

# Language Decline Across the Life Span: Findings From the Nun Study

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The present study examines language samples from the Nun Study. Measures of grammatical complexity and idea density were obtained from autobiographies written over a 60-year span. Participants who had met criteria for dementia were contrasted with those who did not. Grammatical complexity initially averaged 4.78 (on a 0-to-7-point scale) for participants who did not meet criteria for dementia and declined .04 units per year; grammatical complexity for participants who met criteria for dementia initially averaged 3.86 and declined .03 units per year. Idea density averaged 5.35 propositions per 10 words initially for participants who did not meet criteria for dementia and declined an average of .03 units per year, whereas idea density averaged 4.34 propositions per 10 words initially for participants who met criteria for dementia and declined .02 units per year. Adult experiences, in general, did not moderate these declines.

Longitudinal changes in linguistic ability in adulthood have been traditionally studied by testing older adults' vocabulary, usually by assessing their ability to define words (Wechsler, 1981). Across a wide range of tests, both longitudinally and cross-sectionally, vocabulary has been shown to increase throughout the middle adult years but to decline in late adulthood (Albert, Heller, & Milberg, 1988; Arenberg, 1990; Botwinick & Siegler, 1980; Eisdorfer & Wilkie, 1973; Hultsch, Hertzog, Dixon, & Small, 1998; Schaie, 1983; Schaie & Willis, 1993; Zelinski & Burnight, 1997). The present study uses language sample analysis (Kemper, Thompson, Marquis, 2000) to examine linguistic abilities over the life span by using language samples from the Nun Study. The Nun Study is an on-going longitudinal, epidemiological study of aging, directed at investigating risk factors for the development of Alz-

heimer's disease (Snowdon, 1997; Snowdon et al., 1997). One focus of the Nun Study has been the investigation of the relationship of linguistic ability to the risk for Alzheimer's disease and to longevity. Snowdon, Kemper, et al. (1996) analyzed language samples from participants in the Nun Study, all members of the School Sisters of Notre Dame. The participants wrote autobiographies at the time they took their vows and became members of the religious congregation, at 18 to 32 years of age. When the participants were 75 to 95 years of age, they were given a battery of tests of cognition and physical function. Low linguistic ability in young adulthood, indicated by low grammatical complexity or low idea density in these language samples, was associated with increased risk for poor performance on the cognitive and memory tests in late adulthood. Low idea density in young adulthood was also associated with the increased neuropathology characteristic of Alzheimer's disease for a small number of nuns who had died. In a follow-up study, Snowdon, Greiner, Kemper, Nanayakkara, and Mortimer (1999) linked low linguistic ability, measured by idea density in young adulthood, to increased all-cause mortality among the participants. Idea density appears to be a general measure of cognitive and neurological development; low idea density in young adulthood may reflect suboptimal neurocognitive development, which, in turn, may increase susceptibility to age-related decline due to Alzheimer's or other diseases.

The Snowdon, Kemper, et al. (1996) and Snowdon et al. (1999) analyses used measures of grammatical complexity and idea density obtained from autobiographical, written language samples. Cross-sectional studies of young and older adults have shown that grammatical complexity is correlated with measures of working memory, including digit span and reading span (Cheung & Kemper, 1992), whereas idea density is correlated with measures of vocabulary. A similar relationship between grammatical complexity and digit span has been obtained in a longitudinal analysis, spanning 15 years, of language samples collected from the group

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of healthy older adults and older adults with probable Alzheimer's disease (Kemper et al., 2000). Working memory involves both a short-term memory component and an executive component (Baddeley, 1986; Cowan, 1988, 1995; Engle, Tuholski, Laughlin, & Conway, 1999) that controls attention, blocks interference, and maintains information for analysis. Working memory imposes limits on how many digits may be retained (forward digit span), reordered (backward digit span), and how many words may be retained while other sentences are read (reading span). Working memory also imposes limits on grammatical complexity by limiting how many sentence relations, particularly hierarchical relations, may be formulated at one time. Each embedded or subordinate clause increases the burden on working memory by imposing additional requirements, including subject-verb agreement, pronominal choice, linear ordering of adjectives, and other grammatical rules. As working memory declines with advancing age, the grammatical complexity of older adults' speech and writing declines (Kemper, Kynette, Rash, Spratt, & O'Brien, 1989); Alzheimer's disease exacerbates this decline (Kemper, LaBarge, Ferraro, Cheung, Cheung, & Storandt, 1993; Kemper et al., 2000; Lyons et al., 1994).

Idea density (or propositional density), however, is related to the ability to define words (Kemper et al., 2000) and to processing efficiency measures such as reading rate and verbal fluency (Kemper & Sumner, 2001). Idea density is derived from the work of Kintsch and Keenan (1973); it assesses how much information can be packed into a sentence, relative to the number of words. High scores reflect an economy of expression, whereas low scores reflect vague, repetitious, and redundant expression. Idea density is less affected by normal aging processes than grammatical complexity (Kemper et al., 1989); however, Alzheimer's disease leads to a rapid decline in idea density (Kemper et al., 1993, in press; Lyons et al., 1994).

The present study examines longitudinal change in grammatical complexity and idea density and examines how individual differences in education and adulthood experiences affect these measures. An active, engaged adult lifestyle has often been assumed to maintain or enhance intellectual abilities in late life (Schaie, 1983, 1984). Pushkar Gold et al. (1995) examined this hypothesis with the use of archival data from Canadian veterans tested during World War II and retested 40 years later. Their analysis indicated that socioeconomic status, perceived locus of control, and habitual activities, including intellectual, recreational, social, and community activities, defined an engaged lifestyle that helped to maintain verbal abilities in late life. They suggested that better educated veterans were more likely to have acquired "habits, skills, and occupations that helped to maintain verbal intellectual performance in their later years" (Pushkar Gold et al., 1995, p. 301). Although this finding has been challenged by Hulstsch, Hertzog, Small, and Dixon (1999; but see Pushkar et al., 1999; Hertzog, Hulstsch, & Dixon, 1999), Hulstsch et al. (1999) reported that activities that promote "novel information processes . . . such as learning a language or playing bridge" (p. 248) are positively associated with cognitive functioning over a 6-year span. The participants in the Nun Study share a common lifestyle, religious commitment, and access to health care. Their adult lives do differ in some regards. Most were naive speakers of English although some had been reared in non-English-speaking homes and acquired English only after entering school. Although most partici-

pants had completed high school at the time they took their vows, some had not. Their grades in high school vary, with some earning Cs and others As in subjects such as English and algebra. Many went on to complete additional degrees (bachelor's, master's, and doctorate) after taking their vows. Although the School Sisters are a teaching congregation, the participants differ in how many years each spent teaching during her life time. We hypothesized that status as a native speaker of English and high school performance might be associated with the participants' initial level of grammatical complexity and idea density, whereas acquiring advanced degrees, proficiency in other languages, and a lifetime of teaching might help to maintain the participants' cognitive abilities in late life, including grammatical complexity and idea density.

Sliwinski and Buschke (1999) discussed the different types of age effects assessed in both cross-sectional and longitudinal studies. They noted that the cross-sectional approach examines age differences among persons; these age differences are treated as fixed effects and do not allow assessment of differential change. The longitudinal approach allows the assessment of age-related changes within persons and differences in those changes between persons. The latter, differential change effects reflect individual differences in cognitive aging and are modeled as random effects. Age-related changes, which are within-person effects that describe the general or average pattern of change, are modeled as fixed effects. Both differential change effects and patterns of change are of interest in the present study.

The most useful statistical models for assessing longitudinal change in linguistic ability support the estimation of both within- and between-subject effects as discussed above. In addition, the statistical models need to handle the increased complexity present in longitudinal data; these complexities include correlated observations within any individual, varying numbers of observations between participants because of missed observations and dropout, and varying intervals between observations within and between participants. Traditional statistical methods based on the general linear model either do not allow for the above-mentioned complexities or else handle them in a very restrictive manner. However, the general linear *mixed model* (Laird & Ware, 1982; Raudenbush, 1995) provides the flexibility and utility needed to model the longitudinal data used in this study. Mixed models include models that are referred to as multilevel models, hierarchical linear models, and random coefficient models (Bryk & Raudenbush, 1992; Goldstein, 1995). Mixed models have been used in studies of aging to assess change in various types of cognitive function (Jacqmin-Gadda, Fabrigoule, Commenges, & Dartigues, 1997; Rasmusson, Carson, Brookmeyer, Kawas, & Brandt, 1996; Sliwinski & Buschke, 1999; Teri, Hughes, & Larson, 1990). In this study, mixed modeling was used to examine the level and pattern of change over time in grammatical complexity and in idea density. The fixed effects describe two aspects of the linguistic measures: (a) the intercept, or the initial level of grammatical complexity or idea density, and (b) the slope, or the pattern of change over age or time in grammatical complexity or idea density. The models include a coefficient for the intercept and a coefficient for the linear slope for age. Random effects are required in the models to the extent that there is individual variation in the initial level or the pattern of age-related change. Specifically, the intercepts or slopes for the linguistic measures may vary across participants because of factors such as differences in adulthood experiences.

## Method

### Participants

All participants in the Nun Study are members of the School Sisters of Notre Dame. At the start of the study in 1990–1993, there were 678 participants who agreed to annual assessments of cognitive and physical function, brain donation upon death, and access to convent records. All participants share a similar lifestyle, religious commitment, and access to health care. Language samples were analyzed from a total of 180 individuals; 101 took their vows and joined the religious congregation at the Milwaukee, Wisconsin, convent and 79 took their vows and joined the Baltimore, Maryland, convent between 1931 and 1943. These convents preserved original, handwritten autobiographies written at the time the participants took their vows when the participants were between 17 and 32 years of age ( $M = 22.0$  years). In 1957–1959, 39 participants ( $M$  age = 46.6 years) provided updated autobiographies as did 56 participants ( $M$  age = 74.6) in 1987–1989. Most of the autobiographies from 1957–1959 and 1987–1989 were collected from participants at the Milwaukee convent. New autobiographical language samples were requested from the 139 participants who took part in the 1995–1996 annual assessment of the Nun Study, and 127 were able to comply with this request. At the 1995–1996 assessment, the participants were 78 to 90 years of age ( $M = 83.1$  years). In this study, 90 participants (40 from the Milwaukee convent, 50 from the Baltimore convent) contributed two language samples; 36 (33 Milwaukee, 3 Baltimore) contributed three samples, and 20 (all from the Milwaukee convent) contributed four samples. All available handwritten autobiographical language samples were used in this analysis.

Participants in the Nun Study are assessed annually by a battery of tests compiled by the Consortium to Establish a Registry for Alzheimer's Disease (CERAD; Morris et al., 1989). These tests assess global cognitive function (Mini-Mental Status Examination; Folstein, Folstein, & McHugh, 1975), short-term memory (Delayed Word Recall), language (Verbal Fluency and Boston Naming; Kaplan, Goodglass, & Weintraub, 1983), and visuospatial ability (Constructional Praxis). Performance-based testing is used to assess activities of daily living (i.e., the ability to dress oneself, rise to a standing position from a chair, walk, feed oneself, and use the toilet) and instrumental activities of daily living (i.e., handle money, use the telephone, read, use a clock and a calendar, and administer medications).

At any assessment, participants are considered to meet the criteria for dementia if they demonstrate (a) impairment of memory (i.e., less than 4 on the Delayed Recall Test), (b) impairment in at least one other area of cognition (i.e., less than 11 on the Verbal Fluency Test, less than 13 on the Boston Naming Test, or less than 8 on the Constructional Praxis Test), (c) impairment of social or daily function (i.e., inability to use a phone, handle money, or dress oneself), and (d) decline in function from a previous level (Snowdon et al., 1997). Cut scores used to identify impairments in cognition were based on scores that were less than the fifth percentile for the normative data described by the CERAD group (Welsh et al., 1994).

Convent archives provided additional information about each participant. The records indicated whether each participant was a native speaker of English or not. High school grades in English, algebra, geometry, and other subjects were documented in the archives. Grades for 4 years of English and grades for algebra and geometry were converted to a 0–100 scale. The average grade for English I–IV and the average mathematics grade for algebra and geometry were used in the analyses. In addition, convent records were consulted to obtain other indicators of adulthood experiences including educational attainment at the time the participant took her vows and entered the congregation, classified as less than a high school education, a high school education, or an advanced degree (e.g., bachelor's, master's, or higher); the number of additional degrees (e.g., bachelor's, master's, or higher) the participant completed after taking her vows; the number of years the participant spent teaching during her lifetime; and whether or not she was proficient in two or more languages.

### Language Sample Analysis

The autobiographies were analyzed following the procedures described by Kemper et al. (1989). The autobiographies were coded by first segmenting each into sentences and then coding the last 10 sentences of each sample or the entire sample if it consisted of fewer than 10 sentences. Two measures were then obtained from each language sample (see Cheung & Kemper, 1992, for details). The first measure was grammatical complexity based on an index originally developed by Rosenberg and Abbeduto (1987). Grammatical complexity ranges from simple one-clause sentences to complex sentences with multiple forms of embedding and subordination. Each complete sentence was scored, and the average grammatical complexity score for each language sample was then calculated. The second measure was idea density, which can be thought of as a measure of the content of a passage. Idea density was calculated according to the procedures described by Turner and Greene (1977). Each utterance was decomposed into its constituent propositions, which represent semantic concepts and relations between them. The idea density for each autobiography was defined as the average number of propositions per 10 words. Two trained coders independently scored 10% of the language samples to establish reliability. Reliabilities were .94 and .91 for grammatical complexity and idea density, respectively.

## Results

Descriptive statistics and baseline, simple, and complex models for each measure of linguistic ability are presented separately, first for participants who did not meet criteria for dementia and then for participants who met criteria for dementia on the 1995–1996 assessment.

### Data Analysis

The general form of the mixed model used in this study may be represented as a multilevel model with two levels: an individual, within-person growth model at the observation level (Level 1) and a between-person, individual-differences model at the person level (Level 2). These can be combined to yield a mixed model in the form of an unconditional linear growth model:

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + u_{0i} + u_{1i} X_{ij} + e_{ij}, \quad (1)$$

where  $Y_{ij}$  is the outcome for person  $i$  at observation  $j$  and  $X_{ij}$  indicates an observation occasion or the age of the person at this observation. The first two terms of the equation contain fixed-effects parameters that reflect average population characteristics across all individuals. These fixed effects are the intercept coefficient,  $\beta_0$ , and the linear slope coefficient for time or age,  $\beta_1$ . The remaining three terms specify random effects that reflect variability between individuals (Level 2),  $u_{0i}$  and  $u_{1i}$ , and within individuals (Level 1),  $e_{ij}$ . Random effects are required at the person level (Level 2) in the model to the extent that level and age-related changes vary among individuals. Between-person differences in level, or residual intercepts, are represented as  $u_{0i}$ , and between-person differences in slopes, or residual slopes, are represented as  $u_{1i}$ . Of interest are the variance of the residual intercepts ( $\tau_{00}$ ), the variance of the residual slopes ( $\tau_{11}$ ), and covariance between the residual intercepts and slopes ( $\tau_{01}$  or  $\tau_{10}$ ) and whether person-level covariates can account for this variation. Addition of a person-level covariate results in two new fixed-effects results: (a) the relationship between the covariate and the initial level represented by  $\beta_2$  and (b) the relationship between the covariate and the

change over time or age, which is modeled by the interaction between the covariate and the variable representing time or age and represented by  $\beta_3$ .

Interpretations of parameter estimates depend on the values of the time or age variables and the covariates. Specifically, the intercept is the mean value on the dependent variable when all explanatory variables are equal to zero. Therefore, estimated parameters are more easily interpreted if variables are located (centered) by deviating scores about a conceptually relevant value for the variable such as the mean age or the maximum score observed on a covariate. In this study, the choice of centering method varied according to the particular variables. Centering procedures are presented in the discussion of the various variables used in the analyses.

Our modeling strategy involved descriptive analyses followed by alternative evaluations of fixed- and random-effects components as recommended by Wallace and Green (in press). For additional details on specifying and evaluating models by using SAS PROC MIXED, see Singer (1998) and Littell, Milliken, Stroup, and Wolfinger (1996). Starting with a linear time or age model, we used restricted maximum-likelihood estimation (REML) and the associated deviance statistic ( $-2 \log$  likelihood) to evaluate the need for a random intercept and slope. We then progressively evaluated the fixed effects using REML  $F$  tests. The random components were then reevaluated by using REML deviances. Differences in deviance statistics are distributed approximately as the chi-square, with degrees of freedom equal to the difference in the numbers of parameters between nested models. More specifically, in the context of this study, we used this modeling procedure to develop growth models involving age as a predictor of linguistic ability. The random effects in the growth models provided information regarding the variability in initial levels and in slopes (rates of decline) among individuals. We then added covariates to the growth models in an attempt to explain between-subject variance or covariance for the random intercept and slope.

### Descriptive Statistics

*Participants who did not meet criteria for dementia.* Tables 1 and 2 summarize similarities and differences among the participants according to whether they were from the Baltimore or Milwaukee convent. At the time the participants took their vows, idea densities for participants at the Baltimore convent were lower than those at the Milwaukee convent,  $t(135.5) = -12.9, p = .000$ . This difference in idea density also held at the time the late-life autobiographies were collected in 1996,  $t(50.8) = -10.2, p = .000$ . However, at the time the initial autobiographies were written, grammatical complexity was higher for the participants at the Baltimore convent than for those at the Milwaukee convent,  $t(137) = 11.0, p = .000$ . Again, this difference in grammatical complexity was also apparent at the 1996 assessment,  $t(106) = 2.5, p = .013$ . High school English grades also differed between convents. The participants from the Milwaukee convent had higher English grades than the participants from the Baltimore convent,  $t(91.1) = -2.4, p = .019$ . The participants at the two convents did not differ in high school mathematics grades, in the total number of years they spent teaching throughout their lifetimes, or in the number of additional degrees they earned after taking their vows. At the time of the first autobiography, the attained educational

Table 1  
*Descriptive Comparison of Participants Who Did Not Meet Criteria for Dementia From the Baltimore and Milwaukee Convents*

Variable	Convent		<i>p</i>
	Baltimore	Milwaukee	
Age at first autobiography			
<i>M</i> ( <i>SD</i> )	21.3 (2.1)	21.9 (2.9)	.171
<i>n</i>	55	84	
Idea density for the first autobiography			
<i>M</i> ( <i>SD</i> )	5.3 (0.6)	7.2 (1.1)	.000
<i>n</i>	55	84	
Idea density for the 1957–1959 autobiography			
<i>M</i> ( <i>SD</i> )	—	5.6 (0.6)	—
<i>n</i>	—	30	
Idea density for the 1987–1989 autobiography			
<i>M</i> ( <i>SD</i> )	5.7	5.6 (0.6)	—
<i>n</i>	1	43	
Idea density for the 1996 autobiography			
<i>M</i> ( <i>SD</i> )	3.6 (1.1)	5.5 (0.5)	.000
<i>n</i>	42	66	
Grammatical complexity for the first autobiography			
<i>M</i> ( <i>SD</i> )	4.6 (0.9)	2.9 (0.9)	.000
<i>n</i>	55	84	
Grammatical complexity for the 1957–1959 autobiography			
<i>M</i> ( <i>SD</i> )	—	2.8 (0.7)	—
<i>n</i>	—	30	
Grammatical complexity for the 1987–1989 autobiography			
<i>M</i> ( <i>SD</i> )	1.4	2.7 (0.7)	—
<i>n</i>	1	43	
Grammatical complexity for the 1996 autobiography			
<i>M</i> ( <i>SD</i> )	2.9 (1.1)	2.4 (0.9)	.013
<i>n</i>	42	66	
High school English grade			
<i>M</i> ( <i>SD</i> )	86.3 (5.9)	88.6 (4.6)	.019
<i>n</i>	52	75	
High school mathematics grade			
<i>M</i> ( <i>SD</i> )	86.4 (7.7)	87.5 (6.4)	.352
<i>n</i>	52	75	
Total years teaching			
<i>M</i> ( <i>SD</i> )	42.1 (8.8)	40.3 (2.3)	.372
<i>n</i>	55	83	
Degrees earned after first autobiography			
<i>M</i> ( <i>SD</i> )	1.7 (0.6)	1.5 (0.6)	.130
<i>n</i>	55	84	

*Note.* Dashes indicate that data are not available.

level of the participants differed, Pearson  $\chi^2(2, N = 139) = 13.2, p = .001$ . At the Milwaukee convent, 94% of the participants had completed high school, whereas at the Baltimore convent, 73% of the participants had completed high school. Participants from the two convents were equally likely to be native speakers of English and to be proficient in two or more languages.

*Participants who met criteria for dementia.* Tables 3 and 4 summarize similarities and differences among the participants who met criteria for dementia according to whether they had joined the Baltimore or Milwaukee convent. At the time the participants took

Table 2  
Comparison of Participants Who Did Not Meet Criteria for Dementia From Baltimore and Milwaukee Convents

Response	Baltimore	Milwaukee
Educational attainment at first autobiography Pearson $\chi^2(2, N = 139) = 13.2, p = .001$		
Less than high school	.27	.06
High school only	.66	.89
More than high school	.07	.05
English as the native language Pearson $\chi^2(1, N = 122) = 2.7, p = .099$		
No	.02	.10
Yes	.98	.90
Proficient in two or more languages Pearson $\chi^2(1, N = 122) = 1.3, p = .263$		
No	.43	.33
Yes	.57	.67

Note. Cell values are expressed as proportions within the respective convent.

their vows, participants at the Baltimore convent produced lower idea densities than those at the Milwaukee convent,  $t(39) = -2.6, p = .014$ . This difference in idea density also held at the time the late-life autobiographies were collected in 1996,  $t(17) = -3.3, p = .004$ . However, grammatical complexity differed only at the time the initial autobiographies were written; participants at the Baltimore convent had higher grammatical complexity scores than those at the Milwaukee convent,  $t(39) = 4.6, p = .000$ . High school English grades also differed between convents. The participants from the Milwaukee convent had higher English grades than the participants from the Baltimore convent,  $t(26) = -2.2, p = .037$ . The participants at the two convents did not differ in high school mathematics grades, in the total number of years they spent teaching throughout their lifetimes, in the number of additional degrees they earned after taking their vows, in the numbers of participants who had completed high school at the time of writing the first autobiography, or in the numbers of participants who were native speakers of English. Participants at the Milwaukee convent, however, were more likely to be proficient in two or more languages, Pearson  $\chi^2(1, N = 68) = 4.3, p = .038$ .

### Statistical Models of Grammatical Complexity and Idea Density

Grammatical complexity and idea density were modeled separately for participants who did not meet criteria for dementia and participants who did meet criteria for dementia. A set of models treating dementia status as a predictor was also developed; these models were less informative than the separate models. Because of the relative sample sizes, no higher order interactions with dementia status were detected. The separate models do describe different patterns of influence for participants who do versus do not meet criteria for dementia; however, direct comparisons of the two groups are not possible.

In these models, key variables were centered at a mean or other value to aid in interpreting the resulting models. The complete list of variables used in the models is presented in Table 5. The centered variables included age, the level of education attained at the time each participant took her vows, and high school grades in English and math. The centered level of education variable (EDUX<sub>C</sub>) was coded so that a score of 0 meant that the participant had completed only a high school level of education at the time her first autobiography was written, whereas a score of -1 meant she had not yet completed high school, and a score of +1 meant she had more than a high school education. The centered English score

Table 3  
Descriptive Comparison of Participants Who Met Criteria for Dementia From the Baltimore and Milwaukee Convents

Variable	Convent		p
	Baltimore	Milwaukee	
Age at first autobiography M (SD) n	22.2 (2.5) 24	22.6 (3.4) 17	.649
Idea density for the first autobiography M (SD) n	4.3 (1.1) 24	5.2 (1.0) 17	.014
Idea density for the 1957–1959 autobiography M (SD) n	— —	4.8 (1.0) 9	—
Idea density for the 1987–1989 autobiography M (SD) n	4.7 (0.1) 2	4.3 (1.0) 10	.004
Idea density for the 1996 autobiography M (SD) n	3.4 (1.3) 11	5.3 (1.1) 8	.004
Grammatical complexity for the first autobiography M (SD) n	3.9 (1.3) 24	2.1 (1.0) 17	.000
Grammatical complexity for the 1957–1959 autobiography M (SD) n	— —	2.0 (1.5) 9	—
Grammatical complexity for the 1987–1989 autobiography M (SD) n	3.2 (0.4) 2	1.7 (1.5) 10	.000
Grammatical complexity for the 1996 autobiography M (SD) n	2.9 (1.2) 11	2.0 (1.7) 8	.205
High school English grade M (SD) n	83.0 (6.9) 17	88.2 (4.5) 11	.037
High school mathematics grade M (SD) n	84.9 (7.2) 17	84.6 (9.4) 12	.926
Total years teaching M (SD) n	35.5 (16.9) 24	31.3 (0.2) 16	.486
Degrees earned after first autobiography M (SD) n	1.4 (0.9) 24	1.0 (0.9) 17	.141

Note. Dashes indicate that data are not available.

Table 4  
Comparison of Participants Who Met Criteria for Dementia  
From Baltimore and Milwaukee Convents

Response	Baltimore	Milwaukee
Educational attainment at first autobiography Pearson $\chi^2(2, N = 41) = 0.11, p = .944$		
Less than high school	.33	.29
High school only	.63	.65
More than high school	.04	.06
English as the native language (Not testable)		
No	.00	.12
Yes	1.00	.88
Proficient in two or more languages Pearson $\chi^2(1, N = 35) = 1.71, p = .191$		
No	.48	.25
Yes	.52	.75

Note. Cell values are expressed as proportions within the respective convent.

was the deviation of the participant's English grade from the overall mean English grade for the sample, which corresponded to a score of 87.9 on a 100-point scale for participants without dementia (ENGLISH<sub>87.9</sub>) and 86.0 for the participants who met criteria for dementia (ENGLISH<sub>86.0</sub>). Math grades also were deviated around sample means, 87.4 for participants without dementia (MATH<sub>87.4</sub>) and 86.0 for participants who met criteria for dementia (MATH<sub>86.0</sub>). Lastly, age was centered at the grand mean for each sample of participants at the time the first autobiography was written: at 21.7 years for participants who did not meet criteria for dementia (AGE<sub>21.7</sub>) and at 22.0 for participants who met criteria for dementia (AGE<sub>22.0</sub>).

*Grammatical complexity for participants who did not meet criteria for dementia.* As a first step, a baseline model was developed that contained a random intercept, a random slope, and the covariance between the intercept and slope, with AGE<sub>21.7</sub> as the longitudinal predictor. The intercept of the baseline model corresponds to an average grammatical complexity of 3.60 at the average age of 21.7 years,  $\beta_0 = 3.60, SE = .10, t(138) = 35.80, p = .000$ . Grammatical complexity declined with age, as indicated by the slope parameter,  $\beta_1 = -.02, SE = .002, t(181) = -9.56, p = .000$ . Z tests indicated that the intercept and the slope varied significantly among the participants. The estimated intercept variance  $\hat{\tau}_{00}$  was 1.10 with  $SE = .18, z = 6.21, \text{ and } p = .000$ ; the estimated slope variance  $\hat{\tau}_{11}$  is .0002,  $SE = .06, z = 3.31, \text{ and } p = .001$ . The covariance of the two parameters ( $\hat{\tau}_{01}$ ) also contains unexplained, systematic variance:  $\hat{\tau}_{01} = -.01, SE = .003, z = -3.46, p = .001$ .

Next, a series of single-predictor models was tested to account for the unexplained variance in the intercept, slope, and their covariance found in the baseline model. Potential predictors included educational attainment (EDUX<sub>C</sub>), mean English grade (ENGLISH<sub>87.9</sub>), mean mathematics grade (MATH<sub>87.4</sub>), total years teaching (TEACHING), additional degrees earned (DEGREES), convent membership (CONVENT), and whether or not the partic-

ipant was a native speaker of English or proficient in two or more languages. Table 6 summarizes the model equations, parameter estimates, and fit indices for some of these predictors. More teaching experience (TEACHING) attenuated the decline in grammatical complexity with advancing age,  $\beta_3 = .0003, SE = .0002, t(178) = 2.11, p < .036$ . The association between CONVENT and grammatical complexity was statistically significant for both the intercept,  $\beta_2 = -1.67, SE = .147, t(137) = -11.36, p = .000$ , and the slope,  $\beta_3 = .02, SE = .003, t(180) = 6.37, p = .000$ . Including CONVENT as a fixed effect eliminated the significant covariation between the intercept and slope. None of the other predictors, EDUX<sub>C</sub>, ENGLISH<sub>87.9</sub>, MATH<sub>87.4</sub>, DEGREES, and whether or not the participant was a native speaker of English or proficient in two or more languages, accounted for significant variability in grammatical complexity among the participants who did not meet criteria for dementia.

Finally, a complex model that included both TEACHING and CONVENT as predictors for both the slope and intercept was examined. CONVENT was a significant predictor of both the

Table 5  
Common Variables for Participants Who Did Not Meet Criteria  
for Dementia and Those Who Did Meet Criteria for Dementia

Variable	Definition of variable
All participants	
DEGREES	Additional degrees earned after first autobiography
CONVENT	Convent membership at first autobiography; 0 = Baltimore, 1 = Milwaukee
TEACHING	Total years teaching college, high school, or grade school
EDUX <sub>C</sub>	Educational level at first autobiography centered at high school; -1 = less than a high school degree, 0 = high school, +1 = more than a high school degree
Participants who did not meet criteria for dementia	
ENGLISH <sub>87.9</sub>	Mean English grade centered at the average grade for the participants who did not meet criteria for dementia (87.9); <0 = mean English grade less than average, 0 = average English grade, >0 = mean English grade above average
MATH <sub>87.4</sub>	Mean mathematics grade centered at the average grade for the participants who did not meet criteria for dementia (87.4); <0 = mean math grade lower than average, 0 = average math grade, >0 = mean math grade above average
AGE <sub>21.7</sub>	Average age at the first autobiography for participants who did not meet criteria for dementia (21.7 years)
Participants who met criteria for dementia	
ENGLISH <sub>86.0</sub>	Mean English grade centered at the average grade for the participants who met criteria for dementia (86.0); <0 = mean English grade lower than average, 0 = average English grade, >0 = mean English grade above average
MATH <sub>86.0</sub>	Mean mathematics grade centered at the average grade for the participants who met criteria for dementia (86.0); <0 = mean math grade less than average, 0 = average math grade, >0 = mean math grade above average
AGE <sub>22</sub>	Average age at the first autobiography for participants with dementia (22 years)

Table 6  
Summary Table for Models of Grammatical Complexity for Participants Who Did Not Meet Criteria for Dementia

Model	Coefficients for fixed effects	Variance estimates for random effects
Baseline $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + u_{0i} + u_{1i} + e_{ij}$	$\beta_0 = 3.60 (p = .000)$ $\beta_1 = -0.02 (p = .000)$	$\hat{\tau}_{00} = 1.10 (p = .000)$ $\hat{\tau}_{11} = .0002 (p = .001)$ $\hat{\tau}_{01} = -.01 (p = .001)$ $\hat{\sigma}^2 = .32 (p = .000)$
Total years of teaching $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{TEACHING}_i + \beta_3 \text{TEACHING}_i \times \text{AGE}_{21.7ij} + u_{0i} + u_{1i} + e_{ij}$	$\beta_0 = 3.53 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = 0.002 (p = .856)$ $\beta_3 = 0.0003 (p = .036)$	$\hat{\tau}_{00} = 1.11 (p = .000)$ $\hat{\tau}_{11} = .0002 (p = .002)$ $\hat{\tau}_{01} = -.01 (p = .001)$ $\hat{\sigma}^2 = .33 (p = .000)$
Convent $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{CONVENT}_i + \beta_3 \text{CONVENT}_i \times \text{AGE}_{21.7ij} + u_{0i} + u_{1i} + e_{ij}$	$\beta_0 = 4.61 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = -1.67 (p = .000)$ $\beta_3 = 0.02 (p = .000)$	$\hat{\tau}_{00} = .38 (p = .000)$ $\hat{\tau}_{11} = .0006 (p = .033)$ $\hat{\sigma}^2 = .35 (p = .000)$
Teaching and convent $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{TEACHING}_i + \beta_3 \text{CONVENT}_i + \beta_4 \text{TEACHING}_i \times \text{AGE}_{21.7ij} + \beta_5 \text{CONVENT}_i \times \text{AGE}_{21.7ij} + u_{0i} + e_{ij}$	$\beta_0 = 4.78 (p = .000)$ $\beta_1 = -0.04 (p = .000)$ $\beta_2 = -0.004 (p = .557)$ $\beta_3 = -1.68 (p = .000)$ $\beta_4 = 0.0004 (p = .002)$ $\beta_5 = 0.02 (p = .000)$	$\hat{\tau}_{00} = .41 (p = .000)$ $\hat{\sigma}^2 = .41 (p = .000)$

slope,  $\beta_5 = .02, SE = .003, t(177) = 7.13, p = .000$  and the intercept,  $\beta_3 = -1.68, SE = .156, t(135) = -10.81, p = .000$ . TEACHING also was a significant predictor of the slope,  $\beta_4 = .0004, SE = .0001, t(177) = 3.18, p = .002$ , although it was not significantly associated with the intercept. This covariate, however, was retained in the model as a predictor of the intercept in order not to confound the effects of the covariate on the slope and on the intercept (Snijders, 1996). CONVENT and TEACHING together were sufficient to account for the variance associated with the slope; thus, the only random between-persons component in the final model was the random intercept. This final model for predicting the fixed effects of grammatical complexity for participants who did not meet criteria for dementia, based on REML estimation, is given by Equation 2:

$$\text{GRAMMATICAL COMPLEXITY}_{ij} = 4.78 - .04 \text{AGE}_{21.7ij} - .004 \text{TEACHING}_i - 1.68 \text{CONVENT}_i + .0004 \text{TEACHING}_i \times \text{AGE}_{21.7ij} + .02 \text{CONVENT}_i \times \text{AGE}_{21.7ij} \quad (2)$$

Figure 1 illustrates the model. Greater grammatical complexity was exhibited by participants from the Baltimore convent. Overall, grammatical complexity declined by .04 units per year; the rate of decline was reduced for those participants who had more total years teaching. Participants from the Milwaukee convent had a lower initial level of grammatical complexity than participants from the Baltimore convent. The rate of decline was reduced for participants from the Milwaukee convent.

*Grammatical complexity for participants who met criteria for dementia.* The baseline model for grammatical complexity for the participants who met criteria for dementia included the same fixed effects, intercept and slope, as the model for the group who did not meet the criteria for dementia. The random effects, how-

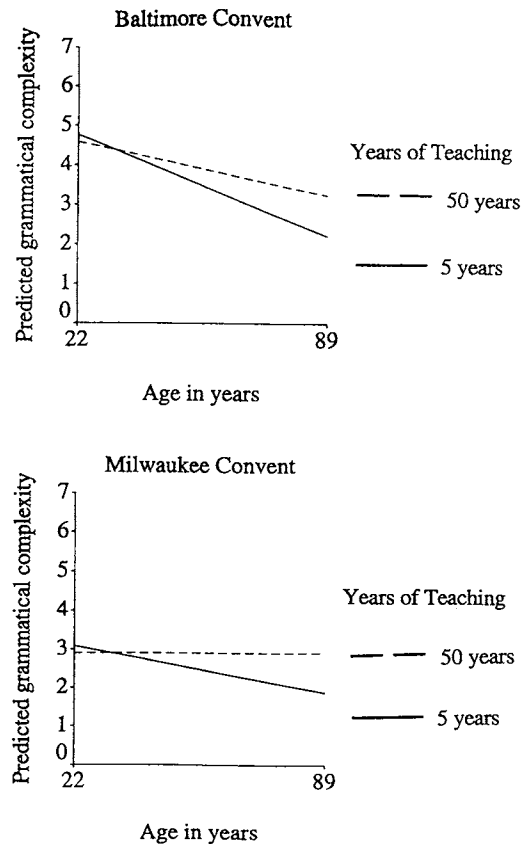


Figure 1. Predicted decline in grammatical complexity from Equation 2. Decline is a function of convent membership, total years of teaching, and age for participants who did not meet criteria for dementia.

Table 7  
 Summary Table for Models of Grammatical Complexity for Participants Who Met Criteria for Dementia

Model	Coefficients for fixed effects	Variance estimates for random effects
Baseline $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + u_{0i} + e_{ij}$	$\beta_0 = 3.14 (p = .000)$ $\beta_1 = -0.02 (p = .000)$	$\hat{\tau}_{00} = 1.53 (p = .000)$ $\hat{\sigma}^2 = .40 (p = .000)$
Convent $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + \beta_2 \text{CONVENT}_i + \beta_3 \text{CONVENT}_i \times \text{AGE}_{22ij} + u_{0i} + e_{ij}$	$\beta_0 = 3.86 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = -1.70 (p = .000)$ $\beta_3 = 0.02 (p = .002)$	$\hat{\tau}_{00} = 1.19 (p = .000)$ $\hat{\sigma}^2 = .30 (p = .000)$

ever, differed for the participants who met criteria for dementia. The only between-subjects random effect in their baseline model was a random intercept parameter with variance  $\hat{\tau}_{00} = 1.53, SE = .393, z = 3.90, p = .000$ . The random effects for the variance in the slope and the covariance between the intercept and slope parameters failed to be significant.

The only covariate that revealed statistically significant fixed effects was CONVENT. As with participants who did not meet criteria for dementia, participants from the Baltimore convent had higher grammatical complexity scores at entry into the convent than did the participants from the Milwaukee convent,  $\beta_2 = -1.70, SE = .386, t(39) = -4.42, p = .000$ . The decline in grammatical complexity with advancing age, however, was greater for participants from the Baltimore convent than for participants from the Milwaukee convent,  $\beta_3 = .02, SE = .005, t(37) = 3.33, p = .002$ . EDUX<sub>C</sub>, ENGLISH<sub>86,0</sub>, MATH<sub>86,0</sub>, TEACHING, DEGREES, and whether the participant was a native speaker of English or fluent in two or more languages failed to account for a significant portion of the variance. The final model for the participants who met criteria for dementia is shown in Table 7; Equation 3 contains the REML estimates for the final model predicting grammatical complexity for participants who met criteria for dementia:

$$\text{GRAMMATICAL COMPLEXITY}_{ij} = 3.86 - .03\text{AGE}_{22ij} - 1.70\text{CONVENT}_i + .02\text{CONVENT}_i \times \text{AGE}_{22ij}. \quad (3)$$

Figure 2 illustrates this model. In contrast with Model 1 in Figure 1, TEACHING did not moderate the decline in grammatical complexity for participants who met criteria for dementia. Grammatical complexity declined by .03 units per year; this decline was somewhat reduced for participants from the Milwaukee convent.

Idea density for participants who did not meet criteria for dementia. Fixed effects remained the same as for previous baseline models with intercept ( $\beta_0$ ) and slope ( $\beta_1$ ) parameters. Again, the slope parameter showed a decline in idea density with increasing age. The baseline model of idea density for participants who did not meet criteria for dementia contained only a random intercept with variance,  $\hat{\tau}_{00} = .81, SE = .14, z = 5.80, p = .000$ ; neither the random slope variance nor the intercept-slope covariance were significant.

Table 8 summarizes relevant single-predictor and complex models of idea density for the participants who did not meet criteria for dementia. Single-predictor models included one covariate in addition to the intercept and slope parameters. The significant single

additional covariates were educational attainment at the time the participants took their vows (EDUX<sub>C</sub>),  $\beta_2 = .56, SE = .198, t(137) = 2.84, p = .005$ ; average high school English grade (ENGLISH<sub>87,9</sub>),  $\beta_2 = .05, SE = .07, t(126) = 2.71, p = .008$ ; and CONVENT,  $\beta_2 = 1.71, SE = .109, t(137) = 15.69, p = .000$ . MATH<sub>87,4</sub>, TEACHING, DEGREES, and whether the participant was a native speaker of English or fluent in two or more languages did not improve the fit of the models. As indicated by the reduction in the variance associated with each model, CONVENT was the best single predictor of idea density in participants who did not meet criteria for dementia (see Table 8).

Complex models combining ENGLISH<sub>87,9</sub> and EDUX<sub>C</sub> with CONVENT did not produce any improvement in fit over the single-predictor model with CONVENT. Convent membership, a likely proxy for other educational and sociological influences on the early development of the participants, is a robust predictor of the participants' initial levels of idea density. Participants from the Milwaukee convent exhibited greater idea density in their first autobiography written when they took their vows than did participants from the Baltimore convent. This advantage for participants from the Milwaukee convent was maintained throughout the participants' lifetimes (see Figure 3). Idea density declined by .03 units per year; educational experiences did not moderate this decline with advancing age. REML estimates for model parameters are given in Equation 4, the final model for predicting idea density for participants who did not meet criteria for dementia:

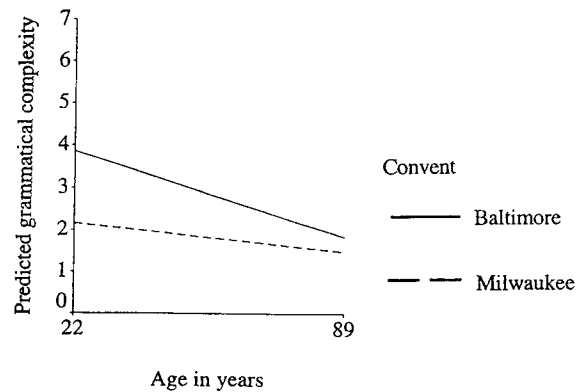


Figure 2. Predicted decline in grammatical complexity from Equation 3. Decline is a function of convent membership and age for participants who met criteria for dementia.

Table 8  
Summary Table for Models of Idea Density for Participants Who Did Not Meet Criteria for Dementia

Model	Coefficients for fixed effects	Variance estimates for random effects
Baseline $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + u_{0i} + e_{ij}$	$\beta_0 = 6.41 (p = .000)$ $\beta_1 = -0.03 (p = .000)$	$\hat{\tau}_{00} = .81 (p = .000)$ $\hat{\sigma}^2 = .59 (p = .000)$
Educational attainment at time of first autobiography $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{EDUX}_{Ci} + u_{0i} + e_{ij}$	$\beta_0 = 6.46 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = 0.56 (p = .005)$	$\hat{\tau}_{00} = .75 (p = .000)$ $\hat{\sigma}^2 = .59 (p = .000)$
Mean high school English grade $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{ENGLISH}_{87.9i} + u_{0i} + e_{ij}$	$\beta_0 = 6.44 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = 0.05 (p = .008)$	$\hat{\tau}_{00} = .78 (p = .000)$ $\hat{\sigma}^2 = .57 (p = .000)$
Convent $Y = \beta_0 + \beta_1 \text{AGE}_{21.7ij} + \beta_2 \text{CONVENT} + u_{0i} + e_{ij}$	$\beta_0 = 5.35 (p = .000)$ $\beta_1 = -0.03 (p = .000)$ $\beta_2 = 1.71 (p = .000)$	$\hat{\tau}_{00} = .09 (p = .100)$ $\hat{\sigma}^2 = .61 (p = .000)$

IDEA DENSITY<sub>ij</sub>

$$= 5.35 - .03\text{AGE}_{21.7ij} + 1.71\text{CONVENT}_i \quad (4)$$

Idea density for participants who met criteria for dementia. The baseline model specified fixed effects for the intercept ( $\beta_0$ ) and the slope for the change in idea density with advancing age ( $\beta_1$ ); the slope parameter indicates a decline of .01 units in idea density per year. The random components in the baseline model for idea density for participants who met criteria for dementia included only a random intercept with estimated variance ( $\hat{\tau}_{00} = .97, SE = .307, z = 3.16, p = .002$ ). Random effects for the slope variance and intercept-slope covariance were not required.

Table 9 summarizes the relevant single-predictor and complex models tested for idea density for the participants who met criteria for dementia. Significant covariates affecting the initial level of idea density were educational attainment at the time the participants took their vows ( $\text{EDUX}_{Ci}$ ),  $\beta_2 = .57, SE = .273, t(39) = 2.08, p = .044$ , and  $\text{CONVENT}$ ,  $\beta_2 = .82, SE = .356, t(39) = 2.30, p = .027$ .  $\text{CONVENT}$  also was a significant predic-

tor of the slope,  $\beta_3 = .01, SE = .006, t(38) = 2.36, p = .024$  (see Table 9). When combined with  $\text{convent}$ , educational attainment provided only a minimal improvement in fit,  $\Delta\chi^2(1, N = 81) = 3.74, p = .053$ . On the basis of the tests of the fixed effects and  $\Delta\chi^2$  results, educational attainment was not included in the final model. The final model for predicting idea density for participants who met criteria for dementia, based on REML estimates, is shown in Equation 5:

$$\text{IDEA DENSITY}_{ij} = 4.34 - .02\text{AGE}_{22ij} + .82\text{CONVENT}_i + .01\text{CONVENT}_i \times \text{AGE}_{22ij} \quad (5)$$

Participants from the Milwaukee convent initially produced higher idea densities than participants from the Baltimore convent; in contrast with the model of idea density for participants who did not meet criteria for dementia, convent membership moderated the decline in idea density with advancing age. Idea densities for participants at the Milwaukee convent declined somewhat more slowly than did idea densities for participants from the Baltimore convent. Overall, idea density declined by .02 units per year. Figure 4 illustrates the relationship between convent and idea density for participants who met criteria for dementia.

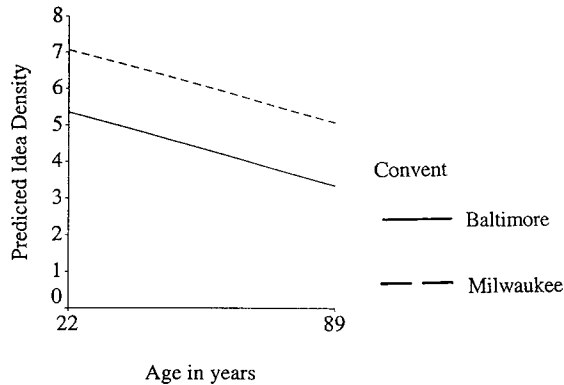


Figure 3. Predicted decline in idea density from Equation 4. Decline is a function of convent membership and age for participants who did not meet criteria for dementia.

Conclusions

This analysis of autobiographical language samples indicated that grammatical complexity and idea density gradually decline across the life span. When the first autobiographies were collected in 1931–1943, the participants averaged 22 years of age; they averaged 83 years in 1996 when autobiographies were again collected. Over this span of approximately 61 years, grammatical complexity for participants who did not meet criteria for dementia declined .04 units per year, and idea density declined .03 units per year. Despite the availability of some language samples from two intermediate periods, 1957–1959 and 1987–1989, this analysis was not sensitive to any departure from linearity; hence, the rate of decline appears uniform throughout this span. Additional language samples from intermediate points would be required to detect any nonlinearity in the pattern of decline.

Table 9  
Summary Table for Models of Idea Density for Participants Who Met Criteria for Dementia

Model	Coefficients for fixed effects	Variance estimates for random effects
Baseline $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + u_{0i} + e_{ij}$	$\beta_0 = 4.70 (p = .000)$ $\beta_1 = -0.01 (p = .000)$	$\hat{\tau}_{00} = .97 (p = .002)$ $\hat{\sigma}^2 = .55 (p = .000)$
Educational attainment at time of first autobiography $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + \beta_2 \text{EDUX}_{Ci} + u_{0i} + e_{ij}$	$\beta_0 = 4.84 (p = .000)$ $\beta_1 = -0.01 (p = .000)$ $\beta_2 = 0.57 (p = .044)$	$\hat{\tau}_{00} = .84 (p = .003)$ $\hat{\sigma}^2 = .55 (p = .000)$
Convent $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + \beta_2 \text{CONVENT}_i + \beta_3 \text{CONVENT}_i \times \text{AGE}_{22ij} + u_{0i} + e_{ij}$	$\beta_0 = 4.34 (p = .000)$ $\beta_1 = -0.02 (p = .000)$ $\beta_2 = 0.82 (p = .027)$ $\beta_3 = 0.01 (p = .024)$	$\hat{\tau}_{00} = .85 (p = .001)$ $\hat{\sigma}^2 = .44 (p = .000)$
Convent and educational attainment $Y = \beta_0 + \beta_1 \text{AGE}_{22ij} + \beta_2 \text{CONVENT}_i + \beta_3 \text{EDUX}_{Ci} + \beta_4 \text{CONVENT}_i \times \text{AGE}_{22ij} + u_{0i} + e_{ij}$	$\beta_0 = 4.48 (p = .000)$ $\beta_1 = -0.02 (p = .000)$ $\beta_2 = 0.76 (p = .032)$ $\beta_3 = 0.50 (p = .055)$ $\beta_4 = 0.01 (p = .027)$	$\hat{\tau}_{00} = .74 (p = .002)$ $\hat{\sigma}^2 = .44 (p = .000)$

For participants who did not meet criteria for dementia, grammatical complexity declined from an average of 4.78 on a 7-point scale to 2.34. Their idea density scores declined from an average of 5.35 propositions per 10 words to 3.52 propositions per 10 words. Initially, the participants were using sentences containing many embedded and subordinate clauses. They used relative clauses in both the subject and predicate as well as complement constructions and comparative constructions. They were also able to convey many ideas by using few words. The lower grammatical complexity scores produced 61 years later indicate that the participants were using these sorts of complex constructions much less frequently although they were still capable of doing so. Further, their later autobiographies were more vague and repetitious in that they used more words to convey the same numbers of ideas.

Compare the two autobiographies (Table 10), written 61 years apart by a participant who does not meet the criteria for dementia. When she first wrote at age 19, this participant wrote in a complex style with many embedded constructions. Her grammatical com-

plexity score for this sample was 2.80 and her idea density score was 7.73. By the time she was 80 years old, this participant used a simpler style; her grammatical complexity had declined to 2.17 and her idea density to 6.12 propositions per 10 words. This decline in grammatical complexity and propositional density reflects, to some extent, differences in the emotional tone and affective content of the two autobiographies (Snowdon, Greiner, et al., 1996). In the first autobiography, the participant commented on the religious significance of her baptismal name as well as on the emotions she experienced when her family moved to a new city.

This pattern of decline in grammatical complexity and decreasing idea density differs from another speech style that has been associated with aging, off-target verbosity (Pushkar Gold, Andres, Arbuckle, & Schwartzman, 1988). Off-target verbosity is characterized as involving both excessive, copious amounts of speech and speech that drifts from topic to topic via a chain of weak associations. Off-target verbosity appears to be a consequence of poor inhibitory function, stress, and extroversion (Pushkar Gold, Andres, Arbuckle, & Zieren, 1993; Pushkar Gold & Arbuckle, 1995; Pushkar Gold, Arbuckle, & Andres, 1994). Individuals who are off-target verbose dominate conversations; they are less interested in their conversational partners, and their partners find their conversations less satisfying (Pushkar, Basevitz, Arbuckle, Nohara-LeClair, Lapidus, & Peled, 2000). Pushkar et al. (2000) concluded that off-target verbosity is "a distinct pattern found in a minority of older people" (p. 371). On the basis of their autobiographies, none of the participants in the present study appears to meet the criteria for off-target verbosity; although their autobiographies differed in length, all were considered to be focused and responsive to the instructions.

The initial scores for grammatical complexity and idea density for participants who met criteria for dementia by 1996 were lower than those of the participants who had not met criteria for dementia (grammatical complexity: without dementia, 4.78, and with dementia, 3.86; (idea density: without dementia, 5.35, and with dementia, 4.34). This confirms the original report by Snowdon,

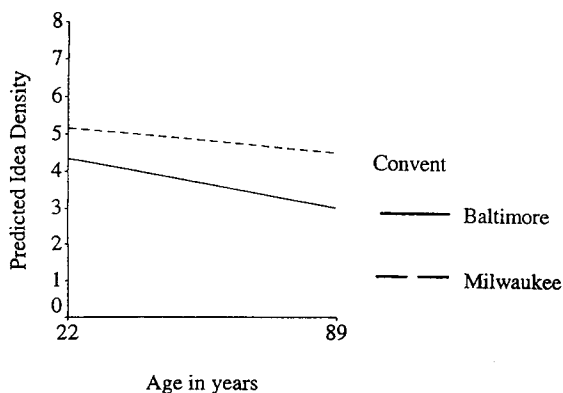


Figure 4. Predicted decline in idea density from Equation 5. Decline is a function of convent membership and age for participants who met criteria for dementia.

Table 10  
*Comparison of Two Autobiographical Language Samples, Written by the  
 Same Participant 61 Years Apart*

Written in 1934, at age 19

In the year 1915, MONTH DAY, I opened my eyes to take a first wee peek at the world, just a tiny part of the immense world, CITY1, STATE1. I was baptized in CHURCH and was named NAME, signifying pearl, certainly a foregoing of the pearl without price, my religious vocation. Two months later, leaving behind the city bordering on the blue waters of Chesapeake Bay, we started for the glowing fields of STATE2. CITY2, STATE2—memories of childhood days, days of mirth and innocence. With joy I watched the new church and school rising gradually to the skies. And when I was six, the school was completed. What a coincidence! I entered upon my school career at the new school, NAME. In May at the age of 8 I received my first Holy Communion. The following June found us on our way to CITY3.

Written in 1995, at age 80

On MONTH DAY, 1915, I was born in the memorable city of CITY1, STATE1. A short time after birth I was baptized in CHURCH and given the name NAME. My father, NAME, was a carpenter and skilled in his work. My mother, NAME, was a wonderful homemaker, taking care of us seven children and running the house very well. In CITY1 where I lived for eight years I attended NAME and received my First Communion in grade two. That summer, 1923, we moved to CITY2.

*Note.* Identifying information has been replaced by generic terms in capital letters.

Kemper, et al. (1996) that low levels of linguistic ability, as measured by grammatical complexity and idea density, are a risk factor for the development of dementia in late life. The present analysis supplements that of Snowdon et al. by including language samples from a second convent (Baltimore). The rate of decline in grammatical complexity and idea density was also slower for participants who met criteria for dementia compared with those who did not meet criteria for dementia, .03 units per year and .02 units per year, respectively.

Many of the most impaired participants who met criteria for dementia did not produce a scorable language sample during the 1995–1996 assessment. Such language samples were, at best, limited to a few dates, place and personal names, or phrases. It is unclear whether these language samples are representative of the participants' linguistic ability or reflect motivational or affective states as preserved grammatical abilities have been observed in some severely demented individuals (Kemper, Curtiss, & Jackson, 1987; Kemper et al., 1993). Nonetheless, these samples could not be scored for their grammatical complexity. Thus, it is likely that grammatical complexity may be subject to "floor" effects or a lower limit that arises from the use of language sample methodology. The scores do not appear to be approaching the actual floor of 0.0 for grammatical complexity (a language sample composed of single clause sentences). It may be, however, that fluent, informative speech imposes a functional floor such that a language sample is likely to contain many utterances with infinitive clauses, compound sentences, and other forms that contribute 1 or 2 points to the calculation of grammatical complexity or contain utterances with many basic predicate–argument relations that contribute to idea density. Hence, those participants with higher initial levels of grammatical complexity will exhibit a more rapid decline as they approach this functional floor than those participants who begin with lower levels of grammatical complexity, hence, initially closer to this floor. This effect of a functional floor is seen in Figure 2; the decline in grammatical complexity for participants who met criteria of dementia from the Baltimore convent is steeper than that for participants from the Milwaukee convent, who had lower initial scores.

Idea density may be less susceptible to a functional floor as even highly fragmented speech can express basic predicates or relations. Hence, in Figure 4, there is no evidence for a functional floor as the decline in idea density for participants who met criteria for dementia is steepest for those from the Baltimore convent who had higher initial scores. However, those language samples that could not be scored for grammatical complexity were also excluded from the analysis of idea densities, thus inflating these means.

This analysis also indicates that the initial levels of grammatical complexity and idea density are not related to educational variables including grades in high school English and mathematics. One variable that was related to the initial level of grammatical complexity and idea density was convent membership. Those participants who joined the Baltimore convent had higher scores for grammatical complexity, but lower scores for idea density, than those participants who joined the Milwaukee convent. There are many differences between these convents, arising from the geographic locations and the pattern of immigration to these areas. Participants joining the Baltimore convent tended to be of Anglo-Irish descent, whereas those joining the Milwaukee convent tended to be descended from German, Polish, and other Eastern European immigrant groups. Different selection factors for the two convents are indicated by the different levels of educational attainment for the participants at the time the first autobiography was written. The Milwaukee convent tended to require that high school be completed before a young woman could join the congregation, whereas the Baltimore convent accepted many young women who had not yet completed high school. It may be that the education received by participants from the Baltimore convent may have been more likely to emphasize the command of English grammar, resulting in their use of complex sentences, whereas that received by the participants joining the Milwaukee convent may have placed less emphasis on grammar. Convent membership may thus be a proxy measure for many sociodemographic and educational differences that affect writing style as well as high school grades.

This study, like the Veterans Study (Pushkar Gold, et al., 1995), suggests that an engaged lifestyle can moderate intellectual decline in old age. Convent membership not only influenced the initial

level of grammatical complexity and idea density but also moderated the rate of decline in grammatical complexity, both for participants who met criteria for dementia as well as those without dementia, and the rate of decline in idea density for participants who met criteria for dementia. A common "rule" regulated daily activities and religious observations at both convents; hence, other factors must have been responsible for the moderating effects of the Milwaukee convent such as the nature of leisure activities. It may be that the Milwaukee convent emphasized intellectual activities such as reading, scholarly writing, or biblical study that helped to maintain linguistic abilities in late life. Total years spent teaching, at any level from kindergarten to college, also moderated the decline in grammatical complexity but only for participants who did not meet criteria for dementia. It may be that these participants continued to emphasize English grammar in their teaching and thus continued to use complex constructions throughout their lives. Alternatively, the participants may have monitored their own ability to use complex constructions in order to gauge their own fitness to continue to teach. It was somewhat surprising that the decline in grammatical complexity or idea density was not moderated by the number of additional degrees the participants earned after taking their vows. Many went on to complete bachelor's degrees, some to complete master's degrees, and a few to complete doctoral degrees. However, advanced educational experiences do not in themselves appear to moderate the age-related decline in linguistic abilities.

The Nun Study provides a unique archive of information. Participants in the Nun Study have led relatively homogeneous adult lives. Participants have the same reproductive and marital histories, have similar social activities and support throughout their adult lives, have similar occupations and incomes, have equal access to preventative health and medical care, and do not smoke or drink alcohol excessively. Previously, we have reported that low levels of linguistic ability in young adulthood appear to be predictive of dementia and Alzheimer's disease (Snowdon, Kemper, et al., 1996) and mortality (Snowdon et al., 1999) in late life. In this analysis, we explored several factors we thought would account for these individual differences in linguistic ability or for the rate of age-related decline in linguistic ability over the life span, including high school grades in English and advanced education. Our analysis indicates that these factors, other than convent membership, contribute little to the initial level of grammatical complexity or idea density in young adulthood or to its rate of decline. In this population, convent membership is strongly related to linguistic ability in young adulthood and moderates its decline over the life span. However, generalizing this finding from this unique population is difficult and may depend on determining more about the selection biases and the ethnic and sociodemographic characteristics of the populations served by the two convents. Nonetheless, it is clear that linguistic ability in young adulthood is predictive of linguistic ability in late life and that linguistic ability gradually declines over the life span.

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