Title: Cognitive ability as moderator of the association between social disadvantage and psychological distress: evidence from a population-based sample

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Background: Social disadvantage consistently predicts both self-reported distress and clinically-diagnosed disorders such as depression. Yet, many individuals who are exposed to disadvantage do not report high levels of distress. This study extends our recent work showing that high cognitive ability may protect against the negative health consequences of exposure to disadvantaged backgrounds. We test whether this 'buffer effect' exists across clinically-relevant indices of mental health in a population-representative sample.

Methods: 27,985 participants were drawn from the UK Household Longitudinal Study (*Understanding Society*). Clinical diagnoses of depression and clinically-relevant measures of psychological distress (i.e. Short Form-12 Mental Component, General Health Questionnaire) and trait neuroticism were assessed. Cognitive ability was derived from performance on word recall, verbal fluency and numerical ability tasks. Early-life disadvantage was gauged using family background measures assessing parental education and occupation at age 14.

Results: Background disadvantage predicted increased levels of reported psychological distress and neuroticism. These associations were moderated by cognitive ability. Across all available mental health measures the negative association between early life disadvantage and poor adult mental health was strongest at low (-1SD) cognitive ability and was no longer evident at high (+1SD) levels of cognitive ability.

Conclusions: The results provide support for a cognitive buffering hypothesis linking high cognitive ability to a decrease in the magnitude of the social gradient in mental health. Those disadvantaged by both low socioeconomic status and low cognitive ability may benefit from targeted prevention and treatment programs aiming to reduce socio-economic disparities in mental health.

Keywords: Socioeconomic status; cognitive ability; depression; psychological distress; mental health

The impact of socio-economic conditions on health is well-documented: those living in poverty experience greater physical morbidity and live shorter lives than the wealthy (Adler et al., 1994; Galobardes et al, 2008; Lawlor et al., 2006). The adverse effects of socioeconomic inequalities are evident at each stage of the life-course and extend beyond physical health. Across diverse populations and contexts lower socioeconomic status (SES) predicts almost every measure of mental health including measures of self-reported distress (Melchior et al., 2013; Molarius et al., 2009; Power & Manor, 1992) and diagnoses of clinical disorders (Dohrenwend et al., 1992; Gilman et al., 2002; Ritscher et al., 2001; Stansfield et al., 2011). Further, the contribution of SES is evident above the poverty threshold: mental health follows a gradient across the full socioeconomic hierarchy. For instance, a meta-analysis of studies examining the social gradient in depression found an almost twofold increase in risk of depression for individuals from low relative to high SES individuals, and this pattern followed a dose-response relation in income and education (Lorant et al., 2003).

Whilst mental health disparities have been consistently demonstrated, the potential consequences of low SES are not necessarily fixed or universal. Many of those raised in disadvantaged circumstances experience few mental health problems subsequently (Fergusson & Horwood, 2003; Masten, 2001). Resilience research has sought to identify the factors that either attenuate or exacerbate the negative psychological consequences of early-life adversity and environmental stressors (Luthar, 2006). One candidate attribute highlighted by this work is high cognitive ability (frequently referred to as intelligence or intelligence quotient/IQ), which has been shown to predict positive academic and behavioural outcomes in the face of adverse life events (Masten et al., 1999; Fergusson & Lynskey, 1996; Flouri et al., 2013; Pargas et al., 2010). Crucially, the protective effect of high cognitive ability has been shown to extend to the psychological effects of stressful life events, including moderating the onset of symptoms of adolescent depression (Riglin et al., 2016) and the occurrence of emotional internalizing problems (Flouri et al., 2014). Further, resilient youths, defined in part by the absence of recurrent depression, have been shown to have higher levels of cognitive ability (Pargas et al., 2010).

In line with this idea, using two British cohorts of individuals born in 1970 and 1958 we recently showed that high levels of childhood cognitive ability were associated with a substantial reduction in the link between social disadvantage and psychological distress from young adulthood to midlife (measured using the ‘Malaise Inventory’; Bridger & Daly, 2017; Rutter et al., 1970). In both cohorts early life disadvantage was unrelated to future risk of distress among those with high levels of cognitive ability (i.e. 1-SD above the mean). This buffering effect was not explained by the potential compensatory role of adult SES. As such, acquiring the financial resources, prestige, and knowledge absent from their initial circumstances did not explain why the adverse consequences of disadvantage were no longer apparent in adulthood for those with high cognitive ability.

We suggest that the buffering effect of cognitive ability may reflect the adaptive nature of intelligence which, by definition, is tied to an individual’s ability to successfully interact with their environment (Legg & Hutter, 2007). This ability might protect against the potentially distressing effects of adverse circumstances by enabling individuals to respond flexibly to stressors and challenges, profit from learned experiences, and subsequently counter environmental threats more effectively. Greater cognitive resources may serve not only to reduce the number of threats encountered in this way but may also help regulate negative emotions in the face of unavoidable stressors (Riglin et al., 2016; Schmeichel & Tang, 2015) and directly protect individuals against the psychological sequelae of repeated exposure to stress.

Building directly on our prior work which examined two birth cohorts using a non-standard mental health measure, the objectives of the present study were to (i) establish whether the potential stress-buffering effect of cognitive ability generalises to a population-representative sample including individuals from across the full adult life-span and (ii) assess the consistency of the buffering effect across a broad set of well-established clinically-relevant mental health measures (e.g. Short Form-12 Mental Component, General Health Questionnaire, clinical diagnosis of depression). The Understanding Society (UKHLS) study records this information in a large population representative sample of UK households along with rich sociodemographic records. Using these data we aimed to estimate the potential mental health effects of one's family background as gauged by parental education and occupational class levels. We examine family background disadvantage in this way to avoid the possibility of reverse causation associated with adult SES which partially reflects the influence of mental health on income and employment prospects throughout life (Chatterji et al., 2007; Egan et al., 2016; Smith & Smith, 2010). Critically, the UKHLS also includes measures of cognitive functioning which allows the potential buffering effect of cognitive ability to be estimated. We hypothesized that cognitive ability would moderate the association between early life social status and mental health such that those with high levels of cognitive ability would tend to experience few adult mental health consequences of their disadvantaged backgrounds relative to other individuals.

Method

Participants

The UK Household Longitudinal Study (UKHLS or *Understanding Society*) is a survey of approximately 40,000 households from across the United Kingdom (England, Scotland, Wales and Northern Ireland). One of the largest surveys of its kind, the Understanding Society panel is representative of the UK population of all ages and has been designed to ensure ethnic minorities are adequately represented. Complete details on the survey design and sample are reported elsewhere (Buck & McFall, 2012) and all study protocols have been scrutinised and authorised by a number of research committees to ensure compliance with the Helsinki Declaration of 1975/2008. Beginning in 2009-2010 (Wave 1), households have been visited every 24-months to capture changes in circumstances over time. To capture relative level of background social disadvantage we combined measures of parents' education and occupation from the first 2 waves (2009-2011). Measures of cognitive ability and mental health were all taken from data collected at Wave 3 (2011-2012).

Measures

Social disadvantage

In order to make claims about the contribution of socioeconomic status to mental health it is important that social disadvantage is assessed before participants have gained substantial experience in the labour force given that mental health contributes substantially to employment and income levels (e.g. Chatterji et al. 2007). Across Waves 1 and 2 of the UKHLS participants reported the highest educational qualifications their father and mother attained (1 = *did not go to school,* 2 = *left school with no qualifications,* 3 = *left school with some qualifications/certificates,* 4 = *gained further qualifications after leaving school,* 5 = *gained university or higher degree*). Responses were reverse-coded so higher numbers reflect greater disadvantage. Participants also reported both parents' job titles[1] when they were aged 14 which were subsequently coded to the ONS Standard Occupational Classification 2010 (ONS, 2010). This is the current standard occupational classification for the UK by which jobs are classified on the basis of their title and subsequently given a coded ranking (range = 111-927, where 111-125 = Managers, Directors and Senior Officials and 911-927 =

[1] Questionnaire routing ensured that participants were only asked to report their parents' jobs at age 14 if they had previously responded that each parent was working at that time. Routing away from this question therefore accounts for the somewhat lower sample size for this variable.

Elementary Occupations) on the basis of both skill level and specialisation. Coded scores were ranked in line with the ordinal nature of this variable. Table 1 reports the frequencies of parental education level as well as mean occupational ranking for both parents for the final sample. A large proportion of mother's occupational data is missing because participants reported that their mothers were not working when they were 14 (39.3% of sample, compared to 5.4% of fathers).

Each of the four measures – mother's and father's highest educational qualification, mother and father's ranked occupational score – were standardised to have a mean of zero and standard deviation of one, before being averaged and subsequently re-standardised to produce a normally distributed measure of social disadvantage with an adequate level of internal reliability (Cronbach's alpha = 0.75). To maximise the sample size, cohort members were included in the analyses if they provided data on at least two of the four key measures (of the 27,985 included in the final study, on average complete data was provided on 3.16 of the four measures [*SD* = .78]).

Cognitive ability

In Wave 3, participants completed a cognitive ability module at home as guided by the interviewer. For the current analysis, data on performance in word recall, numeric ability and verbal fluency tasks were employed. In the word recall tasks (episodic memory), participants listened to a list of 10 words and were asked to immediately recall these words and again later after a short delay. The measure of verbal fluency required participants to name as many animals as they could within one-minute. Performance on such semantic category fluency tasks depends on a set of cognitive functions including searching of semantic memory for category extensions, working memory updating, and self-monitoring to keep track of performance (Daly et al., 2014; Henry & Crawford, 2004). To test numeric ability, participants answered five questions graded in complexity designed to reflect the use of numbers in everyday life (e.g., calculating discounted prices, correct change, and compound interest). Scores from each of the three tasks (see Table 1) were standardised and the subsequent z-scores were averaged to create a composite measure of cognitive ability, with acceptable internal consistency (Cronbach's alpha = 0.69).

SF-12 Mental Component Summary

Participants completed the short-form (SF-12) measure of general health from which separate physical (PCS) and mental component summary (MCS) scales can be derived (Ware et al. 1996). The MCS is a screening tool able to detect depression and anxiety across a variety of populations (Gill et al. 2007; Vilagut et al. 2013). The MCS scores reported here are derived from six questions asking participants how much time over the past four weeks (1 = *all of the time*, 5 = *none of the time*) they had a lot of energy, found physical health or emotional problems interfered with social activities, accomplished less than they would like as a result of emotional problems, did work or other activities less carefully than usual, felt calm and peaceful as well as downhearted and depressed. A multi-step process (including creation of indicator variables, weighting of indicator variables and standardising: for complete details see Ware et al. 2001) converts responses to a single mental health functioning score from 0 (low) to 100 (high). The mean MCS score in the current sample was 49.39 (*SD* = 9.78). Prior to all analyses, SF-12 MCS scores were reverse coded with higher scores representing poorer mental health to facilitate comparison with other variables.

General Health Questionnaire-12

Participants completed the 12-item version of the General Health Questionnaire (GHQ-12), used to detect psychiatric cases in the general population by comparing the respondent's current state with their usual state (Goldberg et al. 1997). The GHQ-12 is a short yet well-validated scale often used as the gold standard in psychiatric case classification (Kelly et al. 2008). Participants responded on a four-item scale (where 1 = *more so than* *usual*, 2 = *about the same as usual*, 3 = *less so than usual* and 4 = *much less so than usual*) to questions about their general happiness, confidence, ability to face problems, overcome difficulties, make decisions and enjoy normal day-to-day activities. GHQ-12 responses were employed here in two ways. Firstly, we generated a continuous variable by totalling responses to give a Likert-like score from 0-36 where higher scores represent poorer mental health. The mean GHQ-Likert in the current sample was 11.07 (*SD* = 5.48). In a second step, we coded "*more so…*" and "*about the same as usual*" responses as 0, whilst "*less so…*" and "*much less so than usual*" responses were recoded to 1. Recoded scores were summed to give a score of 12 where 0 represents least distressed and 12 most distressed. In line with accepted convention (Goldberg et al., 1997), participants with a score of 3 or more were termed as achieving "psychiatric caseness" (i.e. likely to present with psychiatric disorder). 23.63% of the sample met this criterion for caseness on this second GHQ outcome variable.

Diagnosis of clinical depression

At each wave, participants indicated whether a doctor or other health professional had ever told them that they have clinical depression. Data from across the three waves were re-coded into a binary variable reflecting whether or not participants had received a diagnosis of this kind from their doctor. This was the case for 8.94% of the sample.

Neuroticism

Neuroticism refers to a personality trait characterised by high emotionality and sensitivity to stress, which is known to be a robust correlate of depressive symptoms and self-reported lifetime mental disorder (Hakulinen et al., 2015; Jylhä & Isometsä, 2006) and has been used as an indirect measure of risk for depression (Navrady et al., 2017). In the current survey, neuroticism was measured as part of a 15-item questionnaire designed to capture the Big Five personality traits (Donnellan & Lucas, 2008; Lang et al., 2011). Participants were asked to rate three statements, relating to whether they saw themselves as "someone who gets nervous easily", "someone who is relaxed [and] handles stress well", or "someone who worries a lot". For each item, participants responded on a 7-point response scale (where 1 = *does not apply to me at all* and 7 = *applies to me perfectly*). After reverse scoring "someone who is relaxed [and] handles stress well" responses were averaged to produce a measure ranging from low (1) to high (7) neuroticism (M = 3.56, SD = 1.44).

Data Analysis

First, we aimed to determine how social disadvantage and cognitive ability combine to predict mental health (indexed via the SF-12 MCS and GHQ-Likert scores) and neuroticism (also modelled as a continuous variable) in linear regression analyses. Each of these variables was standardised to have a mean of zero and standard deviation of one across the entire sample to facilitate comparability across analyses. In a series of two models, we adjusted first for key background covariates (Model 1: adjusted for age, age-squared, sex, ethnic identity [white/non-white]) and then added the interaction between our standardised measures of cognitive ability and social disadvantage to the initial model (Model 2). Comparable logistic regressions were conducted to test whether disadvantage and cognitive ability were associated with reaching the threshold for 'caseness' using the GHQ-12 and the likelihood of receiving a diagnosis of depression by a doctor (Model 1) and to identify whether the *disadvantage* × *cognitive ability* interaction term also predicted the binary outcomes examined (Model 2). Simple slopes were then generated using the Stata *margins* command and compared to determine the association between social disadvantage and mental health at low (-1SD), medium (mean) and high (+1SD) levels of cognitive ability. Finally, we used the Stata *marginsplot* command to present the simple slopes from fully-adjusted regression models graphically.

Model 1: $\text{Mental health}_i = \beta_{0i} + \beta_1\text{social disadvantage}_i + \beta_2\text{cognitive ability}_i + \beta_3\text{female}_i + \beta_4\text{white}_i + \beta_5\text{age}_i + \beta_6\text{age}^2{}_i + \varepsilon_i$

Model 2: $\text{Mental health}_i = \beta_{0i} + \beta_1\text{social disadvantage}_i + \beta_2\text{cognitive ability}_i + \beta_3\textit{social disadvantage}_i \times \textit{cognitive ability}_i + \beta_4\text{female}_i + \beta_5\text{white}_i + \beta_6\text{age}_i + \beta_7\text{age}^2{}_i + \varepsilon_i$

As part of the Wave 3 self-completion survey (when demographic characteristics, cognitive ability and mental health were measured) 39,296 adults were administered at least one mental health measure and had survey weights available. From this group, 27,985 individuals had available covariate data and were included in the current sample. Participants were excluded primarily because they were missing background social disadvantage data (see Table S1) chiefly due to survey routing in the first two waves of Understanding Society. Specifically, due to survey length constraints, the full set of parental social background questions (i.e. father/mother education and occupation) were only put to participants during the first 6 months of sampling at Wave 1 and the final 18 months of Wave 2. In addition, we excluded new entrants to the adult survey from the youth panel and those joining households (e.g. through marriage) who did not have the opportunity to complete the social disadvantage questions in Waves 1 and 2. The excluded group was therefore notably younger than the existing sample on average, as shown in columns one and two of Table S1.

In contrast, the included and excluded groups differed little in their levels of cognitive ability and mental health. Nevertheless, to account for differences between the included and excluded groups on key covariates we produced inverse probability weights. To do this, we used available covariate data (i.e. age, gender, ethnicity, cognitive ability measures) to predict the probability of inclusion (vs. exclusion) in the current sample in a logistic regression model. The results of this model were used to generate inverse probability weights which were subsequently combined with an existing survey weight designed to take account of non-response, probability of selection and possible sampling error (Knies, 2017). When the final weighting variable was applied the background characteristics, cognitive ability, and mental health of the current study sample aligned very closely with the full representative Wave 3 sample (see columns three and four of Table S1), thus helping ensure that the generalizability of the study results to the population was maintained. Finally, we estimated unweighted regression models which were minimally different to the main results presented below (see Table S2).

Results

Descriptive Statistics

The final sample size was 27,985 (56.21% female) and the sample was 87.36% white and the mean age was 47.97 (range 18-103). Table 1 presents the descriptive statistics for this sample including both cognitive ability measures as well as the measures of parental SES used to index background disadvantage. There was a moderate negative correlation between social disadvantage and cognitive ability (r = -0.31, p<.001, N=27,985). The three continuous mental health measures (SF-12 MCS, GHQ-Likert and Neuroticism) were positively correlated with one another (average r = 0.57, all ps <.001).

Regressions

Table 2 reports the outcomes of the key regressions for the two models and for each of the five adult mental health measures. Higher levels of social disadvantage predicted raised levels of psychological distress as gauged using the SF-12 MCS (β = 0.026, SE = 0.008, p < .001) and the GHQ-Likert measure (β = 0.040, SE = 0.007, p < .001) and disadvantage also predicted slightly increased neuroticism levels (β = 0.015, SE = 0.007, p < .05). A 1-SD increase in background disadvantage was associated with a significant increase in the likelihood of crossing the case criterion of the GHQ (OR = 1.08, 95% CI; 1.04, 1.12) but did not predict an increased risk of being diagnosed with depression. There were statistically significant associations between cognitive ability and mental health across all measures such that higher levels of cognitive ability were associated with fewer mental health problems.

Table 2 also presents the outcomes of the key regressions employed to test our main hypothesis that cognitive ability would moderate the relationship between background disadvantage and current mental health. Across three linear regression models we identified statistically significant interactions between cognitive ability and social disadvantage in predicting adult mental health (SF-12 MCS: $\beta = -0.059$, SE = 0.008, $p < .001$; GHQ-Likert: $\beta = -0.034$, SE = 0.008, $p < .001$; Neuroticism: $\beta = -0.025$, SE = 0.008, $p < .01$). An examination of the simple slopes confirmed that the interaction effects identified were in the direction anticipated. As shown in the lower panel of Table 2 the link between social disadvantage and mental health was substantially stronger at low (-1-SD), compared to medium or high (+1-SD) levels of cognitive ability. On average across the two distress measures (SF-12 MCS and GHQ), a 1-SD increase in disadvantage predicted a .089 SD increase in distress at low cognitive ability, a .043 SD increase at mean levels, and a -.004 SD decrease at high levels of cognitive ability. Figure 1 illustrates this relationship across the distribution of social disadvantage where moving from very low (-2-SD) to very high (+2-SD) levels of social disadvantage was associated with a .36 SD increase in psychological distress at low levels of cognitive ability whereas no adverse effects of disadvantage were observed amongst those with high cognitive ability. A similar, albeit weaker interaction effect was observed between background disadvantage and cognitive ability in predicting neuroticism as shown in Table 2 and illustrated in Figure 1.

Next, we showed that cognitive ability moderated the link between social disadvantage and both GHQ-caseness and being diagnosed with depression. An examination of the simple slopes showed that a 1-SD increase in social disadvantage was linked to a 20% increase in the odds of GHQ-caseness for those with low cognitive ability, a 10% increase for those of medium ability, and was unrelated to elevated GHQ at high cognitive ability levels, as shown in Table 2. Figure 2 plots this interaction effect and indicates that moving from very low (-2-SD) to very high (+2-SD) levels of social disadvantage was linked with an increase in GHQ-caseness of 14 percentage points (from 21 to 35 percent) at low levels of cognitive ability whereas no discernible increase was found for those with high cognitive ability. Finally, the simple slopes analysis revealed marginally significant associations between disadvantage and rates of diagnosis of clinical depression at low and high cognitive ability levels (see Table 2). Whilst social disadvantage was linked to a greater likelihood of depression diagnosis at low levels of cognitive ability as expected, disadvantage predicted a reduced likelihood of being diagnosed with depression at high levels of cognitive ability.

Discussion

Adults from disadvantaged backgrounds were at elevated risk of psychological distress and neuroticism relative to those from more affluent families. However, as anticipated, those characterized by high levels of cognitive ability showed a pattern consistent with being buffered from the potential detrimental psychological effects of even impoverished backgrounds. Similar patterns of results were identified when we examined clinically-significant levels of emotional problems and diagnoses of depression: those with higher cognitive ability levels showed no adverse mental health effect of a disadvantaged upbringing. In contrast, background social circumstances appeared to matter substantially for those with low levels of cognitive ability who showed notable social gradients in distress and mental health problems. The potential stress buffering benefits of cognitive ability appeared to take a graded form: as intelligence levels increased the link between social disadvantage and adverse mental health outcomes diminished. These data represent an important qualification when considering socioeconomic inequalities in psychological distress: social gradients in mental health may not affect all individuals equally, instead they may occur chiefly amongst those with low-to-average levels of cognitive ability.

Resilience research has previously highlighted a buffering effect of cognitive ability on adolescent depressive symptoms (Riglin et al., 2016), but the present report is the first to show that this protective pattern extends to psychological distress in adulthood in a sample that is representative of the entire adult population across all ages. The suggestion that psychological resources may protect individuals from the adverse impacts of early-life disadvantage on mental and physical health is key to a number of influential life-course models of social gradients (Matthews & Gallo, 2011), yet cognitive ability has been somewhat overlooked as a protective resource of this kind. This oversight is intriguing given the diverse ways in which cognitive ability might lessen the negative impact of social disadvantage on psychological health. Greater cognitive resources may, for example, enable greater emotional regulation in the face of stressors (Schmeichel & Tang, 2015) or allow individuals to successfully limit the negative financial and/or social consequences of distressing incidents.

Although future research is needed to uncover the exact mechanisms by which intelligence uncouples the association between background disadvantage and psychological distress, the moderating effect reported here speaks for the inclusion of cognitive ability in diathesis-stress approaches to distress. These posit that psychological distress is not an inevitable consequence of exposure to stress, but is also dependent upon certain vulnerability factors which may or may not predispose an individual to become distressed (Monroe &

Simon, 1991). An interactive perspective of this kind may also be useful for better understanding the role of *cognitive reserve* as outlined in prior reports (e.g. Koenen et al., 2009; Martin et al., 2007). In this literature high cognitive ability is proposed to increase resilience to the emergence of psychiatric symptoms despite the presence of underlying morphologic brain alterations. More efficient use of brain networks may underlie this ability to cope with disease (Stern, 2002). In the context of the current study, it may be the case that superior cognitive function modifies the impact of stressors, broadly defined to encapsulate either environmental or neurological "insults", on symptom expression (Barnett et al., 2006). We suggest that in the case of social deprivation, cognitive function could: i) buffer the effect of exposure to SES-related stress on the development of neuropathology and neuropsychiatric disorders leading to fewer expressed symptoms or, ii) weaken the expression of symptoms within disorders to a greater extent among disadvantaged individuals who have fewer alternative (social, economic) resources to draw on than their more affluent counterparts.

As is the case in the field of resilience, the current findings do not necessarily translate directly into clinical recommendations (Rutter, 2013), but may generate important strategic implications for the development of preventative measures in mental health care. They highlight an at-risk subset of the population, especially vulnerable to developing psychological difficulties and who may be particularly likely to gain from effective support and early intervention. This support could take several forms including tackling contextual concerns (e.g. marital conflict/relationship instability, parental depression; Klebanov et al., 1994), material deprivation (Engle et al., 2011; Leventhal & Brooks-Gunn, 2003), parenting strategies (e.g. Nowak & Heinrichs, 2008), and child social-emotional functioning (Engle et al., 2011; Heberle & Carter, 2015). Supporting socioeconomically disadvantaged individuals with low-to-average cognitive ability in this way may better equip them to negotiate stressors and alleviate some of the distress associated with disadvantage.

The principal divergence from the predicted pattern of results arose for diagnoses of clinical depression, which did not show an association with background disadvantage. One explanation for this divergence is a reduction in power for this variable due to a smaller available sample size and the lower prevalence of depression compared to GHQ-caseness (see Table 1) which may impact the likelihood of detecting a relationship. Nonetheless, we do observe a significant interaction for depression diagnoses, such that the direction of the typical positive association between disadvantage and depression is reversed at high levels of cognitive ability. This may arise because, unlike the remaining self-report measures, a diagnosis of depression is contingent on access to and engagement with a doctor or other healthcare professional. If those from more advantaged neighbourhoods and those with high cognitive ability tend to be more likely to access diagnosis/treatment for mental health problems (e.g. Beier & Ackerman, 2003; Delgadillo et al., 2016) then our proposed interaction effect for clinical depression (as diagnosed by a doctor or healthcare professional) would be markedly diminished. In future, researchers should examine whether and how disadvantage and cognitive ability individually and interactively predict treatment-seeking.

Intriguingly, this apparent reversal of the social gradient at high levels of cognitive ability was also identified when mental health was measured by the SF-12 MCS: higher ability individuals from more socially disadvantaged backgrounds showed significantly *better* mental health than their more socially advantaged counterparts. Differences in the self-reported SF-12 measure cannot be attributed to differential access to treatment and healthcare services and together these patterns appear to further enrich the interactive relationship between cognitive ability and social disadvantage and psychological distress, insofar as they allow for the possibility that better socioeconomic circumstances can in fact be associated with poorer mental health for the above-average intelligent. It is important not to over-interpret this finding given it was not anticipated and was only significant in one of the mental health measures reported here. Nonetheless, it is interesting to note that the SF-12 has been found to be a significantly better at discriminating people with and without mental diagnoses than the GHQ-12 (Gill et al., 2007) and thus may be a more sensitive tool for detecting specific effects of this kind.

The current study has some limitations. We relied on self-report measures of mental health rather than clinician-guided interviews and assessments. Future work should redress this and also seek to determine whether the buffering effect of cognitive ability extends to other clinical diagnoses known to vary with socioeconomic status such as anxiety disorders (Stansfield et al., 2011). Secondly, due to the concurrent timing of our moderator and outcome measures we cannot infer that cognitive ability levels were not affected by the emergence of mental health problems which could result in inconsistent estimates (Boyce, Wood, Delaney, & Ferguson, 2017). Whilst the issue of measurement timing cannot be directly addressed with the Understanding Society data, we note that this interpretation does not apply to previous reporting of this key interaction using longitudinal panel data in which cognitive ability was measured during childhood and many years prior to measurements of adult health (Bridger & Daly, 2017). Further, our reliance on between-person comparisons makes it difficult to rule out alternative explanations for these data particularly given the tendency of multiple risk factors for poor health (including risk of low cognitive ability) to cluster in disadvantaged environments (Belsky et al., 2016; Melchior et al., 2007). To better understand this potential confound future studies should test whether the link between within-person changes in socioeconomic status and mental health is modified by cognitive ability levels.

Finally, we utilised retrospective measures of social disadvantage prior to entry into the labour market in order to rule out reverse causality (whereby adult SES partially reflects the impact of one's mental health; Chatterji et al., 2007; Egan et al., 2016). Such retrospective measures of parental occupation and education are open to concerns about recall bias given that individuals may not always correctly remember or report earlier life events. Although recall bias can vary with age and factors such as complexity of childhood circumstances, accounts from datasets in which it is possible to directly compare retrospective and prospective measures from the same cohorts report a substantial degree of consistency, licensing the use of retrospective measures where necessary (Brown, 2013; Jivraj et al., 2017). Moreover, it has been argued that retrospective reports may in some circumstances lead to an underreporting of the association between socioeconomic status and disease outcomes (Batty et al., 2005). However, it is worth noting that despite this potential attenuation, we report here a substantial difference in distress levels (0.36 SD) between those with low cognitive ability (-1SD) raised in the poorest compared with the most affluent families.

Conclusions

The current results provide further support for the hypothesis that cognitive ability may buffer the long-term association between childhood socioeconomic disadvantage and poor mental health in adulthood. Across all measures available, including self-reported measures of psychological distress, trait neuroticism and clinical diagnoses of depression, the disadvantage-mental health link was strongest for individuals with below average levels of cognitive ability and was no longer detectable among those with above average levels of ability. Future work should seek to identify the precise pathways through which cognitive ability may protect individuals in this way.

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References

Adler N E, Boyce T, Chesney M A, Cohen S, Folkman S, Kahn R L, Syme S L (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist* **49**, 15-24.

Barnett J H, Salmond C H, Jones P B, Sahakian B J (2006). Cognitive reserve in neuropsychiatry. *Psychological Medicine* **36**(8), 1053-1064.

Batty G D, Lawlor D A, Macintyre S, Clark H, Leon D A (2005). Accuracy of adults' recall of childhood social class: findings from the Aberdeen children of the 1950s study. *Journal of Epidemiology and Community Healthy* **59**(10), 898-903.

Beier M E, Ackerman P L (2003). Determinants of health knowledge: An investigation of age, gender, abilities, personality, and interests. *Journal of Personality and Social Psychology* **84**(2), 439-448.

Belsky D W, Moffitt T E, Corcoran D L, Domingue B, Harrington H, Hogan S., ... Poulton R (2016). The genetics of success: How single-nucleotide polymorphisms associated with educational attainment relate to life-course development. *Psychological Science* **27**(7), 957-972.

Boyce C J, Wood A M, Delaney L, Ferguson E (2017). How do personality and social structures interact with each other to predict important life outcomes? The importance of accounting for personality change. *European Journal of Personality* **31**, 279-290.

Bridger E, Daly M (2017). Does cognitive ability buffer the link between childhood disadvantage and adult health? *Health Psychology* **36**, 966-976.

Brown M (2014). Assessing recall of early life circumstances: evidence from the National Child Development Study. *Longitudinal and Life Course Studies* **5**(10), 64-78.

Buck N, McFall S (2012). Understanding Society: design overview. *Longitudinal and Life Course Studies* **3**(1), 5-17.

Chatterji P, Alegría M, Lu M, Takeuchi D (2007). Psychiatric disorders and labor market outcomes: evidence from the National Latino and Asian American Study. *Health Economics* **16**, 1069e1090. http://dx.doi.org/10.1002/hec.1210.

Daly M, McMinn D, Allan J L (2014). A bidirectional relationship between physical activity and executive function in older adults. *Frontiers in Human Neuroscience* **8**, 1044.

Delgadillo J, Asaria M, Ali S, Gilbody S (2016). On poverty, politics and psychology: the socioeconomic gradient of mental healthcare utilisation and outcomes. *The British Journal of Psychiatry*, **209**(5), 429-430.

Dohrenwend B P, Levav I, Shrout P E, Schwartz S, Naveh G, Link B G, Skodol A E, Stueve A (1992). Socioeconomic status and psychiatric disorders: The causation-selection issue. *Science* **255**, 946-952.

Donnellan M B & Lucas R E (2008). Age differences in the Big Five across the life span: Evidence from two national samples. *Psychology and Aging* **23**, 558-566.

Egan M, Daly M, & Delaney L (2016). Adolescent psychological distress, unemployment, and the Great Recession: Evidence from the National Longitudinal Study of Youth 1997. *Social Science & Medicine* **156**, 98 -105.

Engle P L, Fernald L C, Alderman H, Behrman J, O'Gara C, Yousafzai A et al (2011). Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *The Lancet* **378**(9799), 1339-1353.

Fergusson D M, Lynskey M T (1996). Adolescent resiliency to family adversity. *Journal of Child Psychology and Psychiatry* **37**, 281-292.

Fergusson DM Horwood LJ (2003). Resilience to childhood adversity: Results of a 21 year study. In *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*, ed. Suniya S Luthar. Cambridge University Press.

Flouri E, Mavroveli S, Panourgia C (2013). The role of general cognitive ability in moderating the relation of adverse life events to emotional and behavioural problems. *British Journal of Psychology* **104**, 130-139.

Flouri E, Midouhas E, Joshi H (2014). Family poverty and trajectories of children's emotional and behavioural problems: The moderating roles of self-regulation and verbal cognitive ability. *Journal of Abnormal Child Psychology* **42**, 1043-1056.

Galobardes B, Lynch J W, Davey-Smith G (2008). Is the association between childhood socioeconomic circumstances and cause-specific mortality established? Update of a systematic review. *Journal of Epidemiology and Community Health* **62**, 387-390.

Gill S C, Butterworth P, Rodgers B, Mackinnon A (2007). Validity of the mental health component scale of the 12-item Short-Form Health Survey (MCS-12) as measure of common mental disorders in the general population. *Psychiatry Research* **152**, 63-71.

Gilman S E, Kawachi I, Fitzmaurice G M, Buka S L (2002) Socioeconomic status in childhood and the lifetime risk of major depression. *International Journal of Epidemiology* **31**, 359-367.

Goldberg D P, Gater R, Sartorius N, Ustun T B, Piccinelli M, Gureje O, Rutter C (1997) The validity of two version of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine* **27**(1), 191-197.

Hakulinen C, Elovainio M, Pulkki-Råback L, Virtanen M, Kivimäki M, Jokela M (2015). Personality and depressive symptoms: Individual-participant meta-analysis of 10 cohort studies. *Depression and Anxiety* **32,** *461-460.*

Heberle A E, Carter A S (2015). Cognitive aspects of young children's experience of economic disadvantage. *Psychological Bulletin* **141**(4), 723-746.

Henry J D, Crawford J R (2004). A meta-analytic review of verbal fluency performance following focal cortical lesions. *Neuropsychology* **18**, 284–295. doi: 10.1037/0894-4105.18.2.284

Jivraj S, Goodman A, Ploubidis G B, de Oliveira C (2017). Testing comparability between retrospective life history data and prospective birth cohort study data. *Journals of Gerontology: Series B.* doi:10.1093/geronb/gbx042

Jylhä P, Isometsä E (2006). The relationship of neuroticism and extraversion to the symptoms of anxiety and depression in the general population. *Depression and Anxiety* **23**, 281-289.

Kelly M J, Dunstan F D, Lloyd K, Fone D L (2008). Evaluating cutpoints for the MHI-5 and MCS using the GHQ-12: a comparison of five different methods. *BMC Psychiatry* **8**, 10. doi:10.1186/1471-244X-8-10

Khandaker G M, Barnett J H, White I R, Jones P B (2011) A quantitative meta-analysis of population-based studies of premorbid intelligence and schizophrenia. *Schizophrenia Research* **132**, 220-227.

Klebanov P K, Brooks-Gunn J, Duncan G J (1994). Does neighborhood and family poverty affect mothers' parenting, mental health, and social support?. *Journal of Marriage and the Family* **56**, 441-455.

Knies G (2017). Understanding Society – UK Household Longitudinal Study: Wave 1-6, 2009-2015, User Guide, Version 1.2. Colchester: University of Essex.

Koenen K C, Moffitt T E, Roberts A L, Martin L T, Kubzansky L, Harrington HL et al (2009). Childhood IQ and Adult mental disorders: A test of the cognitive reserve hypothesis. *American Journal of Psychiatry* **166**(10), 50-57.

Lang F R, John D, Lüdtke O, Schupp J, Wagner G G (2011). Short assessment of the Big Five: Robust across survey methods except telephone interviewing. *Behavior Research Methods,* **43,** 548-567.

Lawlor D A, Sterne J A C, Tynelius P, Davey Smith G, Rasmussen F (2006). Association of childhood socioeconomic position with cause-specific mortality in a prospective record linkage study of 1,839,384 individuals. *American Journal of Epidemiology* **164,** 907-915.

Legg S, Hutter M (2007). A collection of definitions of intelligence. (https://arxiv.org/pdf/0706.3639.pdf) Last accessed 18 November 2017.

Leventhal T, Brooks-Gunn J (2003). Moving to opportunity: an experimental study of neighborhood effects on mental health. *American Journal of Public Health* **93**(9), 1576-1582.

Lorant V, Deliege D, Eaton, Robert A, Philippot P, Ansseau M (2003). Socioeconomic inequalities in depression: a meta-analysis. *American Journal of Epidemiology* **157**, 98-112.

Luthar S S (2006). Resilience in development: A synthesis of research across five decades. In *Developmental Psychopathology, Vol 3. Risk, Disorder, and Adaptation,* (Eds. D. Cicchetti & D. J. Cohen) pp. 739-795. New York: Wiley.

Martin L T, Kubzansky L D, LeWinn K Z, Lipsitt L P, Satz P, Buka S L (2007) Childhood cognitive performance and risk of generalized anxiety disorder. *International Journal of Epidemiology* **36**, 769-775.

Masten A (2001). Ordinary magic: Resilience processes in development. *American Psychologist* **56**, 227-238.

Masten A, Hubbard J J, Gest S D, Tellegen A, Garmezy N, Ramirez M (1999). Competence in the context of adversity: Pathways to resilience and maladaptation from childhood to late adolescence. *Development and Psychopathology* **11**, 143-169.

Matthews K A, Gallo L (2011). Psychological perspectives on pathways linking socioeconomic status and physical health. *Annual Review of Psychology* **62**, 501-530.

Melchior M, Chastang J-F, Head J, Goldberg M, Zins M, Nabi H, Younes N (2013). Socioeconomic position predicts long-term depression trajectory: a 13-year follow-up of the GAZEL cohort study. *Molecular Psychiatry* **18**, 112-121.

Melchior M, Moffitt T E, Milne B J, Poulton R, Caspi A (2007). Why do children from socioeconomically disadvantaged families suffer from poor health when they reach adulthood? A life-course study. *American Journal of Epidemiology* **166**(8), 966-974.

Molarius A, Berglund K, Eriksson C, Eriksson H G, Lindén-Boström M, Nordström E, Persson C, Sahlqvist L, Starrin B, Ydreborg B (2009). Mental health symptoms in relation to socio-economic conditions and lifestyle factors – a population-based study in Sweden. *BMC Public Health* **9,** 302-311.

Monroe S M, Simon A D (1991). Diathesis-stress theories in the context of life stress research: Implications for the depressive disorders. *Psychological Bulletin* **110**(3), 406-425.

Navrady L B, Ritchie S J, Chan S W Y, Kerr D M, Adams M J, Hawkins E H, Porteous D, Deary I J, Gale C R, Batty G D, McIntosh A M (2017). Intelligence and neuroticism in relation to depression and psychological distress: Evidence from two large population cohorts. *European Psychiatry* **43**, 58-65.

Nowak C, Heinrichs N (2008). A comprehensive meta-analysis of Triple P-Positive Parenting Program using hierarchical linear modeling: Effectiveness and moderating variables. *Clinical Child and Family Psychology Review* **11**(3), 114.

Office of National Statistics - Standard Occupational Classification 2010: Volume 1 Structure and descriptions of unit groups. (https://www.ons.gov.uk/methodology/classificationsandstandards/standardoccupationalclassificationsoc/soc2010) Accessed 18 November 2017.

Pargas R C M, Brennan P A, Hammen C, Le Brocque R (2010). Resilience to maternal depression in young adulthood, *Developmental Psychology* **46,** 805-814.

Power C, Manor O (1992). Explaining social class differences in psychological health among young adults: a longitudinal perspective. *Social Psychiatry and Psychiatric Epidemiology* **27**, 284-291.

Riglin L, Collishaw S, Shelton K H, McManus I C, NG-Knight T, Sellers R et al. (2016). Higher cognitive ability buffers stress-related depressive symptoms in adolescent girls. *Development and Psychopathology* **28**, 97-109.

Ritscher J E B, Warner V, Johnson J G, Dohrenwend B P (2001). Inter-generational longitudinal study of social class and depression: a test of social causation and social selection models. *British Journal of Psychiatry* **178** (suppl 40), s84-s90.

Rutter M, Tizard J, Whitmore K (1970). *Education, health and behaviour*. London, United Kingdom: Longman.

Rutter M (2013). Annual Research Review: Resilience – clinical implications. *Journal of Child Psychology and Psychiatry* **54**(4), 474-487.

Schmeichel B J, Tang D (2015). Individual differences in executive functioning and their relationship to emotional processes and responses. *Current Directions in Psychological Science* **24**, 93-98.

Smith J, Smith G (2010). Long-term economic costs of psychological problems during childhood. *Social Science and Medicine* **71**, 110e115. http://dx.doi.org/10.1016/ j.socscimed.2010.02.046.

Stansfield S A, Clark C, Rodgers B, Caldwell T, Power C (2011). Repeated exposure to socioeconomic disadvantage and health selection as life course pathways to mid-life depressive and anxiety disorders. *Social Psychiatry and Psychiatric Epidemiology* **46**, 549-558.

Stern Y (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society* **8**, 448-460.

Vilagut G, Forero C G, Pinto-Meza A, Haro J M, de Graaf R, Bruffaerts R, Kovess V, de Girolamo G, Matschinger H, Ferrer M, Alonso J (2013). The Mental Component of the Short-Form 12 Health Survey (SF-12) as a measure of depressive disorders in the general population: Results with three alternative scoring methods. *Value in Health* **16**, 564-573.

Ware J E, Kosinski M, Keller S D (1996). A 12-Item Short-Form Health Survey: Construction of scales and preliminary tests of reliability and validity. *Medical Care* **34** (3), 220-233.

Ware J E, Kosinski M, Turner-Bowker D M, Gandek B (2001). How to Score Version 2 of the SF-12® Health Survey (With a Supplement Documenting Version 1). Lincoln, RI, Quality Metric Incorporated.

Figure Legends:

Figure 1: Association between social disadvantage and mental health at low (-1 SD), medium (mean), and high (+1 SD) levels of cognitive ability. Left panel: SF-12 MCS; Middle panel: GHQ-12 Likert; Right panel: Neuroticism.

Figure 2: Association between social disadvantage and mental health at low (-1 SD), mean, and high (+1 SD) levels of cognitive ability. Left panel: GHQ-12 Caseness; Right panel: Diagnosis of Depression.

Table 1: Descriptive statistics for all key variables and the measures employed to comprise the measure of social disadvantage.

	n	
Age (mean)	27,982	47.97 (17.18)
Female	27,982	56.21%
White	27,982	87.36%
Cognitive Ability (mean)		
Word Recall	27,982	11.50 (3.54)
Numeric Ability	27,784	3.60 (1.07)
Verbal Fluency	27,799	21.80 (6.84)
Social Disadvantage		
Father's Education	25,350	
did not go to school		1.82%
left school with no qualifications		40.67%
left school with some qualifications		22.19%
gained further qualifications after leaving school		24.79%
gained university degree or higher degree		10.53%
Mother's Education	26,072	
did not go to school		2.72%
left school with no qualifications		44.29%
left school with some qualifications		29.45%
gained further qualifications after leaving school		16.67%
gained university degree or higher degree		6.87%
Father's Occupational Ranking (mean)	21,918	516.53 (259.11)
Mother's Occupational Ranking (mean)	14,990	573.05 (268.08)
SF-12 MCS (mean)	27,928	49.39 (9.78)
GHQ-Likert (mean)	27,926	11.07 (5.48)
Neuroticism (mean)	27,938	3.56 (1.44)
GHQ-Caseness (%)	27,926	23.63%
Diagnosis of Depression (%)	23,762	8.94%

Standard deviations in parentheses. Weighted estimates are shown for individuals for whom data on the following variables were available: gender, ethnicity, age, cognitive ability, social disadvantage and at least one outcome variable.

[a] Ranging from 111-125 = Managers, Directors and Senior Officials to 911-927 = Elementary Occupations.

Table 2: Outcomes of linear regressions assessing the interaction between cognitive ability and social disadvantage in predicting mental health in the Understanding Society cohort.

	Predictor	SF-12 MCS[a]	GHQ-Likert[a]	Neuroticism[a]	GHQ-Caseness	Diagnosed with Depression
		B (SE)	B (SE)	B (SE)	OR (95% CI)	OR (95% CI)
Model 1	Social Disadvantage (z-score)	.026** (.008)	.040*** (.007)	.015* (.007)	1.082*** (1.04-1.12)	.999 (.94-.106)
	Cognitive Ability (z-score)	-.115*** (.009)	-.115*** (.009)	-.082*** (.009)	.819*** (.79-.85)	.830*** (.78-.88)
	Female	.167*** (.014)	.196*** (.013)	.406*** (.013)	1.397*** (1.31-1.49)	1.862*** (1.67-2.07)
	White	.069** (.022)	.060** (.023)	.222*** (.020)	.957 (.87-1.06)	2.147*** (1.75-2.63)
	Age	.003 (.002)	.017*** (.002)	.004§ (.002)	1.001 (.99-1.01)	1.118*** (1.10-1.14)
	$Age^2/100$	-.014*** (.002)	-.022*** (.002)	-.015*** (.002)	.986** (.98-1.00)	.887*** (.87-.90)
	Constant	-.069 (.059)	-.568*** (.058)	-.627*** (.055)	.266*** (.20-.35)	.002*** (.001-.003)
Model 2	Social Disadvantage (z-score)	.038*** (.008)	.047*** (.008)	.020** (.007)	1.096*** (1.06-1.14)	1.010 (.95-1.07)
	Cognitive Ability (z-score)	-.114*** (.009)	-.115*** (.009)	-.081*** (.009)	.822*** (.79-.86)	.833*** (.78-.89)
	Social Disadvantage × Cognitive Ability	-.059*** (.008)	-.034*** (.008)	-.025** (.008)	.918*** (.88-.95)	.928** (.88-.98)
	Female	.168*** (.014)	.196*** (.013)	.406*** (.013)	1.398*** (1.31-1.49)	1.860*** (1.67-2.07)
	White	.063** (.022)	.057* (.023)	.219*** (.020)	.951 (.86-1.05)	2.130*** (1.74-2.61)
	Age	.004§ (.002)	.017*** (.002)	.005* (.002)	1.003 (.99-1.01)	1.119*** (1.10-1.14)
	$Age^2/100$	-.015*** (.002)	-.023*** (.002)	-.015*** (.002)	.984** (.97-.99)	.886*** (.87-.90)
	Constant	-.099 (.059)	-.585*** (.058)	-.640*** (.055)	.254*** (.19-.34)	.002*** (.001-.003)
	n	27,928	27,926	27,938	27,926	23,762
Effect of Social Disadvantage at each level of Cognitive Ability						
	Low Cognitive Ability (-1 *SD*)	.097*** (.013)	.081*** (.013)	.046*** (.012)	1.195*** (1.13-1.26)	1.089§ (1.00-1.19)
	Medium Cognitive Ability (Mean)	.038*** (.008)	.047*** (.008)	.020** (.007)	1.096*** (1.06-1.14)	1.010 (.95-1.07)
	High Cognitive Ability (+1 *SD*)	-.021* (.009)	.013 (.009)	-.005 (.009)	1.006 (.96-1.05)	.937§ (.87-1.01)

Standard errors/95% confidence intervals in parentheses. Analyses are weighted using the Understanding Society Wave 3 self-completion weight and an inverse probability weight generated to account for selection bias in the sample with available data for this study.

[a] Variable is standardised to a mean of zero and standard deviation of one. SF-12 MCS = Short-form 12 mental component summary. GHQ = General Health Questionnaire. § $p < .1$ * $p < .05$. ** $p < .01$. *** $p < .001$

Figure 1

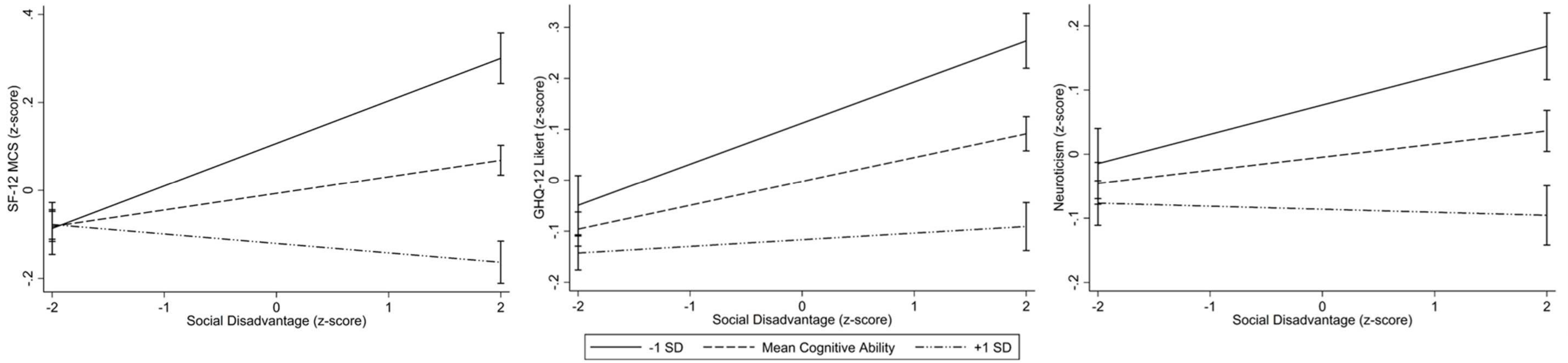
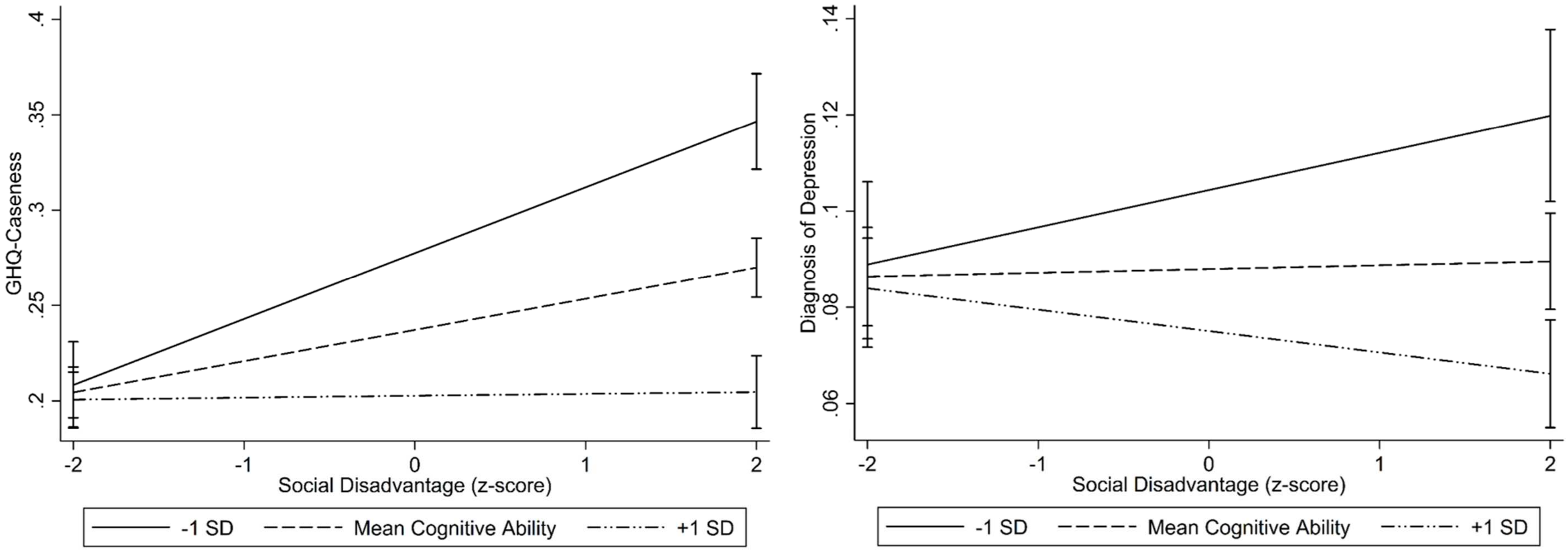

SF-12 MCS (z-score)
GHQ-12 Likert (z-score)
Neuroticism (z-score)
Social Disadvantage (z-score)
-1 SD
Mean Cognitive Ability
+1 SD

Figure 2


GHQ-Caseness
.4
.35
.3
.25
.2
-2
-1
0
1
2
Social Disadvantage (z-score)
-1 SD
Mean Cognitive Ability
+1 SD
Diagnosis of Depression
.14
.12
.1
.08
.06
-2
-1
0
1
2
Social Disadvantage (z-score)
-1 SD
Mean Cognitive Ability
+1 SD

Supplemental Material

Table S1: Descriptive statistics for all key variables for the final included sample, sample not included due to missing data, total sample as well as the final sample after inverse probability weights are applied.

	Included		Excluded		Total sample		Reweighted Included
	n		*n*		*n*		
Age (mean)	27,982	48.89 (17.12)	11,314	45.31 (17.77)	39,296	47.86 (17.38)	47.97 (17.18)
Sex (% female)	27,982	56.90%	11,314	54.24%	39,296	56.13%	56.21%
Ethnicity (% white)	27,982	86.82%	11,102	88.69%	39,084	87.35%	87.36%
Cognitive Ability (mean)							
Word Recall	27,982	11.57 (3.52)	11,310	11.33 (3.69)	39,292	11.50 (3.57)	11.50 (3.54)
Numeric Ability	27,784	3.63 (1.06)	10,165	3.53 (1.11)	38,946	3.60 (1.08)	3.60 (1.07)
Verbal Fluency	27,799	21.97 (6.83)	10,185	21.41 (6.83)	38,979	21.80 (6.83)	21.80 (6.84)
Social Disadvantage							
Father's Education	25,350		723		26,073		
did not go to school		1.85%		3.46%		1.89%	1.82%
left school with no qualifications		41.16%		39.28%		41.11%	40.67%
left school with some qualifications		21.77%		22.68%		21.80%	22.19%
further qualifications after leaving school		24.68%		25.17%		24.70%	24.79%
gained university degree or higher degree		10.54%		9.41%		10.51%	10.53%
Mother's Education	26,072		1,166		27,238		
did not go to school		2.79%		4.20%		2.85%	2.72%
left school with no qualifications		45.06%		46.14%		45.11%	44.29%
left school with some qualifications		28.93%		29.59%		28.96%	29.45%
further qualifications after leaving school		16.48%		14.15%		16.38%	16.67%
gained university degree or higher degree		6.74%		5.92%		6.71%	6.87%
Father's Occupational Ranking (mean)	21,918	515.30 (259.07)	2,108	531.18 (264.18)	24,026	516.70 (259.56)	516.53 (259.11)
Mother's Occupational Ranking (mean)	14,990	573.39 (268.49)	1,163	590.66 (275.70)	16,153	574.64 (269.04)	573.05 (268.08)

SF-12 (mean)	27,928	49.50 (9.73)	11,287	48.93 (10.09)	39,215	49.34 (9.84)	49.39 (9.78)
GHQ-Likert (mean)	27,926	11.04 (5.45)	11,280	11.22 (5.68)	39,206	11.09 (5.52)	11.07 (5.48)
Neuroticism (mean)	27,938	3.54 (1.44)	11,283	3.59 (1.45)	39,221	3.56 (1.44)	3.56 (1.44)
GHQ-Caseness (%)	27,926	23.39%	11,280	24.85%	39,206	23.81%	23.63%
Diagnosis of Depression (%)	23,762	8.87%	1,769	10.06%	25,531	8.95%	8.94%

Table S2: Outcomes of linear regressions assessing the interaction between cognitive ability and social disadvantage in predicting mental health in the Understanding Society cohort (unweighted)

	Predictor	SF-12 MCS[a]	GHQ-Likert[a]	Neuroticism[a]	GHQ-Caseness	Diagnosed with Depression
		B (SE)	B (SE)	B (SE)	OR (95% CI)	OR (95% CI)
Model 1	Social Disadvantage (z-score)	.031*** (.006)	.043*** (.006)	.023*** (.006)	1.082*** (1.05-1.12)	1.014 (.96-1.07)
	Cognitive Ability (z-score)	-.110*** (.007)	-.111*** (.007)	-.076*** (.007)	.821*** (.79-.85)	.842*** (.80-.89)
	Female	.167*** (.012)	.189*** (.012)	.394*** (.012)	1.404*** (1.32-1.49)	1.773*** (1.61-1.96)
	White	.022 (.018)	.026 (.018)	.215*** (.018)	.912* (.84-.99)	2.136*** (1.81-2.51)
	Age	.003§ (.002)	.016*** (.002)	.002 (.002)	1.001 (.99-1.01)	1.112*** (1.09-1.13)
	$Age^2/100$	-.015*** (.002)	-.022*** (.002)	-.013*** (.002)	.986** (.98-.99)	.892*** (.88-.91)
	Constant	-.051 (.050)	-.526*** (.050)	-.566*** (.049)	.272*** (.21-.34)	.002*** (.001-.003)
Model 2	Social Disadvantage (z-score)	.041*** (.007)	.049*** (.007)	.028*** (.007)	1.094*** (1.06-1.12)	1.023 (.97-1.08)
	Cognitive Ability (z-score)	-.109*** (.007)	-.111*** (.007)	-.075*** (.007)	.823*** (.80-.85)	.845*** (.80-.89)
	Social Disadvantage × Cognitive Ability	-.051*** (.006)	-.028*** (.006)	-.021** (.006)	.930*** (.90-.96)	.927** (.88-.98)
	Female	.166*** (.012)	.188*** (.012)	.394*** (.012)	1.40*** (1.32-1.49)	1.772*** (1.61-1.95)
	White	.020 (.018)	.025 (.018)	.214*** (.018)	.910* (.84-.99)	2.134*** (1.81-2.51)
	Age	.004* (.002)	.017*** (.002)	.003 (.002)	1.002 (.99-1.01)	1.113*** (1.09-1.13)
	$Age^2/100$	-.016*** (.002)	-.022*** (.002)	-.014*** (.002)	.984*** (.98-.99)	.891*** (.87-.91)
	Constant	-.078§ (.050)	-.541*** (.050)	-.577*** (.049)	.261*** (.21-.33)	.002*** (.001-.004)
	n	27,928	27,926	27,938	27,926	23,765
Effect of Social Disadvantage at each level of Cognitive Ability						
	Low Cognitive Ability (-1 *SD*)	.093*** (.010)	.078*** (.010)	.048*** (.010)	1.176*** (1.12-1.23)	1.109* (1.02-1.19)
	Medium Cognitive Ability (Mean)	.041*** (.007)	.049*** (.007)	.028*** (.007)	1.093*** (1.06-1.13)	1.028 (.97-1.07)
	High Cognitive Ability (+1 *SD*)	-.010 (.008)	.021* (.008)	.007 (.008)	1.018 (.98-1.06)	.952 (.89-1.01)

Standard errors/95% confidence intervals in parentheses.
[a] Variable is standardised to a mean of zero and standard deviation of one. SF-12 MCS = Short-form 12 mental component summary. GHQ = General Health Questionnaire. § $p < .1$ * $p < .05$. ** $p < .01$. *** $p < .001$