Childhood cognitive ability and smoking initiation, relapse, and cessation throughout adulthood: Evidence from two British cohort studies

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ABSTRACT

Aims: To test the relationship between early cognitive ability and major changes in smoking habits across adulthood, and test whether educational attainment mediates these associations.

Design: Prospective observational study to examine the link between cognitive ability and smoking initiation, relapse, and cessation at multiple time-points throughout adulthood in a pooled analysis of two cohorts.

Setting: Great Britain 1981–2013.

Participants: A total of 16,653 participants from two British cohorts; 7,191 from the 1970 British Cohort Study (BCS) and 9,462 from the 1958 National Child Development Study (NCDS). Participants were 52.9% female and 27.3% were smokers, 24.8% were ex-smokers and 47.9% reported never smoking.

Measurements: Cognitive ability was assessed at age 10 in the BCS and 11 in the NCDS. Outcomes were smoking initiation, relapse, and cessation derived from changes in smoking status observed across five time-points between ages 26–42 in the BCS and six time-points between ages 23–55 in the NCDS. Educational attainment was examined as a mediating variable. Controls were age, gender, social class, self-control, psychological distress, parental smoking, and a study indicator (BCS/NCDS).

Findings: In adjusted regression models, a 1-*SD* increase in cognitive ability predicted a 0.5 percentage point (95% CI = -0.1 – -0.9) reduced probability of smoking and a 2.9 percentage point (95% CI = 2.1–3.7) higher probability of smoking cessation throughout adulthood, but did not significantly change the likelihood of smoking relapse. Differences in educational attainment explained approximately half of the association between childhood cognitive ability and smoking initiation/cessation.

Conclusions: Evidence from two large prospective cohorts shows that lower cognitive ability, measured in childhood before smoking is initiated, predicts a higher likelihood of

taking up smoking and a lower likelihood of quitting in adulthood, and points to education as an important pathway through which this may occur.

INTRODUCTION

Despite widespread public health warnings detailing the adverse health effects of smoking many people continue to smoke tobacco throughout life. There is now convincing evidence that low levels of childhood cognitive ability predict an increased risk of smoking in adulthood [1–6]. Whilst the prospective relationship between cognitive ability and subsequent smoking has been confirmed, the pathways that explain this association remain unclear. We suggest two key paths.

First, there is strong evidence that cognitive ability shapes the uptake of smoking in adolescence [6,7]. For example, a study of over 20,000 Israeli males found that adolescent smokers scored markedly lower than non-smokers on tests of cognitive ability (ES = 0.41) [6]. Furthermore, in that study cognitive ability showed a clear negative relationship with levels of tobacco use among adolescent smokers [6]. Given that adolescent smoking and nicotine dependence tend to persist into adulthood [8], this path is likely to in part explain why childhood cognitive ability predicts smoking later in life.

A second less well explored possibility is that cognitive ability could shape the behaviours that maintain or break smoking habits across adulthood: smoking initiation, smoking relapse, and smoking cessation. There is some evidence that those with lower levels of cognitive ability are more likely to take up smoking in early adulthood [6] and also have difficulty quitting smoking in young adulthood and middle age [5,9,10]. However, a subsequent longitudinal study found no link between cognitive ability and smoking cessation [7]. Whilst prior research has linked individual difference characteristics such as high trait

neuroticism and low self-control [11,12] to higher rates of relapse, the link between early life cognitive ability and relapse to smoking among ex-smokers has not yet been examined.

Although some previous studies have linked cognitive ability to smoking initiation and cessation in adulthood, the measures and designs employed in those studies have been limited in several respects. For example, Weiser *et al.* [6], prospectively examined adult smoking initiation but only from ages 18 to 21. Batty *et al.* [5] relied on showing higher levels of cognitive ability among ex-smokers compared to current smokers at a single time-point to demonstrate a link between cognitive ability and giving up smoking. Taylor *et al.* [9] and Batty *et al.* [10] used retrospective accounts of participants' history of smoking behaviour recalled over decades to link higher levels of cognitive ability to an increased rate of smoking cessation. Such retrospective measures of smoking behaviour are likely to be affected by recall bias [13] which may be greatest among those with lower levels of cognitive ability [14].

To summarise, prior studies aiming to understand the role of cognitive ability in shaping changes in smoking behaviour have been hampered by a reliance on measures of smoking derived from cross-sectional snapshots, short periods of follow-up, and retrospective accounts. The present study therefore set out to systematically test, for the first time, whether individual differences in childhood cognitive ability prospectively predict each of the major changes in smoking habits that can occur across adulthood: smoking initiation, cessation, and relapse. We used two large scale population-based studies, the 1970 British Cohort Study (BCS) and the 1958 National Child Development Study (NCDS). Information on participant smoking was elicited at multiple time-points, removing the need to rely on potentially inaccurate recollections of smoking history.

The NCDS and BCS data have been minimally exploited to examine the link between childhood cognitive ability and changes in smoking behaviour across life. Previous research

has shown that higher levels of cognitive ability predict a reduced risk of smoking in young adulthood and during pregnancy in the NCDS and the BCS [3,5]. Further, higher cognitive ability has been linked to an increased likelihood of being an ex-smoker at age 30 in the BCS [5]. The current study aims to more fully capitalise on the NCDS and BCS data by examining the relationship between cognitive ability and changes in smoking habits over more than three decades of adult life. This study also aims to extend prior work by incorporating controls for previously neglected background variables that have been assessed in the cohort studies. Specifically, we include controls for parental smoking, childhood self-control, and early psychological distress; three key potentially confounding factors which covary with cognitive ability and predict smoking habits [12].

Furthermore, whilst prior studies have considered the role of social background in explaining the link between cognitive ability and changes in adult smoking habits [6,9,10], the specific role of educational attainment as a potential mediator of this association has not been clarified. Cognitive ability is a powerful determinant of educational attainment, explaining approximately a quarter of the variation in school grades [15–17]. Public health campaigns have detailed the dangers of smoking since the 1960s and since then more educated adults have shown lower smoking rates and greater success in smoking cessation across a variety of contexts [18-21]. It is possible that education predicts smoking behaviour because it acts as a 'proxy' for psychological (e.g. self-control, cognitive ability, psychological distress) or social background variables (e.g. childhood social class) [22]. However, we suggest an alternative explanation: that educational attainment acts as a mechanism in its own right by helping to translate higher levels of cognitive ability into changes in smoking habits.

In the current study, we hypothesised that those with high levels of childhood cognitive ability would be more successful at quitting smoking, relapse to smoking at lower

rates, and be less likely to take up smoking as adults. We also hypothesised that educational attainment would act as a mediating pathway through which cognitive ability could enhance the likelihood of smoking cessation and reduce the risk of relapse to smoking and smoking initiation.

METHODS AND MATERIALS

Participants

This study used data from two prospective British birth cohort studies; the BCS, a multidisciplinary study of children born in a single week in 1970 and followed up across multiple waves through to 2012, and the NCDS, a study of those born in a single week in 1958 and traced longitudinally to 2013. We used the BCS data to examine links between childhood cognitive ability at age 10 and changes in smoking behaviour between ages 26, 30, 34, 38 and 42. In the NCDS cognitive ability was measured at 11 and changes in smoking behaviour between ages 23, 33, 42, 46, 50 and 55. In both cohorts, we included those with complete data on childhood cognitive ability and educational attainment and at least two waves of adult smoking data in order to allow smoking initiation, relapse, and cessation to be examined. This produced a total sample size of 16,653 (7,191 in the BCS and 9,462 in the NCDS) across the three (initiation/ relapse/cessation) models. All datasets used are listed in the Supporting Information, Section 1.

Measures

Childhood cognitive ability

In the BCS, cognitive ability was measured at age 10 using the British Ability Scales (BAS). The BAS consists of two verbal (word definitions, word similarities) and two nonverbal tests

(digit-span, matrices) [23]. The word definition test involved indicating the meaning of 37 words and the word similarities test involved producing a word consistent with each of 42 three-word lists. The digit-span test required participants to repeat 34 different sets of digits and the matrices test required participants to fill in a missing section of 28 incomplete patterns. The BAS items show high levels of internal reliability (Cronbach's α=0.93) and convergent validity with other measures of cognitive ability such as Wechsler Intelligence Scale for Children and the Stanford–Binet Intelligence Test [23,24]. To produce an overall measure of cognitive ability we summed correct responses for each test, standardised these four test scores, summed the four variables, and standardised the resulting variable to have a mean of 0 and standard deviation of 1.

In the NCDS, cognitive ability was measured at age 11 using an 80-item general ability test composed of 40 verbal and 40 nonverbal items [25]. The verbal test involved selecting a missing item to complete a set of words and the non-verbal test selecting a missing item to complete a set of shapes. This test has shown high levels of internal reliability (Cronbach's α=0.94) and convergent validity with a contemporaneous IQ test (r = 0.93) used for secondary school selection [25]. To produce an overall measure of cognitive ability we summed correct responses for both tests and standardised the resulting variable to have a mean of 0 and standard deviation of 1.

Adult smoking initiation, relapse, and cessation

Participants rated their smoking status at each survey wave across adulthood in both cohorts. Consistent with the UK Office for National Statistics (ONS) smoking classification system, smokers were defined as those who indicated they "smoke cigarettes every day" or "smoke cigarettes occasionally but not every day". Ex-smokers were defined as those who indicated they "used to smoke cigarettes but don't at all now" and never smokers were those who

reported that they have "never smoked cigarettes". Smoking initiation was defined as reporting being a never smoker at one survey wave and a smoker or ex-smoker at the next recorded time-point. Relapse is typically examined in the context of smoking cessation treatment evaluation trials and refers to "*a period of several days or more of continuous smoking after a period of abstinence or an attempt at abstinence*" [26]. The current study follows recent epidemiological studies that have examined relapse prospectively using multi-wave population data [11,12]. In these studies relapse is defined as reporting being an ex-smoker at one wave and a smoker at the next recorded time-point. This measure aims to capture the change from a period of smoking abstinence to a period of regular smoking. Smoking cessation was defined as reporting being a smoker at one wave and an ex-smoker at the next recorded time-point. The questions used to measure smoking in both cohorts are detailed in the Supporting Information, Section 2.

Educational attainment

Educational attainment was measured via self-report at age 26 in the BCS (age 30 if age 23 was unavailable) and age 23 in the NCDS (age 33 if age 23 was unavailable) and was indexed by National Vocational Qualification (NVQ) rankings, which capture a range of academic achievement from second level or vocational qualifications (NVQ-1) to postgraduate degrees (NVQ-5). Because those without formal qualifications were coded as 0, the resulting education variable ranged from 0 to 5, where 0=no formal qualifications, 1=NVQ-1 (Low O-levels/CSE), 2=NVQ-2 (High O-levels/AS-levels/1 A-level), 3=NVQ-3 (1+ A-levels), 4=NVQ-4 (Diploma/Degree/PGCE), and 5=NVQ-5 (Higher degree).

Covariates

In both cohorts, we adjusted our analyses for age, gender, self-control, psychological distress, social class, parental smoking and a study indicator (BCS/NCDS). In the BCS, childhood self-control was measured at age 10 using 9 teacher-rated items gauging attentional control and perseverance. In the NCDS, self-control was measured at ages 7 and 11 using 13 teacher-rated items from the Bristol Social Adjustment Guide (BSAG) measuring attentional control and impulsive behaviour [27]. The two self-control measures used correspond (r>0.7) with ratings of childhood self-control on contemporary self-control measures [28]. Psychological distress was assessed at age 10 in the BCS using 5 teacher-rated items from the Neuroticism/Anxiety subscale of the Child Developmental Behaviors scale and at ages 7 and 11 in the NCDS using a teacher-rated measure of psychological distress from the BSAG. The individual items used to measure self-control and distress are detailed in the Supporting Information, Section 3.

Social class was derived at birth from a measure of the father's occupation, which was classified, based on the Registrar General's Social Classes, into five categories: I=professional occupations, II=managerial and technical occupations, III=skilled occupations, IV=partly-skilled occupations, V=unskilled occupations. Additional categories were included to code for "Other" occupational categories, such as the father being unemployed or absent, and for missing data.

Parental smoking was measured when the participant was aged 10 in the BCS and 16 in the NCDS. In both cohorts, maternal and paternal smoking behaviour was coded as 0=Non-smoker, 1=1–10 cigarettes per day, 2=11–20 per day, 3=21+ per day, 4=missing data. The NCDS also included a category for parental pipe/cigar smoking. In instances where information on maternal smoking was unavailable at age 16 in the NCDS, we used maternal

smoking levels prior to pregnancy. The individual parental smoking items used are detailed in the Supporting Information, Section 2.

Statistical analysis

Changes in smoking status across adulthood

In our regression analyses we pooled data from both cohorts and used Probit[1] regressions to test the association between childhood cognitive ability and smoking initiation, relapse, and cessation *(Model 1).* We pooled the data from both cohorts because we found no evidence of a statistically significant interaction between cognitive ability and cohort study (BCS/NCDS) in predicting the three smoking outcomes, suggesting that the association between cognitive ability and changes in smoking habits did not differ substantially between studies. We tested the probability of changes in smoking status from one wave to the next between ages 26–42 in the BCS and ages 23–55 in the NCDS. For the initiation analyses we tested whether never smokers at an initial time-point T–1 go on to become smokers or ex-smokers at in the next recorded wave T (outcome coded 0=never smokers and 1=smoker/ex-smoker). For the relapse analyses we examined whether ex-smokers (at T–1) become smokers (outcome coded so that 0=ex-smoker and 1=smoker) in the next recorded wave (T). Finally, for the cessation analyses we estimated the likelihood that smokers at one wave (T–1) went on to become ex-smokers (outcome variable coded 0=smoker and 1=ex-smoker) in the next recorded wave (T). We estimated these associations across all waves of available data simultaneously and used the Stata *margins* command [29] to present our results in terms of percentage point

[1] Our results were essentially identical when using Logistic regressions (analyses available upon request). We did not use Logistic regressions in our main analysis as these are not currently supported in the *khb* procedure used in our mediation analysis.

changes in the probability of initiation, relapse, and cessation. Standard errors were clustered by individual to account for repeated observations across the waves.

$$\textit{Model 1}: \text{Smoking initiation/relapse/cessation}_{it} = \beta_{0i} + \beta_1\text{cognitive ability}_i + \beta_2\text{age}_{it} + \beta_3\text{sex}_i + \beta_4\text{self-control}_i + \beta_5\text{psychological distress}_i + \beta_6\text{parental smoking}_i + \beta_7\text{social class}_i + \beta_8\text{study(BCS/NCDS)}_i + \varepsilon_{it}$$

Our analysis gauges changes in smoking status from one recorded time-point to the next at multiple time-points throughout life and allows multiple changes in smoking status to occur for a given individual. We are therefore capturing the general propensity to change smoking habits in a certain way (i.e. initiation/relapse/cessation) rather than examining single changes in habits that individuals experience from a specific initial time-point (e.g. whether a smoker at age 26 ever reports becoming an ex-smoker in the future). To test whether the estimates from an alternative individual-based design would differ from our 'propensity analysis' we supplemented our main analysis with an analysis of never smokers/ex-smokers/smokers at a specific time-point (age 23 NCDS/age 26 BCS) and subsequent changes in smoking status (i.e. initiation/relapse/cessation) after that time-point. The results of this approach correspond closely to our main findings and are described in the Supporting Information, Section 4.

Educational attainment mediation

To investigate whether educational attainment explained the link between childhood cognitive ability and changes in smoking status we added a measure of education (indexed by NVQ rankings) to *Model 1* and used the Stata khb command [30] to estimate the mediation effect. The *khb* procedure can estimate indirect effects for a binary outcome measured repeatedly over several waves of data, as in the current study. It also allows the total effect of cognitive ability on smoking initiation/relapse/cessation to be decomposed into a direct

effect, not attributable to education, and an indirect pathway from cognitive ability through educational attainment to changes in smoking status. The procedure also performs the necessary decomposition to identify the specific contribution of each NVQ level to explaining the indirect effect of cognitive ability on smoking initiation, relapse, and cessation.

RESULTS

Descriptive statistics

Participants were 52.9% female and on average 27.3% were smokers, 24.8% were ex-smokers and 47.9% reported never smoking at the initial time-point (T–1) examined. Table 1 shows the descriptive statistics and correlations between key variables for both cohorts. The average rate of subsequent smoking initiation between survey waves (i.e. between T–1 and T) among never smokers was 6.6% in the BCS and 6.1% in the NCDS. The rate of relapse among ex-smokers was 19.5% in the BCS and 13.7% in the NCDS. Finally, the average rate of smoking cessation from one wave to the next was 24.8% in the BCS and 23.9% in the NCDS. Childhood cognitive ability was significantly positively correlated with smoking cessation in both cohorts (BCS: r=0.14; NCDS: r=0.17), negatively correlated with initiation in the NCDS (r=-0.04), and unrelated to relapse in either cohort.

An unadjusted comparison showed that on average across the two cohorts, participants with low levels of cognitive ability (the 12.7% of observations in the BCS and 12.9% in the NCDS with cognitive ability scores > 1-*SD* below the mean) had a rate of smoking cessation rate of 18% between baseline and follow-up assessments whereas those with high levels of cognitive ability (the 18.4% of observations in the BCS and 20.4% in the NCDS with ability scores > 1-*SD* above the mean) had a cessation rate of 31%. This

unadjusted association is illustrated in Figure 1. On average across both cohorts those with low cognitive ability also had a 1.5 point higher rate of smoking initiation compared to those with high levels of cognitive ability (7.3 vs. 5.8 percentage points).

Smoking initiation, relapse, and cessation throughout adulthood

The main regression results are shown in Table 2. In analyses adjusting for age, gender, self-control, psychological distress, social class, study (BCS or NCDS), and parental smoking, cognitive ability did not predict smoking relapse but did predict initiation and cessation. A 1-*SD* increase in childhood cognitive ability predicted a 0.5 percentage point (95% CI = -0.1 – -0.9) lower average probability of smoking initiation and a 2.9 percentage point (95% CI = 2.1–3.7) higher average probability of smoking cessation. Our analyses predicted that 6.9% of never smokers with low cognitive ability (-1SD) were predicted to take up smoking compared to 5.9% of never smokers with high cognitive ability (+1SD) from one survey wave to the next recorded time-point. Furthermore, on average, 27.1 percent of smokers with cognitive ability 1-*SD* above the mean were predicted to quit smoking from one survey wave to the next compared to just 21.3 percent of smokers with low cognitive ability (-1SD).

Educational attainment mediation

Next, we aimed to identify if educational attainment mediated the association between cognitive ability and smoking initiation/cessation. As expected, childhood cognitive ability strongly predicted subsequent educational attainment. Across the two cohorts a 1-*SD* increase in cognitive ability predicted a 0.56 unit increase in educational attainment (measured from 0=none, to 5=NVQ level 5) with similar associations identified in fully adjusted analyses of both samples (BCS (*N*=7,191): *b*=0.44, 95% CI=0.40–0.47, *p*<0.001; NCDS (*N*=9,462):

b=0.67, 95% CI=0.64–0.69, *p*<0.001). Higher educational attainment in turn predicted a greater likelihood of smoking initiation/cessation, as shown in Table 2. Compared to those with no formal educational qualifications, those with the highest qualifications were 2.3 percentage points (95% CI=0.6–4.1) less likely to take up smoking and 15.4 percentage points (95% CI=11.0–19.8) more likely to quit smoking as adults.

Formal mediation analysis found that educational attainment explained 48.7% of the link between cognitive ability and smoking initiation (*b*=-0.02, 95% CI=-.03 – -.01, *p*<0.01) and 51% of the link with cessation (*b*=0.05, 95% CI=-.03 – -.01, *p*<0.001), as shown in Table 3. For both outcomes, decomposing this indirect effect revealed that the vast majority (over 80%) of these mediation effects were concentrated among those with the two highest levels of educational attainment (NVQ levels 4 and 5, equivalent to diploma level and above).

DISCUSSION

This study tested the association between childhood cognitive ability and changes in smoking habits across adulthood. Using data from two large population-based UK birth cohorts we found consistent evidence that lower levels of cognitive ability predicted a reduced likelihood of smoking cessation across adult life. Whilst the current study uncovered evidence that strengthens and expands on prior work linking cognitive ability and smoking cessation, our findings in relation to smoking relapse and initiation were equivocal. Those who had never smoked were slightly more likely to start smoking in adulthood if they had low levels of cognitive ability. Furthermore, cognitive ability did not appear to influence whether ex-smokers would relapse to become smokers in either cohort. These results suggest that cognitive ability may shape changes in adult smoking habits chiefly by increasing the likelihood of successfully stopping smoking.

The close association between cognitive ability and smoking cessation was consistent across both cohorts and could not be accounted for by established predictors of smoking habits such as parental smoking, social class, and childhood distress and self-control [11,12,31,32]. On average a 1-*SD* increase in cognitive ability was linked with approximately a 3 percentage point increased likelihood of cessation between one recorded time-point and the next across several waves of follow-up in both cohorts. This finding is in line with previous research linking cognitive ability to smoking cessation [5,9,10]. However, the current study is the first to use multi-wave prospective data to demonstrate that cognitive ability is closely associated with the likelihood of transitioning from being a smoker to being an ex-smoker across adulthood.

To date, there has also been little research formally testing the potential mediating factors linking cognitive ability to smoking cessation. Across both samples we found that approximately half of the prospective association between cognitive ability and both smoking initiation and cessation was explained by educational attainment; children with higher levels of cognitive ability went on to become more highly educated adults, which in turn predicted lower rates of smoking initiation and increased rates of smoking cessation. Taken together these findings underscore the key role of schooling in protecting against smoking behaviours and further highlight the need for tobacco control efforts to target those without a third-level qualification in order to reduce health disparities.

There are many potential pathways through which lower levels of education may have promoted smoking initiation and hampered quit attempts. For example, low levels of education have been linked with social and work environments where smoking is more socially acceptable and cessation is less well supported [33–35]. Conversely, higher levels of education could foster a better understanding of the health consequences of taking up smoking and the potential benefits of smoking cessation treatments, potentially leading to a

lower likelihood of smoking initiation and a greater readiness to quit and to seek support in doing so [35,36].

Limitations

In the present work we focused on two cohorts born in 1970 and 1958, so we cannot say whether the same pattern of results would be observed among younger cohorts. Further, whilst the link between cognitive ability and smoking initiation and cessation was not found to differ significantly between the two cohorts, we cannot rule out the possibility that differences between the cohorts in how cognitive ability was measured (141-item British Abilities Scale in the BCS; 80-item general ability test in the NCDS) and in the timing of the assessment of smoking behaviour (ages 23/26/30/34/38/42 in the BCS; ages 23/33/42/46/50/55 in the NCDS) may have influenced the results [23,25]. Our samples also consisted exclusively of UK citizens so the extent to which our findings are consistent across countries remains unclear. A final limitation of the present work is that smoking was self-reported which, whilst linked to low rates of misclassification [37], could underestimate smoking prevalence [38].

CONCLUSIONS

We investigated whether cognitive ability predicted changes in three adult smoking habits: smoking initiation, relapse to smoking after quitting, and smoking cessation. Our analysis of two large cohorts showed that low levels of childhood cognitive ability were consistently associated with difficulties in smoking cessation, and our mediation analysis found that educational attainment explained half of this association. The risk of smoking throughout

adulthood associated with low cognitive ability [1–6] may partially reflect problems in successfully quitting smoking experienced by this group.

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Table 1 Descriptive statistics and correlations for key variables in the British Cohort Study (BCS) and the National Child Development Study (NCDS).

	BCS (N = 7191)							*NCDS (N = 9462)*						
Variables	*% / M (SD)* [N]	*CA*	*SC*	*PD*	*S*	*PS*	*E*	*% / M (SD)* [N]	*CA*	*SC*	*PD*	*S*	*PS*	*E*
Smoking cessation[a]	24.8% [3055]	**0.14**	**0.11**	**-0.07**	**-0.08**	**-0.15**	**0.17**	23.9% [4077]	**0.17**	**0.11**	**-0.10**	**-0.10**	**-0.11**	**0.23**
Smoking relapse[a]	19.5% [2107]	-0.04	**-0.07**	0.05	0.05	**0.09**	**-0.08**	13.7% [3123]	-0.04	-0.02	0.02	0.05	0.02	**-0.06**
Smoking initiation[a]	6.6% [3682]	-0.02	**-0.06**	-0.01	-0.03	-0.04	-0.02	6.1% [4870]	**-0.04**	**-0.06**	0.03	**-0.04**	**-0.05**	**-0.04**
Cognitive ability	77.3 (14.0) [7191]	1	**0.42**	**-0.22**	**-0.29**	**-0.20**	**0.43**	44.7 (15.6) [9462]	1	**0.37**	**-0.37**	**-0.27**	**-0.13**	**0.54**
Self-control	31.8 (9.9) [7191]		1	**-0.39**	**-0.14**	**-0.16**	**0.29**	11.7 (1.6) [9462]		1	**-0.44**	**-0.12**	**-0.10**	**0.28**
Psych. distress	18.8 (6.2) [7191]			1	**0.06**	**0.03**	**-0.12**	0.9 (1.2) [9462]			1	**-0.13**	**0.09**	**-0.29**
Social class[b]	3.0 (0.8) [6754]				1	**0.20**	**-0.28**	3.1 (0.9) [8688]				1	**0.13**	**-0.31**
Parental smoking[c]	0.8 (0.9) [6600]					1	**-0.23**	0.8 (0.9) [9337]					1	**-0.19**

Education[d]	2.5 (1.4) [7191]	1		2.4 (1.5) [9462]	1

Note. Bolded correlations are significant at $p < 0.01$.
[a]Smoking cessation, relapse and initiation take the average prevalence for all available waves. [b]Social class at birth is based on father's occupational social class ranges from I (highest: professional/managerial occupations) to V (lowest: unskilled occupations) and excludes "other" and "missing" categories in order to include this variable in the correlation matrix. [c]Parental smoking takes the average of "father smoking" and "mother smoking" variables and was rated on a 0 – 3 scale where 0 = Not a smoker, 1 = 1-10 cigarettes per day, 2 = 11-20 per day, 3 = 21+ per day. It excludes "Pipes/cigars" and "missing" categories for the purpose of including this variable in the correlation matrix. If useable data was not available for both parents, we used data on one parent to maximise sample size.[d]Educational attainment was indexed using NVQ rankings, where 0 = None, 1 = NVQ 1 (the lowest qualification) and 5 = NVQ 5 (the highest).
CA = cognitive ability; SC = self-control; PD = psychological distress; S = social class; PS = parental smoking; E = educational attainment.

Table 2 Childhood cognitive ability and percentage point change in probability of smoking initiation, relapse and cessation in the British Cohort Study and National Child Development Study, before and after adjustment for educational attainment levels.

	Smoking initiation		*Smoking relapse*		*Smoking cessation*	
Variable		*+ Educ.*		*+ Educ*		*+ Educ*
Cognitive ability	-0.5**	-0.3	-0.7	-0.3	2.9***	1.4**
	(-0.9 – -0.1)	(-0.7 – 0.1)	(-1.5 – 0.1)	(-1.3 – 0.6)	(2.1 – 3.7)	(0.5 – 2.2)
Education [a]						
None		–		–		–
NVQ 1		-0.7		-0.9		1.5
		(-2.5 – 1.0)		(-4.1 – 2.2)		(-0.7 – 3.8)
NVQ 2		-1.0		-0.7		4.6***
		(-2.5 – 0.5)		(-3.4 – 2.0)		(2.6 – 6.5)
NVQ 3		-1.8*		-0.9		8.0***
		(-3.5 – -0.2)		(-4.1 – 2.2)		(5.4 – 10.7)
NVQ 4		-1.9*		-1.8		9.8***
		(-3.5 – -0.3)		(-4.8 – 1.2)		(7.2 – 12.4)
NVQ 5		-2.3**		-3.8*		15.4***
		(-4.1 – -0.6)		(-7.3 – -0.3)		(11.0 – 19.8)
N	8,552	8,552	5,230	5,230	7,132	7,132
Observations	27,505	27,505	11,841	11,841	17,444	17,444

Note. Cognitive ability is standardised. Data from both cohort studies are pooled into combined analyses. Columns contain Probit marginal effects clustered by the individual participant identifier and converted to percentage point probabilities. Analyses control for age, gender, social class, self-control, psychological distress, parental smoking, and study (BCS or NCDS). 95% confidence intervals in parentheses.
[a]Educational attainment was measured using National Vocational Qualifications (NVQ) levels where None = No formal qualifications; NVQ 1 = Low O-levels/CSE; NVQ 2 = High O-levels/AS-levels/1 A-level; NVQ 3 = 1+ A-levels; NVQ 4 = Diploma/Degree/PGCE; NVQ 5 = Higher degree. Educ. = Educational attainment.
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 3 Decomposition of the total effect of childhood cognitive ability on smoking initiation and smoking cessation via the indirect effect of educational attainment in the British Cohort Study (BCS) and the National Child Development Study (NCDS).

	Smoking initiation		*Smoking cessation*	
	Coefficient (95% CIs)	*P-value*	*Coefficient (95% CIs)*	*P-value*
Total effect	-0.042 (-0.073,-0.012)	< 0.01	0.093 (0.07,0.119)	< 0.001
Direct effect	-0.022 (-0.055,0.011)	0.19	0.045 (0.017,0.073)	< 0.001
Indirect effect	-0.021 (-0.033,-0.008)	< 0.01	0.047 (0.037,0.057)	< 0.001
	Mediation effect	*P-value*	*Mediation effect*	*P-value*
Education[a]				
None	–	–	–	–
NVQ 1	-6.9%	0.41	-3.0%	0.18
NVQ 2	-7.9%	0.19	-4.0%	<0.01
NVQ 3	5.9%	0.05	9.9%	< 0.001
NVQ 4	17.7%	0.02	19.8%	< 0.001
NVQ 5	39.8%	< 0.01	20.2%	< 0.001
Total mediation effect	48.7%	< 0.01	51.0%	< 0.001
N	8,552		7,132	
Observations	27,505		17,444	

Note. Top part of table presents Probit coefficients produced using the *khb* method. Bottom part of table presents mediation effect of childhood cognitive ability on adult smoking by levels of educational attainment by age 30 (BCS) or 33 (NCDS). Analyses control for age, gender, social class, self-control, psychological distress, parental smoking, and study (BCS or NCDS).

[a]Educational attainment was measured using National Vocational Qualifications (NVQ) levels where None = No formal qualifications; NVQ 1 = Low O-levels/CSE; NVQ 2 = High O-levels/AS-levels/1 A-level; NVQ 3 = 1+ A-levels; NVQ 4 = Diploma/Degree/PGCE; NVQ 5 = Higher degree.

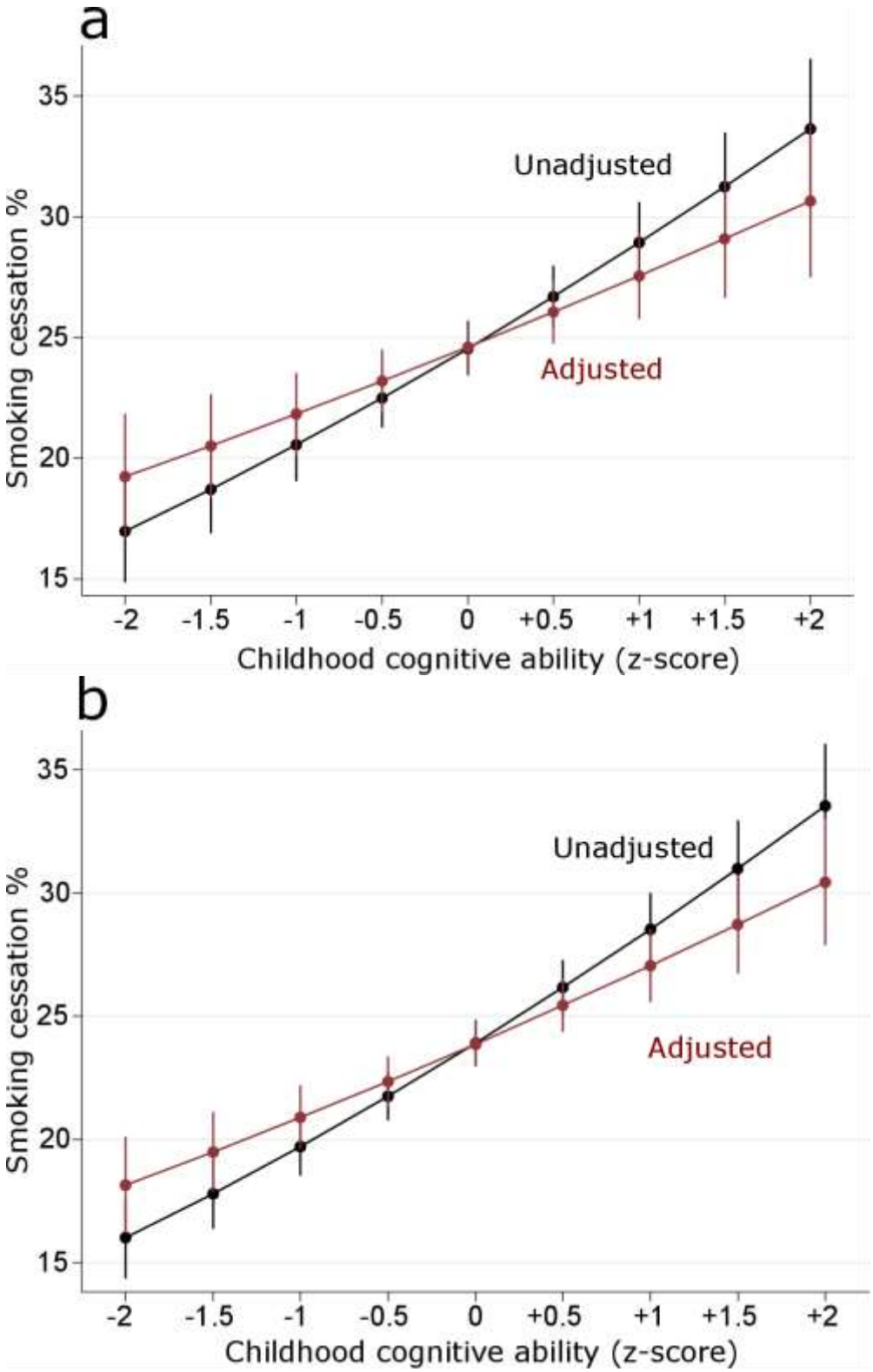

Figure 1 Predicted levels of adult smoking cessation by levels of childhood cognitive ability in the a) British Cohort Study (between ages 26-42) and b) National Child Development Study (between ages 23-55). Adjusted trends control for age, gender, childhood self-control, psychological distress, social class, and parental smoking.