Psychological Predictors of Mortality in Old Age

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Cox regression models examined associations between 17 indicators of psychological functioning (intellectual abilities, personality, subjective well-being, and social relations) and mortality. The sample (N = 516, age range 70-103 years) comprised participants in the Berlin Aging Study assessed between 1990 and 1993. By 1996, 50% had died. Eleven indicators were identified as mortality risk factors at the zero-order level and six when age was controlled. Low perceptual speed and dissatisfaction with aging were uniquely significant after controls for age, SES, health, and the 16 other psychological factors. Low intellectual functioning was a greater risk for individuals aged 70-84 years than for the oldest old (over 85 years). The effects of psychological risk factors did not diminish over time. Future research should focus on the mechanisms and time frames that underlie the death-relatedness of intellectual functioning and self-evaluation.

Epidemiologists are increasingly interested in patterns of late-life mortality and the health predictors thereof (e.g., Manton, 1992; Manton, Stallard, Woodbury, & Dowd, 1994). In the gerontological literature there are also several proposals suggesting that, in old age, lower levels of psychological functioning are associated with imminent death. Cognitive functioning (Swan, Carmelli, & LaRue, 1995; White & Cunningham, 1988), personality characteristics (Berkman, 1988; Friedman et al., 1995; Swan & Carmelli, 1996), social integration (Seeman, Kaplan, Knudsen, Cohen, & Guralnik, 1987), and indicators of subjective well-being (Mossey & Shapiro, 1982; Palmore & Jeffers, 1971) have all been implicated as relevant predictors of mortality. To date, there have been few studies with the explicit goal of comparing the predictive power of these psychological domains in relation to mortality in very old age. The present article is a first step toward addressing some of the many open questions in this area. Of particular interest is the question whether the association with mortality in very old age is general to many domains of psychological functioning, or whether it is specific to a few psychological characteristics. It is also not known whether psychological predictors of mortality are different for the old and the oldest old. A further question concerns the time frame of the predictive period (Ljungquist, Berg, & Steen, 1996). Does the mortality risk associated with lower psychological functioning change over time?

Previous research investigating psychological functioning in relation to mortality has used several different perspectives. Some studies have compared groups of survivors and dropouts from longitudinal studies (e.g., Kleemeier, 1962; Riegel, Riegel, & Meyer, 1967), whereas others have used a dynamic terminal decline framework relating decreases in functioning to the imminence of death (e.g., Deeg, Hofman, & van Zonneveld, 1990). A third group of studies has examined associations between static baseline functioning and follow-up mortality information using survival analysis (e.g., Swan et al., 1995; Wolinsky & Johnson, 1992). In relating baseline functioning to prospectively collected mortality information, the present study follows the latter, static approach. Data reported were collected in the Berlin Aging Study (BASE; Baltes & Mayer, 1999; Baltes & Smith, 1997). These data provided a context for examining predictors of mortality in a sample (M age = 85 years) that had survived longer than the average life expectancy for their birth cohorts.

Many studies have emphasized the role of chronological age and how best to incorporate age into a general framework explaining the relationships between functioning and mortality (e.g., Berkman, 1988; Manton, 1992; Palmore & Jeffers, 1971). Because there are age-associated changes in many areas of psychological functioning, and because age itself is a risk factor for death, it could be argued that it is only interesting to examine predictors of mortality after these age-associated changes are taken into account. On the other hand, partialing age out of the relationship between psychological functioning and mortality may result in loss of the very information that is most interesting to life-span researchers. Age, as an interindividual differences characteristic, reflects a complex host of resources, roles, and accumulated experiences (Wohlwill, 1973).

The solution adopted in the present study attempted to compromise between these two positions regarding the role of age. In a first set of analyses, we report zero-order and age-controlled associations between functioning on 17 psychological dimensions and mortality. The set of age-controlled analyses takes into account the association between age and distance from death. A further set of analyses explicitly examined the risk patterns for two age groups (70-84 years and 85-103 years). This latter strategy was adopted in line with recent suggestions that, as a group, the oldest old (i.e., persons over 85 years) are very different from persons between the ages of 70 and 84 (Suzman, Willis, & Manton, 1992).

Intellectual functioning is the psychological domain that has received the most attention in its relation to mortality (for reviews see Berg, 1996; Siegler, 1975). Researchers studying large enough samples with appropriate statistical techniques have found that reduced intellectual functioning is associated with nearness to death (e.g., Berg, 1987; Swan...
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There is some debate, however, whether the association is more pronounced for some abilities than for others. Using a common distinction between the fluid-like mechanics and the crystallized pragmatics of intelligence (Cattell, 1971), it has been argued that the fluid abilities, as indicators of general brain functioning, should be most predominantly related to mortality (Botwinick, West, & Storandt, 1978; Kleemeier, 1962). Others have suggested that the association with mortality is more salient for the crystallized pragmatics of intelligence, in particular verbal ability. Crystallized abilities are thought to be less affected by normal aging. As a consequence, death-related effects in these abilities should be less obscured by “normal” aging decline (Cooney, Schae, & Willis, 1988; White & Cunningham, 1988). Finally, Berg (1987) has hypothesized that the association between intellectual functioning and mortality is pervasive, and that it can be observed for all intellectual abilities.

The prediction of mortality has also been examined for other domains of psychological functioning. With respect to personality functioning, Friedman and colleagues (1995) reported that conscientiousness was positively associated with longevity in the Terman sample, but that there were no effects for neuroticism, extraversion, and optimism. Swan and Carmelli (1996) reported that state curiosity, an aspect of openness, was related to longevity. It has long been recognized that, in old age, it is important to have close confidants in a social network who provide different aspects of instrumental and emotional support (Antonucci, 1990). In this regard, several epidemiological surveys have revealed associations between lack of social contacts and mortality (Berkman, 1988; Seeman et al., 1987). Other studies found mortality to be associated with perceived lack of support (Yasuda, Zimmerman, Hawkes, Fredman, Hebel, & Magaziner, 1997), and a sense of loneliness (Olsen, Olsen, Gunnar-Svensson, & Waldström, 1991).

There is mixed evidence with respect to associations between subjective evaluations of functioning and mortality. Troll and Skaff (1997) found that perceived personality changes were unrelated to mortality in a sample of persons aged over 85 years. On the other hand, there is a large body of research indicating that subjective evaluations of health predict mortality above and beyond objective health status (Borawski, Kinney, & Kahana, 1996; Idler, 1992; Idler & Kasl, 1991; Mossey & Shapiro, 1982; Wolinsky & Johnson, 1992). There are also reports that perceived problems with aging (Deeg, van Zonneveld, van der Maas, & Habbema, 1989), reduced morale and life satisfaction (Mossey & Shapiro, 1982; Shahtahmasbi, Davies, & Wenger, 1992), as well as feelings of uselessness and unhappiness (Palmore, 1982), are predictive of mortality in old age.

In the majority of studies cited above, the specific goal was not to examine the associations between psychological functioning and mortality or to compare the relative risks associated with predictions from different psychological domains. These were the goals of the present study. Psychosocial measures included in epidemiological studies typically involve single items which are subsequently entered in regression models as dichotomized covariates (e.g., beliefs in control vs no control; Wolinsky & Johnson, 1992). In the context of BASE, we had the advantage of having access to psychometrically developed measures of functioning in the domains of intelligence, subjective well-being, personality, and social relations.

Cox regression analysis (Cox, 1972) was used to examine the associations between functioning on 17 indices of psychological functioning and subsequent risk of death in the years following baseline measurement. We examine whether mortality effects are specific to intellectual functioning or general across several areas of psychological functioning and whether the results change after the relationship between age and mortality is taken into account. We also introduce controls for sociodemographic and health factors. Finally, we report exploratory analyses addressing the length of the predictive period associated with psychological risk factors.

METHOD

Sample

Data considered in this article stem from participants in the Berlin Aging Study (BASE). Detailed information about the BASE design, sample selectivity, and assessment procedure is available in Baltes and Mayer (1999), Baltes and Smith (1997), and Lindenerger, Gilberg, Little, Nuthmann, Pötter, and Baltes (1999). Three general features of the BASE sample and the initial cross-sectional data set make it worthwhile to explore questions about psychological characteristics associated with mortality and survival: local representativeness, sample heterogeneity, and an age by sex stratified sample of individuals aged 70–103 years (M = 85 years). Local representativeness and heterogeneity were achieved by locating the sample through available obligatory city (state) registry records.

From 1990 to 1993, a multidisciplinary assessment battery involving a total of 14 sessions over a period of three to five months was completed by 516 individuals. At this baseline measurement there were an equal number of men (n = 43) and women (n = 43) in each of six age/cohort groups: 70–74 years (born 1915–1922), 75–79 years (born 1910–1917), 80–84 years (born 1905–1913), 85–89 years (born 1900–1908), 90–94 years (born 1896–1902), and 95–103 years (born 1883–1897).

Mortality status information for BASE participants and the date of death for the deceased participants were obtained from the State Registry office. By October 1996 (which represents a 3–6 year period after baseline assessment), 257 individuals, or 49.8% of this sample, were registered in the state records as deceased, and 256 individuals, or 49.6%, were registered as alive. Mortality information for three persons could not be obtained, because these individuals had moved out of the Berlin area. The three individuals with missing mortality information were removed from the analyses. Thus, the present study utilized a sample of 513 persons (257 men and 256 women). Their estimated median survival time after baseline assessment was 62 months. As is to be expected for the advanced age of this sample, a larger proportion of the deceased was from the oldest old (older
than 85 years: n = 194 decedents vs n = 61 survivors) compared to the younger age groups (70–84 years: n = 63 decedents vs n = 195 survivors). As of October 1996, less than 20% of individuals aged 90–103 years at baseline assessment were still alive. In contrast, more than 75% of individuals aged 70–79 years at baseline had survived.

**Measures of Psychological Functioning**

Psychological data collected in BASE included measures of intellectual abilities, subjective well-being, personality dispositions, and social relations. We selected 17 variables from the BASE data protocol to represent these measures. Measures of psychological functioning were always given in the same order and were collected in 4 of 14 individual test sessions (over a period of 3–5 months) carried out at the participants’ place of residence (see Baltes & Smith, 1997). For all analyses, measures of psychological functioning were standardized to $M = 4$, $SD = 1$ (see Appendix, Note 1), and the scales were reversed so that higher values reflected lower, or less desirable, functioning. Below, we present general information about the scales, tests, and procedures of assessment (for further information and descriptive statistics for the BASE sample see Baltes & Mayer, 1999; Lindenberger & Baltes, 1997; Smith & Baltes, 1997).

**Intellectual functioning.**—Five factor scores of psychometric intelligence were included in the present analyses to characterize performance in two broad categories of intellectual abilities—the fluid-like mechanics and the crystallized pragmatics of intelligence. The factors Perceptual Speed, Reasoning, and Memory were selected to characterize functioning associated with the fluid mechanics of intelligence. The factors Knowledge and Fluency were selected to capture aspects related to the crystallized pragmatics of intelligence. In all cases, higher scores in the present analyses indicated lower functioning.

A total of 14 subtests were administered to assess the five intelligence factors (see Lindenberger & Baltes, 1997). Perceptual Speed was measured by the Digit-Letter Test, Digit Symbol Substitution, and Identical Pictures. Reasoning was measured by Figural Analogies, Letter Series, and Practical Problems. Memory was measured by Activity Recall, Memory for Text, and a Paired-Associates Task. Knowledge was measured by a practical knowledge test, Spot-a-Word, and a vocabulary test. Fluency was measured by a Categories and a Word Beginnings test (Letter “S”). Stimulus presentation and data collection were supported by a Macintosh SE/30 equipped with a touch-sensitive screen.

**Subjective well-being.**—Five constructs were included to represent different aspects of subjective well-being. Factor scores for Positive Affect and Negative Affect were obtained using a translated version of the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Factor scores for Agitation, Dissatisfaction with Aging and Dissatisfaction with Life were obtained with a German translation of the 15-item Philadelphia Geriatric Center Morale Scale (PGCMS: Lawton, 1975; Liang & Bollen, 1983). For all measures of subjective well-being, participants were asked to indicate how well items described them using a 5-point scale. Each item was read aloud by an interviewer, and the participant’s response was recorded. In the present analyses, scores were reversed so that higher scores indicated low subjective well-being (i.e., Low Positive Affect, Negative Affect, Agitation, Dissatisfaction with Aging, Dissatisfaction with Life).

**Personality.**—Personality dispositions were represented by three factors: Neuroticism (derived from responses to six items assessing the facets anxiety, depressivity, vulnerability, and hostility), Extraversion (derived from responses to six items assessing the facets gregariousness, positive emotionality, assertiveness, and activity), and Openness (derived from responses to six items assessing the facets fantasy, ideas, feelings, aesthetics, and actions). Items to assess these dimensions were selected from the NEO (Costa & McCrae, 1985). For all personality measures, participants were asked to indicate how well items described them using a 5-point scale. Each item was read aloud by an interviewer, and the individual’s response was recorded. Scores for extraversion and openness were reversed, with higher values indicating less extraversion and less openness.

**Social relationships.**—Four constructs were chosen to represent the social relationship domain: reported number of close confidants, perceived receipt of physical and emotional support, social loneliness, and emotional loneliness. These indices characterize the individual’s subjective evaluation and reports of his/her intimate social ecology and social networks.

The “Circle Task,” or Hierarchical Mapping Technique (Antonucci, 1986), was used to generate the names of all current intimates, friends, and acquaintances of the individual. Participants were shown a diagram of concentric circles, and were told that they should imagine that they stood in the center. They were then asked to name the persons that they considered to be extremely close and important in their lives (the first inner circle), followed by those somewhat less close (second circle), and finally those persons who, although still an important part of their lives, were more distant (third outer circle). In the present analyses, we included the number of Close Confidants nominated in the inner circle. Perceived Support (especially receipt of physical and personal comfort) was assessed with three questions. Participants were asked whether, in the last three months, (a) they had spoken to someone about personal worries and concerns, (b) whether someone had cheered them up at a time when they were feeling sad, and (c) whether someone had given them a kiss or a cuddle, or shown them some tenderness. In the present analyses, scale scores were reversed so that higher scores indicated perceived lack of support and few close confidants.

Items selected from the UCLA Loneliness Scale (Russell, Cutrona, Rose, & Yurko, 1984) were used to assess two aspects of loneliness: Social Loneliness (factor score derived from four items asking about perceptions of belonging to a social group and general availability of trusted others) and Emotional Loneliness (factor score derived...
from four items dealing with feelings of isolation, being alone, and being secluded from contact with others).

Sociodemographic Characteristics and Health Measures

Indicators of sociodemographic characteristics and health measures available in the BASE data protocol were used as control measures. Gender, marital status (married vs not married), and three indicators of socioeconomic resources (years of education, equivalent income, and occupational prestige) were selected to represent sociodemographic characteristics. Equivalent income was computed by weighting the net household income by the number of people sharing the household (Baltes & Mayer, 1999). The social status rating (Wegener, 1985) of the participant's last occupation before retirement formed the measure of occupational prestige. In the case of individuals who were never part of the labor force, the prestige of the last occupation of the spouse (late spouse if widowed) was used as a substitute.

BASE assessment included comprehensive clinical examinations by physicians. For the present analyses, we included an objective, externally assessed health measure (Number of Illnesses) and a subjective health measure (Self-Rated Health). The Number of Illnesses measure represents physician-observed ICD-9 (WHO, 1980) diagnoses of illnesses, weighted by severity. The diagnoses were determined in a clinical examination and supported by additional blood and saliva laboratory assessments. Self-Rated Health was measured with the standard single item question ("How would you rate your health at the present time?") using a 5-point response scale (see also Idler, 1992).

Cox Regression Method

There are two characteristics of the present sample and design that needed to be considered in choosing an appropriate data analytic strategy. First, baseline measures for different individuals were administered over a period of time (1990–1993), whereas mortality status assessment was obtained at a fixed point in time (October 1996). As a result, individuals differed in the length of time they were in the study. Second, data from half of the sample were right-censored (i.e., they had not yet died at the end of the present study). No right-censoring occurred in the first three years following baseline assessment. Censoring became increasingly prominent, however, four and more years after baseline assessment (n = 26 at 4 years, n = 96 at 5 years, n = 95 at 6 years, and n = 38 at 7 years).

Cox regression models (Allison, 1995; Cox, 1972) were selected as a comprehensive method to relate baseline psychological functioning to mortality information that takes censored cases into account. With this method, parameter estimates were derived utilizing the full baseline sample (N = 513). The hazard or risk of dying was the dependent variable in all Cox models reported in this study. Cox regression models are well suited to analyze data from individuals who were in the study for different lengths of time because they model the hazard rather than mortality status as the outcome variable.

Parameter estimates obtained from Cox regression models were used to describe the associations between indicators of psychological functioning and mortality. We report the risk ratio (RR, obtained by exponentiating the parameter estimate) and the 95% confidence limit for the risk ratio (CI). Risk ratios can be interpreted with respect to a one-unit increase in the scale of the predictor. Predictors entered into Cox regression models were expressed on a scale with M = 4, SD = 1 (see also Appendix, Note 1), and risk ratios can be interpreted with respect to standard deviations of the baseline sample. For example, a risk ratio of 1.5 indicates that with every one standard deviation increase in the predictor, the mortality risk is 1.5 times higher. For all indicators of psychological functioning, higher scores indicated lower functioning.

Results

Our findings are reported in four sections. First, we examine associations between mortality risk and four domains of psychological functioning (intellectual functioning, subjective well-being, personality dispositions, and social relations, respectively) in a multivariate hypothesis testing framework. We evaluate the robustness of the effects stemming from these four domains by introducing controls for age, sociodemographic characteristics, and health measures. In the second section, we turn to the individual 17 psychological indicators that were discussed in prior research as potential predictors of mortality and survival. We report the risk ratios associated with each psychological indicator, again with and without statistical controls for age, sociodemographic characteristics, and health measures. Thirdly, we examine the risk patterns associated with lower or less desirable functioning separately for the old and the oldest old. In a final section, we explore whether associations between psychological risk factors and mortality vary with time.

Domains of Psychological Functioning and Risk of Dying

A first set of analyses addressed the general question whether or not functioning in four psychological domains (intellectual functioning, subjective well-being, personality dispositions, and social relations) was associated with risk of dying. Indicators of each domain were entered into the analyses as a block. Three models were run initially for each domain: one model addressing the zero-order relationship between the domain and mortality, one model addressing the relationship controlled for age alone, and one model addressing the relationship controlled for age, sociodemographic characteristics, and health measures. We applied a nested model test procedure using the likelihood ratio test (Allison, 1995) to examine whether a domain was associated with mortality above and beyond the respective covariates. Columns two through four of Table 1 provide the results of these tests.

Cox regression models suggested that level of functioning in each of the four domains was related to an elevated mortality risk (column two of Table 1). When controls for the relationship between chronological age and distance from death were introduced (column three of Table 1), the domains of personality and social relationships were no longer significant. Intellectual functioning and subjective well-being were associated with an increased mortality risk after statistical controls for age (column three of Table 1), as
well as after additional controls for sociodemographic characteristics and health measures (column four of Table 1).

Two additional analyses focused on the observed effects of subjective well-being. Specifically, we wondered whether indicators of subjective well-being predicted mortality risk over and above the prediction stemming from intellectual functioning. As can be seen in column five of Table 1, subjective well-being was associated with mortality risk in a model that controlled for age and intellectual functioning. When additional controls for health measures were introduced, however, subjective well-being was no longer associated with mortality (see column six of Table 1).

**Risk Ratios Associated with Individual Psychological Indicators**

The next set of analyses focused on the risk ratios associated with each of the 17 psychological indicators. Analyses involving the individual 17 psychological indicators were designed to serve three major purposes. First, the indicators were selected from the BASE data protocol in order to test specific hypotheses in the literature about their relation to mortality. Second, it is of interest whether the association patterns obtained from multivariate analyses were in fact in the expected direction (i.e., lower or less desirable functioning associated with an increased hazard of dying). Third, it is possible that potential confounder covariates disattenuate the effects for some psychological indicators, but not for others. To explore this possibility, we report the results of a series of Cox regression models in which the effects for the indicators are examined at a zero-order level, after age was controlled, as well as in the context of additional controls.

At the zero-order level, 11 out of the 17 indicators of psychological functioning were found to be associated with mortality risk, with lower or less desirable functioning related to an increased hazard of dying (column two of Table 2). Associations were most pronounced for intellectual abilities, with lower Perceptual Speed, lower Reasoning, lower Memory, lower Knowledge, and lower Fluency all being related to an increased hazard of dying (see Appendix, Note 2). Every one standard deviation decrease in Perceptual Speed (here coded so that higher scores indicate lower functioning) was associated with a mortality risk 2.03 times higher. Six other psychological indicators (lower Positive Affect, Dissatisfaction with Aging, Dissatisfaction with Life, lower Extraversion, lower Openness, and Emotional Loneliness) were also associated with an increased hazard of dying.

Five of the relationships disappeared when we controlled for the effects of chronological age on mortality risk (see column three of Table 2). Lower functioning on all intellectual abilities and Dissatisfaction with Aging, however, remained associated with an increased mortality risk. As for the crude risk ratios, the risk associated with dissatisfaction with aging after the age control was somewhat lower than the risks associated with indicators of lower intellectual functioning.

We also tried to evaluate comparatively the predictive strength of prototypical markers of the fluid-like mechanics and of the crystallized pragmatics of intelligence. Perceptual speed was selected as a marker of the fluid-like mechanics and Knowledge as a marker of the crystallized pragmatics (see Lindenberger & Baltes, 1997, for a similar selection of markers). A Cox regression model including Low Perceptual Speed and Low Knowledge as predictors indicated that Low Perceptual Speed was still associated with mortality risk ($RR = 2.05, 95\% CI = 1.72-2.46$) but Low Knowledge was not ($RR = 0.99, 95\% CI = 0.83-1.16$). A similar pattern was obtained when we additionally controlled for chronological age (Low Perceptual Speed: $RR = 1.37, 95\% CI = 1.12-1.68$; Low Knowledge: $RR = 1.02, 95\% CI = 0.86-1.21$). Thus, our analyses support the argument that fluid-like abilities are most predominantly related to mortality.

The final columns of Table 1 indicate the robustness of the core set of psychological indicators in Cox regression models that controlled for age and sociodemographic characteristics (column four), age, sociodemographic characteristics, and health measures (column five), and finally age, sociodemographic characteristics, and health measures as well as the 16 other psychological risk factors (column 6). The addition of controls for sociodemographic characteristics did not alter the effects of psychological risk factors—lower functioning on all intellectual abilities and Dissatisfaction with Aging were still associated with an increased mortality risk. When health measures were also included, lower functioning on all intellectual abilities continued to be associated with an elevated mortality risk. The risk ratio for Dissatisfaction with Aging, however, was no longer significantly different from 1 ($RR = 1.16, 95\% CI = 0.99-1.34, p =

### Table 1. Multivariate Associations Between Four Domains of Psychological Functioning and Mortality Risk

<table>
<thead>
<tr>
<th>Domain</th>
<th>Model $\chi^2$ (df)</th>
<th>Age</th>
<th>Age, SES, Health</th>
<th>Age, Intellectual functioning</th>
<th>Age, SES, Health, Intellectual functioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective well-being</td>
<td>44.7 (5), $p &lt; .01$</td>
<td>13.5 (5), $p &lt; .05$</td>
<td>11.2 (5), $p &lt; .05$</td>
<td>12.5 (5), $p &lt; .05$</td>
<td>10.6 (5), n.s.</td>
</tr>
<tr>
<td>Personality characteristics</td>
<td>18.9 (3), $p &lt; .01$</td>
<td>5.1 (3), n.s.</td>
<td>5.1 (3), n.s.</td>
<td>5.1 (3), n.s.</td>
<td>5.1 (3), n.s.</td>
</tr>
<tr>
<td>Social relations</td>
<td>17.8 (4), $p &lt; .01$</td>
<td>0.5 (4), n.s.</td>
<td>0.5 (4), n.s.</td>
<td>0.5 (4), n.s.</td>
<td>0.5 (4), n.s.</td>
</tr>
</tbody>
</table>

**Note.** Domain indicators were coded in the direction of low or less desirable functioning. Domain indicators were entered as blocks to obtain multivariate tests of their effects. Model fits were obtained from Cox regression models. Effects of domain indicators adjusted for covariates were evaluated by likelihood ratio tests comparing nested models (model “covariates only” vs model “covariates plus domain indicators”). SES = five sociodemographic characteristics, Health = a physician-assessed and a subjective health measure (see text for explanation of measures).
Table 2. Relationships Between 17 Indicators of Psychological Functioning and Time to Death: Zero-order and Adjusted Risk Ratios

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Zero-order Risk Ratio</th>
<th>Age, Age, SES</th>
<th>Age, SES, Health</th>
<th>Age, SES, Health, Other Psychological Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low intellectual functioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low perceptual speed</td>
<td>2.03</td>
<td>1.40</td>
<td>1.50</td>
<td>1.32</td>
</tr>
<tr>
<td>Low reasoning</td>
<td>1.79-2.30</td>
<td>1.20-1.62</td>
<td></td>
<td>1.03-1.68</td>
</tr>
<tr>
<td>Low memory</td>
<td>1.93</td>
<td>1.33</td>
<td>1.42</td>
<td></td>
</tr>
<tr>
<td>Low memory</td>
<td>1.66-2.25</td>
<td>1.13-1.57</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>Low knowledge</td>
<td>1.64-2.16</td>
<td>1.14-1.54</td>
<td>1.15-1.58</td>
<td>1.19-1.63</td>
</tr>
<tr>
<td>Low fluency</td>
<td>1.61</td>
<td>1.22</td>
<td>1.32</td>
<td>1.33</td>
</tr>
<tr>
<td>Low perceptual speed</td>
<td>1.43-1.81</td>
<td>1.08-1.39</td>
<td>1.14-1.53</td>
<td>1.15-1.54</td>
</tr>
<tr>
<td>Low fluency</td>
<td>1.92</td>
<td>1.37</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Low subjective well-being</td>
<td>1.67-2.21</td>
<td>1.18-1.59</td>
<td>1.27-1.77</td>
<td>1.27-1.78</td>
</tr>
<tr>
<td>Low positive affect</td>
<td>1.25</td>
<td></td>
<td></td>
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<tr>
<td>Negative affect</td>
<td>1.11-1.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agitation</td>
<td>0.91</td>
<td></td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>Dissatisfaction with aging</td>
<td>0.81-1.04</td>
<td></td>
<td></td>
<td>0.65-0.96</td>
</tr>
<tr>
<td>Dissatisfaction with life</td>
<td>1.18</td>
<td></td>
<td></td>
<td>1.22</td>
</tr>
<tr>
<td>Dissatisfaction with life</td>
<td>1.04-1.33</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Less desirable personality characteristics</td>
<td></td>
<td></td>
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<tr>
<td>Neuroticism</td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Low extraversion</td>
<td>0.99-1.26</td>
<td></td>
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<tr>
<td>Low openness</td>
<td>1.15</td>
<td></td>
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<td></td>
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<tr>
<td>Low openness</td>
<td>1.02-1.30</td>
<td></td>
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<tr>
<td>Low openness</td>
<td>1.14-1.45</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Less desirable social relations</td>
<td></td>
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<tr>
<td>Emotional loneliness</td>
<td>1.28</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Social loneliness</td>
<td>1.14-1.44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low support</td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low support</td>
<td>0.99-1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Few close confidants</td>
<td>1.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.99-1.29</td>
<td></td>
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</tr>
</tbody>
</table>

Note. Risk ratios and their 95% CI are shown. Adjusted risk ratios that were not significantly different from 1 are omitted for clarity. SES = five sociodemographic characteristics, Health = a physician-assessed and a subjective health measure (see text for explanation of measures). *p = .06.

In the final hard test of the robustness of the separate psychological risk factors, which included additional adjustments for the respective other psychological constructs, lower perceptual speed, lower agitation (see Appendix, Note 3), and dissatisfaction with aging were significant.

Comparison of the Old and the Oldest Old

Interpretation of age-controlled risk ratios may be misleading if the involved association patterns are fundamentally different across age groups. Suzman, Willis, and Manton (1992) suggested that this may indeed be the case for the oldest old (older than 85 years). We tried to address this issue empirically by calculating the associations between psychological functioning and mortality separately for the old (70-84 years) and the oldest old (85-103 years). Risk ratios obtained from these analyses suggested that associations were similar for the old and the oldest old for 15 of the psychological dimensions. Differences were revealed on two intellectual abilities, however. The risk ratio for the oldest old was lower for Low Perceptual Speed (85–103 years: \( \hat{R} = 1.43 \)) and the 95% confidence interval around this ratio did not include the estimated risk ratio for the younger group (70–84 years: \( \hat{R} = 2.02 \)). Similarly, the risk ratio for the oldest old was lower for Low Fluency (85–103 years: \( \hat{R} = 1.43 \)) and the 95% confidence interval around this ratio also did not include the estimated risk ratio for the
younger group (70–84 years: \( RR = 1.80 \)). Low Perceptual Speed and Low Fluency appear to be less predominant predictors of mortality among oldest old individuals (see Appendix, Note 4).

**Do the Effects of Psychological Risk Factors Vary With Time?**

A further exploratory set of analyses addressed the length of the predictive period associated with psychological risk factors. We defined a time-dependent covariate for each psychological risk factor as the product of the risk factor and time (see Allison, 1995). For each of the 17 psychological risk factors, we then calculated a Cox regression model that included the respective risk factor and the associated time-dependent covariate as predictors. None of the effects associated with the time-dependent covariates was statistically significant. This set of analyses suggested that the reported effects for psychological risk factors neither diminished nor increased over time. A better test of the time frame of the psychological risk factors would, of course, require longitudinally repeated measures of the psychological constructs.

**DISCUSSION**

Taken together, these results from the BASE cross-sectional data protocol suggest that there are some aspects of psychological functioning in old age that appear to be associated with impending death. At a zero-order level, 11 of the 17 constructs that we examined showed a significant relationship to survival status. For each construct, the relationship was in the expected direction: namely, lower levels of functioning or less positive self-evaluations were associated with a higher risk of subsequent death. Longitudinal assessment of functioning would be needed to determine whether these lower levels indeed reflect death-related decline.

**Psychological Predictors of Mortality**

Our analyses suggest that psychological predictors of mortality in old age may not just be specific to intellectual functioning, but rather that they extend to self-related evaluations of personal well-being. As a domain, intellectual functioning certainly provided the strongest and most robust set of predictors. Effects associated with predictors from the personality, self-related, and social domains appear to be more subtle. With one exception (dissatisfaction with aging), in the present study, predictors from these latter domains were only revealed as significant risks in analyses that did not first control for associations between age and mortality. The predictive effect of dissatisfaction with aging, however, remained significant even after statistical controls for age, sociodemographic characteristics, health measures, and the 16 other psychological variables. This is strong evidence in support of the proposal that intelligence may not be the only aspect of psychological functioning that is death-related.

Intellectual functioning is the main area in psychological research in which hypotheses about terminal decline and the prediction of mortality have been tested (Berg, 1996; Riegel et al., 1967; Siegler, 1975). In many early studies, however, the number of cases was small, samples were highly selected, and the age range limited. In general, the present study suggested that effects associated with intellectual functioning are pervasive rather than ability-specific (see also Berg, 1987). The zero-order risk levels were similar across the five abilities examined in the present study and were reduced to a similar degree by various controls (see columns two through five in Table 2). This pervasiveness may be specific to the older age range of this sample, where it has been argued that due to the common cause of brain aging, all intellectual abilities converge towards a higher commonality (e.g., Balinsky 1941; Lindenberger & Baltes, 1997; Reinert, 1970). Several mechanisms could underlie our findings. At one level, lower intellectual functioning that is death-related could be indicative of general processes of brain atrophy and system breakdown. At a pragmatic and everyday level, lower intellectual functioning could also put individuals at risk for other factors that are more direct causes of death. For example, poor memory and reduced reasoning capacity could have substantial implications for the correct usage of medication and other health-related behavior.

A specific question in the domain of intellectual functioning concerns the relative predictive power of measures associated with fluid versus crystallized abilities. Some researchers argue that fluid abilities are more age-related than death-related, and that the strongest predictors of mortality are among the crystallized abilities (e.g., Cooney et al., 1988; White & Cunningham, 1988). Our results did not reveal stronger predictions from the crystallized than from the fluid abilities. Quite to the contrary, if we considered only perceptual speed (as a marker of the fluid-like mechanics) and knowledge (as a marker of the crystallized pragmatics), it appeared that the stronger prediction of mortality was from the fluid domain. Furthermore, only the fluid ability of perceptual speed remained significant in control analyses that included age, sociodemographic characteristics, health, and the 16 other psychological variables. The measures of crystallized abilities in BASE, however, may not be extensive enough to cover the effects reported in previous studies.

As might be expected from the extensive literature concerning the predictive links between subjective health and mortality (e.g., Idler, 1992), risks associated with subjective evaluations of well-being were found to be strong in the present study. In particular, dissatisfaction with aging, as measured by the subscale of the PGCMS (Lawton, 1975; Liang & Bollen, 1983), remained as a significant risk factor after controls for age and sociodemographic characteristics (columns three and four of Table 2). The effect became marginally significant when additional controls for health were added (column five), but then stood the hardest test (column 6) when pitted against age, sociodemographic characteristics, health, and the 16 other psychological variables. Few other studies have investigated this aspect of perceived well-being in relation to mortality. In the Dutch Longitudinal Study, Deeg and colleagues (1989) found that a single item asking about perceived problems with aging predicted mortality after aspects of health were controlled.

Why are evaluations of subjective well-being associated with increased rates of subsequent mortality? These evalua-
tions might reflect quite accurate summary perceptions about individuals' present status with respect to functioning in a variety of domains. Negative evaluations themselves are probably not the cause for an increased mortality risk, but they may reflect potential causes from other domains of functioning (e.g., intellectual, health, or biological functioning).

Findings reported in the literature with regard to predictors associated with personality dimensions and social relationships are less consistent than those for intelligence. In part, this may be due to between-study variations in construct measurement, sample characteristics, and analysis strategies (e.g., whether controls were introduced for age). At a zero-order level, for example, we found significant risks associated with lower levels of extraversion and openness to new experience. These risks did not remain after the control for age. For these dimensions, our finding is similar to that of Friedman and associates (1995).

We had expected that indicators of social support, loneliness, and the presence of close confidants would also be related to mortality. Only emotional loneliness proved to be a risk at the zero-order level. Although several studies have reported associations between perceived lack of support, loneliness, and the absence of close confidants (e.g., Berkman, 1988; Yasuda et al., 1997), it is also recognized that subjective reports of social support may not fully reflect actual availability of support. Furthermore, social networks and perceived social support may have an indirect effect on mortality through physical health and health behavior (Cohen & Willis, 1985; Sugisawa, Liang, & Liu, 1994). Had we examined other indicators of integration in a social network in the present study or explored the compensatory effects of professional care provision, we might have observed different relationships between social indicators and mortality.

The Role of Socioeconomic Resources and Health

The association between socioeconomic resources (years of education, equivalent income, occupational prestige) and mortality was relatively small in this sample of older individuals from West Berlin. Controlling for these resources, therefore, did not substantially alter the effects of psychological characteristics on mortality. Weak associations between socioeconomic resources and mortality are somewhat in contrast to reports relying on United States samples (e.g., Kitagawa & Hauser, 1973). It is important to note, however, that most of these studies involved younger age groups than those included in BASE. Further, the weak associations found in the present analyses are consistent with other BASE analyses, showing that the prevalence of illness and frailty is minimally associated with socioeconomic resources (Baltes & Mayer, 1999). It is possible that health outcomes in very old age are increasingly dependent on genetically-determined processes, which are relatively independent of socioeconomic conditions.

Introducing physician-assessed and subjective health measures as additional covariates provided a strong test for the robustness of psychological predictors of mortality. The additional controls for health (after age and sociodemographic characteristics) did not alter the risk ratios associated with the intellectual abilities, but they did reduce the risk associated with dissatisfaction with aging. Similar to subjective health (Idler, 1992), dissatisfaction with aging could also be in part a reflection of an individual's poor health status. Rather than attributing psychological functioning to health, however, we consider it more likely that genetic and life history factors may act as additional variables, orchestrating the intertwined relationships among health, psychological functioning, and mortality (see Chris-tensen & Vaupel, 1996; McClearn, Johansson, Berg, Pedersen, Ahrn, Petrill, & Plomin, 1997).

Admittedly, we did not explore a large variety of objective and subjective health measures as potential confounders (see for example Idler, 1992, p. 44). The two indicators selected, however, are recognized as prominent exemplars of external and self-assessed health. In older adults (70–100 years), chronological age is itself a substantial carrier of additional health information, especially functional health. It seems, then, that after controlling for the effects of age and health status, psychological functioning does make a difference in terms of survival.

The Role of Age

We believe that age is a critical variable to consider when patterns of mortality are investigated. Age is related both to functioning and to death in complex ways that cannot be addressed easily in a single set of analyses. At a very general level, increasing age is associated with greater risk of death and a shorter average life expectancy (residual life time) after baseline assessment. Life tables for the Berlin population indicate that the average life expectancy for a 70-year-old person is 12.2 years, whereas for a person aged 80 it is 6.6 years and at age 95, 2.5 years. In the present BASE sample, 89.1% of participants aged 70–84 years at baseline were alive three years after baseline assessment and 75.6% survived until the time of the present study. As was to be expected, fewer participants older than 85 years of age (54.9%) were alive three years after baseline assessment, and only 23.9% had survived until the time of the present study.

In general, our results indicated that controlling for the relationship between age and death reduced the magnitude of six effects of psychological functioning on mortality risk and eliminated five other effects (six indicators were not significant at the zero-order level). That the effects did not vanish altogether suggests that the associations between lower psychological functioning and mortality cannot be equated with age decrements in psychological functioning.

Furthermore, selective survival may also have an effect on the range of functioning observed in different age groups—the oldest old survivors may represent a restricted proportion (positive selection) of the performance distribution of their birth cohort. Changes in cohort membership are quite dramatic in the 30 years from age 70 to age 100. In the Berlin population, 70-year-olds represent on average approximately 70% of their birth cohort, whereas 90-year-olds represent 12%.

In the present study, these dynamics of aging and their relationship to death were also explored by the separate predictive analyses for the old (70–84 years) and oldest old.
This set of analyses suggested that, as a whole, the associations between psychological functioning and mortality risk were fairly similar for the two age groups. However, it is of interest that we found age group differences for two indicators of intellectual functioning—both perceptual speed and fluency appeared to be less prominent predictors of mortality among the oldest old. This decrease in the strength of predictors of death for the oldest old does not seem to be restricted to intellectual functioning. Other research groups examined various indicators of health and functional capacity as mortality predictors and reported a similar decrease in predictive strength among the oldest old (e.g., Dontas, Toupadaki, Tzonou, & Kasviki-Charvati, 1996; Manton, Stallard, Woodbury, & Dowd, 1994). It is possible that mortality risk in younger age groups is relatively closely tied to the level of functioning, while death strikes more randomly in advanced age (Riegel & Riegel, 1972).

Age is also implicated in more complex ways in terms of level of functioning and the relationship between functioning and death. Different aspects of observed functioning decline in older adults may be age- and death-related (Palfour & Jeffers, 1971). Research on terminal decline (Berg, 1996; Siegler, 1975) has often adopted the premise that there are age-related declines in functioning (“normal aging track”) that can be distinguished from death-related declines (“death track”), with the latter exposing a steeper decline trajectory than the former. Apparently it is very difficult to determine whether an individual is still on the “normal aging track” or has already switched to the “death track”. In the present study we did not explicitly attempt to separate the two tracks, because we doubt that such an enterprise would be successful in the absence of longitudinal data on functioning. Our exploratory analyses addressing the length of the predictive period suggest, however, that the “death track” may extend over a considerable time period. Participants in the present study were followed between three and seven years, and there was no indication that the effects of psychological predictors of mortality diminished over this period. Subsequent analyses will be able to examine whether the predictive period extends for an even longer time span, and whether there are domain differences in the length of the predictive period. We consider it plausible that a temporal sequence of steps involves first a decline in intellectual functioning, next a decline in subjective well-being, and finally death.

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Current members of the BASE Psychology Unit include Paul B. Baltes (co-director), Alexandra M. Freund, Ulman Lindenberger, Shu-Chen Li, Heiner Maier, Jacqui Smith (co-director), and Ursula M. Staadinger. We thank our colleagues in the Psychology Unit for their many contributions. In addition, we express our appreciation to Paul B. Baltes, Ulman Lindenberger and John R. Nesselroade for useful comments on an earlier draft.

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Survival in the oldest old: Death risk factors in old and very old sub-


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**Appendix**

**Notes**

1. Standardization to $M = 4, SD = 1$ does not alter the reported findings in terms of their statistical significance. It does, however, does affect the size of the parameter estimates associated with predictors of mortality. The original, raw data metric of our measures of psychological functioning is arbitrary. We chose to standardize because once in standardized metric, individuals’ scores can be interpreted with respect to standard deviation units of the baseline sample. Additionally, it is more convenient to evaluate the strength of different mortality predictors comparatively if the associated parameter estimates are based on scores that are expressed in a comparable metric.

2. We recalculated all models, excluding $n = 109$ individuals with diagnoses of different levels of dementia. In BASE, diagnoses of suspected dementia ($n = 109$) were differentiated at three levels: Level 1 ($n = 37$) indicated participants with symptomatic memory difficulties and Levels 2 and 3 ($n = 33$ and $n = 32$ respectively) indicated cases of moderate to severe symptomatology (DSM-III-R). The reported pattern of findings did not change, suggesting that these effects cannot be explained by an increased mortality risk for individuals with different levels of dementia.

3. In analyses controlling for age, sociodemographic characteristics, health measures and 16 other psychological indicators, higher Agitation was related to survival and lower Agitation to death. It is possible that lower Agitation, or “calmness,” character-
izes the period prior to death. However, we recommend caution in interpreting this finding. The effect was in the opposite direction from what we had originally hypothesized, and it was present only in the Cox regression model with the maximum number of covariates (column six of Table 2) and absent in all other, simpler models (columns two to five of Table 2).

4. Complete data are available from the authors. The decrease in predictive strength for perceptual speed and fluency in the oldest old might be due to floor effects in the measures. We cannot rule out this possibility but the empirical evidence for floor effects is sparse. Inspection of the univariate distributions for the oldest old did not reveal that there was a noticeable clustering of individuals at the lower end of the perceptual speed or of the fluency measure. Lindenberger and Baltes (1997, pp. 420–421) used various approaches to examine the possible existence of age differences in interindividual variability in these measures, and concluded that interindividual variability was remarkably stable with age. We also calculated the risk ratios excluding groups of low performers (lowest 5% and lowest 10%), separately for perceptual speed and fluency. These analyses showed that the age group differences in predicting mortality persisted for the fluency measure but not for the perceptual speed measure. This might be taken as an indication of floor effects in the perceptual speed measure for the oldest old. A conclusive interpretation is rendered difficult, however, because the analyses excluding low performers rely on selected subsamples and have reduced statistical power.