Distance to Death in the Seattle Longitudinal Study: Cognitive, Personality, and Sociodemographic Predictors

Hayden B. Bosworth, K. Warner Schaie, & Sherry L. Willis

Department of Human Development and Family Studies

The Pennsylvania State University

April 24, 1996

RUNNING HEAD: DISTANCE TO DEATH

AUTHOR'S NOTE: This research is supported by Grant R37 AG08055 to the second author and partial support for the preparation of this manuscript was provided by an institutional training grant, Grant T32 MH18904-07. The authors gratefully acknowledge the members and staff of the Group Health Cooperative of Puget Sound for their enthusiastic collaboration.

Address correspondence regarding this paper to K. Warner Schaie, Department of Human Development and Family Studies, 105 Henderson Building South, The Pennsylvania State University, University Park, PA 16802. (814) 863-9735.

Abstract

Longitudinal studies of intellectual ability have shown stability prior to 60 years of age but by the 70's, reliable decrements may be found. A fundamental question remains as to how this decrement should be explained? One explanation for the cognitive decline in old age may be a result of what has been referred to as terminal change. Survival analysis was used to examine how level and change of intellectual functioning, semantic memory, and psychomotor speed in the Seattle Longitudinal Study predicted time to death in a sample of 605 decedents (n = 343 males; n = 262 females; M=73.73 years of age) and 613 (n = 299 males; n=314 females; M=71.91) survivors grouped by age, gender, and education. Medical data were abstracted for 256 of the 1218 participants. Low levels of Verbal Meaning, Immediate and Delayed Word Recall of a word list as well as seven-year change of Verbal Meaning and Psychomotor Speed were predictors of subsequent survival. The findings were maintained for Delayed Word Recall even after controlling for the presence of prior chronic illness. Terminal change was found to be age-specific and was not a pervasive phenomenon; particular abilities were affected by terminal change.

KEY WORDS: COGNITIVE ABILITY, TERMINAL CHANGE, MORTALITY

Distance to Death in the Seattle Longitudinal Study: Cognitive, Personality, and Sociodemographic Predictors

Longitudinal studies of intellectual ability have shown stability prior to 60 years of age but by the 70's, reliable decrements may be found (Hertzog & Schaie, 1988; Schaie, 1996; Schaie & Hertzog, 1983). However, there is great interindividual variability and patterns of change among intellectual abilities vary across abilities. A majority of studies report some decline for individuals once they reach older adulthood. A fundamental question remains as to how should the decline be explained? One explanation for the cognitive decline in old age may be a result of what has been referred to as terminal change. The term terminal change will be used throughout this paper to refer a period of behavior change that is quantitatively greater and/or qualitatively different from normal age changes. This period of time may range from months to years but it is characterized by cognitive decline from previous levels of performance that brings about not only greater losses than expected in age-sensitive variables but losses in variables that are usually regarded as age-invariant (Birren & Cunningham, 1985). It is likely that cognitive performance is a marker of brain functions in both normal and abnormal aging. Lower cognitive performance in older people is associated with subsequent mortality in a number of studies (Deeg, Hofman, & Van Zonneveld, 1990; Liu, LaCroix, White, Kittner, & Wolf, 1990).

Despite the possible implications of terminal change, this phenomenon still remains unclear. Researchers in the past have only looked at how a single measure of cognitive ability

(e.g., Swan, Carmelli, & La Rue, 1995) or relatively few abilities (e.g., White & Cunningham, 1988) predict the time to death. Past studies have also disagreed as to whether terminal change is pervasive for cognitive abilities or restricted to specific abilities (e.g., White & Cunningham, 1988). Many of these studies have examined how level of performance is related to mortality but have neglected to examine how magnitude of change is related to death.

Another problem with earlier studies is that some have failed to include women (i.e., Berkowitz, 1965; Kleemeier, 1962; Swan, Carmelli, & LaRue, 1995). The exclusion of women in studies of terminal change is problematic for two main reasons: First, there are systematic gender differences in cognitive performance (Schaie, 1996). Second, there are also systematic gender differences in longevity (U.S. Bureau of the Census, 1989).

Many studies also fail to report medical problems or custodial care needs of sample participants. This information is lacking particularly in the case of the earlier studies (e.g., Berkowitz, 1965; Kleemeier, 1962; Lieberman, 1965). Berg (1996) suggested that the contradictory evidence of whether terminal change is a global or specific cognitive phenomenon may be attributed to differences in methodology and health profiles. It is often difficult to determine whether preexisting conditions such as cardiovascular disease, diabetes, and arthritis are predictive of cognitive decline and eventually mortality or whether cognitive decline is predictive of a more generalized premorbid state and subsequent death. There are also other social, psychological, behavioral factors that influence the relationship between cognition and mortality; however, few studies have included comprehensive antecedent measures of cognitive abilities.

The Seattle Longitudinal Studies provides an excellent opportunity to explore how various cognitive abilities (i.e., Inductive Reasoning, Verbal Meaning, Numerical Ability, Spatial Orientation, and Word Fluency), semantic memory, and psychomotor speed are related to mortality. The goal of this study is to clarify the relationship between cognitive functioning and time to death. Is cognitive performance predictive of mortality in a large community-dwelling sample of adults after controlling for the effects of age and education? Are those individuals who experience a larger decline in cognitive functioning and/or are cognitively functioning at lower levels at an increased risk for death?

METHODS

Subjects

The Seattle Longitudinal Study has collected data on more than 5,000 participants between the ages of 22 and 95. Subjects were selected randomly from within gender and age/cohort groups from membership in a large Health Maintenance Organization (HMO) in the Seattle, Washington area. The sampling frame was a community-dwelling population representing a wide range of occupational, educational, and economic backgrounds (see Schaie, 1996 for more details). Data were collected in six waves (1956, 1963, 1970, 1977, 1984, and 1991). With each new wave tested, an additional seven-year age interval was added to match the age range of the original samples up to 81 (Schaie, 1994). Two additional separate samples were collected in 1974 and in 1975.

Decedents

There were 605 (n = 343 males; n = 262 females) individuals located who had been tested successfully at least once and for whom there are known death dates by December 1995. Dates of death were obtained from the subjects' HMO records or by checking individuals' social security records which lists the exact day and year of death. This sample at their last measurement before death had a mean age of 73.73 years (SD=9.56, range 34-93 years) and an average 12.83 years of education (SD=3.44, range 1-20). Table 1 summarizes the demographic information for both decedents and survivors while Table 2 contains information on gender frequency for the two groups. A subset of the 605 decedents (n=105; 65 males; 40 females) had their medical data abstracted.

Insert Tables 1-2 about here

Survivors

A second sample consisted of survivors (N=613; n = 299 males; n=314 females) who were selected to be of similar age, gender, and education levels as the decedents. Medical data were abstracted for 151 of these 613 individuals. This sample at their last measurement had a mean age of 71.91 years (SD=9.27, range 34-95 years) and an average of 12.97 years of education (SD=3.13, range 1-20) (see Table 1).

Materials

Personal Data

Various demographic and personal information has been obtained since the inception of the SLS project (see Schaie, 1996, for greater detail). This information included subject's age, family income, gender, and education.

Cognitive Abilities

Thurstone Primary Mental Abilities (PMA)

The 1948 PMA 11-17 version of the Thurstone's Primary Mental Abilities test was used in this study. This test includes the following subtests: Word Fluency, Number, Inductive Reasoning, Spatial Orientation, and Verbal Meaning.

Word Fluency (W) measures the ability to retrieve words from long-term storage, based on a lexical rule. Subjects are asked to list as many words that begin with the letter "S" as they can in five minutes. Word Fluency is scored as the number of valid words listed.

Number (N) involves addition skills. Solutions to addition problems are given, and subjects decide whether the problem was solved correctly or not. There are 70 items, with a time limit of six minutes. Number ability is scored as the number of correct responses minus the number of wrong ones. The maximum possible score is 70.

Inductive Reasoning (R) involves logical problem solving, foreseeing, and planning. The PMA Reasoning test (Thurstone, 1948) measures the ability to identify patterns in a letter series. Subjects chose from among six items the one that logically follows in the stimulus sequence. There are 30 items, and subjects are given six minutes. Inductive Reasoning is scored as the number of correct responses, the maximum score being 30.

Spatial Orientation (S) refers to the ability to think about objects in two-dimensional space and to mentally rotate them. Subjects select from six options and are instructed to circle all the items that are a direct rotation (i.e., not mirror images) of the stimulus figure. There are 20 problems, and the subject is allotted five minutes to complete them. Since there are multiple responses for each problem, this test is scored as the number of correct responses minus the number of incorrectly circled responses. The maximum score on this test is 54.

Verbal Meaning (V) is a test of recognition vocabulary. It is a multiple-choice test in which subjects must identify one of four choices as a synonym of the presented word. The subject has four minutes to complete 50 items, which are arranged in order of increasing difficulty. The test is scored simply as the number correctly answered, and thus the maximum score is 50.

Semantic Memory

Starting in 1984, semantic memory was assessed by means of two word recall tasks. In an Immediate Recall task, participants study a list of 20 words for 3 ½ minutes. They are then

given an equal period of time to recall the words in any order. In the Delayed Recall task, the same list of words used for Immediate Recall is to be recalled by the participant after an hour of intervening activities (other psychometric tests) (Zelinski, Gilewski, & Schaie, 1993).

Psychomotor Speed indicates the individual's rate of emission of familiar cognitive responses. This factor score is obtained from the Test of Behavioral Rigidity (Schaie & Parham, 1975; Schaie, 1996) in which subjects are asked to copy a paragraph or to give synonyms or antonyms for simple words.

RESULTS

Cox's semiparametric proportional hazard models were used to assess mortality as predicted by cognitive decline. The survival function in these analyses is based upon the proportion of those individuals alive until December 31, 1995. The variables for each model were placed in the following order: age, gender, education, and cognitive performance.

Four sets of analyses were conducted. The first set examined the influence of cognitive performance upon survival by gender and age. Cognitive functioning included performance on the five PMAs (Inductive Reasoning, Spatial Ability, Verbal Meaning, Number, Word Fluency) and Psychomotor Speed. Individuals were categorized into four age groups: Middle-Age (<65 years), Young-Old (65-74 years), Old-Old (75-80 years), and the Oldest-old (81+ years).

The second set of analyses included the examination of the risk of sociodemographic variables and cognitive performance trichomotized. The top and bottom tertiles were compared. Sociodemographic variables included age, gender, and level of education.

The third set of analyses examined the relative risk of sociodemographic variables and seven-year decline on cognitive abilities and psychomotor speed. Cognitive decline was defined as change of one standard error of measurement (SEM) or more. The SEM was calculated by taking the standard deviation at time one and multiplying it by the square root of one minus the correlation from time one to time two squared ($SD^*(1-r_{12}^2)^{1/2}$) (Dudeck, 1979).

The fourth set of analyses examined the risk of sociodemographic variables and seven-year cognitive and psychomotor speed decline after controlling for the presence of diabetes, cardiovascular disease (CVD), and muscular and joint diseases (i.e., arthritis).

Effect of Cognitive Performance Upon Survival

The influence of cognitive performance upon survival according to gender and age can be observed by examining the survival curves in Figure 1 for males and Figure 2 for females. Survival curves showed a pattern of increased mortality with increased age. For instance, survival probabilities at five years were .89 and .90 for male and female middle-aged adults, respectively. However, survival probabilities for the oldest-old at 5 years were .75 for males and .82 for females. The difference between groups continued to increase with increasing time. After 10 years, the survival probabilities had decreased to .74 and . 76 for middle-aged men and women and .39 and .55 for oldest-old men and women.

Insert Figures 1 & 2 About Here

Level of Performance

The risk of low levels of cognitive performance after controlling for the effects of age, level of education and gender can be seen in Table 3. Level of cognitive performance was calculated by trichotomizing each cognitive measure. Odds ratios were then computed by comparing the top and bottom tertiles. Verbal Meaning was the only significant cognitive risk factor for mortality (OR =1.29; CI 1.032-1.634). Since the memory measures had only been used at the last two measurements, a separate model was used to examine the risk of low levels of memory after controlling for the effects of age, level of education and gender. Performance in the bottom tertile on Delayed Recall (OR=4.172; CI 2.298-7.754) and Immediate Recall (OR=2.170; 1.213-3.884) was a significant risk factor for subsequent death (Figure 3).

Insert Table 3 and Figure 3 about here

Separate analyses were then conducted for each of the four age groups. Memory measures could not be examined because there were too few subjects. The cognitive measures were not found to be significant risk factors for the middle-aged, young-old and the oldest-old. However, for the old-old adults, low levels of performance on the crystallized abilities which included Verbal Meaning (OR=1.613; CI 1.028 - 2.533) and Word Fluency (OR = 1.768; CI 1.173 - 2. 664) placed individuals at an increased risk of mortality.

Change in Performance

The influence of cognitive change on survival while controlling for age, education, and gender can be seen in Table 4. The relative risk of significant cognitive and psychomotor speed decline as well as the effect of sociodemographic variables were calculated using Cox models. Being a male, increased age and a decline of one SEM on Verbal Meaning and Psychomotor Speed were significant mortality risk factors for decedents. Those decedents who experienced a substantial decline on Verbal Meaning had a relative risk of 1.39.

Survival probabilities varied across abilities observed. Individuals who declined at least one standard error of measurement on Verbal Meaning as well as Psychomotor Speed had steeper slopes than those who remained fairly stable. For instance, at 5 years, survival probabilities on Verbal Meaning were .79 and .84 for decliners and non-decliners, respectively. The difference between the two groups increased over time. At 10 years, survival probabilities on Verbal Meaning were .46 and .58 for decliners and non-decliners, respectively (see Figure 4). A similar pattern was observed for Psychomotor Speed. At five years, the survival probabilities were .77 and .84 for decliners and non-decliners, respectively. The survival probabilities continued to decline; at 10 years the survival probabilities were .52 and .55 for decliners and non-decliners, respectively (see Figure 5).

Insert Table 4 & Figures 4 & 5 About Here

Controlling for Prior Health Conditions

Cox Proportional Hazard models were used to determine how much of a role level and change of cognitive performance and psychomotor speed has in predicting mortality after adjusting for sociodemographic variables and the presence of prior health problems. Prior health problems included diseases of the circulatory system, diabetes, and diseases of the musculoskeletal system and connective tissue. The 256 (105 decedents; 151 survivors) participants with medical data abstracted were used for this purpose (see table 1). Increased age, the presence of CVD, and low levels of Delayed Recall (OR=2.06; CI 1.078 - 3.938) were significant risk factors for subsequent mortality (see Table 5). Cognitive and Psychomotor Speed change were not found to be significant risk factors after controlling for the influence of prior health conditions. However, as can be seen from Table 6, increased age, being a male, and suffering from cardiovascular disease were significant risk factors for mortality.

Insert Tables 5 - 6 About Here

Discussion

There was evidence that intellectual abilities and to a lesser degree psychomotor speed were independent predictors of subsequent mortality, although, the relationship of intellectual abilities and subsequent mortality varied across measures. There was no evidence of fluid abilities predicting subsequent mortality. However, it appears that lower levels of Verbal Meaning, Immediate Recall and Delayed Recall as well as declines of one SEM on Verbal Meaning and Psychomotor Speed were significant mortality risk factors for decedents. Overall,

the pattern of results in the present study indicate that all intellectual abilities are not affected by terminal change.

There was no indication that seven-year change in cognitive performance and psychomotor speed was a better predictor of subsequent survival than level of performance at last measurement. This was not unexpected, because it seems plausible that what really matters for survival is not where one came from, but where one ended up (Deeg, Hofman, van Zonneveld, 1990). However, with only one measurement available for the majority of those who died (52%), there is no way of determining how their cognitive function and psychomotor speed changed and how this change was related to their longevity. The rate of change observed in the study sample is likely to be an underestimation of the rate of change experienced by the total initial sample.

Low levels of Verbal Meaning, Immediate Recall, and Delayed Recall at last measurement, and seven-year change of Verbal Meaning change and Psychomotor Speed were significant risk factors for subsequent mortality in decedents. Even after controlling for the presence of prior health conditions and sociodemographic factors, the robust risk factors for decedents were still found. The consistency of the findings after controlling for these factors strengthens the conclusion that cognitive function does associate independently with death, although it does not rule out the possibility that other uncharacterized or unrecognized conditions may be responsible for both decline in cognitive function and death.

The relationship of Verbal Meaning and distance to death was one of the most consistent findings in this study. Verbal Meaning is known to be less sensitive to age than most other

cognitive abilities. Vocabulary performance does appear to be sensitive to the disease processes primarily responsible for death in the present deceased participants.

The present findings are similar to past studies that have found verbal ability to be uniquely sensitive to terminal decline (Blum, Clark, & Jarvik, 1973; Reimanis & Green, 1971; Siegler, McCarty, & Logue, 1982; White & Cunningham, 1988). For example, Birren (1968), in a 5-year follow-up of individuals in good health at the study's outset, reported that differences between survivors and nonsurvivors were primarily seen in verbal information skills. In a later 11-year follow-up (Granick, 1971) it was concluded that low verbal performance seemed to be a better predictor of length of survival. White and Cunningham (1988) in a study of independently living volunteers from an organization of retired persons showed that an increased risk of mortality was related to low levels of vocabulary.

Similar to these earlier studies, Cooney, Schaie and Willis (1988), Riegel, Riegel, and Meyer (1967), and Siegler and Botwinick (1979) found that participation effects for those who died were more evident on crystallized (e.g., Verbal Meaning and Word Fluency) rather than fluid cognitive abilities. Cooney et al., (1988) suggest that it is not clear why crystallized abilities are prone to survivorship effects. These researchers have proposed that because fluid abilities decline for almost everyone across old age, additional effects related to attrition factors, such as illness or impending death, are obscured. On the other hand, because crystallized abilities are least affected by normal aging it might be possible to see stronger deteriorative effects due to biological antecedents of death.

There have only been a few studies that have analyzed memory in relation to survival. Our findings that semantic memory is related to survival is similar to results of Deeg, Hofman, and van Zonneveld (1990) and the Gothenburg Longitudinal Study (Johansson & Berg, 1989). We did not find any evidence of the association between memory performance and subsequent mortality in the middle-aged (≤65 years) and young-old (65-74 years).

A possible explanation for the lack of a clear association between cognitive abilities, memory, and psychomotor speed measures and mortality in the younger age groups could be attributed to fact that death in younger ages is likely to be the result of accidents or acute diseases that strike suddenly and hence produce limited intellectual decline prior to death. Deeg et al. (1990) found that the rate of decline in memory function was strongly associated with subsequent survival time for those who were 70 years and over, with those with large declines having short survival time but no support for this relationship was found for the young-old age group (65-69 years of age).

These results reinforce the viewpoint that fluid ability changes with age are a function of normal aging and cannot be explained by terminal change. Thus, terminal change appears to exert the greatest influences upon intellectual abilities which are relatively unaffected by age rather than upon those which show normal age decrements. Terminal change therefore appears to be a specific rather than a pervasive phenomenon and is more likely to be experienced by certain age groups (i.e., 74-80 year-olds).

References

Berg, S. (1996). Aging, behavior, and terminal decline. In J.E. Birren & K.W. Schaie (Eds.), *The Handbook of psychology of aging.* (4nd). NY: Academic Press.

Berkowitz, B. (1965). Changes in intellect with age. IV. Changes in achievement and survival in older people. *Journal of Genetic Psychology, 107,* 3-14.

Birren, J.E. (1968). Increments and decrements in the intellectual status of the aged. *Psychiatric Research Reports, 23,* 207-214.

Birren, J.E., & Cunningham, W. (1985). Research on the psychology of aging: Principles, concepts and theory. In J.E. Birren & K.W. Schaie (Eds.), *The Handbook of psychology of aging.* (2nd; pp 3-34). NY: Van Nostrand Reinhold.

Blum, J.E., Clark, E.T., & Jarvik, L.F. (1973). The New York State Psychiatric Institute of Aging Twins. In L.F. Jarvik, C. Eisdorfer, & J.E. Blum (Eds.), *Intellectual functioning in adults.* New York: Springer Pub. Co.

Cooney, T.M., Schaie, K.W., & Willis, S.L. (1988). The relationship between prior functioning on cognitive and personality dimensions and subject attrition in longitudinal research. *Journal of Gerontology, 43,* P12-P17.

Deeg, D.J.H., Hofman, A., & Van Zonneveld, R.J. (1990). The association between change in cognitive function and longevity in Dutch elderly. *American Journal of Epidemiology, 132,* 973-982.

Hertzog, C., & Schaie, K.W. (1988). Stability and change in adult intelligence: 2. Simultaneous analysis of longitudinal means and covariance structures. *Psychology and Aging, 3,* 122-130.

Horn, J. (1978). Human ability systems. In P.B. Baltes (ed.) *Life Span development and behavior.* (pp. 212-251). New York: Academic Press.

Johansson, B., & Berg, S. (1989). The robustness of the terminal decline phenomenon: Longitudinal data from the Digit-span Memory test. *Journal of Gerontology, 44,* P184-P186.

Kleemeier, R. (1962). Intellectual changes in the senium. *Proceedings of the Social Statistics Section of the American Statistical Association.* (pp.290-295). Washington, DC.

Lieberman, M.A, (1965). Psychological correlates of impending death: Some preliminary observations. *Journal of Gerontology, 20,* 181-190.

Liu, I.Y., LaCroix, A.Z., White, L.R., Kittner, S.J., & Wolf, P.A. (1990). Cognitive impairment and mortality: A study of possible confounders. *American Journal of Epidemiology, 132,* 136-143.

Reimanis G., & Green, R.F. (1971). Eminence of death and intellectual functioning in the aged. *Developmental Psychology, 5,* 270-272.

Riegel K.F., Riegel, R.M., & Meyer, G. (1967). The study of drop-out rates in longitudinal research on aging and the prediction of death. *Journal of Personality and Social Psychology, 4,* 342-348.

Schaie, K.W. (1994). The course of adult intellectual development. *American Psychologist, 49,* 304-314.

Schaie, K.W. (1996). *Adult intellectual development: The Seattle Longitudinal Study*. New York: Cambridge University Press.

Schaie, K.W., & Hertzog, C. (1983). Fourteen-year cohort sequential studies of adult intelligence. *Developmental Psychology, 19,* 531-543.

Siegler, I.C., & Botwinick, J. (1979). A long-term longitudinal study of intellectual ability of older adults: The matter of selective attrition. *Journal of Gerontology, 34,* 242-245.

Siegler, I.C., McCarty, S.M., & Logue, P.E. (1982). Wechsler Memory Scale scores, selective attrition, and distance from death. *Journal of Gerontology, 37,* 176-181.

Swan, G.E., Carmelli, D., & LaRue, A. (1995). Performance on the digit symbol substitution test and 5-year mortality on the Western Collaborative Group Study. *American Journal of Epidemiology, 141,* 32-40.

U.S. Bureau of the Census (1989). *Projections of the population by age, sex, and race: 1988-2080.* Current Population Reports, Series P-20. No. 433. Washington, DC: U.S. Government Printing Office.

White, N., & Cunningham, W.R. (1988). Is terminal drop pervasive or specific? *Journal of Gerontology, 43,* p141-p144.

Zelinski, E.M., Gilewski, M.J., & Schaie, K.W. (1993). Three-year longitudinal memory assessment in older adults: Little change in performance. *Psychology and Aging, 8,* 176-186.

Figure Caption:

Figure 1: Male Survivorship by Age Group Predicted by Primary Mental Abilities

Figure 2: Female Survivorship by Age Group Predicted by Primary Mental Abilities

Figure 3: Survivorship Predicted by Level of Cognitive Performance

Figure 4: Survivorship Predicted by Seven-year Change in Verbal Meaning

Figure 5: Survivorship Predicted by Seven-year Change in Psychomotor Speed

Table 1: Summary Demographics for Samples

Sample	Variable	N	M	S.D.	Range
Decedents	Age	605	73.73	9.57	34-93
	Education		12.83	3.43	1-20
	Time in Study (months)		79.97	56.55	1-264
Survivors	Age	613	71.91	9.27	34-95
	Education		12.97	3.13	4-20
	Time in Study (months)		179.58	90.48	1-480
Decedents w/ medical data	Age	105	75.98	9.36	52-93
	Education		14.05	3.26	8-20
Survivors w/ medical data	Age	151	73.20	8.62	39-95
	Education		13.59	2.99	7-20

Table 2: Sample by Gender Frequency

Sample	Male	Female
Decedents	343	262
Survivors	299	314
Decedents with Medical Data	65	40
Survivors with Medical Data	83	68

Table 3: Standard Coefficients and Odds Ratio for Level of Performance

Model	Independent Variables	Standard Coefficient	Odds Ratio	Confidence Interval (95%)
Full	Age	.03	1.04	1.026 - 1.045
	Education (continuous)	.02	1.02	1.000 - 1.048
	Gender (o=female, 1=male)	.33	1.39	1.133 - 1.637
	Verbal	.26	1.30	1.032 - 1.634
	Word Fluency	.02	1.02	.824 - 1.255
	Number	.16	1.18	.958 - 1.451
	Space	.12	1.12	.903 - 1.398
	Reason	-.02	.98	.782 - 1.237
	Psychomotor Speed	.13	1.13	.899 - 1.406
	Immediate Recall	.77	2.17	1.213 - 3.884
	Delayed Recall	1.43	4.17	2.298 - 7.754

Note: for cognitive measures 1 = bottom tertile; 0 = top tertile

Table 4: Standard Coefficients and Relative Risk Ratio for Seven-year Change Before Death

Model	Independent Variables	Standard Coefficient	R.R.	Confidence Interval (95%)
Full	Age	.03	1.03	1.010 - 1.042
	Education (continuous)	.02	1.02	.981 - 1.061
	Gender (o=female, 1=male)	.32	1.38	1.066 - 1.779
	Verbal (>1 = 1 SEM)	.33	1.39	1.050 - 1.849
	Word Fluency	-.33	.72	.541 - .963
	Number	.10	1.10	.835 - 1.454
	Space	-.42	.66	.482 - .913
	Reason	.19	1.21	.914 - 1.610
	Psychomotor Speed	.25	1.29	.976 - 1.709*

* p<.06

Table 5: Standard Coefficients and Odds Ratio for Level of Performance Controlling for the Presence of Prior Health Conditions

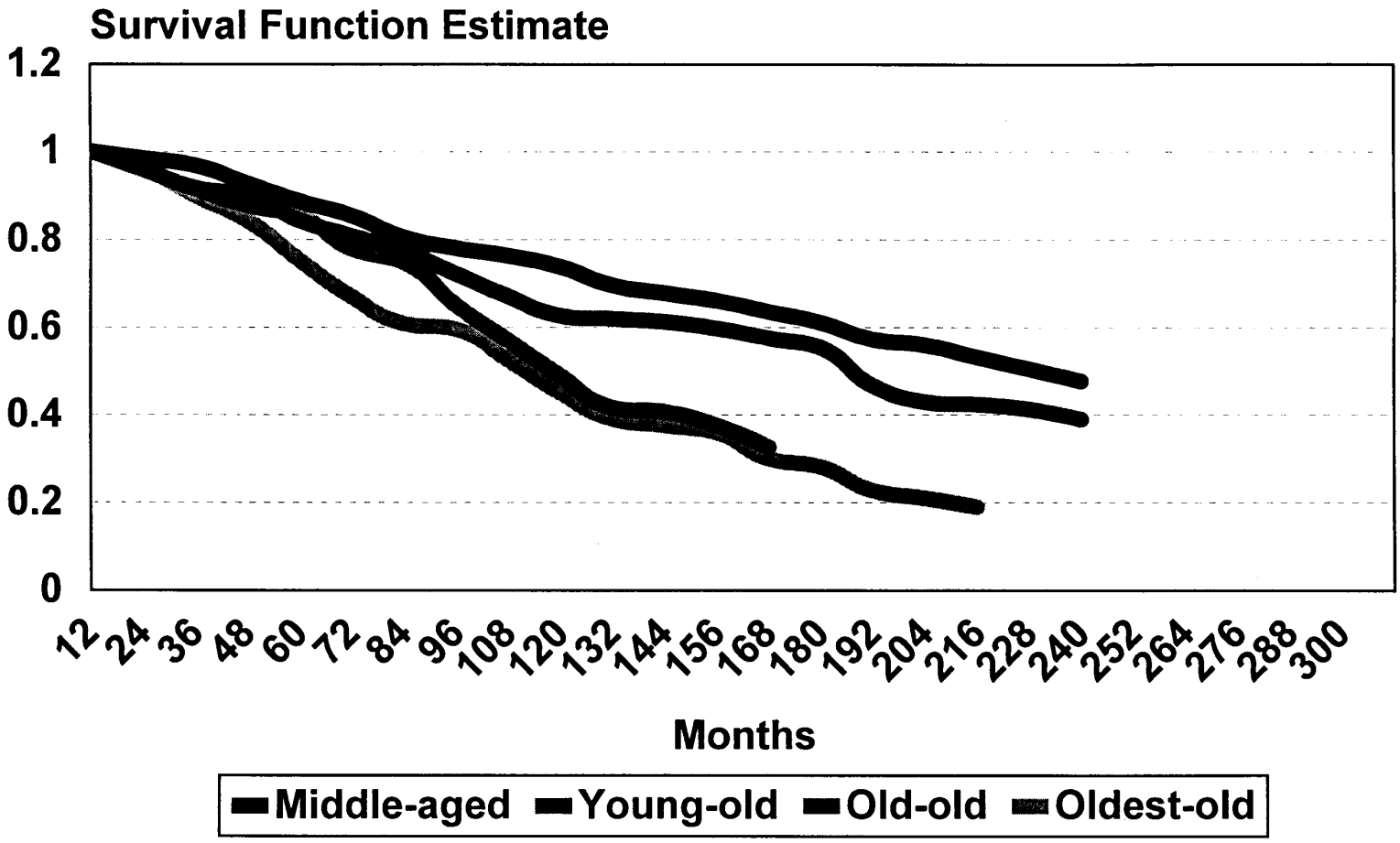
Model	Independent Variables	Standard Coefficient	Odds Ratio	Confidence Interval
Full	Age	.05	1.05	1.026 - 1.079
	Education (Continuous)	.05	1.06	.992 - 1.124
	Gender (1=male)	.15	1.16	.756 - 1.790
	CVD (1=presence)	.11	1.12	1.059 - 1.185
	Diabetes	.13	1.14	.957 - 1.354
	Arthritis	-.07	.94	.857 - 1.021
	Verbal (1= >1 sem)	.18	1.20	.637 - 2.262
	Word Fluency	.07	1.07	.638 - 1.802
	Number	.10	1.11	.658 - 1.869
	Space	-.13	.87	.478 - 1.595
	Reason	.37	1.45	.739 - 2.859
	Psychomotor Speed	-.34	.71	.396 - 1.285
	Immediate Recall	.50	1.65	.832 - 3.288
	Delayed Recall	.72	2.06	1.078 - 3.938

Table 6: Standard Coefficients and Relative Risk Ratio for Seven-year Change Before Death Controlling for the Presence of Prior Health Conditions

Model	Independent Variables	Standard Coefficient	Odds Ratio	Confidence Interval
Full	Age	.03	1.03	1.000 - 1.061
	Education (Continuous)	.04	1.04	.967 - 1.116
	Gender (1=male)	.26	1.30	.816 - 2.065
	CVD (1=presence)	.10	1.11	1.044 - 1.181
	Diabetes	.13	1.14	.955 - 1.348
	Arthritis	-.06	.94	.846 - 1.040
	Verbal	.33	1.39	.837 - 2.310
	Word Fluency	-.38	.68	.414 - 1.127
	Number	-.24	.79	.471 - 1.326
	Space	-.17	.85	.479 - 1.489
	Reason	.25	1.28	.794 - 2.077
	Psychomotor Speed	.18	1.19	.731 - 1.946

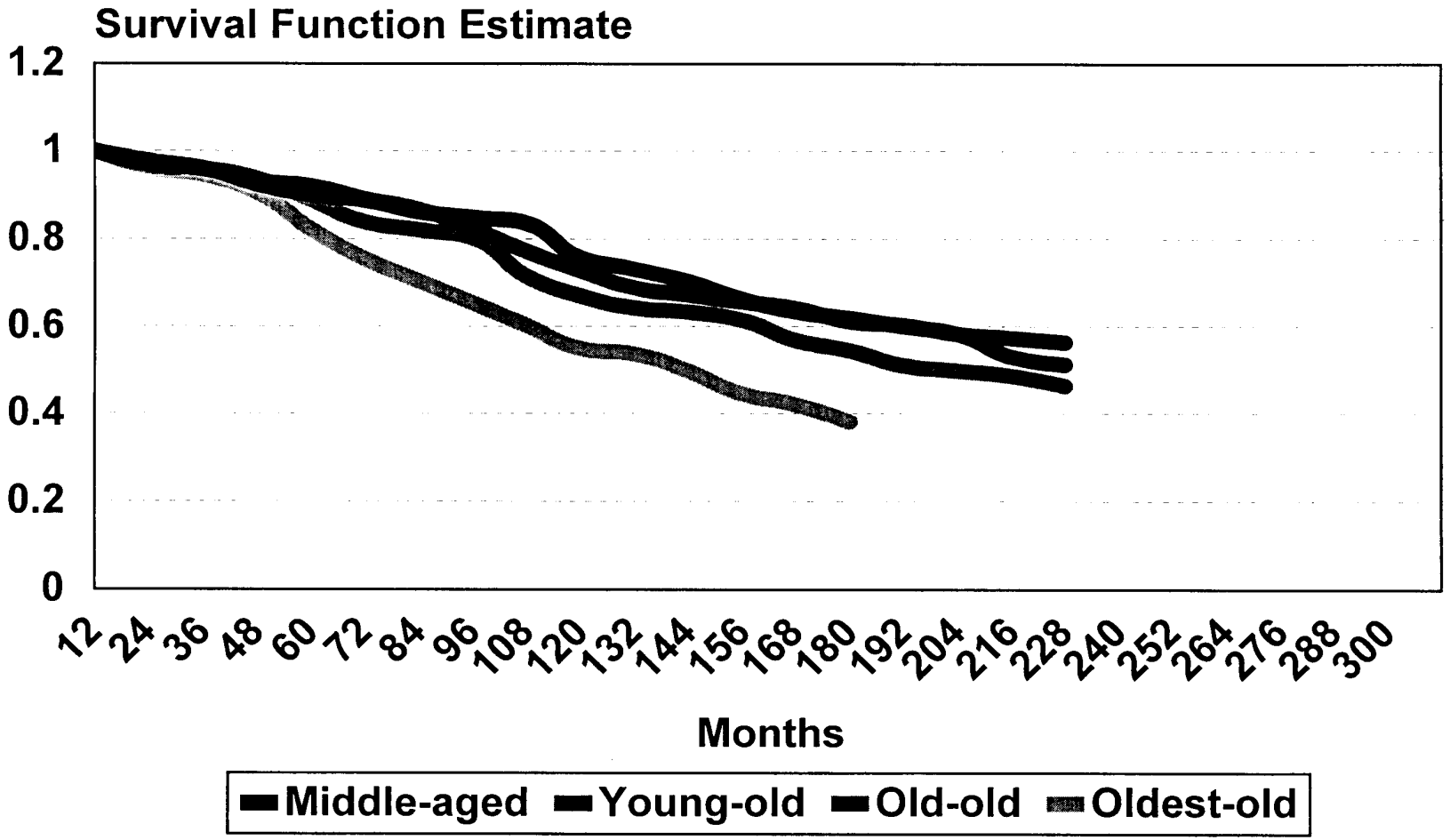
Male Survivorship By Age Group Predicted By Primary Mental Abilities

Adjusted for Education

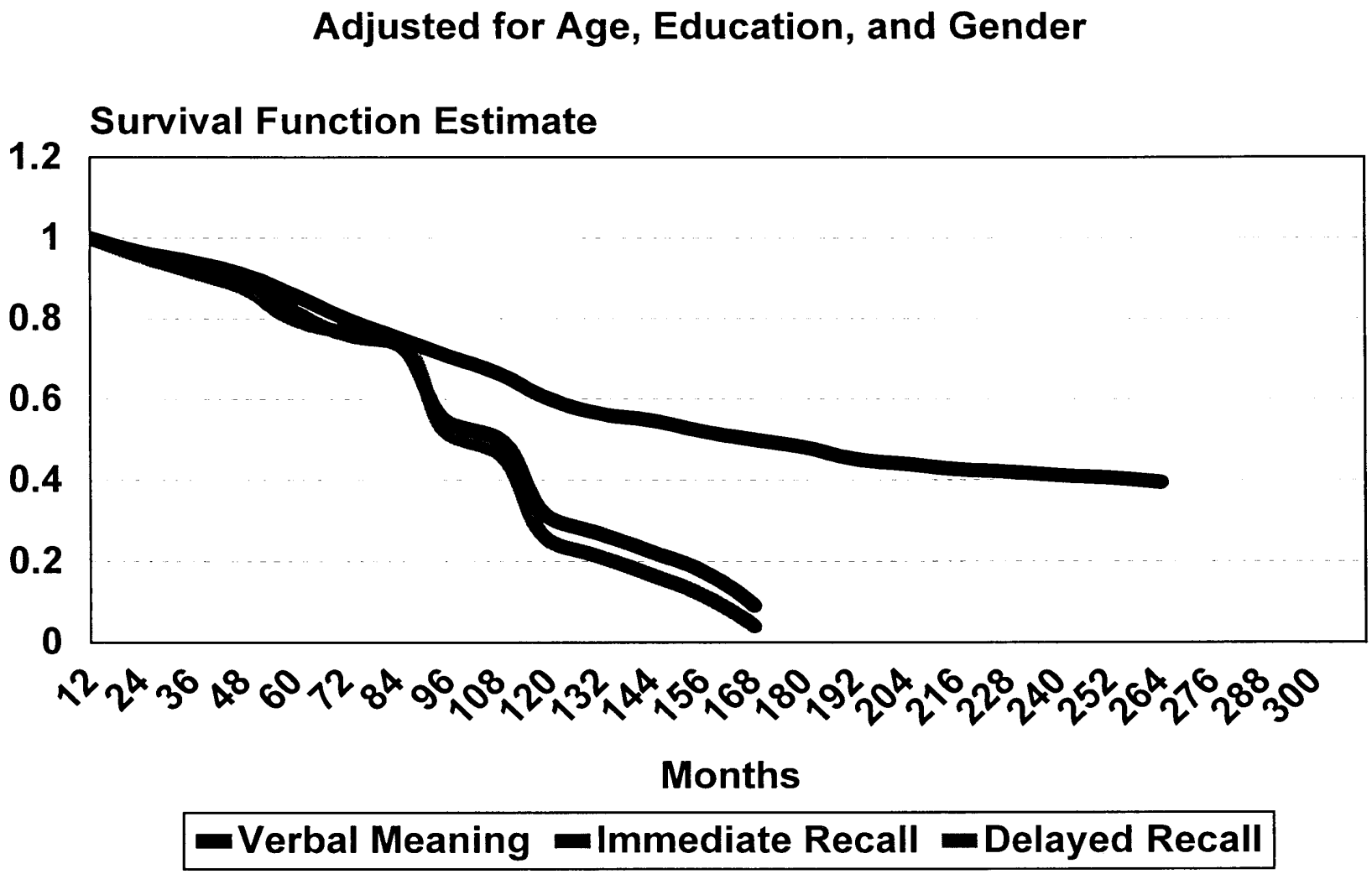


Female Survivorship By Age Group Predicted By Primary Mental Abilities

Adjusted for Education

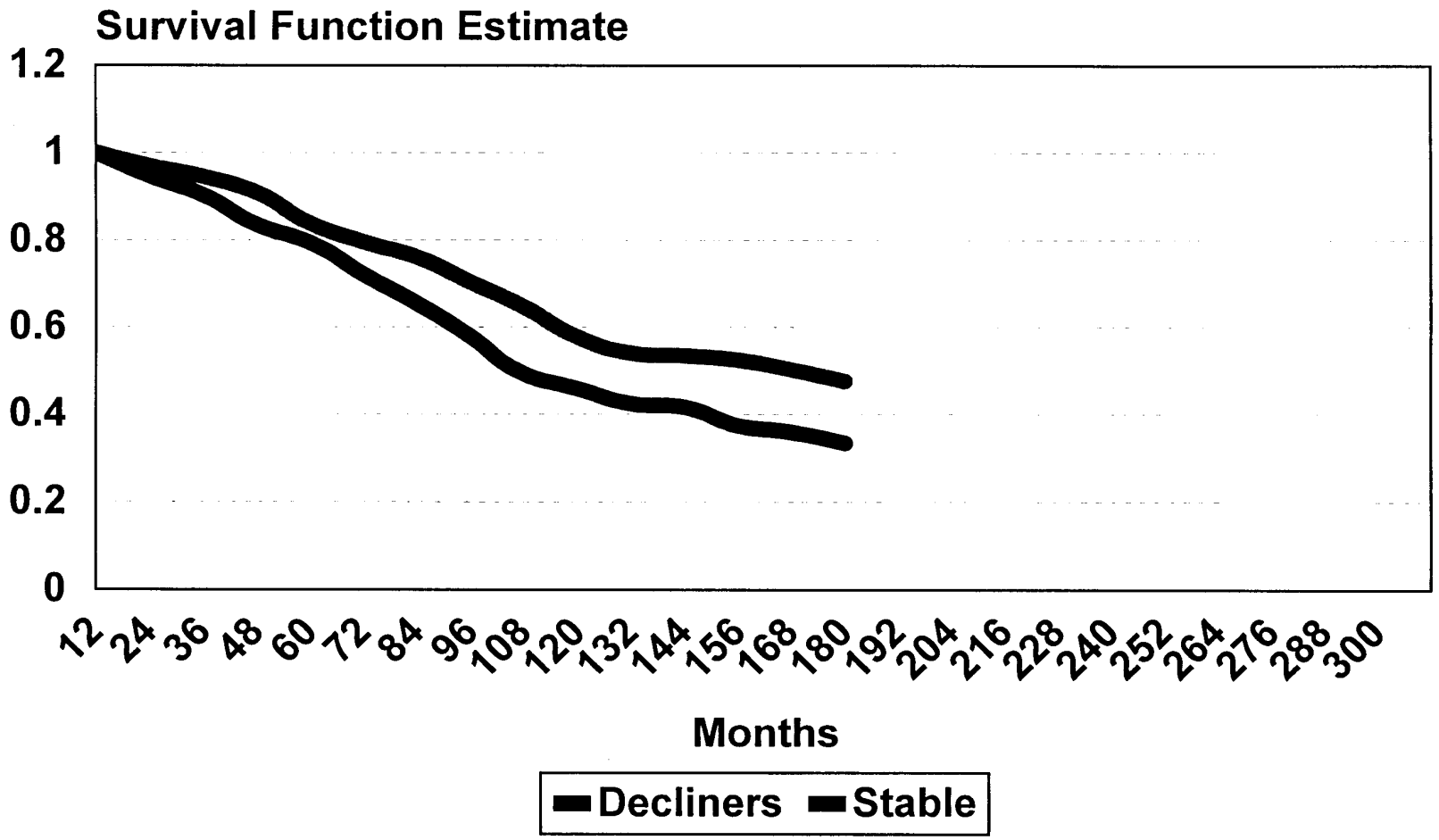


Survivorship Based on Level of Cognitive Performance



Survivorship Predicted By Seven-Year Change in Verbal Meaning

Adjusted for Age, Education, and Gender



Survivorship Predicted By Seven-Year Change in Psychomotor Speed

Adjusted for Age, Education, and Gender