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**Intelligent, dependable children live longer**

A 55-year longitudinal study of a representative sample of the Scottish nation

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## **Abstract**

The associations of childhood intelligence and dependability with adult mortality were examined in 1181 people who were representative of the Scottish nation. Participants were born in 1936 and followed for mortality between 1968 and 2002. Higher intelligence and greater dependability were independent, significant predictors of lower mortality: with both factors entered together, the hazard ratio was 0.80 (95% CI 0.65-0.99,  $p = .037$ ) per standard deviation increase in intelligence, and 0.77 (95% CI 0.63-0.94,  $p = .009$ ) per standard deviation increase in dependability. Children in the lower half of the distribution for intelligence and dependability were more than twice as likely to die compared with those who scored in the top half for these measures (HR 2.82; 95% CI 1.81- 4.41). Studied together for the first time, these two psychological variables are independent lifecourse risk factors for mortality. It is important to discover the mechanisms by which they influence survival.

## Introduction

Predicting death has been called the “ultimate validity” of psychological variables (O’Toole & Stankov, 1992). This validity is enhanced if the prediction can be made from variables during childhood. Few psychological variables have such power, and few longitudinal studies exist with relevant data.

One psychological factor that has recently emerged as an important predictor of mortality is childhood and early adult intelligence, as measured by standard IQ-type tests (Batty, Deary, & Gottfredson, 2007; Hart et al., 2003; O’Toole & Stankov, 1992; Whalley & Deary, 2001). People with lower intelligence test scores tend to die earlier. These findings have been replicated in several different countries. Early evidence suggests that the association does not appear to be explained by childhood socio-economic circumstances, and the extent to which the relation of IQ with mortality could be mediated by adult socio-economic status is, as yet, unclear (Batty, Deary, & Gottfredson, 2007).

Conscientiousness is another psychological variable that appears to be important for longevity. Greater conscientiousness in childhood has been linked with reduced mortality over more than 60 years in the Terman Life-Cycle Study (Friedman et al., 1993; Friedman, in press; Schwartz et al., 1995). The trait concepts from the childhood personality assessment that were associated with survival were denoted by the authors as “*Conscientiousness-Social Dependability*” (4 items) and also “*Permanency of Moods*” (a single item) (Friedman et al., 1993, p. 177). While these findings suggest that conscientiousness and stability of moods may have a long-term influence on risk of death, all the children in the Terman study were cognitively gifted (IQ of 135 or greater). Whether these traits have a similar predictive power in the general population remains unclear.

There is some evidence, though it is not consistent, that IQ and conscientiousness are correlated (Ackerman & Heggestad, 1997; Luciano, Wainwright, Wright, & Martin, 2006). It is also unknown to what extent the link between conscientiousness and subsequent mortality is explained by intelligence.

The present study is the first to examine if measures of intelligence and dependability in childhood together are associated with later mortality, in a nationally representative sample. It has the additional advantage that it includes extensive information on the participants in childhood and subsequently. This allowed us to explore the potentially confounding and/or mediating role of these factors in the links between psychological attributes in early life and subsequent survival up to 55 years later.

## **Method**

### **Subjects**

The subjects in the present study are a representative subsample of the Scottish Mental Survey of 1947 (SMS1947; Scottish Council for Research in Education, 1949). It tested, on June 1<sup>st</sup>, the mental ability of almost everyone born in 1936 and attending Scottish schools on that day ( $N = 70,805$ ). A subsample of this entire year-of-birth population was selected for a more detailed longitudinal survey. This subsample of the SMS1947 is known as the 6-Day Sample ( $N = 1,208$ ; 618 females, 590 males). It comprised all subjects born on the first day of the even-numbered months (February, April, and so forth). After the SMS1947 the 6-Day sample took part in a number of further waves of data collection. These included school-based assessments and home visits. The last of the home interviews took place in 1963, 16 years after the SMS1947, when the subjects were aged about 27 years.

We previously reported the association between childhood intelligence and mortality in some of the 6-Day sample (Deary, Whiteman, Starr, Whalley, & Fox, 2004). These analyses were carried out prior to data from the whole sample being retrieved, were based on sex-adjusted analyses only, had no personality data, and had none of the many additional variables studied here.

#### Assessment of intelligence

The SMS1947 applied, to the whole population, a version of the Moray House Test No. 12. This has been described previously and is a well-validated, group-administered test of general mental ability (Deary et al., 2004). The validation sample for this test was the 6-Day Sample, of whom 1112 took the group-administered Moray House Test in the SMS1947. All 1208 took an individually-administered Form L Terman-Merrill revision of the Binet-Simon test (Binet test) in the months after the SMS1947. The correlation between scores on these two tests was 0.799 ( $p < .001$ ). In the present study the IQ score from the Binet test was used as the childhood intelligence measure.

#### Assessment of personality

As a part of a school-based schedule that took place in 1950, three years after the SMS1947, teachers rated the 6-Day Sample children on several personality attributes. The items, an abbreviated list of those used by Terman in his study of gifted children (Maxwell, 1969, Chapter V), were: “self-confidence”, “perseverance”, “stability of moods”, “conscientiousness”, “originality”, and “desire to excel”. Each characteristic was rated on a five point scale: A = “the pupil possessed the quality of behaviour to a marked degree” (Maxwell, 1969b, p. 150); B = above average; C = average; and D and E “indicated

absence of the characteristic to a greater or lesser extent". Most of these items were correlated significantly with the Binet test IQ scores.

We used regression to remove the IQ variance from each item; personality items were residualised on IQ. We then subjected the standardised residual scores on the six items to principal components analysis. This showed two clear components, using the scree slope criterion, accounting for 68.0% of the total variance. The first rotated component had the following items (loadings): perseverance (.81), stability of mood (.71), conscientiousness (.90). The Cronbach alpha for these three items was .77. A component score, called dependability, was saved for each subject. The other component is not used further in the analyses and was not related to mortality.

#### Assessment of other variables in early life

A 'Random Sample Sociological Schedule' was applied to the 6-Day Sample subjects some months after the SMS1947 (Scottish Council for Research in Education, 1949). Height and weight were measured. We used these data to calculate body mass index ( $\text{kg/m}^2$ ). Height itself is often used in epidemiology as a proxy for social circumstances, illness, nutrition and possibly psychosocial stress in childhood (Batty & Leon, 2002). A range of indicators of socioeconomic position from childhood through to early adulthood was collected. Family size was noted. In the same schedule, the number of rooms in the home (excluding bathroom) was counted, as was the number of people living in the home. These were used to compute an overcrowding index. The father's occupation was noted and graded in five categories according to the UK's classification of occupations ranging from the most manual to the most professional (General Register Office, 1956). The mother's age at the child's birth was noted. From the above-mentioned school schedule in

1950, actual and possible school attendances were computed for the 1948-1949 academic year.

At one home visit by a health visitor in 1951 a number of subjective estimates were made on a standardized schedule. These concerned the child's parents and the family home and its atmosphere. There were nine items. Principal components analysis of these items suggested just one component, using the scree slope criterion, accounting for 53.1% of the total variance. The items loaded as follows: estimate of father's (.75) and mother's (.73) intelligence; impression of general cleanliness of home (.75); emotional atmosphere of home (.68); cultural interests of home (.70); father's (.75) and mother's (.71) personality; and the attitude of the father (.75) and mother (.74) to the child's future career. We saved scores on this component and called them Home scores.

At the same time as the above visit in 1951, any illness serious enough to affect the child's "general health" was noted. From later, yearly, individual interviews of the 6-Day Sample, the number of years of schooling plus any further full time education were noted. The person's own occupation was obtained from these interview records, and classified using the system described above for the father's occupation.

#### Ascertainment of death

With the permission of the Scottish Privacy Advisory Committee, the surname, forename, and date of birth information from the records of the full 6-Day Sample of the SMS1947 were linked to death and health records in Scotland. The Scottish Record Linkage System (SRLS; Heasman & Clarke, 1979) was used to link 6-Day sample data to the Registrar General's death records between 1968 and January 2003. SRLS uses probability matching



methods. A subset of records is compared. Those which share a minimum level of identifying information (name, based on the SRLS's Soundex code, and all elements of date of birth) are given a probability weight. This is converted into absolute odds, which supports the linkage decision. A threshold is identified above which pairs are taken as linked, and below which the pairs are not accepted as linked. This threshold is determined by actual inspection of pairs of records. Of the 1208 people in the 6-Day sample of the SMS1947, 11 were known to have died prior to 1968, and 16 were known to have emigrated. These 27 people were omitted from these analyses, leaving 1181 for linkage to death data.

#### Statistical analyses

The principal analyses used Cox's proportional hazards regression—commonly utilised in epidemiology (Cox, 1972)—to estimate the association of intelligence, personality and other predictor variables with death between 1968 and 2003. These analyses produce hazard ratios (HR) with accompanying 95% confidence intervals. A hazard ratio summarises the association of an explanatory variable with the risk of an event (Altman, 1991). A HR of exactly 1.0 means the predictor has no relation with an outcome. A HR greater than 1.0 indicates that the predictor variable is associated with an increase in mortality risk, whereas a HR below this value is evidence of a decrease in risk. For example, a HR of 1.30 means that there is a 30% increase in the hazard per unit of measurement in the predictor; and a HR of 0.70 means that there is a 30% decrease in the hazard per unit of measurement in the predictor. In the present study the Binet test scores and dependability scores were entered as standardised variables (mean = 0, SD = 1), so that the HRs represent changes in the hazard per SD of these predictors. When we compare the HRs between two groups, the HRs represent the relative mortality rates between the

groups. Confidence intervals that do not span 1.0 (unity) suggest that a relationship is statistically significant at the conventional level ( $p < .05$ ).

## **Results**

In the period between 1968 and 2003 there were 193 deaths. There was a 30% reduced hazard of dying between 1968 and 2003 per standard deviation increase in Binet IQ score tested at age 11 (HR 0.70; 95% CI 0.60-0.82,  $p < .001$ ) (see Table 1). There was a 22% reduced hazard of dying between 1968 and 2003 per standard deviation increase in dependability score tested at age 14 (HR 0.78; 95% CI 0.67-0.90,  $p < .001$ ). For illustration, the Binet IQ scores and dependability scores were divided into quarters, and sex-adjusted survival curves were plotted for each quartile (see Figures 1 and 2). For IQ there is a clear ‘dose’-response association for the top three quarters. The lowest two quarters have effectively identical survival histories. For dependability, there is a dose-response relationship, with improved survival from the lowest to the highest quarters at almost all follow-up points. Other significant predictors of mortality were years of education, the Home score, father’s occupational social class, the number in the family, overcrowding, school attendance, illness in childhood, and the participants’ own occupational social class in their late twenties (see Table 1).

We examined whether the association of IQ and dependability with mortality risk was independent of the afore-described factors. The effect size of the association between intelligence at age 11 and mortality was most strongly attenuated by education (30% reduction in Hazard Ratio), Home score (47%), and the person’s own occupation (30%) (see Table 2). Years of education attenuated the association between dependability and mortality by 14%, and all other attenuations were below 10%.

To find the strongest childhood predictors of mortality, backward stepwise multivariate Cox regression was used, entering all significant factors found in Table 1. The final model included only sex (HR 2.06; 95% CI 1.38-1.08,  $p < .001$ ), Binet IQ (HR 0.80; 95% CI 0.65-0.99,  $p = .037$ ), and dependability (HR 0.77; 95% CI 0.63-0.94,  $p = .009$ ).

As a final illustration of the association between childhood intelligence and personality and survival, people were divided into top and bottom halves for Binet IQ at age 11 and dependability at age 14. The association with survival was examined (see Figure 3). There were 1166 people with full data. Compared with those subjects who were in the top half for both Binet IQ and dependability, the sex-adjusted hazard ratios for mortality in the follow-up period were: top half for Binet IQ/bottom half for dependability, 1.56 (95% CI 0.97-2.50),  $p = .068$ ; bottom half for Binet IQ/top half for dependability, 1.89 (95% CI 1.18-3.02),  $p = .008$ ; bottom half for Binet IQ and dependability, 2.82 (95% CI 1.81-4.41),  $p < .001$ .

## **Discussion**

Childhood Binet IQ scores and an independent, brief, teacher's rating of the internally consistent personality trait of dependability were powerful, independent predictors of death in the 35 year period between 1968 and 2003. Children who scored in the lower half of the distributions for both the Binet test (age 11) and the teacher's dependability rating (age 14) were more than twice as likely to die in the period studied as those whose scores for both these attributes were in the top half of the distributions. This hazard ratio of 2.82 is similar in effect size to the combinations of major, established risk factors for all-cause mortality measured in middle-age (raised serum cholesterol, elevated blood pressure, smoking) in

both women (HR 2.34; 95% CI 1.73-3.15) and in men (HR 3.20; 95% CI 2.47-4.14) (Lowe, Greenland, Ruth et al, 1998). As far as we are aware, this the first time that these two psychological variables have been examined together in the same sample<sup>1</sup>, and one, moreover, that is nationally representative. They survived when other known predictors of mortality were eliminated from the multiple Cox regression equation.

The first aim of cognitive and personality epidemiology is to establish associations between psychological factors and important health outcomes. Therefore, large, longitudinal studies of normative groups are important. Associations are more convincing when the psychological variables are measured in childhood and with a long follow-up period, because reverse causation and comorbidity are unlikely explanations for the associations with mortality and morbidity. After confirming that intelligence and personality have independent ultimate validity (O'Toole & Stankov, 1992), should come a search for the possible mechanisms for their associations with death.

From the rich background data available here, there were no variables that provided more than a small attenuation of the dependability association with mortality. Socioeconomic position in childhood, as indicated by father's social class and overcrowding in the home, predicted mortality in this cohort, as it has in previous studies (Galobardes, Lynch, & Davey Smith, 2004) but, whereas adjustment for these factors slightly attenuated the association between intelligence and mortality, it had very little effect on that between

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<sup>1</sup> Although the Terman Life-Cycle Study's subjects were all cognitively gifted, higher childhood intelligence was associated with lower mortality over a 64-year period in some but not all analyses (Martin & Kubzansky, 2005). These analyses were not run in tandem with data on personality traits.

dependability and mortality. Education had the largest attenuating effect on this association, in agreement with Hampson et al. (2007). There was attenuation of the association between intelligence and mortality when the possible confounding effect of the Home score and the possible mediating effects of education and the person's own social class were considered. Each of these factors might be acting to a greater or lesser extent as surrogate measures of intelligence. For example, although the Home score might represent the material and psychological environmental influences of the person's social background, it could also capture some of the genetic influence on intelligence differences shared between parents and children. The home visitor's assessment of the parents' intelligence, however problematic, was an element of the Home score. It might also be pointed out that, given the large number of background effects captured by the Home score, its attenuation of the Binet IQ score influence was modest, at less than 50%.

There has been progress with both intelligence and conscientiousness with respect to understanding the mechanisms that might underlie their associations with mortality. The specific causes of death that are associated with intelligence are being studied, as are possible mediators of the association. Some data suggest that premature mortality, i.e. death before the age of 65 as was studied here, is especially linked with early life intelligence (Hart et al., 2005). Whereas intelligence early in life is predictive of later cardiovascular disease and death (Hart et al., 2003), it may not have the same relation with incident cancers (Batty, Rasmussen et al., 2007). The best evidence to date suggests that there might be several routes by which mental ability is associated with survival and health more generally (Batty, Deary, & Gottfredson, 2007). These routes include possible but not yet established genetic associations between intelligence and longevity, intelligence as an indicator of general bodily integrity (Deary & Der, 2005), and intelligence as a factor that

can be mediated via socio-economic status (Batty, Deary, & Gottfredson, 2007), health behaviours (Batty, Deary, Schoon, & Gale, 2007), and other risk factors (Batty, Deary, & MacIntyre, 2007) for illnesses.

In the present study, the measure of dependability was derived from two clear conscientiousness items from the teachers' ratings of the children together with an item related to stability of moods. In other research, both conscientiousness and neuroticism have been linked with risk of all-cause mortality (Friedman et al., 1993; Shipley, Weiss, Der, Taylor, & Deary, 2007). Therefore, it is possible that the present study's variable is either a measure of the latent trait of conscientiousness, or a mixture of that and neuroticism. The conscientiousness-social dependability items from the Terman Life-Cycle Study, two of which have the highest loadings on our dependability scale, are related strongly to conscientiousness measured in modern five factor personality scales (Martin & Friedman, 2000). Higher conscientiousness in adulthood also seems to be a protective factor against mortality in much shorter-term follow up studies of older people (Weiss & Costa, 2005; Wilson, Mendes de Leon, Bienias, Evans, & Bennett, 2004). However, childhood conscientiousness is still predictive of lifecourse mortality after adjusting for adult conscientiousness (Martin, Friedman, & Schwartz, 2007).

Friedman and colleagues ruled out some obvious possible explanations of the associations between childhood conscientiousness and survival, such as accident avoidance and alcohol and substance abuse (Friedman et al., 1995). They proposed a number of complex pathways that are involved across the lifecourse (Friedman, in press), with some suggestion that factors such as smoking might mediate some of the adult, but not the childhood, conscientiousness effect (Martin, Friedman, & Schwartz, 2007). Conscientiousness rated

by teachers in childhood was associated with less adult smoking, better self-rated health, and, for women only, low body mass index up to 40 years later (Hampson, Goldberg, Vogt, & Dubanoski, 2006). The influence of childhood conscientiousness on adult eating habits, smoking, and physical activity might be partly mediated via education (Hampson, Goldberg, Vogt, & Dubanoski, 2007), but education had very little mediating effect on the dependability-mortality association in the present study. A meta-analysis of associations between adult conscientiousness and health-related behaviours found positive associations with beneficial behaviours and negative associations with risky behaviours (Bogg & Roberts, 2004).

A limitation of the present study is the known imperfection of the SRLS, which cannot guarantee to identify correctly all individuals given the data available for linkage. Also, it is possible that some individuals who left Scotland—and whose death could not therefore be ascertained by the SRLS—were not identified prior to the analysis. Therefore, it is important to have validating data which indicate that the number of deaths identified in the 6-Day Sample were not substantially underestimated. The General Register Office for Scotland ([www.gro-scotland.gov.uk](http://www.gro-scotland.gov.uk)) supplied us with national mortality data by individual age at death. These were available from 1974, together with age-specific population estimates for that year. In total, there were 59,653 people in Scotland born in 1936 and still alive in 1974. Of these 12,411 (21%) had died by the end of 2002. In the 6-Day sample, 1174 people were still alive in 1974 and 188 (16%) of these died by the end of 2002. Therefore, compared with the national population born in the same year, the death rate in the 6-Day sample is slightly lower. While this difference might be a result of some under-ascertainment of deaths in the sample, it is worth noting that the national death rate

calculated for those born in 1936 is dependent on an estimate of the population, and as such inevitably subject to some error because of the difficulties of monitoring migration.

Psychometrically-tested intelligence and ratings of the personality trait dependability possess “ultimate validity” (O’Toole & Stankov, 1992). They are associated with how long people live. The effects are far from trivial, and the mechanisms by which they influence survival, though not fully understood, are likely to be multiple (Batty, Deary, & Gottfredson, 2007; Friedman, in press; Hampson et al., 2007), and to include partial mediation by health behaviours and education. Further replication of these effects is still necessary, and firmly identifying mechanisms is important for there to be rational interventions in health management and care. Here, for the first time in a true population sample we show that bright, dependable children live longer. This is an important foundation on which a mechanism-oriented health psychology can build.

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**Table 1**

Hazard ratios (95% CI) for mortality (N = 193 deaths) according to childhood characteristics and social class in early adult life. Hazard ratios are adjusted for sex.

Exposure variable	Hazard Ratios (95% CI)	<i>p</i>
IQ (per SD)	0.70 (0.60-0.82)	<.001
Dependability (per SD)	0.78 (0.67-0.90)	.001
Education (per yr of schooling)	0.64 (0.51-0.78)	<.001
Height (per SD)	0.90 (0.78-1.04)	.16
Weight (per SD)	0.96 (0.83-1.12)	.61
BMI (per SD)	1.05 (0.91-1.21)	.49
Home score (per SD)	0.79 (0.66-0.95)	.011
Father's social class	1.31 (0.14-1.52)	<.001
Number in family	1.07 (1.01-1.13)	.014
Overcrowding (persons per room)	1.16 (1.04-1.30)	.008
School attendance (proportion of possible days in 1948/9)	0.15 (0.05-0.50)	.002
Illness in childhood	2.08 (1.21-3.59)	.008
Mother's age at child's birth (yr)	1.00 (0.98-1.02)	.90
Own social class	1.42 (1.22-1.65)	<0.001

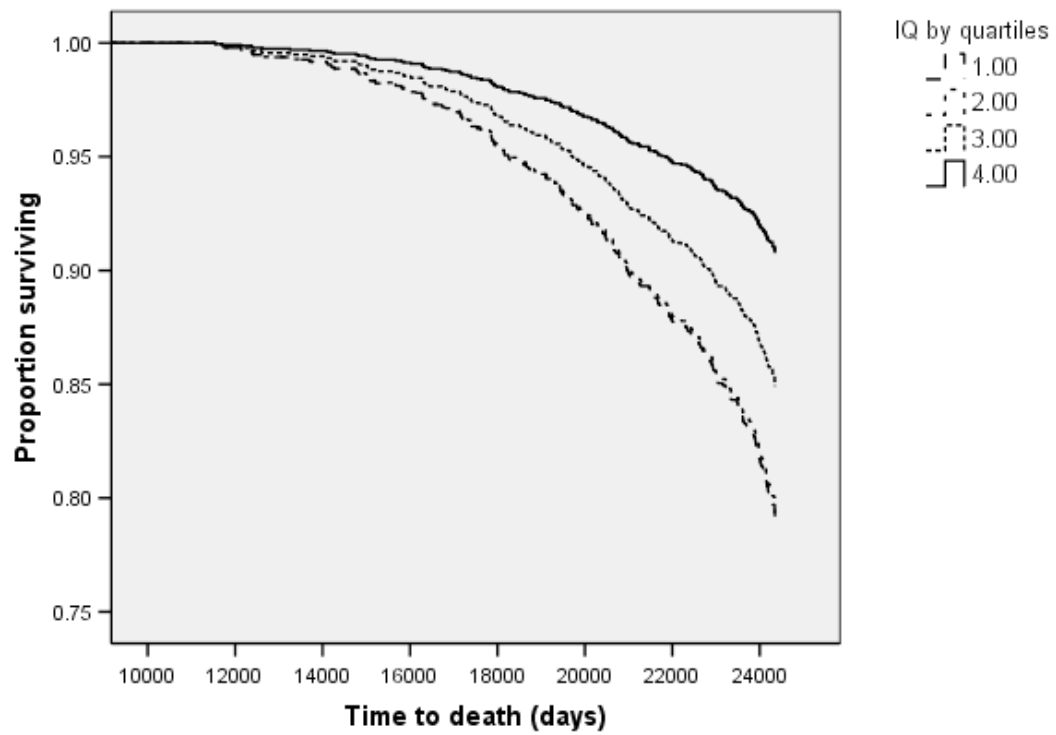
**Table 2**

Hazard ratios (95% CI) for mortality per SD increase in childhood Binet IQ and dependability. Hazard ratios are shown adjusted for sex and with further adjustment for each other characteristic in turn.

Adjustments	HR (95% CI) per SD increase in IQ	<i>p</i>	Percentage attenuation on adjustment	HR (95% CI) per SD increase in personality	<i>p</i>	Percentage attenuation on adjustment
Sex	0.70 (0.60-0.82)	<0.001	-	0.78 (0.67-0.90)	<0.001	-
Sex and each one of the following:						
Education	0.79 (0.67-0.93)	0.006	30%	0.81 (0.70-0.94)	0.005	14%
Height	0.73 (0.62-0.85)	<0.001	10%	0.80 (0.69-0.92)	0.002	9%
Weight	0.72 (0.62-0.85)	<0.001	7%	0.80 (0.69-0.93)	0.002	9%
BMI	0.73 (0.62-0.85)	<0.001	10%	0.80 (0.69-0.93)	0.003	9%
Home score	0.84 (0.67-1.05)	0.12	47%	0.77 (0.64-0.94)	0.010	5%
Father's social class	0.74 (0.63-0.87)	<0.001	13%	0.80 (0.69-0.92)	0.002	9%
Family size	0.72 (0.61-0.85)	<0.001	7%	0.78 (0.68-0.90)	0.001	0%
Overcrowding	0.75 (0.64-0.89)	0.001	17%	0.79 (0.69-0.92)	0.002	5%
Own social class	0.79 (0.66-0.94)	0.007	30%	0.80 (0.69-0.93)	0.003	9%
School attendance	0.73 (0.63-0.85)	<0.001	10%	0.79 (0.68-0.91)	0.001	5%
Illness in childhood	0.70 (0.60-0.82)	<0.001	0%	0.79 (0.68-0.91)	0.001	5%
Mother's age at child's birth	0.72 (0.62-0.85)	<0.001	7%	0.78 (0.68-0.91)	<0.001	0%

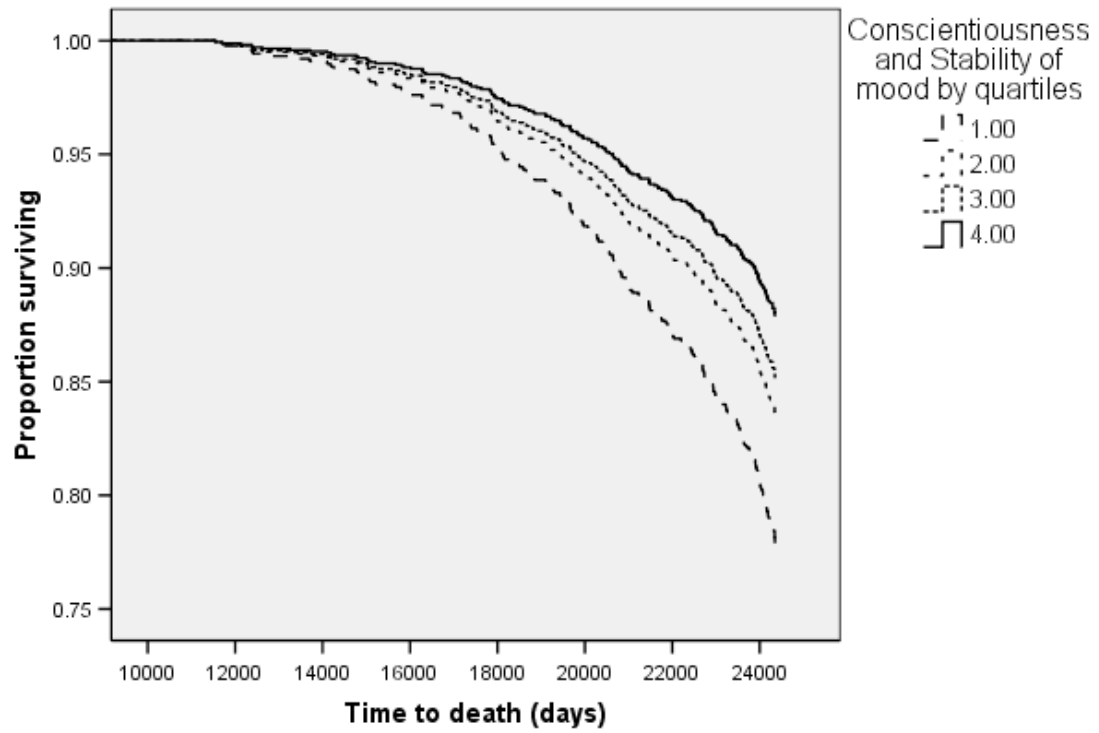
**Figure 1**

Probability of surviving over the follow-up period, adjusted for sex, according to quarters of Binet IQ at age 11.



**Figure 2**

Probability of surviving over the follow-up period, adjusted for sex, according to quarters of dependability at age 14.





**Figure 3**

Percentage of deaths in the follow-up period according to scores in the top and bottom halves of Binet IQ at age 11 and dependability at age 14.

