Neuroticism in Adolescence and Cognitive Function in Midlife in the British 1946 Birth Cohort: The HALCyon Program

Catharine R. Gale,¹ Ian J. Deary,² Diana Kuh,³ Felicia Huppert,⁴,⁵ Marcus Richards,³ and the HALCyon Study Team

¹Medical Research Council Epidemiology Resource Centre, University of Southampton, UK.  
²Centre for Cognitive Ageing and Cognitive Epidemiology, Department of Psychology, University of Edinburgh, UK.  
³Medical Research Council Unit for Lifelong Health and Ageing, University College London, UK.  
⁴Department of Psychiatry and ⁵Well-being Institute, University of Cambridge, UK.

We examined whether higher levels of neuroticism in adolescence were associated with poorer cognitive function in midlife in 2,071 members of the British 1946 birth cohort. Higher neuroticism at age 13 was associated with poorer performance on tests of verbal ability, verbal fluency, and verbal memory at age 53 in sex-adjusted analyses. However, higher neuroticism was also associated with poorer cognitive performance at age 8. After adjustment for childhood cognition or educational attainment, the associations between neuroticism at age 13 and midlife cognition ceased to be statistically significant. The link between neuroticism and subsequent cognitive ability may be a reflection of a long-standing correlation between the stable aspects of these traits since childhood, but further measurements of both traits are needed to confirm this.

Key Words: Personality—Neuroticism—Cognition—Life course and developmental change.

DATA from several prospective studies suggest that people who score higher on measures of neuroticism may have an increased risk of cognitive decline and Alzheimer’s disease (Wilson, Barnes, et al., 2005; Wilson, Bennett, et al., 2005; Wilson, et al., 2006; Wilson, et al., 2007). The underlying mechanisms are unclear, but individuals with higher neuroticism are more prone to experience negative life events and negative emotions (Larsen & Ketelaar, 1991; Magnus, Diener, Fujita, & Pavot, 1993; Ormel & Wohlfarth, 1991), and this cumulative exposure to chronic distress may have detrimental effects on the brain. Evidence from animal studies shows that long-term exposure to glucocorticoid hormones—released in response to stress—can lead to reductions in dendritic branching and synaptic density and permanent loss of neurons, particularly in the hippocampus, an area vital for memory and learning (Sapolsky, 1996). In humans, recurrent depression has been associated with atrophy of the hippocampus and anterior cingulate gyrus (Drevets et al., 1997; Sheline, Sanghavi, Mintun, & Gado, 1999). These findings imply that chronic distress may be linked with changes in the brain that have adverse effects on cognitive function.

Recent research suggests that the potentially detrimental effects of high neuroticism on late life cognitive function may be exacerbated if accompanied by low levels of extraversion. In a longitudinal study of more than 4,000 twins, risk of cognitive impairment at around age 70 was greatest in those who had both high scores for neuroticism and low scores for extraversion 25 years previously (Crowe, Andel, Pedersen, Fratiglioni, & Gatz, 2006). According to Gray’s (1981) theory of personality, people with both high neuroticism and low extraversion are likely to experience high-anxiety levels. This combination of personality traits is particularly common in people with anxiety disorders (Trull & Sher, 1994). The higher risk of cognitive impairment associated with this combination of traits in the twin study may therefore reflect the effect of chronic psychological distress (Crowe et al.).

One limitation of these studies is that they have not been able to take account of the potential confounding effect of cognitive ability much earlier in life when examining the relation between personality and subsequent cognitive impairment. Intelligence in childhood is a powerful influence on cognitive function later in life (Deary, Whalley, Lemmon, Crawford, & Starr, 2000; Deary, Whiteman, Starr, Whalley, & Fox, 2004). There is evidence that lower intelligence tests scores are associated with higher neuroticism in childhood (Harris, Vernon, & Jang, 2007). It is possible, therefore, that findings of a link between neuroticism and cognitive function later in life are more a reflection of an association between these traits in childhood than an indication of the effect of neuroticism on cognitive change. In the present study, we hope to contribute to the understanding of this issue by examining the relation between neuroticism at age 13 and cognitive function at age 53 in a cohort of men and women for whom data on childhood cognition are available. We hypothesized that any association between neuroticism in adolescence and midlife cognitive function would depend on cognitive ability present in childhood.
Any investigation into the link between personality in early life and later life cognitive function also needs to consider the roles that socioeconomic circumstances and educational attainment might play in this association. Childhood socioeconomic circumstances could be a potential confounding factor: Children from more disadvantaged social backgrounds tend as adults to score higher on measures of neuroticism (Bosma, van de Mheen, & Mackenbach, 1999) and lower on tests of cognition (Turrell et al., 2002). Higher educational attainment and higher socioeconomic status in adulthood have been associated with better cognitive performance in middle age (Hatch, Feinstein, Link, Wadsworth, & Richards, 2007; Singh-Manoux, Richards, & Marmot, 2005), and it is possible that these factors may mediate any effect of personality in early life on later life cognitive performance: There is evidence that aspects of childhood personality predict educational and occupational outcomes in adult life (Dubow, Huesmann, Boxer, Pulkkinnen, & Kokko, 2006; Shiner, Masten, & Roberts, 2003).

The HALCyon (Healthy Ageing across the Life Course) is a collaborative research program to investigate how cognitive capability in older people is affected by factors operating across the whole of life by using data from several U.K. cohorts. For this study, we used data from the British 1946 birth cohort (also known as the Medical Research Council [MRC] National Survey of Health and Development) to examine the relation between personality in adolescence and cognitive function at the age of 53 years, taking account of potential confounding or mediating factors.

METHODS

Sample

The MRC National Survey of Health and Development grew out of a maternity survey of all mothers who had a baby in England, Scotland, or Wales in a week in March 1946. A random social class–stratified sample of 5,362 participants, selected from all single legitimate births, has been followed up with more than 20 separate data collections up to the age of 53 years. All participants were White. The sampling procedure and follow-up have been described in detail elsewhere (Wadsworth, Kuh, Richards, & Hardy, 2006).

Personality

At age 13, participants completed the Pintner Aspects of Personality Inventory, which provides a measure of the child’s personality along the spectrums of neuroticism and extroversion or introversion (Pintner & Forlano, 1938, 1939; Pintner, Loftus, & Alster, 1937). The children were required to read 45 statements and indicate whether or not each statement was true of them. The measure was originally validated by comparing scores with the outstanding characteristics of children reported by their teachers (Pintner & Forlano, 1939). When it was readministered to 10- to 11-year-old children, test–retest reliability ranged from .61 to .83 (Pintner & Forlano, 1938). Cronbach alpha for “Neuroticism” and “Extroversion” in the present data were .69 and .45, respectively. In view of the poor psychometric properties of the extraversion scale, we restricted our subsequent analyses to the neuroticism scale only.

Cognitive Function

At age 8, survey participants took four tests devised by the National Foundation for Educational Research (Pidgeon, 1964): reading comprehension (sentence completion), pronunciation, vocabulary, and nonverbal reasoning. Test–retest reliability on these tests ranged from .86 to .96 (Pidgeon). Correlations between scores on these tests ranged from .54 to .87. We therefore summed the raw scores to obtain an overall score representing general cognitive ability in childhood, as has been done in previous studies of this cohort (Richards, Hardy, Kuh, & Wadsworth, 2001). At age 53, participants took a test of verbal fluency (animal naming), which provides a measure of executive function, a test of memory (a 3-trial 15-item word list), and a test of speed and concentration (timed letter search). In addition, they took the National Adult Reading Test (NART; Nelson & Willison, 1991), a test of verbal ability requiring the pronunciation of 50 irregular words of increasing difficulty. Test–retest reliability of the NART is .98 (Nelson & Willison, 1991). As these four tests assess different domains of cognition and these vary in the extent to which they are affected by age-related pathology, we analyzed scores on each test separately.

Socioeconomic Status and Educational Attainment

Socioeconomic position in childhood was represented by father’s occupational social class. Socioeconomic position in adulthood was represented by occupational social class at age 43, based on current or most recent occupation. Social class was classified as professional, managerial, intermediate, skilled manual, semiskilled manual, or unskilled, according to the Registrar General’s classification (Office for National Statistics, 1990). Educational attainment was defined by highest academic qualification and their vocational equivalent attained by age 26 and was classified as none, vocational only, ordinary secondary (O levels), advanced secondary (A levels), or degree level or equivalent.

Statistical Analysis

We used correlation coefficients to examine the characteristics of the participants. Spearman correlations were used for categorical variables and point biserial correlations for binary variables. We used multivariate analysis of variance to examine whether neuroticism at age 13 was associated overall with the four cognitive test scores at age 53 as...
separate examination of each cognitive test increases the risk of Type I error. We subsequently used multiple linear regression to examine the associations between neuroticism and scores on each of the four cognitive tests at age 53, with adjustment for covariates. This method of analysis allows for multiple intercorrelated outcomes. Preliminary analyses showed that the results did not differ by sex, so we analyzed men and women together, adjusting for sex. Regression coefficients (95% confidence intervals [CIs]) for the differences in each standardized cognitive test score for a standard deviation increase in neuroticism scores are shown adjusted for sex and with further adjustment for other potentially confounding or mediating factors. Cognitive ability at age 8 and father’s social class were viewed as potential confounders and educational attainment and own social class as potential mediators of the relation between personality in adolescence and cognitive function at age 53.

To explore whether loss to follow-up might have produced selection bias, we carried out a sensitivity analysis in which we used multiple multivariate imputation (Royston, 2004), using neuroticism and cognition variables together with sex, educational attainment, paternal, and own social class, to impute values in any variables with missing data among the 5,362 individuals who took part in the initial survey. We used switching regression in STATA software (Royston) and carried out 20 cycles of regression switching and generated 20 imputation data sets. The multiple multivariate imputation approach creates a number of copies of the data (in this case 20 copies) each of which has missing values imputed based on available data and with an appropriate level of randomness using chained equations. The final estimates are obtained by averaging across the estimates from each of these 20 data sets using Rubin’s rules and taking into account the uncertainty in the imputation as well as uncertainty due to random variation.

**Results**

In total, 3,035 of the original participants took part in the follow-up at age 53. Of these, 2,071 (68%) had complete data on neuroticism at age 13, cognitive function at age 8 and 53, and the covariates. Compared with the participants with complete data, those with missing data were less likely to come from a nonmanual social class background in childhood (31% vs. 43%, p < .001) and had lower mean scores for overall cognitive ability at age 8 (mean [SD] 21.0 [7.57] vs. 22.7 [6.71], p < .001) and for each of the component subtests (reading comprehension, pronunciation, vocabulary, and nonverbal reasoning), but there were no significant differences in levels of neuroticism at age 13.

Table 1 shows the correlations between neuroticism at age 13 and other characteristics in childhood and adult life. Participants who had lower scores for neuroticism at age 13 tended to have higher cognitive ability in childhood, higher educational attainment by age 26, and a more advantaged socioeconomic background either in childhood or at age 43. Lower levels of neuroticism were associated with higher scores on the tests of verbal ability, verbal fluency, and verbal memory at age 53. By contrast, higher neuroticism was associated with better (faster) performance on the test of search speed. Female participants tended to have higher levels of neuroticism.

Multivariate analysis of variance of neuroticism at age 13 in relation to scores on the four tests of cognitive function at age 53 showed an overall association of neuroticism with cognitive function (all multivariate criteria—Wilks’ lambda, Pillai’s trace, Lawley-Hotelling trace, and Roy’s largest root—p < .001). Table 2 shows associations between neuroticism at age 13 and standardized scores on each test of cognitive function at age 53 after adjustment for covariates in multivariate multiple linear regression. Results are expressed as regression coefficients (95% CI) for a standard deviation increase in neuroticism. In analyses adjusting for sex, scores on tests of verbal ability, verbal fluency, and verbal memory, though not search speed, were significantly lower in people who were higher in neuroticism at age 13. Further adjustment for potential confounding and mediating factors weakened these associations to varying degrees, with cognition at age 8 and educational attainment having the strongest, and similar, attenuating effects. After adjustment for either variable, the associations between neuroticism and verbal ability and verbal fluency ceased to be statistically significant. The relation between neuroticism and verbal
memory persisted after adjustment for cognition at age 8 but was attenuated and no longer statistically significant after adjustment for educational attainment and further weakened by full adjustment for all covariates. Adjustment tended to strengthen the relation between neuroticism and search speed, such that higher neuroticism was associated with significantly faster search speed after full adjustment, but the size of the association was very modest. Higher neuroticism in adolescence was associated with lower educational attainment by age 26 and being in a more disadvantaged social class at age 43 (see Table 1; The association between neuroticism in adolescence and educational attainment \([r = −.11, p < .001]\) was only slightly attenuated when controlled for childhood cognition \([r = −.06, p < .001]\), but the association between neuroticism in adolescence and social class at age 43 \([r = .04, p = .03]\) was markedly reduced by this adjustment \([r = .001, p = .960]\)

Both these factors were strongly predictive of poorer performance on all four tests of cognition at age 53 and remained so after adjustment for neuroticism. Table 2 shows that the small effect of neuroticism on verbal ability and verbal memory, and to a lesser extent verbal fluency, at age 53 was attenuated when adjusted for either social class at age 43 or, more particularly, educational attainment by age 26, suggesting that these factors partially mediated the associations.

To explore whether loss to follow-up might have affected our findings on neuroticism in adolescence in relation to later life cognition, we repeated our analyses using the imputation data sets for the 5,362 individuals who took part in the initial survey. Table 3 shows multivariable-adjusted regression coefficients for a standard deviation difference in cognitive test scores at age 53 for a standard deviation increase in neuroticism at age 13, before and after imputation of missing data. The results obtained after imputation were virtually the same as those obtained in the sample of 2,071 people with complete data.

**Discussion**

In this study of men and women followed up since birth, people with a greater propensity to distress in adolescence, as indicated by higher neuroticism, had slightly lower scores on tests of verbal ability, verbal fluency, and verbal memory at age 53 but they also scored lower on tests of cognitive ability at age 8. After adjustment for childhood cognition, educational attainment, and adult social class, the links between higher neuroticism and poorer performance at verbal ability, verbal fluency, and verbal memory at age 53 disappeared.

**Comparison With Other Studies**

Several cross-sectional studies have found that there is a modest inverse association between performance on tests of cognition in childhood, adulthood and in later life, and levels of neuroticism (Ackerman & Heggestad, 1997; Austin, Hofer, Deary, & Eber, 2000; Harris et al., 2007; Jorm et al., 1993; Meier, Perrig-Chiello, & Perrig, 2002; Schaeie, Willis,

Table 2. Regression Coefficients (95% CI) for the Difference in Standardized Cognitive Test Scores at Age 53 per Standard Deviation Increase in Neuroticism Scores at Age 13, Adjusted for Sex and Other Covariates

<table>
<thead>
<tr>
<th>Adjustments</th>
<th>Verbal ability</th>
<th>Verbal memory</th>
<th>Verbal fluency</th>
<th>Search speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>−0.09 (−0.13 to 0.05)**</td>
<td>−0.09 (−0.13 to 0.05)**</td>
<td>−0.04 (−0.09 to 0.001)*</td>
<td>0.03 (−0.01 to 0.08)</td>
</tr>
<tr>
<td>Sex and each of the following</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal social class</td>
<td>−0.05 (−0.09 to 0.01)**</td>
<td>−0.06 (−0.10 to 0.02)**</td>
<td>−0.03 (−0.07 to 0.02)</td>
<td>0.04 (−0.001 to 0.08)</td>
</tr>
<tr>
<td>Cognition age 8</td>
<td>−0.02 (−0.05 to 0.01)</td>
<td>−0.04 (−0.08 to 0.02)</td>
<td>−0.01 (−0.05 to 0.03)</td>
<td>0.05 (0.01 to 0.10)*</td>
</tr>
<tr>
<td>Educational attainment age 26</td>
<td>−0.02 (−0.06 to 0.02)</td>
<td>−0.04 (−0.08 to 0.02)</td>
<td>−0.01 (−0.05 to 0.03)</td>
<td>0.05 (0.01 to 0.10)*</td>
</tr>
<tr>
<td>Social class age 43</td>
<td>−0.05 (−0.09 to 0.01)**</td>
<td>−0.06 (−0.10 to 0.02)**</td>
<td>−0.03 (−0.07 to 0.02)</td>
<td>0.04 (−0.001 to 0.08)</td>
</tr>
<tr>
<td>All covariates</td>
<td>0.01 (−0.03 to 0.04)</td>
<td>−0.02 (−0.05 to 0.02)</td>
<td>0.01 (−0.04 to 0.05)</td>
<td>0.06 (0.02 to 0.10)**</td>
</tr>
</tbody>
</table>

Notes: CI = confidence interval.

***p < .001; **p < .01; *p < .05.

Table 3. Multivariable-Adjusted Regression Coefficients for Difference in Standardized Cognitive Test Score at Age 53 per Standard Deviation Increase in Neuroticism Scores at Age 13, Before and After Imputation of Missing Data

<table>
<thead>
<tr>
<th>Neuroticism</th>
<th>Verbal ability</th>
<th>Verbal memory</th>
<th>Verbal fluency</th>
<th>Search speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before imputation</td>
<td>0.01 (−0.03 to 0.04)</td>
<td>−0.02 (−0.05 to 0.02)</td>
<td>0.01 (−0.04 to 0.05)</td>
<td>0.06 (0.02 to 0.10)**</td>
</tr>
<tr>
<td>After imputation</td>
<td>0.01 (−0.02 to 0.04)</td>
<td>−0.02 (−0.06 to 0.01)</td>
<td>0.01 (−0.04 to 0.03)</td>
<td>0.06 (0.02 to 0.10)**</td>
</tr>
</tbody>
</table>

Notes: CI = confidence interval.

*Adjusted for sex, paternal social class, educational attainment at age 26, and social class at age 43.

bN = 2,071 before imputation and n = 5,362 after imputation.

***p < .001; **p < .01; *p < .05.
Interpretation of such cross-sectional associations in old age is complicated by the possibility that awareness of declining mental abilities may itself increase symptoms of depression and anxiety and make people more likely to endorse neuroticism. Some prospective studies of older people have shown significant links between higher levels of neuroticism and increased risk of cognitive decline and of Alzheimer’s disease (Wilson, Barnes, et al., 2005; Wilson, Bennett, et al., 2005; Wilson, et al., 2006; Wilson, et al., 2007), though this is not a consistent finding (Hultsch, Hertzog, Small, & Dixon, 1999; Jelicic et al., 2003; Wetherell, Reynolds, Gatz, & Pedersen, 2002). One recent case–comparison study using informer ratings of personality found that women with higher neuroticism in midlife had a younger age at onset of dementia but no such association was observed in men (Archer et al., 2009).

In the present study, initial analyses suggested that men and women with higher levels of neuroticism at age 13 had slightly poorer cognition in several domains at age 53. Adjustment for cognition at age 8 had a marked attenuating effect. Adjustment for educational attainment, itself in large part a consequence of childhood cognitive ability (Deary, Strand, Smith, & Fernandes, 2007), also weakened the associations to a similar degree. Previous studies of the relation between neuroticism and cognitive function in older people have not been able to take account of childhood cognition, but in three prospective studies, associations between higher neuroticism and risk of cognitive decline (Wilson, Bennett, et al., 2005; Wilson, et al., 2007) or Alzheimer’s disease (Wilson, et al., 2006) persisted after adjustment for educational attainment.

One explanation for the discrepancy between our findings and those of previous studies might lie in the far younger age at which personality was assessed in this cohort. Neuroticism assessed by self-report at age 13, a time when self-concept may still be developing, may only partially reflect levels of these traits assessed in adulthood (Costa & McCrae, 1994). Although there is considerable evidence for continuity in personality over time (Caspi & Silva, 1995; Martin, Friedman, & Schwartz, 2007)—largely derived from investigation of stability and change at the aggregate level—studies using individual growth modeling of personality trait trajectories suggest that there are interindividual differences in intraindividual change, with some people remaining stable in neuroticism over time, whereas others change (Mroczek & Spiro, 2003; Vaidya, Gray, Haig, Mroczek, & Watson, 2008).

In studies that found associations between higher neuroticism and risk of cognitive decline or dementia, neuroticism and cognition were assessed at markedly older ages than in the present study (Wilson, Barnes, et al., 2005; Wilson, Bennett, et al., 2005; Wilson, et al., 2006; Wilson, et al., 2007). It may be that if neuroticism does have some detrimental effect on cognitive aging, its impact is predominant in later life. Studies in rats show that at older age, there is less plasticity of the brain monoaminergic system and an impaired ability to terminate the hypothalamic-pituitary-adrenal response to stress (Pardon & Rattray, 2008), which could make the brain more vulnerable to stress-induced impairment. Future studies of cognitive decline in this cohort will be able to explore whether susceptibility to the influence of chronic distress increases as individuals move into their 60s and beyond.

Consistent with many other studies across the age range, we found that neuroticism scores tended to be higher in women than in men (Jorm, 1987). These sex differences are present in nearly all cultures and do not appear to be due to differential sensibility to emotional experience (Costa, Terracciano, & McCrae, 2001). Such differences might reflect a greater willingness among women to express distress, although findings from a U.S. study that men were no less ready than women to report distress (Fujita, Diener, & Sandvik, 1991) makes it unlikely that the gender bias in neuroticism is purely artefactual.

Strengths and Limitations

The strengths of our study include its size and the availability of longitudinal data, including prospective information on potential confounding factors, such as cognitive ability and socioeconomic position in childhood. It also has some limitations. First, there has inevitably been some attrition in the cohort over time. Men and women who were included in our study had higher cognitive ability in childhood and a larger proportion had fathers in nonmanual occupational social classes than those who were excluded due to incomplete data, though there was no difference in neuroticism between these groups. However, results of analyses using imputation of missing data suggest that loss to follow-up has not affected the generalizability of our findings. Second, although the Pintner Personality Inventory includes items on extraversion, the psychometric properties of the extraversion scale in these data were poor, so we were unable to examine whether the relation between neuroticism and subsequent cognition was moderated by level of extraversion, as suggested in an earlier study (Crowe et al., 2006). Finally, cohort members completed the Pintner Aspects of Personality Inventory only once, in early adolescence. It was not therefore possible to assess the degree of stability of neuroticism over time using this measure or to examine whether changes in this trait were associated with changes in cognition, although previous findings in this cohort that high scores on the Pintner neuroticism scale at age 13 were associated with an increased risk of psychiatric disorder at both 36 and 43 years suggest that this measure is a good indicator of long-term propensity to distress (Paykel, Hayhurst, Abbott, & Wadsworth, 2001).

In this longitudinal study, we found that the link between higher neuroticism in adolescence and slightly poorer scores...
on tests of cognitive function in midlife appeared to be dependent on cognitive ability present in childhood. The association may be a reflection of a long-standing correlation between the stable aspects of these traits since childhood, but the lack of repeated measures of both neuroticism and cognition makes it impossible to confirm that. Follow-up of this cohort into later life will show if neuroticism at age 13 has any long-term implications for the maintenance of cognitive abilities.

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**Correspondence**
Address correspondence to Catharine Gale, PhD, MRC Epidemiology Resource Centre, University of Southampton, Southampton General Hospital, Southampton SO16 6YD, UK. Email: cgr@nrec.soton.ac.uk

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