

# Change in Object Naming Ability During Adulthood

Lisa Tabor Connor,<sup>1,2</sup> Avron Spiro III,<sup>3</sup> Loraine K. Obler,<sup>2,4</sup>  
and Martin L. Albert<sup>2</sup>

<sup>1</sup>Department of Radiology, Washington University School of Medicine, St. Louis, Missouri.

<sup>2</sup>Department of Neurology, Boston University and VA Boston Healthcare System, Massachusetts.

<sup>3</sup>Epidemiology, Boston University and VA Boston Healthcare System, Massachusetts.

<sup>4</sup>Program in Speech & Hearing Sciences, City University of New York.

**Using longitudinal data on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) collected over 20 years from healthy individuals aged 30 to 94, we examined change in lexical retrieval with age, gender, education, and their interactions. We compared results between random-effects longitudinal and traditional cross-sectional models. Random-effects modeling revealed significant linear and quadratic change in lexical retrieval with age; it also showed a Gender  $\times$  Education interaction, indicating poorest performance for women with less education. Cross-sectional analyses produced greater estimates of change with age than did longitudinal analyses.**

**D**ESPITE reports of word retrieval difficulties by older adults (Burke, Worthley, & Martin, 1988; Goodglass, 1980), a debate, beginning with a report by Borod, Goodglass, and Kaplan (1980), has played out over the past 20 years as to whether lexical retrieval decline is a normal part of the aging process. Many studies have reported evidence supporting age-related decline in lexical retrieval accuracy or speed of retrieval (these studies are denoted by an asterisk in the references). There are, however, several studies reporting either no age-associated decline in lexical retrieval or a nonsignificant trend toward decline with age (these studies are denoted by a dagger in the references).

Two review papers have attempted to resolve this ongoing discussion as to the nature of change in lexical retrieval abilities with age. Goulet, Ska, and Kahn (1994) conducted a qualitative review of 23 picture-naming studies to determine if there were age-related declines. They argued that factors such as differing age ranges, study designs, task demands, and statistical techniques across studies compromise the ability to unequivocally attribute age-related declines in picture naming to the aging of the lexical retrieval process per se. Feyereisen (1997) conducted a quantitative meta-analysis of the effect sizes in published studies to examine whether, despite the inconsistencies pointed out by Goulet, Ska, and Kahn, there was statistical evidence for age-related decline in lexical retrieval in confrontation naming tasks. On the basis of results from 11 (of 32) published studies that met his inclusion criteria, he concluded that decline in lexical retrieval began after a person reached the age of 70 years.

Although meta-analysis is a powerful technique, most of the published studies were not eligible for inclusion in Feyereisen's meta-analysis. Therefore, we turn in this study to an alternative empirical-statistical approach to determine whether lexical retrieval does decline in healthy older adults. We capitalized on more than 500 administrations of the Boston Naming Test that we have accumulated during a 20-year-long longitudinal study, using a relatively new statistical technique, random-effects

modeling (e.g., Laird & Ware, 1982; Verbeke & Molenberghs, 2000). The advantage of this technique is that one can examine a collection of longitudinal observations made on individuals who vary both in the number of times evaluated and in the interval between evaluations. In addition, we compared age trends estimated from the random-effects approach with those obtained from the more commonly employed cross-sectional approach. Finally, we addressed questions of whether education or gender, factors that have been shown to influence lexical retrieval in prior studies (Borod et al., 1980; Neils et al., 1995; Welch, Doineau, Johnson, & King, 1996), influence the rate of change in lexical retrieval with age.

## METHODS

### *Sample*

We recruited participants from the Greater Boston metropolitan area for a longitudinal study of age-related change in language abilities, the Language in the Aging Brain project, which began in 1979. Inclusion criteria were as follows: (a) no history of serious neurological incident, including head injuries (in the event of a head injury, a "serious" event is defined as any incident leading to loss of consciousness or a skull fracture); (b) no history of regular use of illegal drugs such as cocaine, LSD, or heroin; (c) no history of alcohol abuse; (d) no reported history of chronic psychological illness or symptoms of ongoing psychological disorders (e.g., depression); (e) no history of left-handedness or ambidexterity; and (f) being a native English speaker or acquiring English as a second language prior to the age of 6 years. In addition, participants passed an audiology examination for pure tone hearing level of 40 dB or better at three test frequencies (500, 1000, and 2000 Hz) in at least one ear. Participants demonstrated at least 20/40 corrected vision as determined by performance on a standard Snellen chart.

We initially recruited 160 participants from four defined age spans: 30–39 years old, 50–59 years old, 60–69 years old, and

Table 1. Age and Education Distribution by Gender and Session

		Age			Education		
Session (Years)	<i>n</i>	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range
Men							
1 (1979–1981)	75	57.87	14.62	30–79	14.05	2.48	9–25
2 (1983–1984)	62	61.11	14.29	31–82	14.61	2.81	9–25
3 (1986–1987)	71	63.10	14.83	34–87	14.87	2.78	9–25
4 (1993–1995)	50	65.84	14.67	40–88	14.70	2.44	10–22
5 (1998–1999)	23	69.52	13.20	46–87	14.30	2.69	10–22
Women							
1 (1979–1981)	65	56.48	14.46	30–80	13.65	2.89	8–20
2 (1983–1984)	66	58.64	14.22	33–81	13.64	2.82	8–20
3 (1986–1987)	66	61.35	14.48	36–83	13.88	2.65	8–20
4 (1993–1995)	30	67.87	14.25	44–87	15.43	2.80	12–20
5 (1998–1999)	31	68.42	13.81	47–94	14.52	2.98	9–20

Note: Each year of formal education beyond a terminal degree was included.

70–80 years old. Within each age span, about half of the participants were men and about half were women. If participants dropped out at Time 2 or Time 3, we replaced them with persons of the same gender and age who met the inclusion criteria. After Time 3, we did not systematically recruit new participants to replace dropouts. We also screened participants at each test session and excluded some on the basis of new information about eligibility. For instance, if a participant experienced a stroke between visits, he or she was excluded from that time forward, though earlier data were included in the data set. Table 1 presents the sample sizes at each test session, stratified by gender.

Over 20 years, 236 participants (129 men, 107 women) initially aged 30 to 87 were tested up to five times. We included data in the present analysis only if the complete Boston Naming Test (BNT) was accurately administered and recorded. Participants provided a total of 539 observations: 4% ( $n = 10$ ) were tested five times; 15% ( $n = 35$ ) four times; 22% ( $n = 51$ ) three times; 24% ( $n = 56$ ) twice; and 36% ( $n = 84$ ) once. Among those who were tested more than once, retest intervals varied from 2.1 to 15.0 years ( $M = 4.8$ ,  $SD = 2.7$ ). The mean age of the sample at first testing was 58.4 ( $SD = 14.9$ ), and the mean years of education was 14.2 ( $SD = 2.7$ ). On average, the time between consecutive assessments was 4, 3, 7, and 4 years. Participants received modest monetary compensation for their time and travel expenses upon completion of each test session.

### Materials

We administered the BNT as part of a larger test battery at each of the five sessions. At Occasions 1–4, we used the 85-item experimental edition (Kaplan, Goodglass, & Weintraub, 1976). At Occasion 5, we administered the 60-item published version of the test (Kaplan et al., 1983). The scores reported are the percentage named correctly of the 60 items retained in the published version of the BNT (BNT %).

During the administration of the BNT, we asked participants to name simple line drawings of objects. If the participant was unable to name the item (e.g., accordion) as a result of an apparent difficulty in perceiving the object (for instance, said “It’s a high-rise building”), then we gave a predetermined semantic cue (e.g., “It’s a musical instrument,” though the cue

for the other items was not always a superordinate category name). If the response was semantically related but incorrect (“a piano”), then we gave an eliciting cue (“Is there another word for that?”) to prompt for another response. If the participant continued to be unable to give a response or gave an incorrect response, then we provided a predetermined phonemic cue (“acc”). Responses were tape-recorded. We transcribed and scored all responses, both correct and incorrect. For more information about the types of errors that participants make and the degree to which they benefit from cueing, see MacKay, Connor, Albert, and Obler (2002) and Nicholas, Barth, Obler, Au, and Albert (1997).

### RESULTS

We first examined whether men and women differed in age and education, which are known to affect BNT scores (Borod et al., 1980; Neils et al., 1995; Welch et al., 1996). To the extent that such differences were found, we included them in our modeling of age-related change in BNT%. We found no gender difference in age (men,  $M = 58.3$ ,  $SD = 15.2$ , vs women,  $M = 58.5$ ,  $SD = 14.6$ ,  $t(234) = 0.09$ ,  $p > .9$ ) or education (men,  $M = 14.4$ ,  $SD = 2.5$  vs women,  $M = 13.9$ ,  $SD = 2.9$ ,  $t(234) = 1.42$ ,  $p > .15$ ). When we compared initial BNT% performance between men and women, we found men to have a higher score than women, 92% versus 87%,  $t(237) = 4.02$ ,  $p < .001$ . The zero-order correlation between age and BNT% for participants’ first administration of the BNT ( $N = 238$ ) was  $r = -.40$ .

We used the random-effects approach to model change in BNT% with age in order to make optimal use of the data available. These models estimate both fixed effects (which indicate how BNT% changes with age for the sample as a whole) and random effects (which indicate whether there are differences among persons in change). In other words, the fixed-effects portion of the model describes average change over time; the random-effects portion describes individual differences in change.

In our models, we centered age at 62, the mean across observations, and then converted the centered age to decades (i.e.,  $\text{age}_c = (\text{age} - 62)/10$ ). Thus, the coefficients for age indicate BNT% change per decade. We first compared linear and quadratic ( $\text{age}^2$ ) fixed and random effects of age. All models

Table 2. Random-Effects Model for BNT%

Effect	Estimate	SE	<i>t</i>	<i>df</i>	<i>p</i>	<i>z</i>
Fixed effects						
Intercept	91.61	0.87	105.53	232	<.001	
Age	-2.19	0.32	-6.85	301	<.001	
Age <sup>2</sup>	-0.48	0.14	-3.48	301	<.001	
Education	0.27	0.23	1.15	232	.25	
Female	-5.36	1.13	-4.73	232	<.001	
Female × Education	0.89	0.31	2.87	232	.003	
Random effects						
Variance						
(intercept)	31.35	5.00			<.001	6.27
Variance (age)	6.64	1.87			<.001	3.55
Covariance						
(intercept, age)	12.12	1.97			<.001	6.14
Residual variance	18.91	1.62			<.001	11.67

Notes: Age was centered at 62 and then converted to decades (i.e., divided by 10). Thus, coefficients for age represent change per decade. Education was centered at 12 years. BNT% = percentage of items named correctly in the Boston Naming Test.

included education (centered at 12 years) and a dummy variable for gender (1 = female); interactions among gender, education, and age were also considered (results not shown because all of them were nonsignificant). On the basis of these preliminary comparisons, we estimated the following model:

$$\begin{aligned} \text{BNT\%} = & \text{Intercept} + \text{Female} + \text{Education} \\ & + \text{Age}_c + \text{Age}_c^2 + \text{Female} \times \text{Education} \\ & + \text{Intercept}_i + \text{Age}_{ci} \end{aligned}$$

The first six terms on the right side of the equation are the fixed-effects portion of the model, which describes BNT% performance for the sample as a whole; the last two terms (with a subscript *i*) refer to the random-effects portion of the model, indicating that individual participants were allowed to deviate from the overall sample curve in both level (intercept<sub>*i*</sub>) and linear rate of change with age (age<sub>*ci*</sub>). That is, a given participant could have a predicted BNT% (at age 62, the intercept<sub>*i*</sub>) that was higher or lower than the sample as a whole, and the participant could also have a rate of change in BNT% (age<sub>*ci*</sub>) that differed from the sample average. In other words, random-effects models allow persons to show different average levels and to change at different rates.

The model provided an acceptable fit to the data (−2 log likelihood = 3508.2); the residual variance was 19.12. Estimates of fixed and random effects are shown in Table 2. Examining the fixed effects, we see that the intercept of 91.58% indicates the predicted value of BNT% at age 62 for men with 12 years of education; the effects for education, gender, and the Gender × Education interaction are the predicted differences from this value for women and for those with more (or less) than 12 years of education. The age effects indicate the linear and quadratic change in BNT% per decade; these effects were constant across gender and education (i.e., there were no interactions of age with either gender or education).

The random-effects estimates, shown in the lower portion of Table 2, were significantly different from zero for all three parameters. Thus, there was significant variation in the sample in

both the level and the linear rate of change in BNT% over time, and the level and rate of change covaried positively. Those with a higher level of BNT% demonstrated less decline with age.

Using the fixed effects estimates, we computed predicted BNT trajectories separately for men and women with different educational levels; they are shown in Figure 1. The trajectories are based on the following equation, computed from Table 2, where we have adjusted the intercepts to include the effects of gender, education, and their interaction:

$$\text{BNT} = k - 2.19 \times \text{Age} - 0.48 \times \text{Age}^2,$$

where  $k = 92.70$  for men with 16 years education,  $k = 92.61$  for men with 12 years education,  $k = 90.87$  for women with 16 years education, and  $k = 86.25$  for women with 12 years education. As specified by the model, the curves for the various gender and education groups are parallel (because there were no interactions of age with either education or gender). Note that BNT% scores for women with 12 years of education were 5 to 6 percentage points lower than the other groups' scores.

Most studies of BNT performance in relation to age have been cross-sectional. To determine whether inferences based on the longitudinal random-effects model differ from those based on simpler cross-sectional analyses, we fit the same model as shown here to the initial data for our 236 participants. The results of this model are presented in Table 3. Compared with results of the random-effects model, shown in Table 2, the cross-sectional model gives higher estimates for both the linear and the quadratic components of change with age. For example, the linear decline in BNT% with age was 2.17 per decade in the random-effects model, but it was 3.24 (50% larger) in the cross-sectional model. The cross-sectional estimate is more extreme for the quadratic age effect, being about twice as large (−0.85) as that in the random-effects model (−0.48).

The effect of gender is also different in the cross-sectional model, being somewhat larger (−5.9 vs −5.3); the main effect for education was not significant in either model. However, the Gender × Education interaction was significant in the random-effects model, but not in the cross-sectional model ( $p = .052$ ). These differences are evident in several ways (compare Figures 1 and 2). For both men and women, the trajectories based on the cross-sectional model are slightly higher from 35 to 55, and decline faster, than the random-effects trajectories.

## DISCUSSION

We raised three questions about age-related change in object naming: First, does lexical retrieval decline with age? Second, do education or gender influence the rate of change in lexical retrieval with age? Third, are there differences between random-effects and cross-sectional models of change in object naming with age? Clearly, the answer to the question of whether lexical retrieval declines with age is “yes.” On average, BNT performance declined 2 percentage points per decade in our sample (with a slight acceleration over the age range). One possible explanation for why some other researchers have not found lexical retrieval declines with advancing age is that the decline is subtle. Therefore, a limited age range, or a limited number of participants in the oldest age groups, or a short retest interval would, perhaps, render it invisible. One of the studies claiming little change in naming ability across five age groups (ranging from 60 to 85 years) was

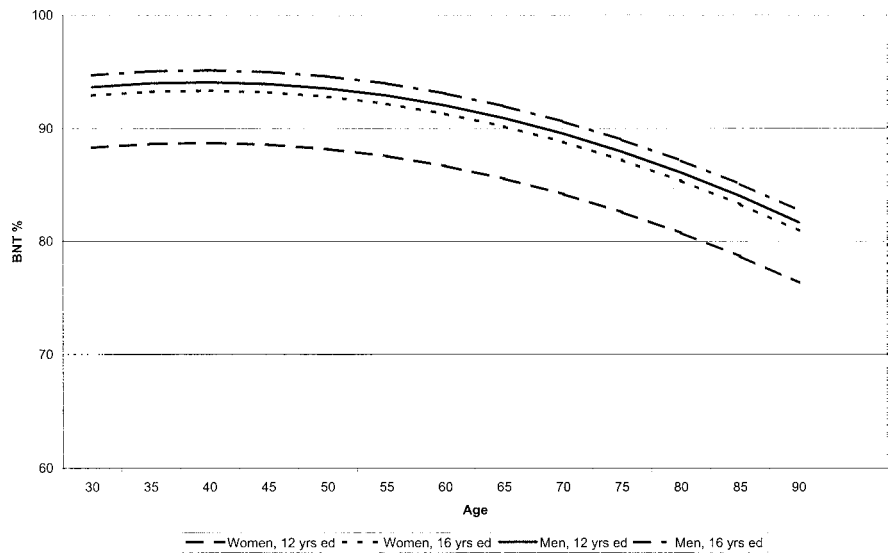


Figure 1. Predicted BNT% (percentage of items named correctly in the Boston Naming Test) by gender and education: random-effects model.

that by LaBarge, Edwards, and Knesevich (1986). With only 3 participants in the age group from 60 to 64 years and 5 participants in the age group from 80 to 85 years, it should not be surprising that little difference was seen among their five age groups. Likewise, Villardita, Cultrera, Cupone, and Mejia (1987) included only 10 participants in each group (ranging from less than 25 to 74 years) and reported no significant differences with age. Cruice, Worrall, and Hickson (2000) had a 4-year retest interval. The current study included 236 individuals ranging in age from 30 to 94 years, with a 20-year maximum follow-up period; it may, therefore, have been more sensitive to subtle declines with age.

With regard to the second question, we found that education affects naming, which is not surprising (Borod et al., 1980; Neils et al., 1995; Welch et al., 1996), but our results did not produce the Age  $\times$  Education interaction reported by Welch and colleagues. Somewhat more surprising to us was that the interaction of gender and education was a predictor of performance. Though the rate of change in naming ability was not gender dependent, the average score was lower for women than for men, particularly for women with less education. This finding, though not unprecedented for the BNT (e.g., Fastenau, Denburg & Mauer, 1998), is by no means universal; however, we can offer no good explanation for it, and we offer this topic as relevant for future research.

With regard to our third question, our comparison of longitudinal and cross-sectional models of change in naming revealed notable differences. Specifically, the cross-sectional model produced larger estimates for change with age—a finding that has been reported by others for the BNT (e.g., Cruice et al., 2000) and for other measures of cognitive performance (e.g., Hultsch, Hertzog, Small, McDonald-Miszczak & Dixon, 1992; McCarty, Siegler, & Logue, 1982; cf. Zelinski & Burnight, 1997). Those individuals who remained in the study may have benefited from practice effects that were due to taking the test several times, whereas those who dropped out may have been more likely to experience difficulties in naming.

We considered the first possibility by comparing, at Exams 1–4, those who were first tested at that time with those tested previously; we found no differences in BNT%. We considered potential dropout effects by comparing BNT% between those who had only one assessment with those who had more, and we found no differences; we also compared, at each of the first three exams, those who were subsequently retested and those who were not, and we found no differences in BNT%. These findings demonstrate that practice effects and selective dropout effects are unlikely explanations for the cross-sectional model overestimating change with age. Cohort effects, however, may be responsible for the difference between cross-sectional and longitudinal estimates of change.

Why do older adults experience accelerating decline in lexical retrieval abilities? Accelerating decline with advancing age is not unique in the field of cognitive aging. In fact, the psychometric literature is full of examples of this pattern. Salthouse, Fristoe, and Rhee (1996) provided a striking example, showing remarkably similar trajectories of accelerating decline for measures of perceptual speed, episodic memory,

Table 3. Cross-Sectional Regression Model for BNT%

Effect	Estimate	SE	<i>t</i>	<i>p</i>
Intercept	92.14	1.01	91.26	<.001
Age	−3.51	0.47	−7.52	<.001
Age <sup>2</sup>	−0.96	0.24	−4.02	<.001
Education	0.36	0.26	1.36	.2
Female	−5.81	1.26	−4.62	<.001
Education $\times$ Female	0.70	0.36	1.93	.056
<i>R</i> <sup>2</sup>	32.09			
<i>F</i>	21.73			
<i>df</i>	5, 230			
<i>p</i>	<.001			

Notes: *n* = 236. Age was centered at 62 and then converted to decades (i.e., divided by 10). Thus, coefficients for age represent change per decade. Education was centered at 12 years. BNT% = percentage of items named correctly in the Boston Naming Test.

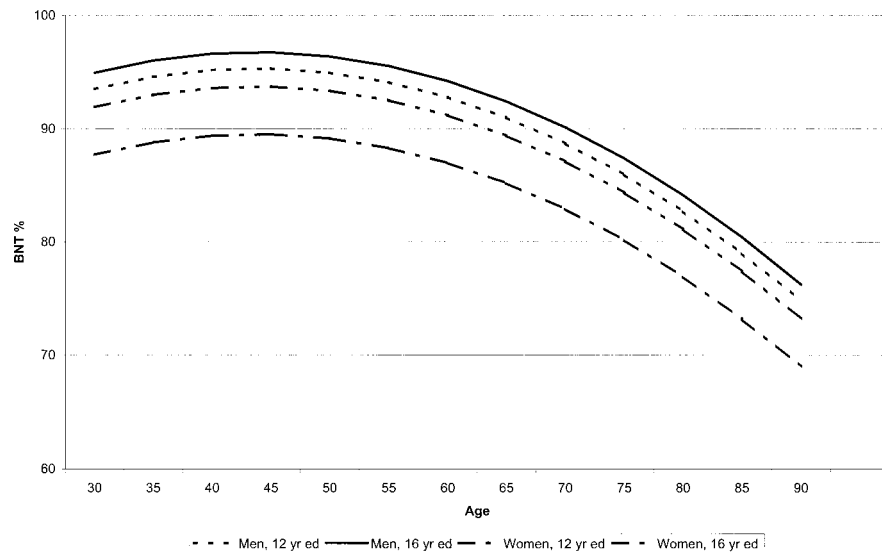


Figure 2. Predicted BNT% (percentage of items named correctly in the Boston Naming Test) by gender and education: cross-sectional model.

inductive reasoning, and spatial visualization. Because this pattern is ubiquitous in cognitive aging, it may require a more general explanation rather than one that focuses on decline in lexical retrieval specifically. In their review of methodological approaches to assessing psychological change in adulthood, Hertzog and Nesselroade (2003) reviewed evidence for terminal decline as a model of cognitive development. Rabbitt and colleagues (2002) reported variables that predict time to death. Interestingly, although the correlation between age and verbal ability (the ability to accurately define “rare” words) was not significant over all participants, decline in verbal ability was a predictor of death. Our findings may reflect the performance of older participants who are experiencing terminal decline and are thus drawing the overall distribution down at the end of the age distribution. We know that there are individual differences in rate of change, based on the significant random effects portion of our model; this might indicate that older individuals are showing greater decline. Unfortunately, the issue of terminal decline must remain unaddressed because we have followed few participants until their death.

Another account of cognitive decline in old age is focused at the level of changes in the neural substrate of cognition. Cumulative health burdens may produce decline in cognitive processing in older adults (Hassing et al., 2002; MacDonald, Dixon, Cohen, & Hazlitt, 2004). For example, Rubin and colleagues (1998) argued that healthy older adults measured longitudinally on an array of cognitive measures maintained their level of performance until they developed a dementing illness, after which they showed a rapid rate of decline. Though this could explain decline on the BNT, a recent study by MacKay, Connor, and Storandt (in press) showed that dementia does not explain the negative correlation between age and BNT in a sample of older adults screened annually for dementia. Moreover, the magnitude of the correlation in the study by MacKay and colleagues ( $r = -.36$ ) was similar to the zero-order correlation found in the current study ( $r = -.40$ ).

Another approach to examining the effects of health on cognition is to measure risk factors for cerebrovascular disease,

best demonstrated by Brady and colleagues (Brady, Spiro & Gaziano, 2004; Brady, Spiro, McGlinchey-Berroth, Milberg, & Gaziano, 2001). Their findings suggest that frontally mediated cognitive functions such as verbal fluency, working memory, and memory retrieval are negatively influenced by the accumulation of stroke risk factors throughout the life span. To address the issue of stroke risk factors and decline in language abilities in future work, we are currently collecting self-reported health information and objective measures of cerebrovascular disease risk in participants whom we continue to follow.

An interesting finding in our study was that individuals who had high levels of performance showed less decline over time. This result is consistent with some other findings in the literature (e.g., Rubin et al., 1998) that are often cited as supporting the cognitive reserve hypothesis (e.g., Satz, 1993; Scarmeas & Stern, 2003). The cognitive reserve hypothesis posits that some combination of high levels of intelligence, education, and a cognitively active lifestyle offer a neuro-protective benefit. That is, individuals who have these characteristics either possess more brain reserve or are better able to compensate for pathological brain abnormalities that accumulate throughout life.

Finally, there are a few limitations of this study worth noting. The fact that our sample was virtually all Caucasian suggests that these findings may not be generalizable beyond this group (see Fillenbaum, Huber, & Taussig, 1997). Further, as we aimed to screen out individuals with medical or psychological histories that might themselves diminish naming abilities, our results cannot pretend to generalize to the population of all older adults. Because we eliminated individuals with medical or psychological illnesses, our findings, more likely than not, underestimate the true extent of decline in naming abilities across the life span. A final limitation is that we used one type of object naming test, the BNT, as a measure of lexical retrieval abilities. Older adults frequently report retrieval failures in proper name retrieval at higher rates than naming of objects. Therefore, we anticipate that using other tests might reveal

a more or less severe naming impairment. Nonetheless, we believe that the BNT taps an important object naming ability that adequately represents lexical retrieval abilities as a whole. These data are valuable as a first approximation because the BNT is widely used in both neuropsychology and speech-language pathology as a measure of lexical retrieval abilities.

It is also important to frame our findings within the realm of clinical experience. The decline in lexical retrieval is extremely subtle. It may be, therefore, many years before decline in individuals' lexical retrieval abilities becomes measurable by standard techniques in the laboratory, even though naming lapses may be troubling to them. Clearly the next steps are to further explore factors associated with aging, such as stroke risk, that bring about the decline in lexical retrieval abilities in most, but not all, individuals, establish whether rates of change are similar or different across measures of language functioning and among other cognitive abilities, and determine what accounts for individual differences in the timing and rate of decline.

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