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What social network or support factors are associated with cognitive abilities in old
age?

Running head: Social contact, social support and cognitive ability

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Abstract

Background. Social networks and support have been proposed as cognitively protective in old age. As studies often consider these social factors in isolation the question of which characteristics of the social environment are beneficial remains.

Objective. The current study examined associations between measures of social networks (including contact with friends/family, marital status and living arrangement), feelings of loneliness and social support, and a range of cognitive outcomes.

Methods. Social network, loneliness and support data were available in the Lothian Birth Cohort 1936 (LBC1936, N = 1091) at age 70. Participants completed a battery of cognitive tests, and factor scores were available for general cognitive ability, and the cognitive domains of processing speed and memory. Childhood cognitive ability data from age 11 were also available.

Results. When examined in separate ANCOVAs, lower loneliness and more social support were significantly associated with better cognitive abilities at age 70, though not memory (independently of age, sex, childhood cognitive ability and social class), accounting for about 0.5% to 1.5% of the variance. When the social factors were considered simultaneously, higher loneliness remained associated with lower general cognitive ability ($\eta_p^2 = .005, p = .046$), and those living alone ($\eta_p^2 = .007, p = .014$) or with less social support ($\eta_p^2 = .007, p = .016$) had slower processing speed. When these final models were repeated including a depression symptoms score as a covariate, the associations between loneliness and general cognitive ability, and social support and processing speed, were no longer significant. However, the association between living alone and processing speed remained ($\eta_p^2 = .006, p = .031$).

Conclusions. Of the social factors considered, loneliness, social support and living arrangement were most consistently associated with aspects of cognitive ability in older people, and these associations appeared to be partly, though not wholly, accounted for by symptoms of depression. Although longitudinal follow-up is required to examine the causal direction of the effects more definitively, it may be beneficial to promote the development of interventions to reduce loneliness and social isolation, and to increase social support.

Keywords: social networks, social support, loneliness, cognitive ability, cognitive ageing.

Introduction

Identifying the determinants of cognitive ageing is a research priority. Individuals receiving more social support, or those more integrated within a close social network, have higher cognitive ability and are less likely to experience deleterious cognitive changes in old age [1-5]. Social networks and their associated characteristics are thus attractive targets as cognitively protective factors because they are potentially amenable to intervention. The aim of the current study was to examine associations between measures of social contact and support (from basic measures of marital status and living arrangement to more detailed assessments of actual contact with others and support received) and a range of cognitive abilities in the Lothian Birth Cohort 1936, an ageing cohort, for whom childhood cognitive ability data were available. The associations between the social factors and cognitive abilities were considered separately to highlight the existence and relative size of these associations, and then simultaneously to examine the independence of the associations.

Individuals receiving more social support, or those more integrated within a close social network, are healthier, live longer, and are less likely to experience deleterious cognitive changes [1-3,6-9]. Many of the reported effects have been based on relatively simple measures characterising social contact, such as marital status or living arrangements [10-12]. In the FINE study, for example, men who remained married during a five year period experienced less cognitive decline over a subsequent ten year follow-up than those who were classified as married to unmarried over the same period [10]. Other studies have suggested that single individuals or those living alone were about twice as likely to develop dementia [11,12]. Though interesting, these basic structural assessments might fail adequately to account for the potential gradient that exists in the degree of social support received; Berkman [13], for

example, noted that one close relationship is likely to be insufficient in itself as a protective factor against cognitive decline, and that there exists a certain substitutability of contacts so that no particular form of contact, for example a spouse, is necessary.

Other aspects of engaging socially have been considered, including social connectedness and network characteristics, social activity participation, social support, and loneliness, encompassing various structural and functional elements of social interaction. Structural measures (for example, the number of close friends and relatives an individual can rely on, or their membership of various social groups) attempt to index how embedded an individual is within a network. They generally assess the quantity of social ties through which support can potentially be transmitted. Functional measures look at the role fulfilled by supportive others (whether the support received, if indeed it is received, provides emotional or financial support, for example). Structural and functional assessments may not be strongly related, and the particular aspect of the social environment considered may determine whether or not effects on important health and psychological outcomes are observed [14-16].

Though these various social factors have been described as cognitively protective, there are inconsistencies depending on the social characteristic considered [17]: studies relying on measures of the size of social networks or the level of social support received provide patchy evidence, whereas measures of loneliness are more conclusive. As the assessment of social networks and social support vary substantially between studies, systematic comparisons have proved problematic and are limited to mostly descriptive summaries [1].

A further limitation is that studies have generally considered one aspect of an individual's social environment in isolation. The question remains whether there is

something specific about the aspects of networks or support considered in their associations with cognitive ability, or whether they might essentially be proxies or surrogates of a more general benefit of social engagement. If social isolation, support and marital status were assessed concurrently, would they make independent contributions to cognitive ability or would one factor predominate and account for the associations reported when the factors were considered individually? The answer could help to identify aspects of the social environment most worthy of intervention efforts.

In explaining the cognitive protective effect of certain social factors, it is often proposed that the social support or network characteristics might be relatively distal in the mechanistic pathway, with other factors, such as depression, health behaviours, or the physiological response to stress being more proximal [2,10]. However, studies have often reported that positive associations between social factors and cognitive outcomes remain after controlling for depression [10,12]. Though clearly of interest, depression may only partly account for any link [17]. Alternative, though not mutually exclusive, mechanisms have highlighted the ways in which social interaction might stimulate individuals mentally, offering increased opportunities for cognitive challenge [5,18]. More complex interactions may result in more complex environments, along similar lines to those proposed by Kohn and Schooler [19] in the occupational arena.

In the existing literature there is a rarely a detailed assessment of cognitive ability, and the over-reliance on single measures of cognitive ability has been criticised [18]. As a result, the extant literature does not allow a full consideration of whether the assessed social characteristics affect cognitive abilities and change in general, or whether there are domain-specific effects. The current study therefore

sought to examine the existence of possible domain-specific effects by including battery of cognitive measures to characterise key cognitive domains: general ability, memory and processing speed.

Within cognitive ageing research, an issue confounding the identification of cognitively protective or detrimental factors is reverse causation. Cognitive ability shows a high degree of stability across the lifespan, illustrated previously in the current cohort [20]. Cognitive ability from youth also predicts a number of important life outcomes and behavioural choices, including education and attained social class [21]. As such, a cross-sectional association between cognitive ability and some factor of interest in old age, for example, leisure activity participation [22], might be due to both being predicted by cognitive ability from an earlier period. That is, cognitive ability and some variable X (a putative determinant of cognitive ageing) may be associated via the lifelong stable trait of intelligence, rather than variable X's playing a causative role in later cognitive ability and change.

To test for the possibility of this confounding or reverse causation, study designs would need to control for a measure of cognitive ability recorded as long as possible before the investigation of cognitive ability or change in old age. Such data are rarely available. The possibility of confounding or reverse causation therefore remains largely unaddressed. Whereas confounding or reverse causation may appear to be more applicable to certain health behaviours or lifestyle choices [22,23], there is good reason to investigate its influence on the putatively protective social factors. In a large linkage study, for example, marital status at midlife was associated with childhood cognitive ability, such that higher ability men were more likely to be married than those of lower ability, whereas lower ability women were less likely to be married [24]. It is unclear the extent to which reported associations between social

networks or support and cognitive ability are confounded by reverse causation. One study to address the issue reported that loneliness accounted for about 2% of the variance on a test of general cognitive ability at age 79, independently of childhood performance on the same test [4]. As only general cognitive ability was available, it was not clear whether the effect would also be found across other aspects of cognition (memory, processing speed, etc.).

The aim of the current study was twofold: to examine simultaneously associations of diverse measures of social contact and support with cognitive ability; and to include a number of well-characterised cognitive domains. Both structural and functional elements of the social environment were considered, to examine which aspects were particularly associated with cognitive abilities. Assessing diverse aspects of both the structure and function of social networks should provide more detailed information than the assessment of marital status or living arrangements alone, for example, to further develop our understanding of the underlying nature of the associations. Furthermore, the study also examined the extent to which any of these reported associations were attributable to reverse causation.

Methods

The Lothian Birth Cohort 1936 (LBC1936) is a longitudinal study of ageing comprising 1091 adults [25]. All participants were born in 1936 and most had been included in the Scottish Mental Survey of 1947; in this national survey, almost all children who were born in 1936 and attending a Scottish school completed a test of mental ability at mean age 11 years. In total, 70,805 children were tested [26].

Survivors of this survey were identified in Edinburgh and the surrounding areas, and recruited into a follow-up referred to as the LBC1936 at mean age 70. Each participant completed a half-day assessment session at the Wellcome Trust Clinical

Research Facility, Edinburgh, UK. Recruitment and testing details are available in a freely-accessible protocol paper [25]. Ethical approval was obtained from the Multi-Centre Research Ethics Committee and from Lothian Research Ethics Committee. All participants gave written, informed consent.

Cognitive testing. At age 11, participants completed the Moray House Test No. 12 (MHT) [26], a test of mostly verbal reasoning. At age 70, participants repeated the MHT. Scores were corrected for age in days at time of testing and converted to an IQ-type scale for the LBC1936 sample (mean = 100, sd = 15), referred to as age-11 or 70 IQ throughout.

Participants completed a battery of cognitive tests at age 70, mainly taken from the Wechsler Adult Intelligence Scale (WAIS)-III UK [27] and Wechsler Memory Scale (WMS)-III UK [28], supplemented by tests of reaction time [29] and inspection time [30]. Principal components analysis (PCA) of the tests provided scores for general cognitive ability, and for the cognitive domains of processing speed and memory, described previously [31,32].

Social variables. At their clinical assessment, participants were asked to report their current marital status (which was grouped as married or cohabiting, versus unmarried, being those who were divorced, widowed or single), and living arrangement (alone or with others). In a self-report questionnaire, participants completed seven items on social contact (each answered yes/no), for example: “In the last 2 weeks, excluding people you live with, have you: seen someone in your family to chat to?” or “Had contact by telephone or letter with a friend?”, adapted from a previous study [33]. Items are shown in Supplementary Table 1. The seven items were summed to give a social contact score (Cronbach’s $\alpha = .60$), with higher scores indicating more contact. Participants answered the question, “At the present moment

do you feel lonely?” on a five-point scale from most of the time to never; higher scores represented increased feeling of loneliness [4].

A 12-item social support scale was completed. Six items concerned the level of support received (“How often were there people you could really count on to be dependable when you needed help?”), answered on a five-point scale (from all of the time to none of the time). Six items asked about the participant's level of satisfaction with this, answered on a six-point scale (from very satisfied to very dissatisfied). These items were adapted from the Social Support Questionnaire (Short Form) [34,35]. PCA of the 12 items supported a first unrotated social support component explaining 72.1% of the variance (Cronbach’s $\alpha = .96$). Scale details and component loadings are in Supplementary Table 2. As a standardised score, social support had a mean of 0 and a standard deviation of 1.

Social class. Participants reported their highest status occupation, classified according to the Classification of Occupations [36]. This system has six classes from I, professional, to V, unskilled (class III being divided into IIIN and IIIM, non-manual and manual, respectively). Married women also reported their spouse’s occupation, and were assigned the higher social class.

Symptoms of depression. During their age-70 clinical assessment, participants completed the Hospital Anxiety and Depression Scale (HADS) [37]. From the 14-item scale, the 7 items defining an overall depression symptoms score were used in the current analysis, which was scored as described. The depression symptoms scores ranged from 0 to 16, with a mean of 2.8 (sd = 2.2); five participants had scores of 11 or higher.

Statistical analysis

Separate general linear models (ANCOVA) were used to examine the variance accounted for by marital status, living arrangement, social contact, loneliness or social support in each cognitive outcome. The main analyses consisted of accounting for variance in the cognitive outcomes using all social variables simultaneously, after removing those not making significant contributions. A depression symptoms score was included in the later stages of the analysis, whereby any reduction in the effect size after its inclusion was interpreted as potentially mediating the reported association between the social factors and cognitive ability.

Results

At the time of the assessment (age 70), 266 (24.4%) of the 1091 participants were living alone. The majority (795, 72.9%) were married/cohabiting. Of the 963 participants who answered the question about loneliness, 53.8% ($N = 518$) reported never feeling lonely, with 29.6% ($N = 285$) and 12.8% ($N = 123$) seldom or only occasionally feeling lonely, respectively. Only 3.2% ($N = 31$) reported feeling lonely quite often, and 0.6% ($N = 6$) most of the time. Scores for social contact ranged from 0 to 7, with a mean of 6.6 ($sd = 0.88$), median = 7.

Participants living alone were lonelier (2.21 versus 1.50, $t(956) = 11.68$, $p < .001$), had less social contact (6.35 versus 6.68, $t(954) = -5.17$, $p < .001$), and less social support (-.26 versus .08, $t(946) = -4.59$, $p < .001$; this represents about one third of a standard deviation difference in social support. [Note, these comparisons were also conducted using Mann-Whitney tests given the measurement level of some of the variables, but the results were unchanged.] Unmarried participants (those who were currently divorced, widowed or single) were lonelier (2.24 versus 1.47, $t(961) = 13.41$, $p < .001$), had less social contact (6.32 versus 6.70, $t(954) = -6.13$, $p < .001$), and less social support (-.29 versus .10, $t(946) = -5.40$, $p < .001$) than participants who

were married or cohabiting. Table 1 displays the associations between the continuous social variables. All associations were small to moderate, significant, and in the expected directions: lower feelings of loneliness were associated with higher levels of social contact and support, for example.

Correlations between cognitive ability and the continuous social variables are shown in Table 1. All cognitive ability scores at age 70 were associated negatively with loneliness ($\rho = -.08$ to $-.14$) and positively with social support ($\rho = .09$ to $.15$). There were no significant associations between the cognitive ability scores at age 70 and social contact, other than a negative association with age-70 IQ ($\rho = -.08$, $p = .009$).

In terms of marital status and living arrangements, participants who were unmarried or who lived alone performed more poorly on all the cognitive measures (Table 2) though the differences were significant only for marital status and general cognitive ability and processing speed.

As social contact was positively skewed, it was recoded into a dichotomous variable for the main analyses (those reporting the maximum social contact versus not). Table 3 summarises the results of the general linear models in which the social factors were considered as independent variables in separate analyses (first with age and sex included as covariates, then with age-11 IQ and social class in addition). Loneliness was associated with all cognitive ability scores in the initial models, accounting for between 0.9% and 2.5% of the variance. In the fully-adjusted models, loneliness accounted for 0.5% to 1.1% of the variance in age-70 IQ, general cognitive ability and processing speed; the addition of age-11 IQ accounted for most of the attenuation of the association. The results for social support followed the same pattern as those for loneliness: about 0.6% to 2.2% of the variance was explained in the initial

models, which decreased to 0.6% to 1.5% in the final models (again, the association with memory was no longer significant). In general, marital status, living arrangement and social contact had few significant associations with any of the cognitive outcomes.

The models of principal interest were run including all five social variables simultaneously (Table 4). In the initial models, the effect of each social variable in the presence of the others is shown, with age and sex as covariates. The results were generally consistent with the individual models (Table 3): limited effects for marital status or living arrangement (except for processing speed), with loneliness and social support being most consistently associated with the cognitive outcomes. The initial models were therefore repeated removing the social variables not making significant contributions, with minimal changes in the effect sizes reported. In the next iteration which additionally included age-11 IQ and social class, loneliness remained associated with general cognitive ability, accounting for about 0.5% of the variance. Living arrangement and social support made independent contributions to processing speed, each accounting for about 0.7% of the variance. The social variables were not associated with age-70 IQ or memory in this model. In a final set of models, the depression symptoms score was added as a covariate. The association between loneliness and general cognitive ability was no longer significant. For processing speed, the effect of living arrangement remained ($\eta_p^2 = .06$, $p = .031$), though social support was no longer associated.

Discussion

In the separate analyses, social support accounted for 0.6% to 1.5% of the variance in cognitive abilities at age 70, once childhood cognitive ability, age, sex and social class were controlled; receiving more social support was associated with better cognitive

performance (there was no association with memory). The effects of loneliness were similar, though the variance accounted for was slightly less (0.5% to 1.1%). There was little evidence that marital status or the number of social contacts were protective of cognitive abilities. When the social factors were considered simultaneously, a higher level of loneliness was associated with lower general cognitive ability, whereas not living alone and higher social support were independently associated with faster processing speed (each accounting for less than 0.7% of the variance). Once a depression symptoms score was also considered, the associations between loneliness and general cognitive ability, and social support and processing speed, were no longer significant; this might suggest that these social factors influence mood, which then has the resultant effect on cognitive abilities. However, the association between living arrangement and processing speed remained, and accounted for about 0.6% of the variance. These results will be discussed in the context of the current study aims: to consider a range of social factors simultaneously to examine the independence of their effects, and to consider whether different cognitive domains are differentially affected.

Although the effect sizes were small, they are comparable to more established risk factors for cognitive decline: possession of the $\epsilon 4$ allele of the *APOE* gene—one of the few replicated genetic determinants—accounted for no more than 1.0% of the variance in general ability and speed measures in the LBC1936 [31]. That social characteristics accounted for a small but significant percentage of the variance in cognitive ability is consistent with results from other studies [1], including those from an older Scottish cohort for whom childhood cognitive data were also available [4]. In the current analyses, the effect of depression symptoms (either accounting for the effect of the social factors, or independent of this) was of the same order of

magnitude. Furthermore, the inclusion of a measure of childhood cognitive ability provides an estimate of the association between the social variables and cognitive ability in old age, accounting for the likelihood of reverse causation. In general, initial associations were reduced by 40% to 60% with the addition of age-11 IQ in the models, suggesting that confounding or reverse causation may partly account for some of the social support/loneliness-cognition associations. Any protective effects of lifestyle factors should ideally remain after the adjustment for an early measure of cognitive ability to reduce the likelihood of the results being due to reverse causation. To a small extent, higher ability in childhood was associated with reduced loneliness in old age, suggesting these individuals may have been better able to manage and maintain social relationships across the lifecourse. Accordingly, the effect sizes reported in the literature [2,3,5] should be reduced in magnitude, probably by about half.

In explaining the link between social support and cognitive abilities, it has been mooted that associations might partly be driven by those declining cognitively being more likely to withdraw socially [2], although Hertzog et al. [17] suggested there was little evidence for this. It is also possible that those who had experienced cognitive decline before their baseline assessment were least able to correctly complete the questionnaires. These alternative explanations do require further consideration, although the longitudinal studies conducted are at least supportive of the protective effect of the assessed social factors [2,18,38]. Given the current study was cross-sectional and was designed to specifically address the relative importance of a range of social factors on contemporaneous cognitive measures, the available data do not allow further examination of the direction of the associations reported.

The participants are, however, undergoing repeat cognitive testing which will allow cognitive changes across 6 years to be examined.

Social support may 'activate' during periods of increased stress to mitigate the negative physiological consequences of those stressors, or act as a resource accessed in more general situations resulting in enhanced health and wellbeing [15,39], slowing the ageing process more generally, including cognitive ageing. Given that depression symptoms accounted for the associations between loneliness and social support and general cognitive ability and processing speed respectively, the suggestion that these factors are affecting pathways more proximal to cognitive functions, including depression and stress responses, is a possibility [2]. Alternative mechanisms could act via the increased cognitive engagement required by more complex social networks [10,11], though as social contact was generally unrelated to cognition in the LBC1936 this is a less likely explanation. Living alone, however, may be an indicator of a lack of mental stimulation from a social perspective. Recent analyses from the English Longitudinal Study of Ageing linked increased loneliness to risky health behaviours, such as smoking and lack of activity, and social isolation to cardiovascular risk factors [40]. These pathways may underlie some of associations between cognition and loneliness, living alone and social support in older people.

Rather than identify mechanisms, the present study was designed specifically to identify the independence of the associations between the social characteristics and cognitive abilities. If these effects are not independent, then it is necessary to identify the underlying factor driving these in order to design effective interventions. The effect of loneliness or social support seemed most consistent in terms of associations with cognitive ability, rather than a purely quantitative assessment of an individual's social network, in agreement with previous findings with dementia where a lack of

social contact was not a risk factor as long as whatever contact was reported was perceived as satisfying [11]. Similarly, although unmarried individuals had poorer cognitive performance, significantly so for general cognitive ability and processing speed (consistent with previous findings [10]), these effects were not apparent in the final models. Being single and lacking social support are not necessarily the same thing [13]. It appears that it is not a person's marital status or social contact which is the key factor, but rather their perception of the support received. Strategies to increase social participation or reduce loneliness, or at least diminish the perception of the latter, in the elderly, via interventions delivered in direct care settings or through more informal support networks of family and friends, may have benefits in terms of cognitive function. If these are designed to purely increasing the quantity of social contact, the current results would suggest this might be less advantageous.

This disconnect between the effect of measures of contact and support might be partly due to the nature of the measures. Social contact was defined by summing a number of items to give a general indication of a participant's contact with others, whereas the social support factor was a first unrotated component, and accounted for over 70% of the item variance. Furthermore, an individual might report increased social contact through personal choice, that is, their desire to interact with others, or because family and friends are fulfilling some kind of caregiving role due to a reduced ability to live independently. The latter possibility might explain the small negative associations with IQ, although it would be as likely to occur with the social support measures also. The social contact variable was highly skewed towards the maximum possible, and therefore may not be methodologically able to distinguish discrete levels of actual social contact. Both social contact and support lacked discriminatory power at the top end of the spectrum, with most participants reporting the highest scores.

Given the range of items in the scales, however, there is no simple method of increasing this discriminative ability. Simply adding more items may not be sufficient if the participants are generally well socially connected. The lack of variance will have reduced the power to detect effects, suggesting that the actual effect sizes in more representative samples may be larger. Loneliness, although also positively skewed, did show a better distribution of scores and the results with this were consistent with those for social support.

It is not clear why the associations would be primarily with general ability and processing speed but not memory, given that the mechanisms proposed are relatively general. Previous analyses have often relied upon a single measure of cognitive ability, sometimes limited to the MMSE [10], so have been unable to investigate the associations across different domains, which was a secondary aim of the study. A methodological possibility is that the memory factor in the LBC1936 explains about 43% of its constituent tests, versus over 50% for general ability and processing speed [32]. Follow-up with the participants over time will allow an examination of whether social factors might influence change in memory (and general ability and processing speed) over time, as the current analyses were with level alone. Further studies with broad cognitive batteries are required to replicate and explain the current findings, so that more definitive explanations for domain-specific effects can be proposed.

The current results are based on a relatively large sample of adults in their early seventies. Given the voluntary nature of the study, the participants were self-selected and healthier than the general population. The true effect sizes are therefore likely to be larger than those reported. Although the results are cross-sectional and a number of covariates were not considered (such as stress exposure or response), the principal intention was to examine the magnitude of the independent effect of the

social variables. Further follow-up with the cohort, up to age 76, will allow a longitudinal examination of the effects of social support on cognitive change, including a consideration of possible explanatory mechanisms.

The current results suggest that social support and the alleviation of loneliness and social isolation may provide a useful target for the development of interventions to maintain cognitive functioning in old age, however, methods based on simply increasing social contact may not be effective.

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Table 1

Correlations of social contact, support and cognitive abilities

	Social contact	Loneliness	Social support
Loneliness	-.25***	-	-.46***
Social support	.32***	-.46***	-
Age-11 IQ	-.10**	-.06	.04
Age-70 IQ	-.08**	-.10**	.09**
General cognitive ability	-.03	-.14***	.13***
Processing speed	.02	-.12***	.15***
Memory	-.02	-.08**	.10**

Note. Loneliness is a single item answered on a five-point scale (higher scores representing increased feelings of loneliness); social contact was the sum of seven yes/no items and social support was the first unrotated component of a twelve item scale (higher scores represent more social contact/support). The associations are reported as Spearman's rho. N = 897-957.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 2

Cognitive ability by marital status and living arrangement

	Marital status			Living arrangement		
	Married/cohabiting	Unmarried	t-test (<i>p</i>)	With others	Alone	t-test (<i>p</i>)
Age-11 IQ	100.38 (15.3)	98.96 (14.2)	-1.36 (.175)	100.05 (15.3)	99.86 (13.9)	-0.17 (.863)
Age-70 IQ	100.51 (14.5)	98.83 (15.2)	-1.67 (.095)	100.22 (14.6)	99.54 (15.0)	-0.65 (.513)
General cognitive ability	.05 (1.0)	-.15 (1.0)	-2.93 (.003)	.03 (1.0)	-.10 (1.0)	-1.94 (.052)
Processing speed	.05 (1.0)	-.13 (1.1)	-2.53 (.012)	.02 (1.0)	-.06 (1.0)	-1.00 (.318)
Memory	.01 (1.0)	-.04 (1.0)	-0.68 (.495)	.01 (1.0)	-.02 (0.9)	-0.32 (.753)

Note. Figures are mean cognitive tests scores (and sd) for the listed categories, and associated t-test results. Unmarried included participants who were single, divorced or widowed.

Table 3

Separate ANCOVA models for the association between social factors and cognitive abilities in the Lothian Birth Cohort 1936

Independent variable	Model covariates	Age-70 IQ		General cognitive ability		Processing speed		Memory	
		<i>p</i>	η_p^2	<i>p</i>	η_p^2	<i>p</i>	η_p^2	<i>p</i>	η_p^2
Marital status	Age + sex	.152	.002	.016	.005	.014	.006	.454	.001
	Age + sex + age-11 IQ	.627	.000	.119	.002	.075	.003	.864	.000
	Age + sex + age-11 IQ + social class	.689	.000	.230	.001	.155	.002	.601	.000
Living arrangement	Age + sex	.690	.000	.218	.001	.456	.001	.824	.000
	Age + sex + age-11 IQ	.862	.000	.270	.001	.540	.000	.961	.000
	Age + sex + age-11 IQ + social class	.917	.000	.450	.001	.708	.000	.735	.000
Social contact	Age + sex	.059	.004	.384	.001	.589	.000	.382	.001
	Age + sex + age-11 IQ	.494	.001	.176	.002	.025	.006	.202	.002
	Age + sex + age-11 IQ + social class	.684	.000	.252	.002	.054	.004	.430	.001
Loneliness	Age + sex	<.000	.016	<.000	.025	<.000	.023	.003	.009

	Age + sex + age-11 IQ	.029	.005	.001	.012	.001	.013	.242	.002
	Age + sex + age-11 IQ + social class	.039	.005	.003	.010	.002	.011	.434	.001
Social support	Age + sex	.001	.011	<.000	.013	<.000	.022	.020	.006
	Age + sex + age-11 IQ	.021	.006	.002	.011	<.000	.015	.127	.003
	Age + sex + age-11 IQ + social class	.025	.006	.003	.010	<.000	.015	.275	.001

Note. Living arrangement was coded as living with others versus living alone; marital status was coded as married or cohabiting versus single, divorced or widowed; social contact was coded as the maximum contact score versus not. Also see note Table 1. Each social factor was analysed in a separate ANCOVA model. The p value and associated partial eta² (η_p^2) show the effect of the respective social factor in the model. Significant results are highlighted in bold. The initial model included the social factor, plus age and sex (although as age-70 IQ was already age-adjusted, age was not included in the models with that as the dependent variable), model 2 additionally included age-11 IQ, and model 3 added social class.

Table 4

ANCOVA models for the association between social factors and cognitive abilities in the Lothian Birth Cohort 1936

Independent variable	Model covariates	Age-70 IQ		General cognitive ability		Processing speed		Memory	
		<i>p</i>	η_p^2	<i>p</i>	η_p^2	<i>p</i>	η_p^2	<i>p</i>	η_p^2
Marital status	Age + sex	.268	.001	.154	.002	.010	.007	.735	.000
	Age + sex + age-11 IQ					.012	.007		
	Age + sex + age-11 IQ + social class					.059	.004		
	Age + sex + age-11 IQ + social class + depression					.081	.004		
Living arrangement	Age + sex	.117	.003	.097	.003	.002	.011	.396	.001
	Age + sex + age-11 IQ					.002	.011		
	Age + sex + age-11 IQ + social class					.014	.007		
	Age + sex + age-11 IQ + social class + depression					.031	.006		

Social contact, social support and cognitive ability

Social contact	Age + sex	<.001	.015	.006	.008	.188	.002	.056	.004
	Age + sex + age-11 IQ	<.001	.015	.006	.008				
	Age + sex + age-11 IQ + social class	.433	.001	.897	.000				
	Age + sex + age-11 IQ + social class	.448	.001	.856	.000				
	+ depression								
Loneliness	Age + sex	.001	.012	<.001	.017	.004	.009	.010	.007
	Age + sex + age-11 IQ	.001	.012	<.001	.019	.004	.009	.003	.009
	Age + sex + age-11 IQ + social class	.229	.002	.046	.005	.068	.004	.434	.001
	Age + sex + age-11 IQ + social class	.548	.000	.179	.002	.224	.002	.740	.000
	+ depression								
Social support	Age + sex	.016	.006	.050	.004	.006	.009	.140	.002
	Age + sex + age-11 IQ	.015	.006	.048	.004	.011	.007		
	Age + sex + age-11 IQ + social class	.094	.003	.092	.003	.016	.007		
	Age + sex + age-11 IQ + social class	.252	.002	.278	.001	.075	.004		

+ depression

Note. See notes on Tables 1 and 3 for variable descriptions. The social factors were included simultaneously in the ANCOVA models. The p value and associated partial η^2 (η_p^2) show the effect of the respective social factor in the model. Significant results are highlighted in bold. The initial model included the social factors and age and sex (although as age-70 IQ was already age-adjusted, age was not included in the models with that as the dependent variable), model 2 included only those social factors with significant effects in the initial model, model 3 additionally included social class and age-11 IQ, and model 4 also included depression symptoms score. Blank cells reflect the process by which social factors not contributing to the baseline model were excluded from later analyses.