0.01	n.s.	.04
	Age	0.31	0.10	<0.01	.36
High	Hearing (PTA)	0.02	0.04	n.s.	.11
	Cognitive Ability	0.17	0.16	<0.01	-.25
	Verbal Ability	0.17	0.01	n.s.	.02
	Age	0.28	0.12	<0.01	.40

* p value reflects significance of change in R² at each step of model

** standardized multiple regression coefficient

Table 3

Intercorrelations Among Predictor Variables

Predictor Variables	Hearing Acuity	Cognitive Ability	Verbal Ability
Cognitive Ability	-.30 [*]		
Verbal Ability	.10	.54 ^{***}	
Age	.05	-.42 ^{**}	-.04

Note:

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