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Does IQ Vary Systematically with All Measures of Socioeconomic Status in a Cohort of Middle-Aged, and Older, Men?

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Differences in IQ have been offered as an explanation for socioeconomic gradients in morbidity and mortality. Previous research has largely relied on linking education and conscription testing data with later life health. As this early life testing was used to determine a person's academic path it is difficult to disentangle the effects of IQ from education. This study used IQ and socioeconomic status (SES) data collected concurrently in mid-life from men who did not experience IQ-test-driven career path direction in early life. If IQ is associated with SES generally then multiple domains of IQ it will be associated with all components of SES. In a subsample of men aged 35 - 80 (n = 287) from the Florey Adelaide Male Ageing Study, we evaluated relationships between each of four domains of cognitive ability (IQ domains): fluid (Gf); crystallised (Gc); visual/spatial (Gv) and processing speed (Gs). SES was measured as standardized education, income, occupational prestige and deprivation score. Age-adjusted linear regression was used to test each SES-z-score individually against each IQ domain. Then all four SES measures were included in a single model for each IQ domain. This study found that a panel of standard IQ tests were positively associated with attained education but not with income or area-level deprivation score. Two IQ abilities, Gf and Gc, were also associated with occupational prestige score. These associations suggest that lesser levels of health associated with lower socioeconomic status is not accounted for by a lesser innate ability and that intervention may be possible.

Keywords: Intelligence; Social Class; Health Inequalities; Socioeconomic Status

Introduction

Socioeconomic gradients in morbidity and mortality are well established; each step in the socioeconomic hierarchy has poorer health, shorter life expectancy and earlier onset of disease than the step above (Marmot, 2004). Although the term "socioeconomic" makes it clear that material deprivation is a major contributor at the bottom of the social hierarchy, it is less clear why, even in economically well-off populations, differences can still be found through middle and into higher social positions. Differences in IQ have been offered as an explanation (Batty, Deary, & Gottfredson, 2007) and the area of research has been dubbed "cognitive epidemiology" (Deary & Batty, 2007). Intelligence quotient (IQ), is considered to index, albeit imperfectly, innate cognitive ability.

If cognitive ability, as indexed by IQ, is a fundamental driver of socioeconomic gradients in health and is not only acting via education, then, at least within a gender, it should also be graded across multiple measures of social position. Cognitive epidemiologists support their hypothesis with the observation that scores on IQ tests are worse the lower the social status (Neisser et al., 1996) and it is presumed that people with low IQ are unable to understand health education messages. A systematic review of scores from childhood and early adulthood found that tests taken at either time are associated with greater later mortality (Calvin et al., 2011). Proponents of the hypothesis also note that low IQ is "clustered" with a set of measures of low social standing (Deary, Batty, Pattie, & Gale, 2008). There are several problems with this argument. First, higher IQ is associated with greater educational attainment which suggests a possible effect at the upper end of the socioeconomic spectrum as well as the bottom. Also, many of the IQ tests used in the previous research were used to stream children or young adults into graded academic pathways (Pearce, Deary, Young, & Parker, 2006: pp. 1-21; Hemmingsson, Essen, Melin, Allebeck, & Lundberg, 2007: p. 1412) which suggests a clear link between educational attainment and social position, but makes it difficult to separate the effects of IQ from education in producing socioeconomic gradients in health.

There is also a significant body of research demonstrating that the IQ scores, as opposed to cognitive abilities, of the entire population have increased steadily throughout the twentieth century to the present (the Flynn effect (Flynn, 1987)) and the tests have to be frequently "renormed" to keep the mean IQ score for the population at 100. While the health of the entire population has improved socioeconomic gradients in health have not declined in any substantive way over this same period of time (Queensland University of Technology & Australian

Institute of Health and Welfare, 2004). Also, education is not the only pathway to high income and presumably, high social position.

Social position, socioeconomic status (SES), and social class, are all terms used to describe the phenomenon that humans tend to sort themselves into social hierarchies. Research within sociology and population health has demonstrated that social position results from a number of measurable aspects of modern Western society including gender, educational attainment, income, occupational prestige and area-level measures of aggregate advantage/disadvantage, and these factors are strongly correlated (Liberatos, Link, & Kelsey, 1988). The key finding for health is that morbidity and mortality tend to be graded across any measure of social position as do the risk factors for disease (Marmot, 2004).

The IQ data used in cognitive epidemiology research largely consists of childhood IQ measures (collected between ages 7 and 14) and from armed forces conscription-testing conducted in early adulthood. A body of research has found that childhood IQ measures are significantly associated with parental measures of social position such as occupation (Batty & Deary, 2005; Chandola, Deary, Blane, & Batty, 2006; Lawlor, Batty, Clark, McIntyre, & Leon, 2008; Pearce et al., 2006), attained education level (Chandola et al., 2006; Lawlor et al., 2006), childhood family income (Lawlor et al., 2006), area-level deprivation (Hart et al., 2003); and also with attained education (Chandola et al., 2006; Lager, Bremberg, & Vagero, 2009; Lawlor et al., 2008) and attained occupational status (Chandola et al., 2006; Hart et al., 2003). IQ measures from conscription cohorts have also been shown to be associated with paternal occupation (Batty, Deary, Tengstrom, & Rasmussen, 2008; Batty, Gale, Tynelius, Deary, & Rasmussen, 2009; Hemmingsson et al., 2007), attained education (Batty, Shipley, et al., 2008), attained occupational status (Hemmingsson et al., 2007), and mid-life income (Hemmingsson et al., 2007). As these education and conscription tests were used to determine socioeconomic pathways providing access to more academically-focused schools or placing the respondent at officer positions in the armed forces (Hemmingsson et al., 2007; Pearce et al., 2006) it is difficult to determine whether early life labelling or actual ability was the driving factor for a person's mid-life social position.

IQ is, conceptually, more complex than just the tests used in educational or conscription assessments. Contemporary IQ theory has converged into a model that is sometimes called CHC theory (Carroll, 1993, Horn & Cattell, 1966, Horn & Noll, 1997). This model comprises, depending on the level of analysis, approximately eight broad abilities, some of which are: fluid ability (Gf), the basic processes of reasoning; crystallized ability (Gc), the breadth of knowledge, experience, learning, and acculturation; visual ability (Gv), the perception and processing of visual form and spatial relationships; and cognitive processing speed (Gs), the rapid cognitive processing of information. Abilities considered to be less related to education (Gf, Gv, Gs) are less likely to be used in the data sets used by cognitive epidemiology research because much of this research utilizes pre-existing data from educational and conscription testing. Therefore, the relationship between SES and a wider array of cognitive abilities has not been broadly tested. Those abilities that are less linked to education would be a better test of the cognitive epidemiology hypothesis that socioeconomic position is tied to IQ.

One aspect of IQ, crystalized ability (Gc), is considered to be stable over time and shows little change with aging. This can be confirmed if the relationship between IQ and SES holds into middle age. Deary and colleagues (Deary, Whiteman, Starr, Whalley, & Fox, 2004) had 80-year old study participants complete the same tests at age 11 and again at age 80. The substantial content of these tests was similar to the measures of modern crystallised ability (Gc) tests. The researchers found a moderate-to-high correlation between the two tests of 0.66 which demonstrates reasonable stability. The researchers subsequently found that childhood IQ was related to mortality before age 65 but not thereafter (Hart et al., 2005). In their report the authors highlighted the problem with testing the elderly where it is hypothesized that people with low IQ are less likely to have survived into old age and are therefore not available for testing. In another study of older adults researchers measured verbal and numeric abilities (similar to Gc) at ages 56 and 78. The researchers also found high correlations between the IQ abilities between the two time points (all $r > 0.73$) (Deary, Allerhand, & Der, 2009). They then analysed the impact of adding IQ to statistical models using different SES measures to explain health outcomes and found that IQ had the greatest effect in reducing the size of the association for education and the least effect for area-level deprivation. They also found that the magnitude of the effect of IQ on reducing the association between SES and health varied greatly by health outcome (Batty, Der, Macintyre, & Deary, 2006). This does not support the idea of a generalised role for IQ in explaining health inequalities.

In summary, childhood and early adulthood IQ have been shown to be associated with mortality but much of the evidence is derived from IQ testing used to direct people onto more- or less-academic pathways making it difficult to determine whether innate ability (IQ) or the economic advantage of education is driving the associations. Evidence from a population where education was not the only pathways to high social position needs to be assessed. And, given that there is a modest relationship between early and late life IQ, does the IQ-SES relationship still hold in mid-life?

We examined the following questions in a group of middle-aged Australian men for whom education was not the only pathway to socioeconomic success.

1) Does a relationship between IQ and SES exist in middle-aged and older men?

2) Is IQ associated with any other measures of SES than education?

Methods

Participants

Data were from a sub-study of the Florey Adelaide Male Aging Study (FAMAS). FAMAS is a multidisciplinary population-based cohort study examining the health and health behaviours of 1195 randomly selected men, 35 - 80 years, living in the northwest regions of Adelaide, Australia (Martin et al., 2007). The study was begun in 2002 and the participants are periodically re-examined or sent updating questionnaires. Between Dec 2005 and Feb 2007 all participants were invited to participate in a sub-study and 300 men (aged 37 - 83) volunteered to complete an extensive battery of tests assessing cognitive abilities. The FAMAS cohort is representative of the male population from which it was drawn (Martin et al., 2007) and this sub-cohort did not differ for age, country of origin, marital

status, employment status, or annual income. Compared with the source population, the entire FAMAS cohort does have a greater proportion of men with post-secondary qualifications, in particular university qualifications (Martin et al., 2007) while this sub-cohort had a slightly greater proportion with post-high school, non-university qualifications such as trade qualifications (see **Table 1**).

This study was approved by the Human Research Ethics Committee of the Royal Adelaide Hospital. All subjects gave written informed consent.

Measurements

Cognitive ability was measured with eleven tests selected to measure four broad domains of ability; these were administered during a single session. The test- battery consisted of:

1) Two measures of fluid ability (Gf): i) Comprehensive Ability Battery—Inductive Reasoning; (Hakstian & Cattell, 1975); and ii) Standard Raven Progressive Matrices (Raven, Raven, & Court, 1998). Gf involves reasoning and problem solving often with novel stimuli and is linked to cognitive complexity (Schrank, 2005).

2) Three measures of crystallised ability (Gc): i) the Spot the Word Test; ii) Mill Hill Vocabulary Scale—Senior Form ((Raven et al., 1998); and iii) the Information subtest of the WAIS-R (Australian Adaptation, (Wechsler, 1981)). Gc is sometimes referred to as acculturated knowledge.

3) Three measures of visuospatial ability (Gv): i) Comprehensive Ability Battery—Flexibility of Closure; ii) Mental Rotations Test (Vandenberg & Kuse, 1978); and iii) Space Relations: Paper Folding. Gv is the ability for apprehension of spatial forms, often involving their manipulation or rotation in imagination (Schrank, 2005).

4). Three measures of speed of processing (Gs) were used: i) WAIS-R Digit Symbol; ii) Woodcock-Johnson III—Visual Matching; iii) Woodcock-Johnson Revised—Cross Out Subtest (Schrank, 2005). Gs is a measure of speed of processing and involves the ability to perform quickly and automatically with either over-learned or novel stimuli (Schrank, 2005).

A measurement model was fitted as shown in **Figure 1** using MPlus v6.0 (Muthén & Muthén, 2010). All loadings and the covariances of the four latent variables were statistically significant and the fit of the model was excellent ($\chi^2(38) = 58.1$, $p = .019$, CFI = .99, TLI = .98, SRMR = .036, RMSEA = .043, CI90 = (.018, .064). An attempt to estimate a higher-order g-factor was not successful with the higher-order g being identical with Gf, a common occurrence (Undheim & Gustafgsson, 1987). Standardised intelligence tests are age-normed; an individual's score is referenced to the average score obtained by people of their age in a large population-representative samples. For any age, the mean IQ is defined as 100 and the standard deviation is 15. However, in this analysis we used latent variable scores derived from raw scores from the tests, adjusted only for age at time of testing on the basis that different abilities have different age trajectories (Salthouse, 2004).

Socioeconomic status (SES) was measured with education, income, occupational prestige and an area-level measure. Education was assessed as the highest level attained: less than or equal to high school (reference); trade/apprenticeship; certificate/diploma; university. Household income categories were (in thousands of Australian dollars): up to 20 (reference); increasing in increments of 20, up to 80-or-more. The occupational title supplied by the respondent was coded to the ANU4 scale (Jones 2001) developed for Australian Occupations. Area-level SES was based on one of the Socio-Economic Indexes for Areas (SEIFA) scores, developed by the Australian Bureau of Statistics, which are derived from postcode information (Australian Bureau of Statistics, 2003). The Index of Relative Socio-Economic Disadvantage (SEIFA-dis) was used in this analysis. For analysis all SES measures were converted to z-scores with a mean of zero and a standard deviation of one.

Table 1.
Descriptive Statistics of the Study Cohort by to age group (mean (SD) or n(%)).

Education n (%)	
<= high school	63 (22.0%)
Trade/apprenticeship	91 (31.7%)
Diploma/certificate	81 (28.2%)
university	52 (18.1%)
Income in thousands of Australian dollars n (%)	
<12/year	20 (7.0%)
12 - <20/year	43 (15.0%)
20 - <30/year	35 (12.2%)
30 - <40/year	40 (13.9%)
40 - <50/year	36 (12.5%)
50 - <60/year	28 (9.8%)
60 - <80/year	37 (12.9%)
80+	48 (16.7%)
Index of Relative Socio-economic Disadvantage	
mean (SD)	961.6 (78.7)
ANU4 Occupation Score	
mean (SD)	45.0 (22.5)

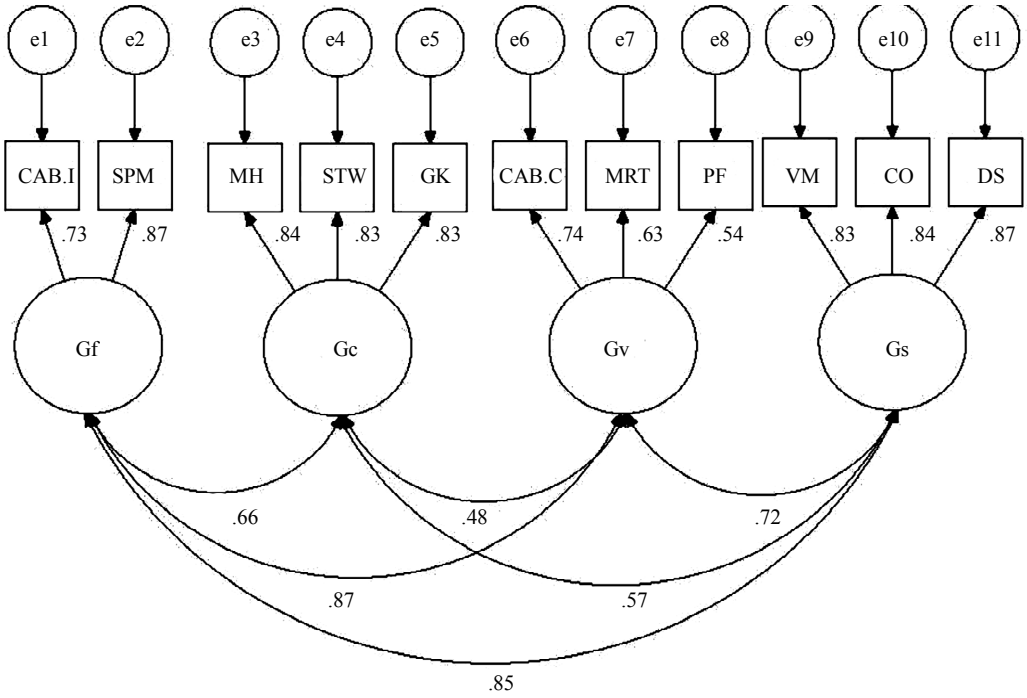
Statistical Analysis

Linear regression was used to test each SES-z-score individually against each IQ domain (16 regressions). Then all four SES measures were included in a single model for each IQ domain. All regressions also included age as a continuous variable. Stata /IC 11.0 was used in all analyses (Statacorp, College Station, TX, USA). Results are presented as unstandardised coefficients and 95% confidence intervals.

Results

Table 1 describes 287 men who had complete data and were included in the analysis. Approximately one-fifth each had a high school or less education or a university education. Seven percent reported an income of less than 12,000 Australian dollars per year. As expected education was strongly correlated with all the IQ abilities as were income and occupation (**Table 2**). Income had the lowest correlation with Gc while Gv and Gs had low correlations with occupation. Area-level SES was correlated only with Gc.

In the age-adjusted models that examined the relationship between each ability and each SES measure all models but one



CAB.I = Inductive Reasoning; SPM = Standard Progressive Matrices; MH = Mill Hill Vocabulary Test; STW = Spot-the-Word; GK = General knowledge; MRT = Mental Rotation Test; PF = Paper Fodling; VM = Visual Matching; CO = Cross Put; Ds = Digit Symbol.

Figure 1.
Measurement model for four latent variables showing standardised parameter estimates.

Table 2.
Selected Pearson's Correlation Coefficients (p) between the Standardized SES variables and the IQ ability factors (n = 287).

	1	2	3	4
1) Education				
2) Income	0.22			
	<0.001			
3) Occupation	0.49	0.23		
	<0.001	<0.001		
4) SEI	0.12	0.18	0.21	
	0.047	0.002	<0.001	
Gf	0.39	0.37	0.24	0.11
	<0.001	<0.001	<0.001	0.07
Gc	0.40	0.19	0.35	0.14
	<0.001	0.002	<0.001	0.014
Gv	0.35	0.34	0.17	0.08
	<0.001	<0.001	0.004	0.160
Gs	0.32	0.40	0.18	0.10
	<0.001	<0.001	0.030	0.085

found a significant relationship between the ability and the SES domains (**Table 3**). Gv was not associated with income.

When all the SES and ability measures were included in the same age-adjusted model education was statistically significant for each IQ domain and occupational prestige was statistically significant in the models for Gf and Gc (**Table 3**). Neither income nor area-level disadvantage score was statistically significantly associated with IQ in any of the multivariate models.

Discussion

Main Findings of This Study

Education, in this cohort of men was not the only path to higher income (and presumably a higher SES).We found that age-adjusted latent-variable-ability scores were primarily associated with higher education when all SES measures were included in the regression model. Two IQ abilities, Gc and Gf, were also associated with occupational prestige. These findings do not support the view that socioeconomic gradients in health can be explained by gradients in IQ.

What Is Already Known on This Topic

By using data from a population that were not streamed into educational/career pathways based on their results from IQ tests we were able to test whether there was any the relationship between innate ability and SES attainment in life. We did not observe an association between multiple domains of intelligence test scores with all measures of socioeconomic status. Our results suggest that previous research indicating IQ associations with health may have been largely driven by the strong relationship between IQ and education and not by a relationship between low cognitive ability and low social position. The majority of the research body in this area has focused on life-course pathways that might link earlier life circumstances with later life health and thus is not strongly comparable to this piece of work. The only other study to compare IQ and SES collected concurrently in middle-age was the West of Scotland Twenty-

Table 3.
Linear Regression of each ability factor score with individual standardized SES measures (n = 287).

	Latent ability variable association with each individual SES variable adjusted for age			Latent ability variable association in full model with all SES variables and adjusted for age		
			Fluid IQ			
Standardized SES	**b**	**95% CI**	***p***	**b**	**95% CI**	***p***
Education	0.42	0.29, 0.54	<0.001	0.31	0.17, 0.45	<0.001
Income	0.19	0.03, 0.35	0.018	0.02	–0.13, 0.17	0.793
Occupational prestige	0.39	0.26, 0.51	<0.001	0.18	0.03, 0.33	0.018
Area-level SES	0.18	0.04, 0.31	0.010	0.10	–0.03, 0.23	0.135
			Crystallized IQ			
	b	**95% CI**	***p***	**b**	**95% CI**	***p***
Education	1.43	1.03, 1.83	<0.001	1.01	0.55, 1.47	<0.001
Income	0.58	0.07, 1.10	0.025	–0.02	–0.52, 0.47	0.932
Occupational prestige	1.40	0.99, 1.82	<0.001	0.77	0.25, 1.26	0.002
Area-level SES	0.58	0.14, 1.02	0.010	0.31	–0.10, 0.73	0.141
			Visual Spatial IQ			
	b	**95% CI**	***p***	**b**	**95% CI**	***p***
education	0.50	0.33, 0.68	<0.001	0.41	0.21, 0.61	<0.001
income	0.16	–0.06, 0.37	0.156	–0.03	–0.25, 0.18	0.760
occupational prestige	0.41	0.23, 0.59	<0.001	0.16	–0.05, 0.38	0.146
area-level SES	0.20	0.01, 0.38	0.037	0.12	–0.06, 0.30	0.194
			Processing Speed			
	b	**95% CI**	***p***	**b**	**95% CI**	***p***
Education	1.07	0.65, 1.50	<0.001	0.77	0.28, 1.26	0.002
Income	0.73	0.21, 1.24	0.006	0.28	–0.25, 0.80	0.299
Occupational prestige	1.03	0.60, 1.47	<0.001	0.44	–0.08, 0.96	0.094
Area-level SES	0.57	0.12, 1.01	0.012	0.33	–0.11, 0.77	0.141

07 Study (Ginty, Phillips, Der, Deary, & Carroll, 2011). In this Scottish study, people in a manual occupation had significantly lower IQ scores than those in a non-manual occupation which is consistent with our findings for occupational prestige but the study did not include attained education as in this study.

Our failure to identify socioeconomic gradients in IQ is perhaps not surprising as the debate around IQ and health often fails to distinguish between IQ (theorised as innate ability) and cognitive performance (as used within the medical field) which does not make any assumptions about innate ability. It has been repeatedly shown that exposure to chronic stress such as severe illness, extended care-giving, or incarceration reduces cognitive function (e.g., (Lee, Kawachi, & Grodstein, 2004)). At any age, lower social position is also associated with more daily hassles, more worries, financial hardship, etc (Orpana, Lemyre, & Kelly, 2007). As these stressors increase in prevalence with decreasing social position, this phenomenon has been suggested to account for the decline in cognitive function at an earlier age that is seen with lower social position (McEwen & Gianaros, 2010). Anecdotal reports suggest that declines in cognitive performance often reverse when the stressors are removed.

What This Study Adds

From a policy perspective these findings are encouraging. When cognitive ability is regarded as "innate" ability it is perceived as immutable (i.e., impossible to improve). But our findings and the Flynn effect suggests that low SES people are not incapable of understanding health messages or making lifestyle changes. Or, to phrase it in more empowering terms; the inverse relationship between health-adverse behaviours and SES is not accounted for by intellectual ability and there is potential for change as demonstrated by the enormous reduction in smoking prevalence over the past six decades (http://www.cancercouncil.com.au/31901/reduce-risks/smking-reduce-risks/tobacco-facts/statistics-on-smoking-in-australia/?pp=31901).

Strengths and Limitations

A strength of this study is the use of multiple measures of ability. We should have been able to identify any differences in innate ability that could not be largely attributed to education because three of the four abilities estimated in our good fitting

measurement model (Gf, Gv, and Gs) are not considered to depend on formal education. The two comparable studies from older adults have relied primarily upon tests of vocabulary, comprehension and mathematical skills (Deary, Allerhand, & Der, 2009; Deary, Whiteman, Starr, Whalley, & Fox, 2004) which are consistent with the Gc ability.

Another strength is the use of four measures of social position. The SES measures in this study cohort were not highly correlated with each other which is in contrast to much of the literature from Europe and North America (eg, (Treiman, 1977) (Blundell, Dearden, Meghir, & Sianesi, 1999)). The low correlation likely reflects the unusual circumstances of Australian men in this age group where education was not the only path to a high-paying job. Indeed one-fifth of those with only high school or less education were in the highest two income quartiles and one-third of those with a university education were in the lowest two income quartiles. Age is unlikely to have confounded the results as it was accounted for in statistical analyses, and because most men would have been well established in their careers or heading into retirement in this study population and should have already reached their maximum educational attainment.

This analysis was limited by the possibility of a survivor bias where the most intellectually disadvantaged individuals died young and/or failed to participate. Also the participants in the sub-cohort are self-selected and a greater proportion had tertiary education than reported in 2001 census data (Holden et al., 2005) and a slightly greater proportion than seen in census data also reported not being in the workforce. In spite of this higher level of education we do have a good distribution of household income levels with 22% of this sub-study group reporting that they were in the less than 20,000 dollars per year category or had only high school or less education level. Compared with the large linkage datasets used in cognitive epidemiology research our, relatively, small sample size, may have limited our ability to identify subtle differences in ability. Unfortunately, the sample size in a project such as this is limited by the practical realities of executing such an extensive test battery. Within the data there is evidence of variability in ability scores with no skewness or kurtosis which suggests no systematic bias in these observations.

Conclusion

This study found that a panel of standard IQ tests were positively associated with attained education but not with income or area-level deprivation score. Two IQ abilities, Gf and Gc, were also associated with occupational prestige score. These associations suggest that lesser levels of health associated with lower socioeconomic status is not accounted for by a lesser innate ability and that intervention may be possible.

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REFERENCES

Australian Bureau of Statistics (2003). Census of population and housing. Belconnen, ACT: Central Office, Australian Bureau of Statistics.

Batty, G. D., & Deary, I. J. (2005). Education and mortality: A role for intelligence? *Journal of Epidemiology & Community Health, 59,* 809-810.

Batty, G. D., Deary, I. J., & Gottfredson, L. S. (2007). Premorbid (early life) IQ and later mortality risk: A systematic review. *Annals of Epidemiology, 17,* 278-288. doi:10.1016/j.annepidem.2006.07.010

Batty, G. D., Deary, I. J., Tengstrom, A., & Rasmussen, F. (2008). IQ in early adulthood and later risk of death by homicide: Cohort study of 1 million men. *British Journal of Psychiatry, 193,* 461-465. doi:10.1192/bjp.bp.107.037424

Batty, G. D., Der, G., Macintyre, S., & Deary, I. J. (2006). Does IQ explain socioeconomic inequalities in health? Evidence from a population based cohort study in the west of Scotland. *British Medical Journal, 332,* 580-584. doi:10.1136/bmj.38723.660637.AE

Batty, G. D., Gale, C. R., Tynelius, P., Deary, I. J., & Rasmussen, F. (2009). IQ in early adulthood, socioeconomic position, and unintentional injury mortality by middle age: A cohort study of more than 1 million Swedish men. *American Journal of Epidemiology, 169,* 606-615. doi:10.1093/aje/kwn381

Batty, G. D., Shipley, M. J., Mortensen, L. H., Boyle, S. H., Barefoot, J., Gronbaek, M. et al. (2008). IQ in late adolescence/early adulthood, risk factors in middle age and later all-cause mortality in men: The Vietnam Experience Study. *Journal of Epidemiology & Community Health, 62,* 522-531. doi:10.1136/jech.2007.064881

Blundell, R., Dearden, L., Meghir, C., & Sianesi, B. (1999). Human capital investment: The returns from education and training to the individual, the firm and the economy. *Fiscal Studies, 20,* 1-23. doi:10.1111/j.1475-5890.1999.tb00001.x

Calvin, C. M., Deary, I. J., Fenton, C., Roberts, B. A., Der, G., Leckenby, N., & Batty, G. D. (2011). Intelligence in youth and all-cause-mortality: A systematic review with meta-analysis. *International Journal of Epidemiology, 40,* 626-644. doi:10.1093/ije/dyq190

Chandola, T., Deary, I. J., Blane, D., & Batty, G. D. (2006). Childhood IQ in relation to obesity and weight gain in adult life: The National Child Development (1958) Study. *International Journal of Obesity, 30,* 1422-1432. doi:10.1038/sj.ijo.0803279

Deary, I. J., Allerhand, M., & Der, G. (2009). Smarter in middle age, a cross-lagged panel analysis of reaction time and cognitive ability over 13 years in The West of Scotland Twenty-07 Study. *Psychology and Aging, 24,* 40-47. doi:10.1037/a0014442

Deary, I. J., & Batty, G. D. (2007). Cognitive epidemiology. *Journal of Epidemiology & Community Health, 61,* 378-384. doi:10.1136/jech.2005.039206

Deary, I. J., Batty, G. D., Pattie, A., & Gale, C. R. (2008). More intelligent, more dependable children live longer. A 55-year longitudinal study of a representative sample of the Scottish nation. *Psychological Science, 19,* 874-890. doi:10.1111/j.1467-9280.2008.02171.x

Deary, I. J., Whiteman, M. C., Starr, J. M., Whalley, L. J., & Fox, H. C. (2004). The impact of childhood intelligence on later life: Following up the Scottish Mental Surveys of 1932 and 1947. *Journal of Personality & Social Psychology, 86,* 130-147. doi:10.1037/0022-3514.86.1.130

Flynn, J. R. (1987). Massive IQ gains in 14 nations: What IQ tests really measure. *Psychological Bulletin, 101,* 171-191. doi:10.1037//0033-2909.101.2.171

Ginty, A. T., Phillips, A. C., Der, G., Deary, I. J., & Carroll, D. (2011). Cognitive ability and simple reaction time predict cardiac reactivity in the West of Scotland Twenty-07 Study. *Psychophysiology, 48,* 1022-1027. doi:10.1111/j.1469-8986.2010.01164.x

Hakstian, A. R., & Cattell, R. B. (1975). *The comprehensive ability battery*. Champaign, IL: Institute for Personality and Ability Testing.

Hart, C. L., Taylor, M. D., Davey Smith, G., Walley, L. J., Starr, J. M., Hole, D. J., & Deary, I. J. (2003). Childhood IQ, social class, depri-

vation, and their relationships with mortality and morbidity risk in later life: Prospective observational study linking the Scottish Mental Survey of 1932 and the Midspan Studies. *Psychosomatic Medicine, 65,* 877-883. doi:10.1097/01.PSY.0000088584.82822.86

Hart, C. L., Taylor, M. D., Smith, G. D., Whalley, L. J., Starr, J. M., Hole, D. J., & Deary, I. J. (2005). Childhood IQ and all-cause mortality before and after age 65: Prospective observational study linking the Scottish mental survey 1932 and the midspan studies. *British Journal of Health Psychology, 10,* 153-165. doi:10.1348/135910704X14591

Hemmingsson, T., Essen, J. v., Melin, B., Allebeck, P., & Lundberg, I. (2007). The association between cognitive ability measured at ages 18-20 and coronary heart disease in middle age among men: A prospective study using the Swedish 1969 conscription cohort. *Social Science & Medicine, 65,* 1410-1419. doi:10.1016/j.socscimed.2007.05.006

Holden, C. A., McLachlan, R. I., Pitts, M., Cumming, R., Wittert, G., Agius, P. A., & de Kretser, D. M. (2005). Men in Australia telephone survey (MATeS): A national survey of the reproductive health and concerns of middle-aged and older Australian men. *Lancet, 366,* 218-224. doi:10.1016/S0140-6736(05)66911-5

Lager, A., Bremberg, S., &Vagero, D. (2009). The association of early iq and education with mortality: 65 Year longitudinal study in Malmo, Sweden. *British Medical Journal, 339,* B5282. doi:10.1136/bmj.b5282

Lawlor, D. A., Batty, G. D., Clark, H., McIntyre, S., & Leon, D. A. (2008). Association of childhood intelligence with risk of coronary heart disease and stroke: Findings from the Aberdeen Children of the 1950s Cohort Study. *European Journal of Epidemiology, 23,* 695-706. doi:10.1007/s10654-008-9281-z

Lawlor, D. A., Najman, J. M., Batty, G. D., O'Callaghan, M. J., Williams, G. M., & Bor, W. (2006). Early life predictors of childhood intelligence: Findings from the Mater-university Study of Pregnancy and Its Outcomes. *Paediatric and Perinatal Epidemiology, 20,* 148-162.

Lee, S., Kawachi, I., & Grodstein, F. (2004). Does caregiving stress affect cognitive function in older women? *Journal of Nervous and Mental Disease, 192,* 51-57. doi:10.1097/01.nmd.0000106000.02232.30

Liberatos, P., Link, B. G., & Kelsey, J. L. (1988). The measurement of social class in epidemiology. *Epidemiologic Reviews, 10,* 87-121.

Marmot, M. (2004). *Status syndrome: How your social standing directly affects your health and life expectancy*. London: Bloomsbury.

Martin, S., Haren, M., Taylor, A., Middleton, S., Wittert, G., & FAMAS. (2007). Cohort profile: The Florey Adelaide Male Ageing Study (FAMAS). *International Journal of Epidemiology, 36,* 302-306. doi:10.1093/ije/dyl279

McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: Links to socioeconomic status, health and disease. *Annals of the New York Academy of Sciences, 1186,* 190-222. doi:10.1111/j.1749-6632.2009.05331.x

Muthén, L. K., & Muthén, B. O. (2010). *Mplus User's guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.

Neisser, U., Boodoo, G., Bouchard Jr., T. J., Boykin, A. W., Brody, N., Ceci, S. J., & Urbina, S. (1996). Intelligence: Knowns and unknowns. *American Psychologist, 51,* 77-101. doi:10.1037//0003-066X.51.2.77

Orpana, H. M., Lemyre, L., & Kelly, S. J. (2007). Do stressors explain the association between income and changes in self-rated health? A Longitudinal analysis of the national population health survey. *International Journal of Behavioral Medicine, 14,* 40-47. doi:10.1007/BF02999226

Pearce, M. S., Deary, I. J., Young, A. H., & Parker, L. (2006). Childhood IQ and deaths up to middle age: The Newcastle Thousand Families Study. *Public Health, 120,* 1020-1026. doi:10.1016/j.puhe.2006.06.015

Queensland University of Technology, & Australian Institute of Health and Welfare (2004). *Health inequalities in Australia: Mortality health inequalities monitoring series*. Canberra: AIHW.

Raven, J., Raven, J. C., & Court, J. H. (1998). *Manual for Raven's progressive matrices and vocabulary scales. Sections 1 - 7 with 3 research supplements.* San Antonio, TX: Harcourt Assessment/ Pearson Assessment.

Salthouse, T. A. (2004). What and when of cognitive aging. *Current Directions in Psychological Science, 13,* 140-144. doi:10.1111/j.0963-7214.2004.00293.x

Schrank, F. (2005). Woodcock-Johnson III tests of cognitive abilities. In D. P. Flanagan, & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (2nd ed., pp. 371-401). NY: Guilford Press.

Treiman, D. J. (1977). *Occupational prestige in comparative perspective*. New York: Academic Press.

Undheim, J. O., &Gustafgsson, J. E. (1987). The hierarchical organization of cognitive abilities: Restoring general intelligence through the use of linear structural relations (LISREL). *Multivariate Behavioral Research, 22,* 149-171. doi:10.1207/s15327906mbr2202_2

Vandenberg, S. G., & Kuse, A. R. (1978). Mental rotations: A group test of three-dimensional spatial visualisation. *Perceptual and Motor Skills, 47,* 599-604. doi:10.2466/pms.1978.47.2.599

Wechsler, D. (1981). *Wechsler adult intelligence test-revised*. San Antonio, TX: Psychological Corporation.