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Estimating when and how words are acquired: A natural experiment on the development of the mental lexicon

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Abstract

Purpose—Sensitivity of subjective estimates of Age of Acquisition (AOA) and Acquisition Channel (AC) (printed, spoken, signed) to differences in word exposure within and between populations that differ dramatically in perceptual experience was examined.

Methods—50 participants with early-onset deafness and 50 with normal hearing rated 175 words in terms of subjective age-of-acquisition and acquisition channel. Additional data were collected using a standardized test of reading and vocabulary.

Results—Deaf participants rated words as learned later (M = 10 years) than did participants with normal hearing (M = 8.5 years) ($F(1,99)$ = 28.59; $p < .01$). Group-averaged item ratings of AOA were highly correlated across the groups (r = .971), and with normative order of acquisition (deaf: r = .950 and hearing: r = .946). The groups differed in their ratings of acquisition channel: Hearing: printed = 30%, spoken = 70%, signed =0%; Deaf: printed = 45%, spoken = 38%, signed = 17%.

Conclusions—Subjective AOA and AC measures are sensitive to between- and within-group differences in word experience. The results demonstrate that these subjective measures can be applied as reliable proxies for direct measures of lexical development in studies of lexical knowledge in adults with prelingual onset deafness.

An individual adult's lexical knowledge is a function of that individual's psycholinguistic experience in interaction with biologically determined language processing factors. Various indices or measures of lexical knowledge have been demonstrated to be predictive of psycholinguistic functions, such as word acquisition, and the speed and ease of word recognition, naming, and recall. Some indices of lexical knowledge have involved attributes of words themselves, such as word length. Other indices of word knowledge are based on models of the mental lexicon, such as neighborhood density (Luce & Pisoni, 1998).

Another type of index is a subjective estimate of an individual's experience with words, such as word familiarity (Auer, Bernstein, & Tucker, 2000a; Gernsbacher, 1984) and word age-of-acquisition (AOA) (K. J. Gilhooly & Logie, 1980). It is with the subjective measure of word AOA that this study is primarily concerned.

[1]Throughout this paper, the term “deaf” is applied to individuals with severe to profound hearing impairments (80 dB HL or greater 3-frequency pure tone average in the better ear) who rely primarily on vision for speech perception. These individuals may use hearing aids and gain benefit from residual hearing, but their primary source for language acquisition is vision.

[2]In this group, hearing aids are typically used to enhance speechreading, not the other way around.

Subjective Measures of Lexical Experience

Once an individual has acquired a word, the AOA of that word is fixed is forever for that individual. This fact is of interest, because of the possibility that the individual's internal lexical context of word learning is itself important, and AOA has received considerable attention in the literature on word recognition due to its potential explanatory importance (Ellis & Lambon Ralph, 2000; Ellis & Morrison, 1998; Garlock & Walley, 2001; Gerhand & Barry, 1999a, 1999b; Juhasz, 2005; Monaghan & Ellis, 2002; Morrison & Ellis, 1995; Morrison, Ellis, & Quinlan, 1992; Smith, Cotrell, & Anderson, 2001; Turner, Valentine, & Ellis, 1998; Zevin & Seidenberg, 2002). This interest is notwithstanding the fact that direct measures of life-long psycholinguistic experiences are not available to the researcher or clinician. Instead, proxy measures have to be developed. The psycholinguistic literature offers a subjective measure of AOA, which is typically obtained in a subjective rating task for which isolated words are rated on a scale of age or school level (K. J. Gilhooly & Logie, 1980). Previous studies have demonstrated the reliability and validity of subjectively measured AOA within typically developing individuals.

In addition to demonstrations that the subjective measure is a reliable and valid proxy for an objective measure, several different variations on the subjective AOA rating task have been used to show that there is a reliable relationship between the age at which words are subjectively estimated to have been acquired and the efficiency with which those words are recognized under experimental paradigms (for review see (Juhasz, 2005; Morrison & Ellis, 1995), such as, lexical decision, word naming, and picture-naming (Brown & Watson, 1987; Carroll & White, 1973a, 1973b; Ellis & Morrison, 1998; Gerhand & Barry, 1999a; K.J. Gilhooly, 1984; K. J. Gilhooly & Logie, 1980; Juhasz, 2005; Morrison & Ellis, 1995; Morrison et al., 1992; Turner et al., 1998). In general, early acquired words (e.g., *drink*) are associated with faster, more accurate performance than later acquired words (e.g., *prove*).

The decision to use a subjective versus an objective measure of word AOA could interact importantly with the research or clinical goals. Corpora do exist from which normative objective AOA measures can be obtained [e.g., (K. J. Gilhooly & Logie, 1980)], but the sample populations from which the AOA data are obtained are typically normally developing children, not particular clinical population that vary importantly from such children. Subjective measures of lexical experience have a potential advantage over objective measures, if the goal is to extend insights obtained from studies of AOA with normative populations to clinical populations and individual differences. Specifically, subjective measures can, perhaps, provide a means to look back at the development of the lexicon in adult participants for whom no direct objective developmental data are available at the time. If so, it would be possible to estimate the particular lexical experiences of participant groups or even the individuals from whom they are collected.

Language, and specifically word learning, is typically delayed in children with prelingual onset deafness. The departure from the typical word AOA is likely to affect the development and function of the word recognition system as a whole. The AOA measure, if sensitive and reliable, could be used in studies of developmental effects on adult psycholinguistic functions. AOA was measured here within a research program investigating individual and group (hearing versus deaf) differences in speechreading ability.

As suggested above, hypothetically, measures that depend on experience should vary as a function of psycholinguistic population differences—such as deaf versus hearing—as well as individual differences in word exposure. Extreme differences in hearing thresholds, such as those between early-onset deaf adults versus normal-hearing adults, are expected to lead inevitably to differences in psycholinguistic experience, knowledge, and functions. These

differences in adults are interesting and important for clinical assessment and for understanding the interplay of biological and environmental factors in language processing.

Speechreading accuracy has been shown to vary widely between and within the populations of hearing and deaf adults and is frequently enhanced in individuals with prelingual-onset, severe or profound hearing impairments (Auer & Bernstein, 2007, in press; Bernstein, Demorest, & Tucker, 2000). However, as of yet, the individual and group differences have not been explained. For example, although it would be correct to state that, in general, being deaf versus hearing predicts, on average, better speechreading; it would be incorrect to state that hearing thresholds predict speechreading scores (Bernstein, Demorest, & Tucker, 1998). The reason is that variation within populations is not predicted by gross population differences. In fact, self-reports of competency communicating with hearing people are better predictors of deaf adults' speechreading proficiency than are audiological factors (Bernstein et al., 1998).

The point about population versus indivicual differences can be illustrated using results from Auer and Bernstein (Auer, Bernstein, & Tucker, 2000b), in which subjective familiarity ratings were obtained for words collected from the large samples of deaf and hearing individuals that were studied for the current report. On average, deaf participants consistently judged words to be less familiar than did hearing participants, although, the item (word) familiarity ratings were highly correlated across the groups (r = .90). An important difference between the groups emerged upon more detailed analysis of the ratings within and across groups. Irrespective of the level of familiarity of the stimulus words (HIGH, MEDIUM, LOW), on an individual word level, deaf participants used the familiarity scale more like other deaf participants than like hearing participants. This result suggests that despite the global similarity between the two groups, each group apparently experienced different ambient language samples—just as would be predicted from the different developmental histories.

In this study, subjective AOA ratings were obtained and the channel by which words were acquired (print or speech) was also rated. Typically, in literate hearing individuals, early words are all learned via spoken language, whereas later, as literacy increases, larger percentages of words are acquired via print. This difference in the learning context could lead to representational differences in the mental lexicon. Representational differences could in turn lead to psycholinguistic processing differences. For example, in literate individuals, some proportion of words learned through print might have to be recognized later in spoken form using, In that event, on internally generated representations based on reading would need to be used to recognize the spoken word stimuli. This necessity could hinder or facilitate recognition. For example, word recognition is facilitated by previous encounters with the word in an identical or highly similar perceptual form (Palmeri, Goldinger, & Pisoni, 1993). Differences in experience with spoken and printed channels have been demonstrated to influence the speed and ease of word recognition (Chateau & Jared, 2000; Gaygen & Luce, 1998).

The perceptual details of previous word experience have been shown to influence recognition when priming and implicit memory methodologies were applied and the interval between two word exposures was relatively short (Palmeri et al., 1993). These results have lead to proposals that the mental lexicon retains a large quantity of the perceptual detail of encounters with words, and that these details affect the speed and ease of the recognition process (Goldinger, 1996, 1998; Palmeri et al., 1993). Recent studies of subjective estimates of word experience have been interpreted as evidence that the processing channel in which word experience occurs may accumulate and be retained over an individual's lifespan (Amano, Kondo, & Kakehi, 1995; Balota, Pilotti, & Cortese, 2001; Gaygen & Luce, 1998).

The Current Study

Given that differences in lexical experience have been observed within groups of participants expected to have similar developmental experiences due to their having normal hearing and other similar factors, groups with dramatically different word experience were predicted to show differences greater than those obtained within groups. In the present study, subjective AOA and communication channel through which words were acquired was investigated in college-educated deaf and hearing adults, groups with a shared native language, college-level educational success, but different lexical development. It was hypothesized that early-onset profound hearing loss led to later word acquisition and, as a consequence, later subjective word AOA ratings. In addition, it was hypothesized that the deaf individuals in the current study acquired their vocabularies as the result of reading, speechreading[2], and/or the use of some type of an English-based manual sign system. To investigate their potentially greater variety in channels of word acquisition in comparison with those with lifelong hearing, a new lexical experience measure was collected, Acquisition Channel (AC). Participants were asked to judge via which channel (i.e., spoken, printed, or signed) each word was acquired. For both groups, acquisition channel was hypothesized to be related to the age when words were acquired, such that earlier learned words were expected to be learned via speech, and later learned words were expected more likely to have been learned through print. Between groups, it was hypothesized that the deaf group would exhibit a greater reliance on non-spoken channels for lexical acquisition. Within the deaf group, it was hypothesized that better speechreaders would rate a greater percentage of words as having been acquired through spoken language, however the strength of this association could be reduced due to our screening of participants to be skilled speechreaders.

Methods

The data reported here were collected as part of a project on lexical knowledge and processing in skilled deaf speechreaders, including word familiarity ratings that were previously reported in Auer et al. (2000).

Participants

Participants were screened for the following characteristics: (a) between 18 and 45 years of age; (b) currently enrolled in or graduated from college; (c) no self-reported learning disabilities; (d) self-report of English as a native language; (e) vision 20/30 or better in each eye, as determined with a standard Snellen chart; and (f) average or better performance on a speechreading screening test, as referenced to the appropriate distribution of performance by deaf or hearing college-educated adults (Bernstein et al., 2000; Demorest & Bernstein, 1992). Additionally, deaf participants were screened to have: (g) bilateral severe or profound hearing impairment, (greater than 80 dB HL pure tone average across 500, 1000, and 2000 Hz); (h) self-reported onset of loss prior to 4 years of age; (i) self-reported use of English as the primary language of the participant's family; and (j) education in mainstream and/or oral program for eight or more years. All participants were paid for their participation.

Hearing participants—The project was begun at Gallaudet University (GU) and completed at the House Ear Institute (CA). Sixty-four participants with normal hearing were recruited from among graduate students at GU and from the campuses of California State University, Northridge (CSUN), and the University of Southern California, and University of California, Los Angeles. Seven House Ear Institute employees also participated. Thirteen participants were dropped due to technical malfunctions, and one withdrew. Fourteen of the fifty in the resulting group were male. Fifteen were from GU. The group mean age was 25.6 (range 18.5 to 43.8) years.

Deaf participants—Fifty-eight deaf participants were recruited from GU and CSUN. Eight were dropped due to a technical malfunction, early withdrawal from the study, or having been inappropriately selected based on review of their screening measures. Of the resulting fifty, fourteen were from GU. Fourteen were male. Participant reported age at onset of hearing impairment was as follows: birth–36; 0-1 years–4; 1-2 years –3; 2-3 years–2; 3-4 years–2. Three participants reported an unknown age of onset, however for all three, the hearing impairment was discovered prior to four years of age. The majority (43) of participants had 90 dB HL or greater pure tone averages (profound hearing impairment) (pure tone averages: left ear M = 104.4 dB HL, SD = 12.79; right ear M = 103.97 dB HL, SD = 12.21). The reported causes of the hearing impairments were: unknown–29; meningitis–7; genetic/hereditary–6; maternal rubella–5; premature birth–1; high fever–1; other–1. The mean age across the group was 23 (range 18.0 to 32.0) years of age.

The participants in both groups were tested on measures of printed word familiarity, reading vocabulary and comprehension, and speechreading ability. The details of these tests and the results were previously reported (Auer, Bernstein, & Tucker, 2000c). Taken together, the print-based measures provided a consistent description of our participant groups. The deaf group was characterized as having poorer reading comprehension as well as poorer printed word vocabularies than the hearing group. However, the deaf individuals in the current study differed substantially from the larger population of early-onset profoundly deaf individuals, which demonstrates relatively low levels of reading comprehension and vocabulary knowledge. Typically, mean reading comprehension scores for deaf children plateau at approximately a third-grade level (Allen, 1986) and only 10% of all deaf 18-year-olds can read at or above the 8th grade level (Trybus & Karchmer, 1977).

In the speechreading screening test, the deaf participants had a mean score of 54% words correct, and the normal hearing participants had a mean score of 28% words correct. All of the deaf participants scored above 75 percent of the hearing participants, and the best deaf participants far outperformed the best hearing participants. This between-group difference is not surprising, given that the higher screening criterion used for the deaf participants. The different criterion was used, because passing scores were based on normative data collected for the relevant participant group and reflect known population differences between the two participant groups(Auer & Bernstein, 2007; Bernstein et al., 2000).

Materials and Procedure

Age-of-acquisition—One hundred and seventy-five words from the Peabody Picture Vocabulary Test revised (PPVTr), Form M (Dunn & Dunn, 1981) were used for the AOA ratings. This word set was chosen, because the normative order of acquisition for the test words by hearing individuals had been previously determined as part of the test's development. Use of the PPVTr afforded the possibility to assess independently the concurrent validity of the AOA ratings obtained in the present study.

Participants were tested individually in a quiet room. They were seated in front of a computer monitor and were given verbal instructions. A certified sign language interpreter administered instructions to the deaf participants using simultaneous communication, i.e., signs in English word order produced in synchrony with speech. Five different random orderings of the entire word list were generated. Participants were randomly assigned to the different orderings, such that ten participants in each participant group received the same randomization. Each participant started with a ten-word practice set of words, not part of the stimulus set, followed by the test block.

In the AOA rating task, a trial began with the presentation of the word to be rated appearing in the center of the computer screen, followed by a prompt to enter an AOA rating. An 11-

point scale was implemented on a labeled keyboard. The points on the scale were labeled both with an age in years and a schooling level as follows: *2 years old (Pre-Nursery); 3 (Pre-Nursery); 4 (Nursery); 5 (Kindergarten); 6 (1st Grade); 7-8 (2nd-3rd Grade); 9-10 (4th-5th Grade); 11-12 (6th-7th Grade); 13-17 (8th-12th Grade); 18-21 (College); Don't Know Word*. Immediately after entering an AOA rating, participants were prompted to rate how they thought they had acquired the word: through spoken, printed, or signed language. Hearing participants received the same options, although they were unlikely to have learned any of the words via sign. For words that participants rated as not yet acquired, the options were stated in terms of the question how they thought they would learn the word.

Results and Discussion

Subjective AOA Ratings

A total of 8,750 responses were collected from each participant group. To compare the two groups, both subject- and item-level analyses were performed. Item-level summaries are available at the first author's website http:\\people.ku.edu\~auer\aoadh.txt. For each participant, mean AOA rating and total number of words rated as known were computed. Deaf participants rated words to have been learned later than did hearing participants (mean AOA in years, for deaf = 10.0, s.d. = 1.43; and for hearing = 8.5, s.d. = 1.39) [$F(1, 99) = .28.59$, $p < .01$]. Deaf participants also rated fewer words as known than did the hearing participants (mean number known out of 175, for deaf = 158, s.d. = 14.35; and for hearing = 164, s.d. = 7.78) [$F(1, 99) = 7.88$, $p < .01$].

Corrrelations among Measures

To examine the relationship between the AOA ratings and the PPVTr normative acquisition order, within-group average AOA ratings were calculated for each word. Pearson correlations were computed separately between the individual word means from each of the participant groups and the normative PPVTr acquisition order. Average AOA ratings within each participant group were highly correlated with the normative word order in the PPVTr, ($r = .950$ for the deaf group, and $r = .946$ for the hearing group). The average AOA ratings for stimulus items were also highly correlated across participant groups ($r = .971$), a partial consequence of the fact that correlations are independent of means. Thus, the order of acquisition was essentially invariant across groups, although the overall subjective age range was shifted upward by the deaf participants.

Typically, research on lexical experience focuses on item-level analyses. However, the focus in the current study was on group and individual differences. Thus, subject-level analyses were performed. To assess the sensitivity of the AOA measure to individual variation in language knowledge and ability and within the deaf participant group, correlations were computed using a set of audiologic measures (pure tone average for each ear, age of loss, and age of discovery of loss), and individual mean AOA scores and number of words a participant rated as known, as well as the Stanford vocabulary subtest, Stanford comprehension subtest, the alternate form of the PPVTr, speechreading ability, and mean familiarity. These analyses sought evidence to validate mean AOA and number of items rated as known as measure of an individual's lexical knowledge. Significant correlations between the AOA measures and well established measures of lexical knowledge were interpreted as evidence that the AOA measures are sensitive to individual differences in lexical knowledge.

In screening the data, it was discovered that one deaf participant scored very poorly on objective measures of language and vocabulary and yet reported an extremely high number of words as known. This participant was clearly an outlier from the majority of the deaf participants. Thus, correlation analyses were performed with and without this participant's data. This participant's

responses illustrate one potential pitfall of using subjective ratings tasks to study lexical knowledge.

Tables 1 and 2 display the Pearson correlation coefficients for each group. Because none of the correlations with the audiological factors reached significance, those correlations are not displayed. Mean AOA ratings and the number of words reported as known were significantly correlated with several measures of printed vocabulary knowledge for each group. In both participant groups, individual mean AOA was significantly correlated with three independent vocabulary measures (Stanford vocabulary subtest, PPVTr, and Familiarity) such that individuals with higher scores on tests of vocabulary knowledge rated words as learned earlier and also rated more words as already acquired. An individual Mean AOA rating can serve as a proxy for earliness of vocabulary acquisition, with earlier vocabulary acquisition being associated with larger vocabularies. These reliable correlations are interpreted as evidence that subjective AOA ratings and the number of words reported as known are sensitive to individual variation in language knowledge.

Subjective AC Ratings

The percentage of words learned in each of the three channels (spoken, signed, printed) was calculated for each participant based only on words rated as known. The groups differed in the patterns of their ratings: Hearing: printed = 30%, spoken = 70%, signed =0%; Deaf: printed = 45%, spoken = 38%, signed = 17%. Hearing participants rated the majority of the tested words as acquired through the spoken channel. However, deaf participants rated the majority of the tested words as acquired via printed language. This difference in how words are learned across groups is likely related to several differences in psycholinguistic experience. For example, early access to spoken language is extremely different in the two groups. Hearing individuals are experiencing spoken language from infancy via an acoustic signal that affords redundantly encoded phonetic information adequate for distinguishing all of the phonemes in English. Furthermore, the acoustic speech signal is available for perception, regardless of whether or not the infant or child can see the talker. In contrast, for the deaf individual, the available phonetic information in the visible speech signal is reduced compared to acoustic speech. In addition, the talker must be in view. These differences are consistent with the patterns obtained among the ratings: Individuals with normal hearing relied predominantly on spoken language for acquisition, whereas deaf individuals relied on alternate channels, including print and manually encoded language.

The channel through which words are acquired is likely to be related to when that word is acquired. For example, in hearing individuals the earliest learned words will only be acquired via the spoken channel. As the child begins to read, an increasing number of words will be acquired via print. To investigate this relationship, the percentage of words in each AC as a function of AOA was computed. Figures 1 and 2 show the proportions of responses for each channel as a function of AOA for the hearing participants and deaf participants respectively. In Figure 1, the pattern expected for normal-hearing individuals was observed. Words with early AOA ratings were all rated as learned via the spoken language channel, then as AOA increased, the percentage of words rated as acquired in print increased. Thus, as reading skills likely were acquired, reliance on reading for vocabulary acquisition increased to the point at which it eventually became more dominant than spoken language.

In Figure 2, evidence for a different pattern of vocabulary acquisition in deaf individuals is observed. The spoken channel still dominated for words with early AOA ratings with some contribution of manually encoded language. However the proportion of words with early AOA ratings is smaller than in the hearing individuals. The printed channel emerges earlier as the dominant source of vocabulary acquisition in the deaf participant group.

Within the deaf group, substantial variability exists in the ability to make use of any of these acquisition channels. Two analyses were performed to investigate the possible relationship between speechreading ability and how words were acquired. First, a Pearson correlation was performed between the proportion of words that was rated as learned through speech and percent words correct on the speechreading screening test. Better speechreading was related to rating more words as acquired via spoken language ($r = .43$, $p < .01$). Second, a median split was performed on the speechreading screening scores of the deaf individuals. The proportions for each acquisition channel differed between average deaf speechreaders (print = 47%, spoken = 31%, sign = 22%) and the best deaf speechreaders (print = 12%, spoken = 45%, sign = 43%). Both analyses support the existence of a positive relationship between speechreading ability and acquisition of words via speech. The existence of such a relationship is consistent with the hypothesis that enhanced speechreading may be a result of more experience with processing visible speech (Auer & Bernstein, 2006; Bernstein et al., 2000; Tillberg, Ronnberg, Svard, & Ahlner, 1996).

General Discussion

This study investigated whether subjective age of word acquisition and the channel through which words are acquired varies across deaf and hearing adults. Both participant groups rated words to have been learned in a similar order, however they differed on the overall time frame over which words were learned and the acquisition channel used to learn the words.

The significant correlation between the AOA ratings and the normative ordering of words in the PPVT for both groups supports the validity of subjective word AOA as a measure of the order in which words are acquired and extends its use to this deaf population. Assuming that the deaf adults in our sample had less access to language during their lifetimes, the shift in AOA ratings across groups provides evidence that the subjective AOA is sensitive to the age when words are acquired: Deaf participants consistently reported words to have been learned later than did the hearing participants. Thus, these results support the conclusion that subjective AOA provides an index of individual variability in age of word acquisition. Intriguingly, within this sample of prelingually deaf participants, audiological variables were unrelated to any language measures. Neither the level of hearing loss nor the age at which it was discovered was associated with language measures, suggesting that differences between these individuals associated with language outcome are attributable, at least in part, to more central processing functions within the nervous system.

The current results also provide insights into differences between early and late learned words. The AC data demonstrate that early versus later learned words frequently differ in how they were judged to have been acquired. Not surprisingly, in normal-hearing undergraduates, early acquired words tend to be rated as acquired through spoken language, while later learned words have an increasing probability of being rated as acquired via print. This pattern of results shows that the AOA measure has a second underlying dimension, the channel of word acquisition, which has not been taken into account in previous research. As a consequence, depending on the age range of words used in a particular study, results could incorporate effects of acquisition channel, in addition to age of word acquisition.

Within the deaf participant group, evidence was obtained for an important relationship between channel through which words were acquired and perceptual processing of words in a specific channel. Those deaf participants who were the best speechreaders relied more on spoken language than did the average speechreaders. This relationship has emerged previously. Bernstein et al. (Bernstein et al., 1998) investigated individual differences in audiological variables, familial history, communication preferences, and measures of reading among the participants reported in Bernstein-et-al. (2000). Regression analysis led to three factors with a

multiple *R* value of .77 for scores on speechreading sentences, which were (1) self ratings of success in understanding the speech of the general public, (2) use of speech for communication at home, and (3) English reading score. The first two factors suggest that the experience one has successfully communicating via speech is important, suggesting the possibility that, by virtue of their increased ability to speechread, some deaf individuals get more practice speechreading.

Recently, Auer & Bernstein (2006) obtained further evidence of the association between speechreading ability and self-assessments of ability to communicate via spoken language with friends and with the general public. Specifically, speechreading accuracy for sentence length materials correlated with self-assessment of ability to understand friends speech (r = -.330), ability to understand the speech of the general public (r = -.303), ability of friends to understand your own speech (r = -.390); and ability of the general public to understand your own speech (r = -.412).

The present set of results extends previous demonstrations of the validity of the AOA measure to deaf participants. It also introduces a novel AC measure that may be of particular importance in studying this population. Importantly, these subjective measures provide a means to look back at the development of the lexicon in adult participants for whom no direct developmental data are available. This measure could have important clinical applications. For example a screening tool using AOA and AC could be developed for assessment of early language experience in prelingually deaf adults. Recently, this population has increasingly presented for evaluation for cochlear implant surgery, however the outcome of such surgeries has been difficult to predict (Moody-Antonio et al., 2005). It is possible that their early lexical experience along with other factors would be predictive of outcome and the present subjective measures provide a means for quantifying and assessing their early lexical experience.

In conclusion, early and late learned words were found to differ beyond the chronological age at which they were acquired: They differed in how they were acquired and the channel by which they were acquired. The results of the present study suggest that populations that differ in lexical experience provide a promising context for discovering how age of word acquisition affects lexical processing.

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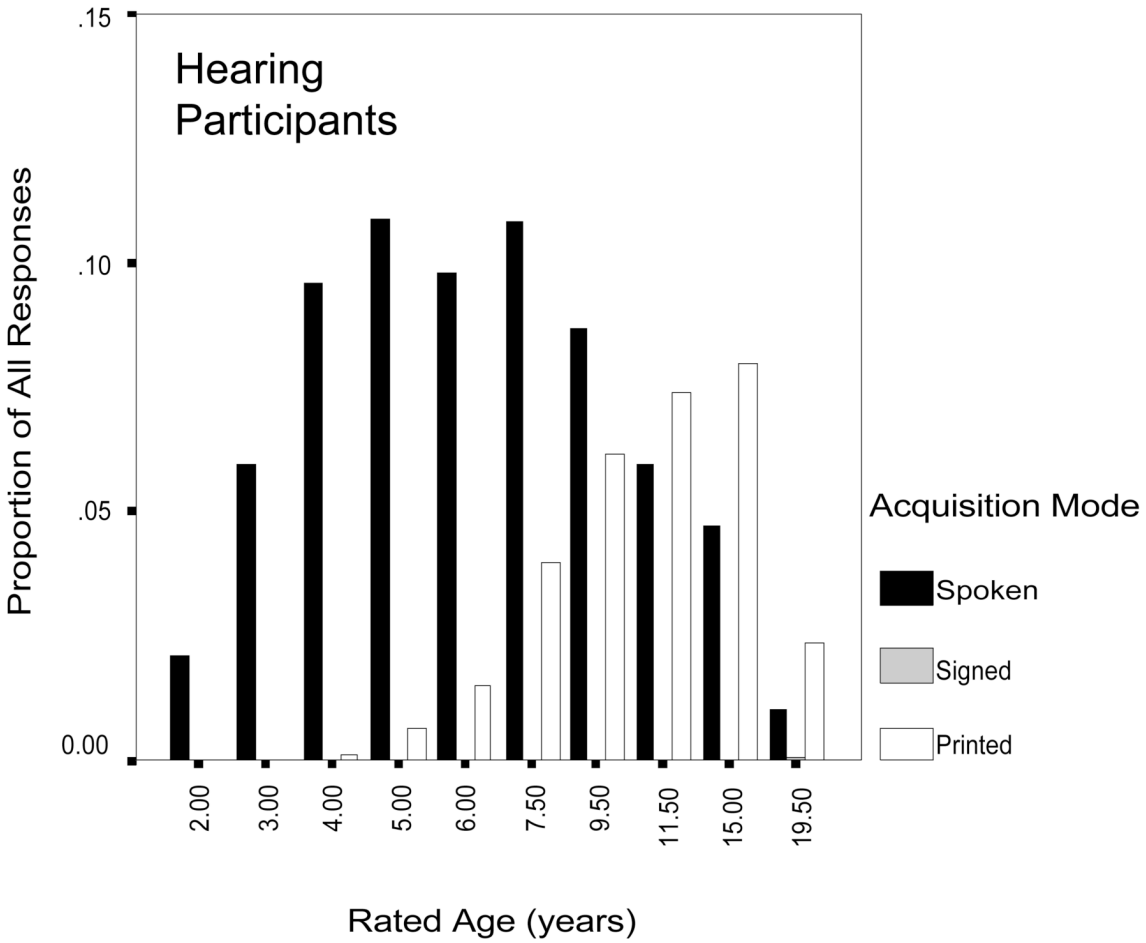

Figure 1.
Proportion of AC responses are displayed as a function of estimated AOA for the normal hearing participants. Dark bars represent proportion of words acquired through spoken language. Grey bars represent proportion of words acquired through signed language. Light bars represent proportion of words acquired through printed language.

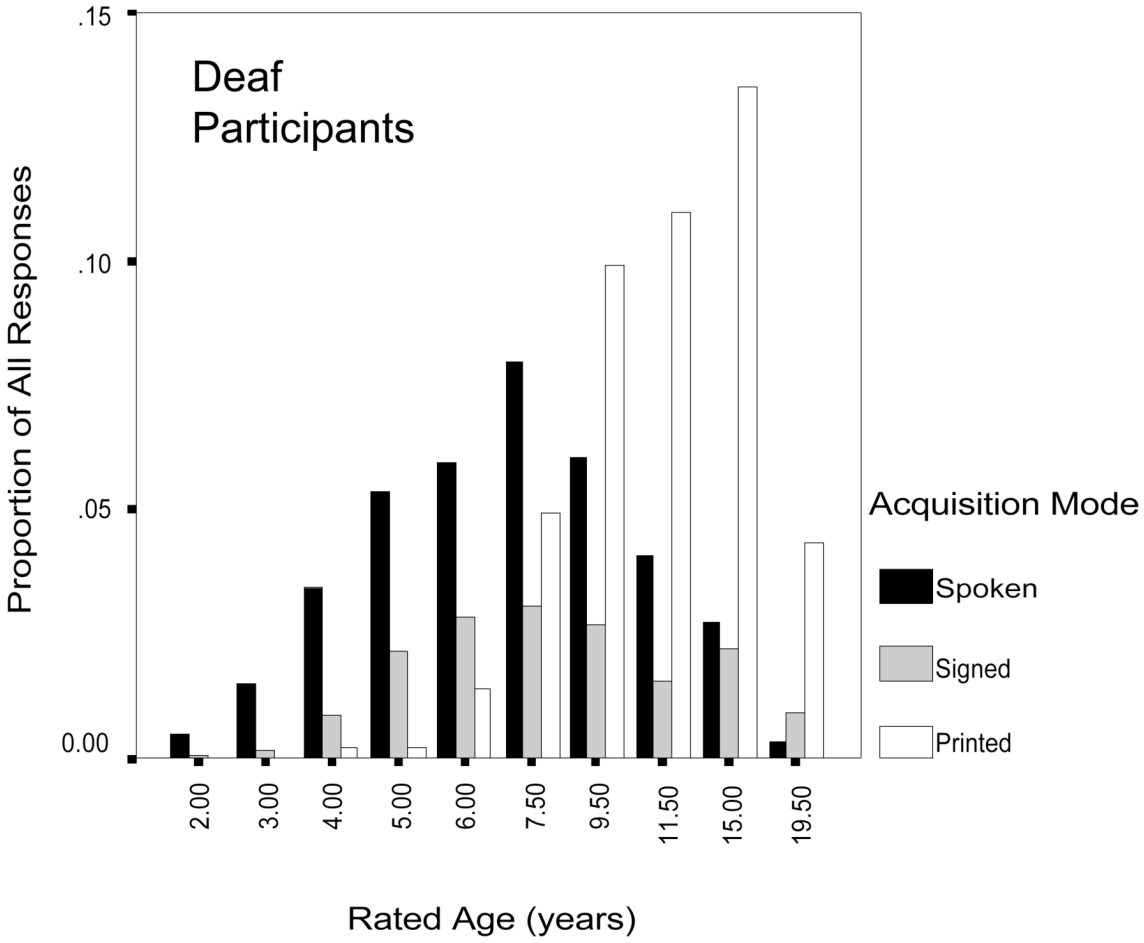

Figure 2.
Proportion of AC responses are displayed as a function of estimated AOA for the deaf participants. Dark bars represent proportion of words acquired through spoken language. Grey bars represent proportion of words acquired through signed language. Light bars represent proportion of words acquired through printed language.

Table 1

Pearson correlation coefficients for individual deaf participants' measures of printed and spoken language

Measure 1		2	3	4	5	6	7
1. Mean AOA	--	-.45**	-.45**	-.30	-.49**	-.12	-.48**
		(-.46**)	(-.28)	(-.19)	(-.38**)	(-.12)	(-.48**)
2. Number of rated AOA words		--	.64**	.54**	.53**	.09	.84**
			(.49**)	(.45**)	(.45**)	(.09)	(.81**)
3. Stanford (Voc.)			--	.84**	.82**	.30	.64**
				(.85**)	(.85**)	(.26)	(.49**)
4. Stanford (Comp.)				--	.78**	.36*	.59**
					(.80**)	(.33)	(.49**)
5. PPVT					--	.21	.58**
						(.20)	(.49**)
6. Speechreading						--	.06
							(.09)
7. Mean Familiarity							--

Note. Correlations without parentheses were performed with a single outlying participant removed. Numbers in parentheses are performed on the full participant group. Only CA deaf participants contributed to the correlations with the Stanford Achievement Test scores (n = 36).

* p < .05,

** p < .01.

Table 2

Pearson correlation coefficients for individual hearing participant measures of printed and spoken language

Measure	1	2	3	4	5	6	7
1. Mean AOA	--	-.34*	-.37*	-.26	-.32*	.22	-.37**
2. Number of AOA		--	.52**	.68**	.78**	.05	.77**
3. Stanford (Voc.)			--	.49**	.63**	-.10	.42*
4. Stanford (Comp.)				--	.69**	.01	.42*
5. PPVT					--	-.02	.68**
6. Speechreading						--	-.17
7. Mean Familiarity							--

Note. Only the CA hearing participants contributed to the correlations with the Stanford Achievement Test (n = 35).

** $p < .01$;

* $p < .05$.